(12) **INTER PARTES REVIEW CERTIFICATE** (1505th)

United States Patent
Öjelund et al.

(10) **Number: US 9,329,675 K1**
(45) **Certificate Issued: Oct. 25, 2019**

(54) **SYSTEM WITH 3D USER INTERFACE INTEGRATION**

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(73) Assignee: **3SHAPE A/S**

Trial Number:

IPR2018-00197 filed Nov. 22, 2017

Inter Partes Review Certificate for:

Patent No.: **9,329,675**
Issued: **May 3, 2016**
Appl. No.: **13/991,513**
Filed: **Jun. 4, 2013**

The results of IPR2018-00197 are reflected in this inter partes review certificate under 35 U.S.C. 318(b).

INTER PARTES REVIEW CERTIFICATE
U.S. Patent 9,329,675 K1
Trial No. IPR2018-00197
Certificate Issued Oct. 25, 2019

AS A RESULT OF THE INTER PARTES REVIEW PROCEEDING, IT HAS BEEN DETERMINED THAT:

Claims **1-19** are cancelled.

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Paper 22
Entered: May 29, 2019

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ALIGN TECHNOLOGY, INC.
Petitioner,

v.

3SHAPE A/S,
Patent Owner.

Case IPR2018-00197
Patent 9,329,675 B2

Before ELENI MANTIS MERCADER, MICHELLE N. WORMMEESTER, and JESSICA C. KAISER, *Administrative Patent Judges*.

MANTIS MERCADER, *Administrative Patent Judge*.

FINAL WRITTEN DECISION
35 U.S.C. § 318(a)

I. INTRODUCTION

A. Background

Align Technology, Inc. ("Petitioner") filed a Petition requesting an *inter partes* review of claims 1–19 of U.S. Patent No. 9,329,675 B2 (Ex. 1001, "the '675 patent"). Paper 2 ("Pet."). 3Shape A/S ("Patent Owner") filed a Preliminary Response. Paper 5 ("Prelim. Resp.").

Upon consideration of the Petition, the Preliminary Response, and the associated evidence, we instituted trial to determine whether claims 1, 2, 9–11, and 18 are anticipated under 35 U.S.C. § 102 by Kriveshko,[1] whether claims 1–5, 8–11, and 14–19 would have been obvious under 35 U.S.C. § 103 over Kriveshko in combination with Serra,[2] and whether claims 6, 7, 12, and 13 would have been obvious under 35 U.S.C. § 103 over Kriveshko in combination with Serra and Brennan.[3] *See* Paper 7, 6, 31 ("Institution Decision" or "Inst. Dec."). After institution of trial, Patent Owner filed a Patent Owner Response. Paper 11 ("PO Resp."). Petitioner replied. Paper 14 ("Pet. Reply").

An oral hearing was conducted on February 4, 2019. A transcript of that hearing is entered in the record. *See* Paper 21 ("Tr.").

We have jurisdiction under 35 U.S.C. § 6. This decision is a Final Written Decision under 35 U.S.C. § 318(a) as to the patentability of claims 1–19 of the '675 patent. For the reasons discussed below, we hold that Petitioner has demonstrated by a preponderance of the evidence that claims 1–19 of the '675 patent are unpatentable.

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[1] US 2007/0171220 A1 (July 26, 2007) ("Kriveshko"; Ex. 1005).
[2] US 2006/0020204 A1 (Jan. 26, 2006) ("Serra"; Ex. 1006).
[3] US 8,903,476 B2 (Dec. 2, 2014) ("Brennan"; Ex. 1007).

B. Related Matters

The parties identify *inter partes* review proceeding IPR2018-00198 that also challenges the '675 patent. Pet. 55, Paper 4, 1. Patent Owner further submits that the following is a list of judicial and administrative matters that would affect, or be affected by, a decision in this proceeding: *Align Technology, Inc. v. 3Shape A/S*, Petition for *Inter Partes* Review of U.S. Patent No. 9,329,675 B2, filed on November 22, 2017; U.S. Provisional Application No. 61/420,138, filed on December 6, 2010; and PCT International Application No. PCT/DK2011/050461, filed on December 5, 2011. Paper 4, 1.

Petitioner states that the '675 patent has not been involved in any litigation proceedings. Pet. 55.

C. The '675 Patent

The '675 patent relates to handheld intraoral scanner device 100 and computer screen 101. Ex. 1001, Fig. 1, 11:29–31. Operator 102 uses the intraoral scanner 100 to record some intraoral 3D geometry and the user interface functionality to rotate, pan, and zoom displayed 3D model 105 of the scanned data on computer screen 101. *Id.* at 11:31–37. The integration of the user interface functionality in device 100 is provided by motion sensors (not visible), which can be accelerometers inside scanner 100, whose readings determine the orientation of 3D model 105 of the teeth acquired by scanner 100 on computer screen 101. *Id.* at 11:37–42. Figure 1 of the '675 patent is reproduced below.

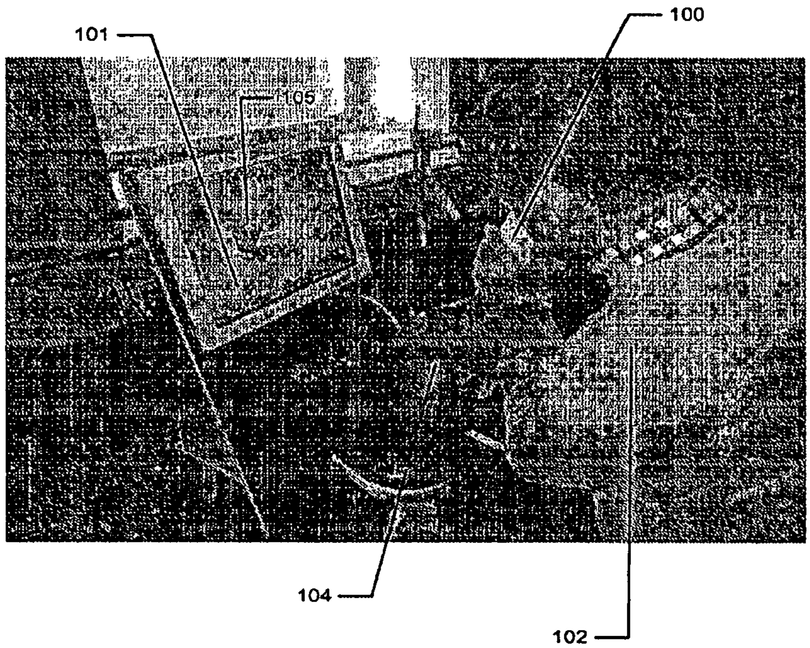

Figure 1 above shows operator 102 using intraoral scanner 100 to record some intraoral 3D geometry and displayed 3D model 105 of the scanned data on computer screen 101. *Id.* at Fig. 1, 11:31–37.

The 3D user interface functionality is provided by at least one motion sensor built into or on the device. *Id.* at 6:46–56. Two different types of motion sensors are described. *Id.* at 6:48–59. One type of motion sensor includes accelerometers, gyros, and magnetometers, which can sense rotations, lateral motion, and/or combinations thereof. *Id.* at 6:48–51. Another type of motion sensor uses infrared sensing. *Id.* at 6:51. At least one infrared sensor is mounted on the device, and at least one infrared emitter can be mounted in the surroundings of the device. *Id.* at 6:51–54. Conversely, the at least one emitter can be mounted on the device, and the at least one sensor in the surroundings. *Id.* at 6:54–56. Another possibility is to use infrared reflector(s) on the device, and both sensor(s) and emitter(s) on the surroundings. *Id.* at 6:56–58.

An example of user interface functionality in the form of remote controlling using the handheld device to determine the view to be displayed is provided by Figures 2a and 2b and respective descriptive disclosure. *Id.* at 11:9–42. The motion sensors (not shown) in handheld device 100, i.e. scanner, allow user 102 to determine the view shown on the display 101, i.e. screen, by moving handheld device 100. *Id.* at 11:10–14.

The operation functionality of device 100 is to record some intraoral 3D geometry, and the user interface functionality is to rotate, pan, and zoom 3D model 105 of the scanned data on computer screen 101. *Id.* at 11:32–37. The integration of the user interface functionality in device 100 is provided by motion sensors (not visible), which can be accelerometers inside scanner 100, whose readings determine the orientation of 3D model 105 of the teeth acquired by scanner 100 on computer screen 101. *Id.* at 11:37–42.

The user interface functionality is illustrated in Figure 2a, reproduced below. Figure 2a shows that pointing device 100 down can provide 3D model 105 of the scanned teeth shown from a downward viewing angle. *Id.* at 11:15–17.

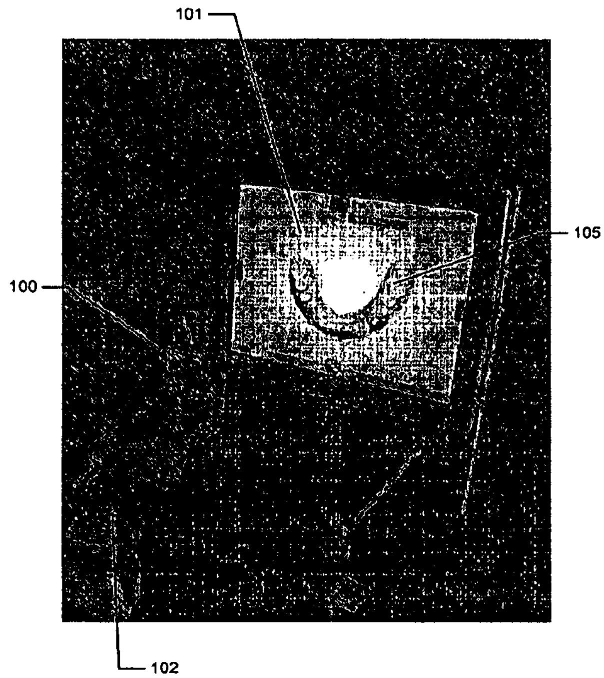

Fig. 2a)

Figure 2a above shows operator 102 using intraoral scanner 100 pointed downwards to provide 3D model 105 of the scanned teeth shown from a downward viewing angle. *Id.* at Fig. 2a, 11:15–17.

Figure 2b reproduced below shows that holding the scanner in a horizontal position can provide that the viewing angle is likewise horizontal from the front, such that 3D model 105 of the scanned teeth is shown from the front. *Id.* at 11:18–21.

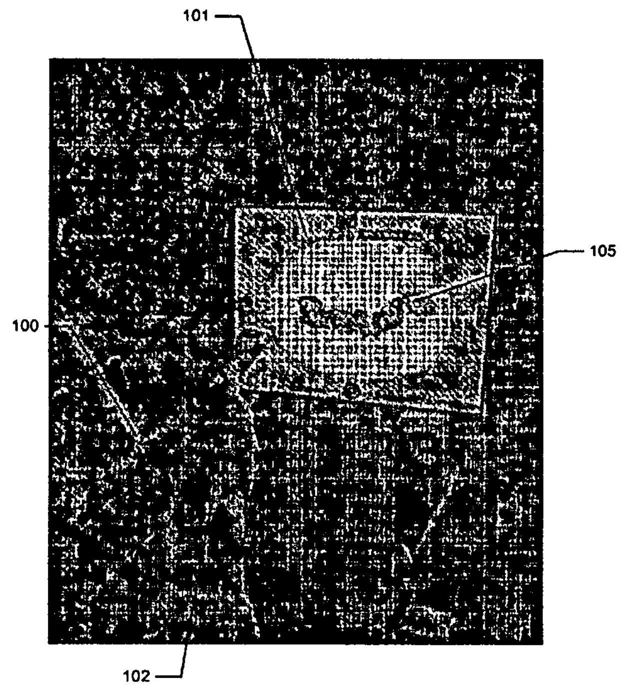

Fig. 2b)

Figure 2b above shows operator 102 using intraoral scanner 100 pointed horizontally to provide 3D model 105 of the scanned teeth shown from a horizontal frontal viewing angle. *Id.* at Fig. 2b, 11:18–21.

Additional functionality to start/stop scanning is provided by button 103 as seen in Figure 3. *Id.* at Fig. 3, 11:42–45. Figure 3 of the '675 patent is reproduced below.

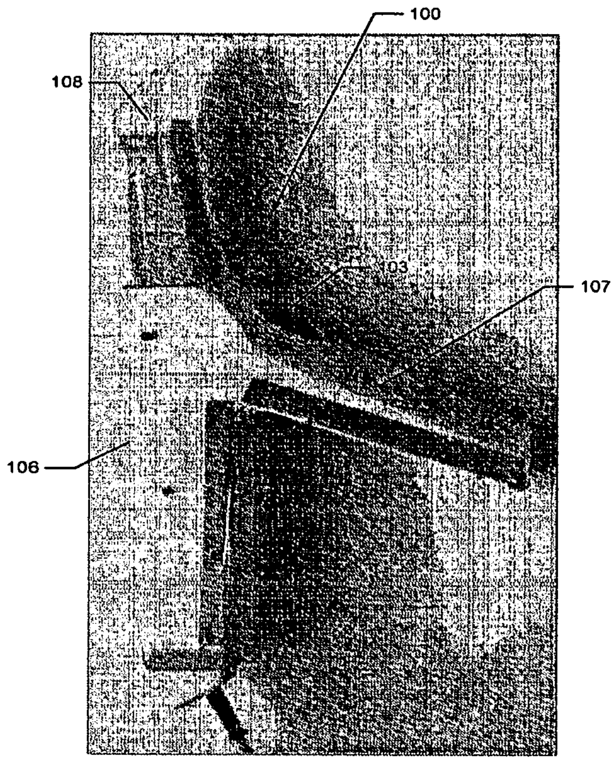

Figure 3 above shows button 103 being located where the user's index finger can reach it conveniently. *Id.* at 11:44–46. When the button is pressed quickly the handheld device is prepared for scanning, e.g., it is set for performing at least one action, the scanning procedure, in the physical 3D environment. *Id.* at 3:58–61. The scanning is stopped when the button is pressed quickly a second time. *Id.* at 3:61–63. While the scanning is performed, a virtual 3D representation is visually built on the display and the user can press and hold the button. *Id.* at 3:61–66. This action puts the handheld device in a controller mode, where the handheld device is adapted for remotely controlling the view with which the 3D environment, such as scanned teeth, is represented on the display. *Id.* at 3:66–4:3. While the button is pressed, the system will use signals from a motion sensor in the handheld device to determine how to present the view of the virtual 3D environment on computer screen 101. *Id.* at 4:3–5.

D. The Challenged Claims

Petitioner challenges claims 1–19 of the '675 patent. Claims 1 and 19 are independent and are reproduced below:

> 1. A scanning system for scanning a 3D environment, the scanning system comprising:
>
> a handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment; and
>
> at least one display remotely connected to the handheld device,
>
> wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment, and the at least one display is adapted for visually representing the physical 3D environment; and
>
> the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display.

Ex. 1001, 15:29–42.

> 19. A system comprising:
>
> a handheld device and at least one display;
>
> wherein the handheld device is adapted for switching between
>
> performing at least one action in a physical 3D environment, wherein the at least one display is adapted for visually representing the physical 3D environment; and remotely controlling the display to adjust the view with which the 3D environment is represented on the display;

> wherein the handheld device is an intra-oral 3D scanner and the at least one action performed in the physical 3D environment is scanning and that the view is remotely controlled by at least one motion sensor arranged in the handheld device, and wherein an actuator provided on the handheld device switches between performing the at least one action and remotely controlling the view.

Id. at 16:35–50.

E. Instituted Grounds of Unpatentability

On April 24, 2018, the Supreme Court issued its decision in *SAS Institute Inc. v. Iancu*, 138 S. Ct. 1348 (2018). Consistent with the Supreme Court's decision in *SAS Institute Inc.*, as well as *PGS Geophysical AS v. Iancu*, 891 F.3d 1354, 1360 (Fed. Cir. 2018), we instituted a trial on all the asserted grounds of unpatentability, which are set forth in the table below.

Reference(s)	**Basis**	**Challenged Claims**
Kriveshko	§ 102	1, 2, 9–11, and 18
Kriveshko and Serra	§ 103	1–5, 8–11, and 14–19
Kriveshko, Serra, and Brennan	§ 103	6, 7, 12, and 13

Inst. Dec. 6. Petitioner relies on the declaration of Chandrajit L. Bajaj, Ph.D. for support (Ex. 1003). With its Response, Patent Owner submits the declaration of Ravin Balakrishnan, Ph.D. (Ex. 2011). The transcripts of the depositions of Dr. Bajaj and Dr. Balakrishnan are entered in the record as Exhibits 2008 and 1037, respectively.

F. Level of Ordinary Skill in the Art

In determining whether an invention would have been obvious to an ordinarily skilled artisan at the time it was made, we consider the level of ordinary skill in the pertinent art at the time of the invention. *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17 (1966). "The importance of resolving the level of ordinary skill in the art lies in the necessity of maintaining objectivity in the obviousness inquiry." *Ryko Mfg. Co. v. Nu-Star, Inc.*, 950 F.2d 714, 718 (Fed. Cir. 1991). The person of ordinary skill in the art is a hypothetical person who is presumed to have known the relevant art at the time of the invention. *In re GPAC, Inc.*, 57 F.3d 1573, 1579 (Fed. Cir. 1995). The level of ordinary skill in the art may be reflected by the prior art of record. *Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001). Factors that may be considered in determining the level of ordinary skill in the art include, but are not limited to, the types of problems encountered in the art, the sophistication of the technology, and educational level of active workers in the field. *GPAC*, 57 F.3d at 1579. In a given case, one or more factors may predominate. *Id.* Generally, it is easier to establish obviousness under a higher level of ordinary skill in the art. *Innovention Toys, LLC v. MGA Entm't, Inc.*, 637 F.3d 1314, 1323 (Fed. Cir. 2011) ("A less sophisticated level of skill generally favors a determination of nonobviousness . . . while a higher level of skill favors the reverse.").

Relying on the declaration testimony of Dr. Bajaj, Petitioner contends that a person of ordinary skill ("POSITA") at the relevant time would have had a bachelor's degree in computer engineering, computer science, computer vision or an equivalent field, as well as at least one or two years of industry experience in three-dimensional imaging systems, or at least five years of comparable industry experience in three-dimensional imaging systems. Pet. 13 (citing Ex. 1003 ¶¶ 19–22). In particular, according to Petitioner, a POSITA would have had experience with, and knowledge of, three-dimensional imaging systems. *Id.*

Patent Owner responds that Petitioner's definition of an ordinarily skilled artisan is inadequate at least because Petitioner's definition does not take into account that the '675 Patent relates to user interfaces. PO Resp. 7–8 (citing Ex. 1001's title ("System with 3D User Interface Integration"); Ex. 2011 ¶¶ 40–43).

The parties' dispute regarding the level of ordinary skill is based on the type of relevant experience. Patent Owner's declarant agrees a POSITA would have had "a bachelor's degree in computer engineering, computer science, computer vision or an equivalent field, as well as at least one or two years of industry or research experience," but Patent Owner's declarant testifies that experience would have been "with user interfaces used in three-dimensional imaging systems" rather than three-dimensional imaging systems generally. Ex. 2011 ¶ 41. Patent Owner's declarant also notes that his opinions would not change under either formulation. *Id.* ¶ 43.

Based on the evidence of record, including the testimony of the parties' declarants as cited above, the subject matter at issue, and the prior art of record, we determine that Patent Owner's proposed skill level is appropriate, and we adopt Patent Owner's articulation of the level of ordinary skill in the art. Our analysis, however, would not differ under either party's definition, and this is consistent with Patent Owner's declarant's statement noting that his opinions would not change under either formulation of the level of the ordinary skilled artisan. *See* Ex. 2011 ¶ 43.

II. DISCUSSION

A. Claim Construction

Claims in an unexpired patent subject to *inter partes* review are given their broadest reasonable interpretation in light of the specification of the patent in which they appear. 37 C.F.R. § 42.100(b) (2017)[4]; *Cuozzo Speed Techs., LLC v. Lee*, 136 S. Ct. 2131 (2016). Consistent with the broadest reasonable construction, claim terms are presumed to have their ordinary and customary meaning as understood by a person of ordinary skill in the art in the context of the entire patent disclosure. *In re Translogic Tech., Inc.*, 504 F.3d 1249, 1257 (Fed. Cir. 2007).

The breadth of a claim term can be limited in two instances: (1) where the Specification reveals a special definition given to a claim term by the patentee acting as a lexicographer that differs from the meaning it would otherwise possess (*see CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d 1359, 1366 (Fed. Cir. 2002)); or (2), where the Specification reveals an intentional disclaimer, or disavowal, of claim scope by the inventor (*see SciMed Life Sys., Inc. v. Advanced Cardiovascular Sys., Inc.,* 242 F.3d 1337, 1343–44 (Fed. Cir. 2001)). An inventor may provide a meaning for a term that is different from its ordinary meaning by defining the term in the specification with reasonable clarity, deliberateness, and precision. *In re Paulsen*, 30 F.3d 1475, 1480 (Fed. Cir. 1994).

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[4] A recent amendment to this rule does not apply here because the Petition was filed before November 13, 2018. *See* "Changes to the Claim Construction Standard for Interpreting Claims in Trial Proceedings Before the Patent Trial and Appeal Board," 83 Fed. Reg. 51,340, 51,340 (Oct. 11, 2018) (to be codified at 37 C.F.R. pt. 42).

Intrinsic evidence "is the most significant source of the legally operative meaning of disputed claim language." *Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996). When the specification is clear about the scope and content of a claim term, there is no need to turn to extrinsic evidence for claim interpretation. *3M Innovative Props. Co. v. Tredegar Corp.*, 725 F.3d 1315, 1326–28 (Fed. Cir. 2013).

The parties separately argue proposed constructions for various limitations of the claims. *See* Pet. 9–12; PO Resp. 5–7; Pet. Reply 2–4, 17–25. In light of the parties' arguments and evidence developed during trial, we address two claim terms: (1) "motion sensor"; and (2) "user interface." *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("only those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy").

1. "motion sensor"

Claims 4, 5, 7, 8, and 19 of the '675 patent recite a "motion sensor." Ex. 1001, 15:50–16:9, 16:35–50. Petitioner and Patent Owner agree that the term "motion sensor" requires "[a] sensor detecting motion." Pet. 11; PO Resp. 6; Pet. Reply 16 (all citing Ex. 1001, 10:35). Petitioner contends that "[w]here the parties diverge is in regard as to what sensors qualify as motion sensors." Pet. Reply 16. Petitioner alleges that Patent Owner "seeks to limit the scope of the claimed 'motion sensor' to exclude sensors that collect position and orientation data." *Id.* at 17.

Petitioner contends that the '675 patent specification defines a motion sensor as

> [a] sensor detecting motion. Motion can be detected by: sound (acoustic sensors), opacity (optical and infrared sensors and video image processors), geomagnetism (magnetic sensors,

> magnetometers), reflection of transmitted energy (infrared laser radar, ultrasonic sensors, and microwave radar sensors), electromagnetic induction (inductive-loop detectors), and vibration (triboelectric, seismic, and inertia-switch sensors). MEMS accelerometers, gyros, and magnetometers are examples of motions sensors.

Pet. 11 (citing Ex. 1001, 10:35–39).

Petitioner further references the ’675 patent specification for the teaching of infrared sensors mounted on the device to track the probe in the surroundings. Pet. Reply 18 (citing Ex. 1001, 6:46–59). Petitioner contends that Patent Owner’s own extrinsic evidence (Ex. 2013) explains that infrared sensors, such as the ’675 patent’s infrared sensors, function as motion sensors by tracking position and orientation. *Id.* at 19. Petitioner further points us to the deposition testimony of Patent Owner’s declarant Dr. Balakrishan that infrared (“IR”) trackers can track position and orientation. *Id.* (citing Ex. 1037, 44:15–17). Petitioner contends that Dr. Balakrishan acknowledged that the ’675 patent does not provide any “particular way to sense motion.” *Id.* Petitioner contends that the ’675 patent recitation of “motion sensors” is sufficiently broad to include sensors that sense motion by tracking position and orientation. *Id.* at 20.

Patent Owner asserts that a 3D tracking system that detects 3D position and orientation and records time does not constitute a motion sensor because it detects 3D position data and not 3D motion data. PO Resp. 19 (citing Ex. 1006 ¶ 74, Fig. 7; Ex. 2011 ¶ 59). Patent Owner asserts a distinction exists between a 3D sensor that detects “absolute values” of position as opposed to a motion sensor that detects “relative values” equated with motion of “how far they move rather than where they are.” *Id.* at 26 (quoting Ex. 2013, 92). During the hearing, Patent Owner’s counsel stated "you can use many different technologies to detect motion, but the fact of the matter is a motion sensor detects motion. It's different than detecting position. It's different than tracking position. It's different than sensing orientation and it's different from tracking orientation." Tr. 28:5–8. Patent Owner's counsel acknowledged, however, that "[m]otion can be a change in orientation and position." *Id.* at 30:1–2.

We agree with Petitioner that the '675 patent specification teaches a non-exclusive extensive list of motion sensors including acoustic, optical, and infrared sensors. Pet. 11 (citing Ex. 1001, 10:35–43). The non-exhaustive list of motion sensors includes accelerometers. *Id.*

According to the '675 patent specification, the system uses signals from a motion sensor in or on the handheld device to determine how to present the view of the virtual 3D environment on computer screen 101. Ex. 1001, 4:3–5. The function of the motion sensor used in the '675 patent is described in pertinent part as follows:

> The integration of the user interface functionality in the device 100 is provided by motion sensors (not visible), which can be accelerometers inside the scanner 100, whose readings determine the orientation, as seen in FIGS. *2a* and *2b,* of the display on the screen of the 3D model 105 of the teeth acquired by the scanner 100.

Ex. 1001, 11:37–42 (emphasis added).

The particular descriptions of Figures 2a and 2b show that the viewing angle changes based on holding or pointing the scanner downwards or horizontally. Ex. 1001, 11:15–21. Thus, the '675 patent specification contradicts Patent Owner's assertion that the motion sensor excludes sensors that detect position and orientation. *See* PO Resp. 19 (citing Ex. 1006 ¶ 74, Fig. 7; Ex. 2011 ¶ 59). In fact, the '675 patent specification discloses the reading of the orientation of the motion sensor at a downward angle of the scanner shows a downward viewing angle displayed in Figure 2a (*see* Ex. 1001, 11:15–17, Fig. 2a) compared to the reading of the orientation of the motion sensor at a horizontal direction which shows a horizontal viewing angle displayed in Figure 2b (*see id.* at 11:18–21, Fig. 2b).

Thus, we agree with Petitioner that the '675 patent's "motion sensors" do not exclude sensors that track position and orientation. *See* Pet. Reply 17–20.

Patent Owner further contends the '675 patent specification discloses that position and orientation data is from the 3D image data recorded by the handheld device, not from the motion sensor. PO Resp. 22 (citing Ex. 1001, 9:1–3 ("The 3D data recorded by the handheld device can be registered in real time with the a-priori data, such that the position and orientation of the device can be detected."), 1:24–25, 1:32–35 (disclosing that "3D data" refers to displayed image data)). Patent Owner concludes that the '675 patent distinguishes position and orientation data, from motion data detected by a motion sensor. *Id.* (citing Ex. 2011 ¶ 63).

We do not agree with Patent Owner's contention. The context for the cited embodiment is provided below:

> *In some embodiments the handheld device is a mechanical tool.* In some embodiments, *the tool has at least one motion sensor built in.* In other embodiments, other user-interface elements are built in as well, for example buttons, scroll wheels, touch-sensitive fields, or proximity sensors.
>
> *In some embodiment[s] the 3D geometry of the 3D environment is known a-priori or a 3D representation of the environment is known a priori, i.e. before the actions (s) are performed. For example in surgery, a CT scan may have been taken before the surgical procedure. The handheld device in*

> *this example could be a surgical instrument that a physician needs to apply in the proper 3D position. To make sure this proper position is reached, it could be beneficial to view the 3D environment from multiple perspectives interactively, i.e. without having to release the surgical instrument.*
>
> *An advantage of the system, also in the above surgery example, is the ability of the handheld device to record the 3D environment at least partially, typically in a 3D field-of-view that is smaller than the volume represented in the a-priori data. The 3D data recorded by the handheld device can be registered in real time with the a-priori data, such that the position and orientation of the device can be detected.*

Ex. 1001, 8:49–9:3 (emphases added). Furthermore, the '675 patent specification discloses that the system uses signals from a motion sensor in the handheld device to determine how to present the view of the virtual 3D environment on computer screen 101. *Id.* at 4:3–5. These disclosures in the '675 patent demonstrate the handheld device (i.e., surgical instrument) includes a built in motion sensor that allows the physician to place the surgical instrument in the *proper 3D position* by allowing viewing of the previously acquired 3D environment (i.e., CT scan used to create an a priori 3D representation) from multiple perspectives. *See* Ex. 1001, 8:49–63. The system uses signals from a motion sensor in the handheld device (i.e., in this instance a surgical instrument) to determine how to present the view of the virtual 3D environment on the computer screen. *See* Ex. 1001, 4:3–5. Accordingly, the reading of the *position and orientation signals of the motion sensor* located in the handheld surgical instrument allows viewing the respective view of the 3D environment in order to guide the surgical instrument at the right position.

The citation by Patent Owner (Ex. 1001, 9:1–3) refers to the additional embodiment where a handheld device is performing a scanning procedure *in real time* creating a smaller 3D field-of-view than the 3D image produced a-priori and the two sets of images can be co-registered so that *the position and orientation of the device can be detected. See id.* at 8:64–9:3. In other words, the co-registration of the images allows for determination of the position and orientation of the surgical instrument in real time by reading the signals from the motion sensor. Although the excerpt cited by Patent Owner does not reference the motion sensor, the earlier paragraph, when read in context, reveals the use of a motion sensor so that the position and orientation of the surgical instrument can be determined. *See* Ex. 1001, 8:49–9:3. Thus, in the embodiment cited by Patent Owner, the signals of position and orientation read from the motion sensor of the handheld device (whether the handheld device is a surgical instrument and/or a scanner) are still what determine the view to present on the display.

Nowhere in the '675 patent specification do we see a special definition or disavowal of a particular type of motion sensor to exclude those sensors that can only detect position and orientation information to detect motion. On the contrary, the specification describes examples of motion sensors that detect position and orientation as described above.

Furthermore, we see no disavowal of a particular type of motion sensor to exclude those sensors that only detect position and orientation information. In particular, we see no distinction between using a motion sensor that is delineated as a "position" versus a "motion" sensor.

Thus, the breadth of a claimed term is not limited because (1) the specification does not reveal a special definition given to "motion sensor" by the patentee acting as a lexicographer that differs from the meaning it would otherwise possess (*see CCS Fitness, Inc. v. Brunswick Corp.*, 288 F.3d at 1366); and (2) the specification does not reveal an intentional disclaimer, or disavowal, of claim scope by the inventor (*see SciMed Life Sys.*, 242 F.3d at 1343–44).

Accordingly, we determine that, under a broadest reasonable interpretation in light of the specification of the '675 patent, the term "motion sensor" does not exclude motion sensors that track position and orientation.

When the specification is clear about the scope and content of a claim term, there is no need to turn to extrinsic evidence for claim interpretation. *3M Innovative Props. Co.*, 725 F.3d at 1326–28. However, for completeness we also address the extrinsic evidence of record.

Patent Owner's expert testified that "tracking 3D position over time provides 3D position over time . . . simply sensing position over time does not give me motion." Ex. 1037, 79:19–80:12. Furthermore, Patent Owner provides the extrinsic evidence of the "Buxton table" to indicate that motion and position are fundamentally different properties and that one ordinarily skilled in the art would have understood that motion sensed at particular times is different than position sensed at particular times. PO Resp. 21–22 (citing Ex. 2009, 149). The Buxton Table is reproduced below.

Property sensed		Number of Dimensions 1	2	3	Sensing type
Position		Rotary Pot, Sliding Pot	Tablet, Light Pen, Joystick	3D Joystick	M
Position			Touch Tablet, Touch Screen		T
Motion		Continuous Rotary Pod, Treadmill, Thumbwheel	Trackball	Trackball	M
Motion		Tasa Ferinstat	Tasa X-Y Pad		T
Pressure		Torque Sensing, Pressure Pad	Isometric Joystick		T

The Buxton Table

The Buxton Table reproduced above shows "Motion" and "Position" as different properties sensed. Ex. 2009, 149.

Petitioner asserts that Patent Owner tries to exclude sensors that derive motion from position and orientation from the scope of the '675 patent's claimed "motion sensor," by turning to studies on the taxonomy of input devices that show certain devices categorized based on whether they sense motion (e.g., trackball, treadmill) or position (e.g., joystick, light pen, etc.). Pet. Reply 23 (citing PO Resp. 21 (citing Ex. 2013, 130)).

Petitioner cites to a different section of the reference provided by Patent Owner showing a table as reproduced below to emphasize that trackers that sense "position" do so by tracking position and orientation. Pet. Reply 23–24 (citing to Ex. 2013, 130).

		Number of Dimensions					
		1		2		6	
Property Sensed	Position	Bend Sensor	Linear Slider	Tablet and Stylus	Isotonic Joystick	Trackers (Position & Orientation)	M
				Touch Tablet			T
	Motion		Treadmill	Mouse	TrackBall		M
	Pressure	Torque Sensor			Isometric Joystick	SpaceBall & SpaceMouse	T

Figure 4.30 of Exhibit 2013 shows the "position" property being sensed by trackers (depicted under numeral 6 of the table) sensing position and orientation. Pet. Reply 24; *also see* Ex. 2013, 130.

Petitioner contends that Patent Owner misreads the Buxton table to mean that something listed as a position sensing device cannot detect motion. Pet. Reply 24. According to Petitioner, "a motion sensor can be formed from a position and orientation tracker." *Id.* Petitioner contends that other extrinsic evidence, namely, a book titled "3D User Interfaces Theory and Practice" (i.e., "Bowman" which cites to the Buxton Table),[5] clarifies that "there are a number of different *motion-tracking* technologies in use, which include . . . optical tracking" and that infrared emitters can be used in optical tracking for position and orientation tracking. *See* Pet. Reply 24 (citing Ex. 1038, 97), 19–20 (citing Ex. 1038, 97, 101).

[5] Different portions of Bowman are reproduced by Patent Owner and Petitioner. Patent Owner's Exhibit 1038 and Petitioner's Exhibit 2013 are Bowman excerpts.

Petitioner further points us to Patent Owner's U.S. Patent Application Publication No. 2014/0022352, which discloses that "[i]n some embodiments the motion is determined by determining the position and orientation of one or more of the sensors" (Ex. 1039 ¶ 49) and that "'[i]n some embodiments the motion is determined by means of 3D position sensors.' (*Id.* ¶ 51; Ex. 1040, WO 2013/010910, 28:1–2; Ex. 1037, 38:22–39:7.)" Pet. Reply 20.

Petitioner during the hearing pointed us to the disclosure of the '675 patent specification including infrared emitters or reflectors mounted on the device whereby their detection can be used to track the probe in its surroundings to determine "the position and the orientation of this device: its lateral movement, its rotation, and you can track that movement of this device and use that for this virtual interface that allows you to control the display of the scanned 3D data that's being rendered on the display panel." Tr. 13:8–15:4 (citing Ex. 1001, 6:46–59, 10:35–43). As pointed out by Petitioner, Patent Owner's declarant, Dr. Balakrishnan, stated that "[a]n IR receiver [and] detector, if configured in a particular way, could be a position and orientation tracker." Pet. Reply 19 (citing Ex. 1037, 44:15–17).

Based on the evidence discussed above, we are persuaded by Petitioner that the Buxton Table does not, contrary to Patent Owner's contentions, distinguish motion sensors from position sensors, especially since trackers including IR emitters or sensors identified as "position" sensing in Buxton Figure 4.30 are identified as motion sensors in the '675 patent. *See* Ex. 1001, 6:46–59; Ex. 1037, 44:15–17.

Patent Owner further argues that the motion sensor of the '675 patent detects *relative* values, because the property sensed is the motion of the sensor ("how far they move rather than where they are"), not the absolute position. PO Resp. 26 (citing Ex. 2013, 92). Petitioner responds that Patent Owner's attempt to distinguish sensors based on detection of absolute or relative values (PO Resp. 25–26) fails because the exact same sensors (i.e., tracking sensors) are in the '675 patent's contemplation of infrared emitter/sensor-based motion sensors. Pet. Reply 24 (citing Ex. 1040, 16:9–14; Ex. 1037, 40:9–41:19).

We agree with Petitioner's contentions for the reasons stated by Petitioner. We further note that Patent Owner's assertion that a "motion sensor" must detect relative values equated with motion of "how far they move rather than where they are" (PO Resp. 26), is not supported by the '675 patent specification. On the contrary, the '675 patent specification, as discussed above, teaches reading of the motion sensor's position and orientation to display the respective previously acquired image/3D model (i.e., top view versus horizontal view, as shown in Figs. 2a and 2b of the '675 patent specification).

On this record, we agree with Petitioner and determine that the extrinsic evidence is consistent with the '675 patent specification, and that it does not support Patent Owner's contentions that the recited "motion sensor" excludes sensors that detect position and orientation data to detect motion.

Accordingly, under the broadest reasonable interpretation in light of the'675 patent specification as well as the extrinsic evidence presented, the term "motion sensor" is properly construed as a motion sensor that detects motion and does not exclude sensors that collect position and orientation data.

2. "user interface"

Claim 1 of the '675 patent recites that "the handheld device includes *a user interface* for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." Ex. 1001, 15:40–42 (emphasis added). We address the claim construction of the term "user interface" in our discussion of Petitioner's challenge to claim 1 as anticipated by Kriveshko.

B. Anticipation by Kriveshko

Petitioner argues that Kriveshko anticipates claims 1, 2, 9–11, and 18. Pet. 15–24. For the reasons explained below, we are persuaded that Petitioner has demonstrated by a preponderance of the evidence that these claims are unpatentable on this ground.

1. Overview of Kriveshko (Ex. 1005)

Kriveshko's Figure 1, reproduced below, shows system 100 including scanning device 102 with input device 116. Ex. 1005 ¶¶ 51, 72.

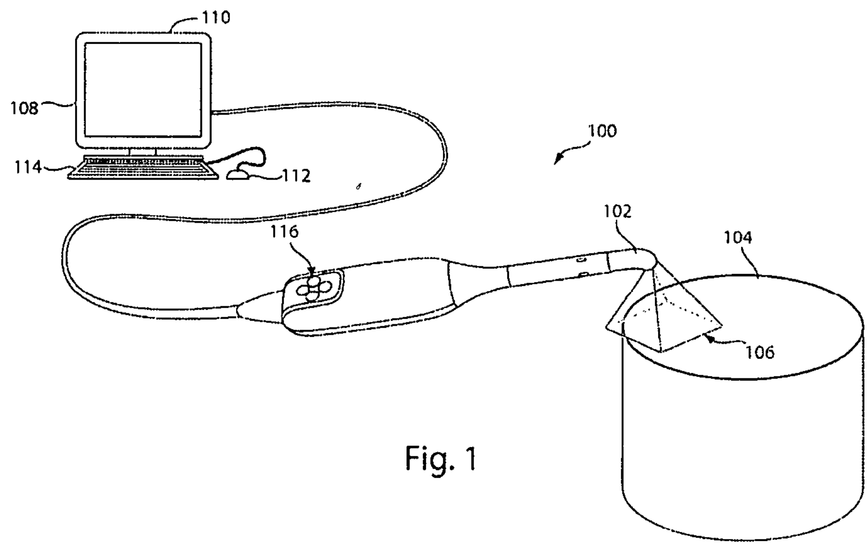

Fig. 1

Figure 1 shows handheld scanner 102 having input device 116 located on scanner 102 wherein scanner 102 is remotely connected to display 110. Ex. 1005, Fig. 1.

Kriveshko discloses "scanner 102 is *a handheld, freely positionable probe having at least one user input device, such as a button, lever, dial, thumb wheel, switch, or the like*, for user control of the image capture system 100 such as starting and stopping scans." *Id.* ¶ 52 (emphasis added). The scanning device 102 acquires three-dimensional data. *Id.* Kriveshko's scanning system 100 includes computer 108 having display 110. *Id.* ¶ 51.

Kriveshko's Figure 4 is reproduced below:

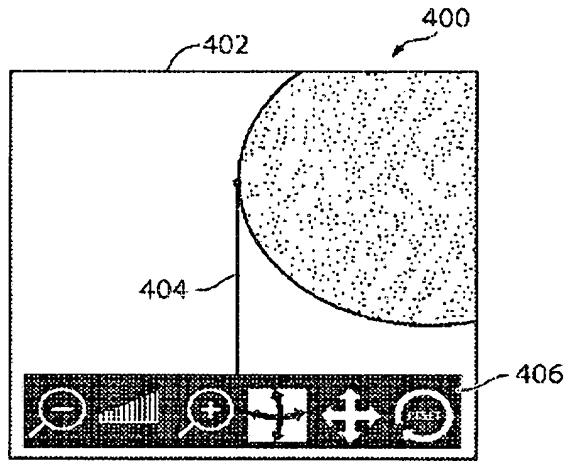

Fig. 4

Figure 4 shows user controls 406 which can be manipulated by any of the user input devices. *Id.* ¶¶ 90–91.

Kriveshko's Figure 4 shows that,

> [w]ithin the window 402, a video image may be displayed including a field of view of a scanner, such as the scanner 102 of FIG. 1. Within the field of view, a subject 404, such as the subject 104 of Figure 1 may be displayed, along with one or more user controls 406.

Id. ¶ 90. Kriveshko discloses that

> user controls 406 may generally include one or more controls for manipulating the three-dimensional model (e.g., rotating, scaling, panning, and the like), selecting a landing target, controlling operation of the image capture system (e.g., starting or stopping an acquisition), and so forth. The one or more controls may be manipulated, for example, using any of the user input devices described above with reference to FIG. 1.

Id. ¶ 91.

2. Analysis

To establish anticipation, each and every element in a claim, arranged as recited in the claim, must be found in a single prior art reference. *See Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008); *Karsten Mfg. Corp. v. Cleveland Golf Co.*, 242 F.3d 1376, 1383 (Fed. Cir. 2001). Although the elements must be arranged or combined in the same way as in the claim, "the reference need not satisfy an *ipsissimis verbis* test," i.e., identity of terminology is not required. *In re Gleave*, 560 F.3d 1331, 1334 (Fed. Cir. 2009); *accord In re Bond*, 910 F.2d 831, 832 (Fed. Cir. 1990).

Claim 1

Petitioner relies on Kriveshko as disclosing the limitations of independent claim 1. Pet. 15–20. In particular, Petitioner provides mappings of Kriveshko's disclosure to claim 1 as further supported by Dr. Bajaj's declaration. *Id.*

For example, for the preamble (e.g., "[a] scanning system for scanning a 3D environment"), Petitioner relies on Kriveshko's disclosure of system 100 (e.g., the scanning system) for "scan[ning] complex surfaces . . . by maintaining a continuous three-dimensional scan across separated subsections of the surface." Pet. 15 (citing Ex. 1005 ¶ 8). Scanning device 102 is passed over a surface of subject 104. *Id.* at 15–16 (citing Ex. 1005 ¶ 58). Scanning device 102 captures images of subject 104 within image plane 106. *Id.* at 16 (citing Ex. 1005 ¶ 51). Based on Kriveshko's disclosures as discussed above, we are persuaded that Kriveshko discloses claim 1's recited "scanning system."

Claim 1 further recites "a handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment." For this limitation, Petitioner points us to Kriveshko's scanning device 102, which is disclosed as a "handheld, freely positionable probe" and includes an "optical scanner" optically acquiring three-dimensional data. Pet. 16 (citing Ex. 1005 ¶¶ 51–52; Ex. 1003 ¶ 95). Petitioner explains that, in Kriveshko, the 3D environment to be scanned is selected by freely positioning (e.g., pointing) scanning device 102 over the surface of subject 104 (e.g., the 3D environment) and capturing images of the subject within image plane 106. *Id.* at 17 (citing Ex. 1003 ¶¶ 94–96). Petitioner provides an annotated version of Kriveshko's Figure 1, reproduced below, to further support its contentions:

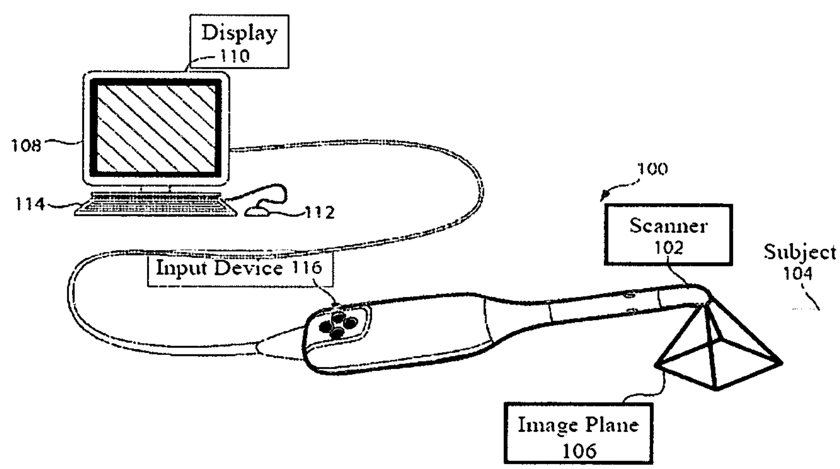

Fig. 1

Annotated Figure 1 (reproduced above) shows pointing freely positionable handheld optical scanner 102 over 3D environment 104 to be scanned. *See* Pet. 16–17. Based on the record before us, we are persuaded that Kriveshko discloses claim 1's recited "handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment."

Claim 1 further recites "at least one display remotely connected to the handheld device." Regarding this limitation, Petitioner points us to Kriveshko's Figure 1 (annotated version reproduced above) showing scanning system 100 with computer 108 that includes display 110 (e.g., the at least one display). Pet. 17 (citing Ex. 1005 ¶ 51, Fig. 1; Ex. 1003 ¶ 98). In Kriveshko, display 110 is remotely connected to handheld optical scanning device 102. Ex. 1005 ¶ 51, Fig. 1. Petitioner explains that similar to the '675 patent's wired scanning device 100 remotely connecting to display 101 (Ex. 1001, Fig. 3), Kriveshko's scanner 102 is remotely connected to display 110 by a wire. *Id.* at 17–18 (citing Ex. 1005, Fig. 1; Ex. 1003 ¶¶ 98–99). Petitioner contends that Kriveshko's display 110 is remotely connected to its handheld scanner 102 in the same way that the '675 patent's display 101 is remotely connected to scanning device 100. *Id.* at 18 (citing Ex. 1003 ¶¶ 97–100). Petitioner adds that when handheld scanning device 102 performs a scan of subject 104, computer 108 presents images of the scan on display 110 for viewing by an operator of scanning device 102. *Id.* (citing Ex. 1005 ¶¶ 60, 90, Fig. 1; Ex. 1003 ¶¶ 97–100).

Based on the record before us, we are persuaded that Kriveshko discloses claim 1's recited "at least one display remotely connected to the handheld device."

Claim 1 further recites "wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment." For this limitation, Petitioner relies on Kriveshko's handheld scanning device

102 capturing images of subject 104 in an image plane 106 while the handheld scanning device 102 is passed over subject 104. Pet. 18 (citing Ex. 1005 ¶¶ 51, 56, 58). Based on the record before us, we are persuaded that Kriveshko discloses that its "handheld device" performs a scanning action in a physical 3D environment.

Claim 1 also recites "the at least one display is adapted for visually representing the physical 3D environment." Petitioner relies on Kriveshko as disclosing that display 110 presents a virtual representation of subject 104 in its environment, which Petitioner asserts is an example of "visually representing the physical 3D environment," as claimed. Pet. 19 (citing Ex. 1005 ¶¶ 60, 90, Fig. 4; Ex. 1003 ¶¶ 76, 105–108). Petitioner points us to an annotated version of Kriveshko's Figure 4 wherein the visual representation of subject 104 is being rendered within window 402 of user interface 400 on display 110. *Id.* (citing Ex. 1005 ¶¶ 60, 90).

The annotated version of Kriveshko's Figure 4 provided by Petitioner is reproduced below:

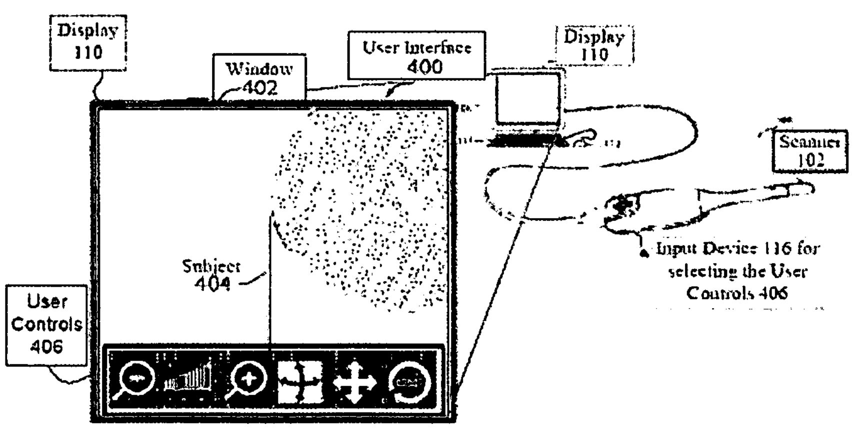

Fig. 4

The annotated Figure 4 includes display 110 visually representing subject 404. Based on the record before us, we are persuaded that Kriveshko discloses that its "display" visually represents a physical 3D environment.

Finally, claim 1 recites "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." For this limitation, Petitioner relies on Kriveshko's handheld scanning device 102 including user input device 116 (e.g., a button, lever, dial, thumb wheel, or switch) for user control of image capture system 100. Pet. 20 (citing Ex. 1005 ¶ 52). Petitioner explains that Kriveshko's user interface of user input device 116 is used to select one or more controls that are presented on display 110, resulting in the manipulation of a three-dimensional model from a scan of the 3D environment. *Id.* (citing Ex. 1005 ¶¶ 90–91; Ex. 1003 ¶¶ 76, 109–111). According to Petitioner, such manipulation includes adjusting the view, which in the 3D environment is represented on the display by rotating, scaling, or panning the view of the three-dimensional model. *Id.*

Petitioner's contentions are further supported by Dr. Bajaj's testimony that Kriveshko's user controls for manipulating the three-dimensional model are selected via a user input element of the scanning device. Ex. 1003 ¶ 76. Dr. Bajaj explains that as illustrated in Figure 1, Kriveshko discloses that scanner 102 includes user input device 116, such as a button, lever, dial, thumb wheel, or switch, for user control of image capture system 100. *Id.* ¶ 110 (citing Ex. 1005 ¶ 52). Furthermore, Dr. Bajaj, referring to Figures 4–9, testifies that Kriveshko discloses presenting one or more user controls 406 on display 110 for manipulating a three-dimensional model, e.g., rotating, scaling, and panning. *Id.* ¶¶ 76, 110 (citing Ex. 1005 ¶¶ 90, 91).

Additionally, Dr. Bajaj explains that in Kriveshko, user controls may be selected using user input devices. *Id.* ¶ 111 (citing Ex. 1005 ¶¶ 90, 91). Dr. Bajaj concludes that a person of ordinary skill in the art would have understood that in Kriveshko, the user input device of scanner 102 would have been used to manipulate the user controls to adjust the view of the display as illustrated in Petitioner's combined annotated version of Figures 1 and 4 as reproduced below. *See id.*

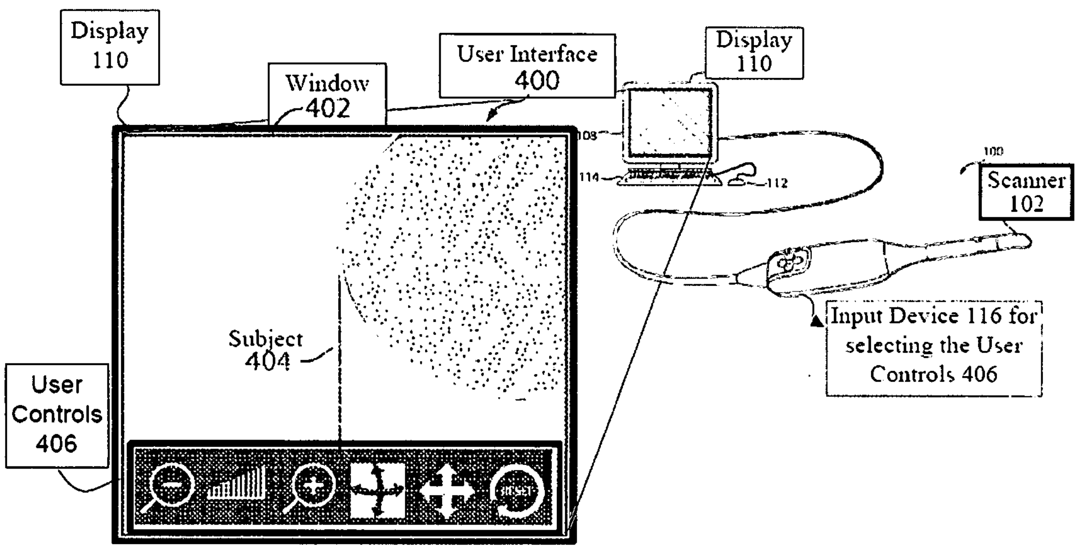

Fig. 4

The combined annotated Figures 1 and 4 of Kriveshko show user input device 116 for remotely selecting user controls 406. *See* Ex. 1003 ¶ 111.

Based on the record before us, we are persuaded that Kriveshko discloses "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display," as recited in claim 1.

As detailed above, we have reviewed Petitioner's explanations and supporting evidence as to how Kriveshko discloses the limitations of claim 1, and we agree with and adopt Petitioner's analysis. *See* Pet. 15–20.

For this challenge to claim 1, Patent Owner argues only that Kriveshko does not disclose the recited "user interface." *See* PO Resp. 33. Claim 1 of the '675 patent recites that "the handheld device includes *a user interface* for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." Ex. 1001, 15:40–42 (emphasis added). Patent Owner argues that the '675 patent disclaims 2D user interfaces from the claim term "user interface." PO Resp. 7, 33–35.

Patent Owner asserts that when read in light of the specification, the claim term "user interface" should be construed as "not encompassing a mere 2D user interface." *Id.* at 7 (citing Ex. 2011 ¶¶ 47–48). Patent Owner asserts that the specification clearly disavows 2D user interfaces from the claim term "user interface" because the specification criticizes the use of such 2D user interfaces. *Id.* at 33–34. According to Patent Owner, the specification states that "prior art user interface devices can be inconvenient, awkward and difficult to use, and they can be labor-intensive, and thus costly to sterilize or disinfect." *Id.* at 34 (citing Ex. 1001, 4:39–42). Patent Owner explains that the specification discloses that prior art user interfaces include "'intraoral scanners [that] use a touch screen, a trackball, or a mouse to determine the view in the display'—all examples of 2D user interfaces." *Id.* at 34 (citing Ex. 1001, 4:38–39). Further, according to Patent Owner, the title of the '675 patent explicitly discloses that the '675 patent relates to a system having an integrated "3D user interface." *Id.* (citing Ex. 1001, entitled "System with 3D user interface integration"). Patent Owner concludes that the '675 patent specification specifically identifies and criticizes 2D user interfaces, and distinguishes the same from the 3D user interfaces. *Id.*

Petitioner responds that contrary to the supposed disavowal of 2D input devices, the '675 patent explicitly lists 2D user interface elements, such as buttons and scroll-wheels, in describing embodiments of the claimed invention. Pet. Reply 3 (citing Ex. 1001, 7:9–17). Furthermore, Petitioner asserts that Patent Owner ignores that the '675 patent makes similar statements in its specification about 2D and 3D user interfaces. *Id.* at 7. According to Petitioner, if Patent Owner's relied-upon language disavows 2D user interfaces, then the '675 patent also disavows 3D user interfaces. *Id.* In particular, Petitioner cites the following disclosure from the '675 patent:

> Various user interaction devices are in use for software that displays 3D data; these devices are: *3D mice, space balls*, and touch screens. The operation of these current interaction devices *requires physically touching them*.
>
> Physically touching a user-interaction device *can be a disadvantage* in medical applications due to risks of cross-contamination between patients or between patient and operator, or in industrial applications in dirty environments.

Id. (citing Ex. 1001, 1:24–31).

Petitioner further points us to Patent Owner's declarant's deposition testimony wherein Dr. Balakrishnan acknowledged that the '675 patent's discussion of the disadvantages applied to any device that needed to be physically touched, whether it is a 2D or 3D interface. Pet. Reply 7–8. Petitioner's excerpt quotes the pertinent deposition section as follows:

> Q Thank you for clarifying. The space balls, are those typically 2D or 3D input devices?
>
> A *A space ball* is -- one skilled in the art – typically, those *would be considered 3D input devices*.
>
> Q Okay. And a touch screen?
>
> A A touch screen would typically be considered a 2D input device.
>
> Q Okay. And what does it say about those devices on lines 28 through 30?
>
> A It says 'Physically touching a user interaction device can be a disadvantage in medical applications due to risks of cross-contamination between patients or between patient and operator, or in industrial applications in dirty environments.'
>
> Q Would you understand that to mean that this *3D mice and space balls have a disadvantage*?
>
> A I think -- I understand this to mean that *physically touching some device can be a disadvantage* for the reasons provided here that can be ameliorated -- I believe it talks further in the patent -- by appropriate sanitization measures.

Id. (quoting Ex. 1037, 55:4–56:5 (emphasis added)).

We are persuaded by Petitioner's argument and evidence. The specification may "disavow [a prior art] embodiment," even if it "would otherwise be covered by the plain language of the claims," by criticizing such an embodiment in the specification. *In re Abbott Diabetes Care Inc.*, 696 F.3d 1142, 1149–50 (Fed. Cir. 2004). We are mindful that "the claims must 'not be read restrictively unless the patentee has demonstrated a clear intention to limit the claim scope using words or expressions of manifest exclusion or restriction.'" *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1347 (Fed. Cir. 2015).

We agree with Petitioner to the extent that the '675 patent disparages 2D user interfaces, because of the need for sterilization or disinfection, the '675 patent similarly disparages 3D user interfaces (i.e., 3D mice and space balls). *See* Pet. Reply 7 (citing Ex. 1001, 1:24–31). Furthermore, Patent Owner's own declarant acknowledges that the '675 patent disparages 3D user interfaces such as 3D mice and space balls in the same way as it disparages 2D user interfaces. *Id.* at 7–8 (citing Ex. 1037, 55:4–56:5). In other words, the problem identified in the specification of the '675 patent relates to interfaces that require physical touch, rather than whether those interfaces are 2D or 3D.

Accordingly, we determine that "user interface" as recited in the challenged claims is not limited to 3D user interfaces. *See Williamson*, 792 F.3d at 1347.

Patent Owner further argues that the 2D user interfaces disclosed by Kriveshko are disclaimed from the term "user interface" recited in claim 1. PO Resp. 35–37. Patent Owner points us to Kriveshko's disclosure stating that the user input can be received through input device 116 on scanner 102, mouse 112, keyboard 114, or display 110. *Id.* at 35 (citing Ex. 1005 ¶ 72). However, according to Patent Owner, input device 116, mouse 112, keyboard 114, and display 110 are not 3D user interfaces. *Id.* at 36 (citing Pet. 26). Patent Owner points to Petitioner's concession and its declarant's declaration testimony that input device 116 disclosed by Kriveshko is a 2D input device and not a 3D user interface. *Id.* at 36–37 (citing Pet. 26; Ex. 1003 ¶ 241; *see also* Ex. 2001 ¶ 3; Ex. 2011 ¶ 81).

Patent Owner's argument is based on its proposed construction of the term "user interface" as excluding 2D user interfaces. As we stated previously, we are persuaded the term "user interface" does not exclude 2D user interfaces, and thus, we disagree with Patent Owner's argument that Kriveshko's 2D input devices cannot meet the "user interface" limitation.

For the reasons discussed above, we determine that Petitioner has shown, by a preponderance of the evidence, that claim 1 is anticipated under 35 U.S.C. § 102 by Kriveshko.

Claims 2, 9–11, and 18

We have reviewed Petitioner's explanations and supporting evidence for this ground regarding claims 2, 9–11, and 18. In particular, Petitioner contends Kriveshko discloses the additionally recited limitations of claims 2, 9–11, and 18. Pet. 20–24. Petitioner provides detailed explanations and specific citations to Kriveshko indicating where in the reference the claimed features are disclosed. *Id.* (citing Ex. 1005 ¶¶ 52, 54, 60–61, 76, 90–91, 103).

Patent Owner does not offer specific and separate arguments regarding claims 2, 9–11, and 18. PO Resp. 37–38. We determine that Petitioner, for reasons set forth in its analysis which we adopt as our own, has shown by a preponderance of the evidence that dependent claims 2, 9–11, and 18 are unpatentable under 35 U.S.C. § 102 as anticipated by Kriveshko.

C. Obviousness over Kriveshko and Serra

Petitioner argues that claims 1–5, 8–11, and 14–19 would have been obvious over Kriveshko and Serra. Pet. 24–46. For the reasons explained below, we are persuaded that Petitioner has demonstrated by a preponderance of the evidence that these claims are unpatentable on this ground.

1. Overview of Serra (Ex. 1006)

Serra teaches switches or manual actuators on a handheld probe to allow user control of display parameters by actuating one or more buttons on a probe. Ex. 1006 ¶ 53. Serra further teaches that a button can be used to use the probe to scan an image or to use it to rotate the entire virtual scene, which is a common 3D data set interactive visualization operation. *Id.* The handheld scanning device collects tracking information corresponding to the movement of the scanning device and the user interface of the scanning device "rotate[s] the entire scene (effectively changing the viewpoint of the user over the entire 3D scene)." *Id.* ¶ 54.

2. Independent Claim 1

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when in the record, objective evidence of nonobviousness. *See Graham*, 383 U.S. at 17–18. In that regard, an obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 550 U.S. at 418.

As discussed above with respect to anticipation by Kriveshko, Petitioner argues that Kriveshko teaches all the limitations recited in claim 1. Regarding the limitation "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display," however, Petitioner relies alternatively on Serra. Pet. 24–25. Specifically, Petitioner directs us to where Serra teaches a handheld scanning device that includes a button that can be used to rotate the entire visual scene. *Id.* at 25 (citing Ex. 1006 ¶ 54).

Petitioner further asserts that incorporating Serra's 3D user interface into a scanning device provides *ergonomic advantages* over other scanning systems by permitting the user to both perform a scanning process and examination process with the same device. Pet. 26 (citing Ex. 1006 ¶ 53). Petitioner explains that a person of ordinary skill would have been motivated and would have found it obvious to incorporate Serra's 3D user interface into Kriveshko's optical handheld device in order to provide an ergonomic handheld scanning device with a user interface that is adapted to control the display of three-dimensional imaging data displayed from an optical scan of the 3D environment. *Id.* at 27 (citing Ex. 1006 ¶¶ 11, 53; Ex. 1003 ¶¶ 153–164, 239–244).

In particular, Petitioner contends that Serra "provides an improvement over 2D input devices, such as the input device 116 of Kriveshko." Pet. 26.

Petitioner asserts that in Serra, such improvement over 2D input devices is provided by the use of a *single* "handheld scanning device including a user interface consisting of a 3D sensor, one or more switches, or other manual actuators." *Id.* at 25–26.

Patent Owner argues that Serra does not attribute the improvement over 2D input devices to the use of a single handheld device. Rather, according to Patent Owner, Serra attributes the improvement over 2D input devices to the use of a system including *two* handheld devices. PO Resp. 39–40.

We disagree with Patent Owner's argument. We agree with Petitioner's contention that Serra teaches ergonomic advantages by permitting a scanning process and an examination process with the same device. Pet. Reply 11–12 (citing Ex. 1006 ¶¶ 53, 54). In particular, Serra's paragraph 53 reads in part:

> *Because a user is generally always holding the ultrasound (or other substantially real-time image acquisition) probe, it is ergonomically convenient to allow him to control display parameters by actuating one or more buttons on the probe.* For example, a button can be used to indicate when to use the probe to scan real-time or *when to use it to rotate the entire virtual scene*, which is a common a [sic] 3D data set interactive visualization operation. . . .

Ex. 1006 ¶ 53.

Thus, Serra teaches a single device with two alternative modes of scanning and 3D data set interactive visualization actuated by one or more buttons. We further agree with Petitioner that "Serra's scanning device includes a 3D user interface that rotates a visual representation of 3D data *based on movement of the scanning device determined by a motion sensor*." *See* Pet. 26 (citing Ex. 1006 ¶¶ 53–54).

Accordingly, we agree with Petitioner that a POSITA would have been motivated and found it obvious to incorporate Serra's 3D user interface into Kriveshko's optical handheld device "[g]iven Serra's explicit acknowledgement of the ergonomic benefits of modifying a scanning device to include the ability to adjust display parameters." Pet. 27.

Based on the record before us, we are persuaded that the combination of Kriveshko and Serra teaches the recited "user interface." We also are persuaded that Petitioner's proffered reasoning for modifying Kriveshko's handheld device to include Serra's user interface, namely, to provide an ergonomic handheld scanning device, is sufficient to support the conclusion of obviousness. *See In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) ("[T]here must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.").

We also note that the test for obviousness is not whether a secondary reference's feature (e.g., 3D sensor) can be bodily incorporated into the structure of the primary reference. *In re Keller*, 642 F.2d 413, 425 (CCPA 1981). Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. *Id.* Petitioner's analysis is supported by its declarant's testimony, and we find that testimony persuasive. Pet. 27 (citing Ex. 1003 ¶¶ 153–164, 239–244).

Thus, we are persuaded by Petitioner that claim 1 would have been obvious over the Kriveshko and Serra combination.

2. *Dependent Claims 2, 3, 9–11, 14–18*

We discuss Petitioner's contentions that dependent claims 2, 3, 9–11, and 14–18 would have been obvious over the combination of Kriveshko and Serra below. Patent Owner does not present specific arguments for these dependent claims, other than the argument for claim 1 discussed above. *See* PO Resp. 41–42. We determine Petitioner has shown, by a preponderance of the evidence, that claims 2, 3, 9–11, and 14–18 would have been obvious over the combination of Kriveshko and Serra based on the analysis below, which we adopt as our own.

Claim 2

Petitioner contends that Kriveshko teaches or suggests "wherein the handheld device is adapted to record the 3D geometry of the 3D environment," as required by dependent claim 2. Pet. 30. Petitioner explains that modified handheld scanning device 102 records 3D geometry of the 3D environment by using its cameras to capture (i.e., record) images of the 3D environment from which "a three-dimensional point cloud may be recovered." *Id.* (citing Ex. 1005 ¶¶ 52, 60–61; Ex. 1003 ¶¶ 165–167).

We are persuaded by Petitioner that claim 2 would have been obvious over the Kriveshko and Serra combination.

Claim 3

Petitioner contends that Kriveshko as modified by Serra teaches or suggests, "wherein the user interface includes means for manually switching between performing the at least one scanning action and remotely controlling the view," as required by dependent claim 3. Pet. 30.

Petitioner contends that Serra teaches that its handheld optical scanning device includes means for manually switching between performing the at least one scanning action and remotely controlling the view by virtue of the button on Serra's handheld device. *Id.* at 31 (citing Ex. 1006 ¶ 53). Petitioner states that Serra teaches that the "button can be used to indicate when to use the probe to scan real-time or when to use it to rotate the entire virtual scene, which is a common a 3D data set interactive visualization operation." *Id.* Additionally, Petitioner states that the button in Serra can be used to activate two modes of operation: (i) a scanning mode (where the button switch is ON) and (ii) an interactive mode (where the button switch is OFF). *Id.* (citing Ex. 1006 ¶ 54; Ex. 1003 ¶¶ 168–172).

According to Petitioner, a POSITA would have understood how and why to modify Kriveshko to include this teaching of Serra because doing so would have been nothing more than the use of known technique to improve similar devices in the same way. *Id.* (citing *KSR Int'l Co.*, 550 U.S. at 416; Ex. 1003 ¶¶ 153–164, 168–173, 239–244).

We are persuaded by Petitioner that claim 3 would have been obvious over the Kriveshko and Serra combination.

Claim 9

Petitioner contends that Kriveshko in view of Serra teaches or suggests, "wherein the handheld device is adapted to change a viewing angle with which the 3D environment is represented on the at least one display," as required by dependent claim 9. Pet. 35.

Petitioner asserts that the modified handheld scanning device 102 in Kriveshko rotates the three-dimensional environment represented on the display 110 via the user controls 406. *Id.* (citing Ex. 1005 ¶¶ 90–91; Ex. 1003 ¶¶ 195–196). *Id.*

Petitioner further points us to where Serra teaches rotating a visual presentation of a 3D scene using the movement of a scanning device. *Id.* at 36 (citing Ex. 1006 ¶¶ 53, 54; Ex. 1003 ¶¶ 197–198). Petitioner asserts that Serra further teaches that the scanning device is used to rotate a virtual scene presented on a display—effectively changing the viewpoint of the user over the entire 3D scene. *Id.* (citing Ex. 1006 ¶¶ 53, 54; Ex. 1003 ¶¶ 197–198.)

According to Petitioner, a POSITA would have understood how and why to modify Kriveshko to include this teaching of Serra to meet this claim because doing so would have been nothing more than the use of known techniques to improve similar devices in the same way. *Id.* (citing *KSR Int'l Co.*, 550 U.S. at 416; Ex. 1003 ¶ 199).

We are persuaded by Petitioner that claim 9 would have been obvious over the Kriveshko and Serra combination.

Claim 10

Petitioner argues that Kriveshko teaches or suggests, "wherein the handheld device is adapted to change a magnification factor with which the 3D environment is represented on the at least one display," as required by dependent claim 10. Pet. 36.

According to Petitioner, the modified handheld scanning device 102 in Kriveshko is adapted to scale the three dimensional environment represented on display 110 via the user controls 406, which can be manipulated by the handheld device. *Id.* (Ex. 1003 ¶¶ 200–204). Petitioner points us to annotated Figures 1 and 4 of Kriveshko to illustrate that user controls 406 include a first graphical user interface icon that includes a magnifying glass and plus sign, and a second graphical user icon that includes a magnifying glass and a minus sign. *Id.* at 37 (citing Ex. 1003 ¶¶ 200–204).

Petitioner further points us to Serra's teaching that its handheld scanning device performs three-dimensional volumetric operations to modify a magnification factor of a viewpoint of scanned objects. *Id.* at 37–38 (citing Ex. 1006 ¶ 57 ("Once such a selection is made, the clinician can, for example, use the pen or other tracked handheld tool to control the way in which to see the objects by performing various 3D volumetric operations upon them, such as, for example, described in detail in *Zoom Slider, Zoom Context* and 3D Matching . . . .") (emphasis added); Ex. 1003 ¶¶ 205–207).

Petitioner further points us to Serra's zoom operation wherein as illustrated in annotated Figure 5 of Serra, the size of a scanned subject displayed on a monitor is magnified in response to a zoom effect operation (performed by the handheld device) in order to realize an optimal viewpoint for viewing the objects present within the 3D environment. *Id.* at 38 (citing Ex. 1003 ¶¶ 205–206; Ex. 1006, Fig. 5, ¶¶ 57–58).

Petitioner asserts that a POSITA would have understood how and why to modify Kriveshko to include this teaching of Serra to meet this claim because doing so would have been nothing more than the use of known techniques to improve similar devices in the same way. *Id.* (citing *KSR*, 550 U.S. at 416; Ex. 1003 ¶¶ 200–207, 239–246).

We are persuaded by Petitioner that claim 10 would have been obvious over the Kriveshko and Serra combination.

Claim 11

Petitioner asserts that Kriveshko teaches or suggests, "wherein the handheld device is an intra-oral 3D scanner," as required by dependent claim 11. Pet. 39. We agree with Petitioner that Kriveshko teaches a dental imaging application wherein subject 104 scanned using scanning device 102 includes a tooth, a quadrant of teeth, or a full collection of teeth. *Id.* (citing Ex. 1005 ¶ 54; Ex. 1003 ¶¶ 208–211). Furthermore, Petitioner points us to Kriveshko's Figure 10 description stating that

> A scan of the arch using the image capture system 100 described above may include a continuous scan of exposed tooth surfaces from within a dental patient's mouth . . . .

Id. (citing Ex. 1005 ¶ 103; Ex. 1003 ¶¶ 209–210).

We are persuaded by Petitioner that claim 11 would have been obvious over the Kriveshko and Serra combination.

Claim 14

Petitioner asserts that Kriveshko teaches or suggests, "wherein the handheld device is an in-ear 3D scanner," as required by dependent claim 14. Pet. 39. We agree with Petitioner that Kriveshko teaches an imaging application wherein the subject 104 includes "a human head, or a portion thereof, from which a three-dimensional model is desired for custom fitting of a hearing aid . . . ." *See id.* (citing Ex. 1005 ¶ 54.)

Additionally, we agree with Petitioner that a POSITA would have understood that the fitting of a hearing aid requires the handheld device to be an in ear 3D scanner allowing for collection of three-dimensional data used to fit the hearing aid inside the hearing canal of a human. *Id.* at 39–40 (citing Ex. 1003 ¶¶ 212–215).

We are persuaded by Petitioner that claim 14 would have been obvious over the Kriveshko and Serra combination.

Claim 15

Petitioner asserts that Kriveshko as modified by Serra teaches or suggests, "wherein the at least one display is defined as a first display, and where the system further comprises a second display," as required by dependent claim 15. Pet. 40.

Petitioner relies on Serra's Figure 8 (as annotated in the Petition) that shows an ultrasound scanner system comprising a first computer and a main monitor, and an external box system comprising a second computer with 3D graphics capabilities and a second monitor. *Id.* (citing Ex. 1006, Fig. 8 ¶¶ 75–76; Ex. 1003 ¶¶ 216–220). Petitioner asserts that Serra further teaches that the second monitor receives "as an input the ultrasound image (either as a standard video signal or as a digital image), and provides as an output a 3D display." *Id.* (citing Ex. 1006 ¶ 75, Fig. 8). As an example, Serra provides that the three dimensional display output by the second monitor includes an autostereoscopic display or a polarized display. *Id.* (citing Ex. 1006 ¶ 76; Ex. 1003 ¶¶ 216–220).

Petitioner asserts that a POSITA would have understood why and how to modify Kriveshko to include this teaching of Serra to meet this claim because doing so would have been nothing more than the use of known technique to improve similar devices in the same way. *Id.* at 40–41 (citing *KSR Int'l Co.*, 550 U.S. at 416; Ex. 1003 ¶¶ 221–224, 245–246).

We are persuaded by Petitioner that claim 15 would have been obvious over the Kriveshko and Serra combination.

Claim 16

Petitioner asserts that Kriveshko as modified by Serra teaches or suggests, "wherein the second display indicates where the handheld device is positioned relative to the 3D environment," as required by dependent claim 16. Pet. 42.

Petitioner contends that Kriveshko teaches displaying images and visual cues that indicate the position of a scanning device relative to the three-dimensional environment during an acquisition mode. *Id.* (citing Ex. 1003 ¶¶ 225–228). Petitioner further provides an example wherein Kriveshko teaches,

> During this phase of the process 200, *a video image such as a video image of the subject from a position or point of view of the scanning device*, may be rendered on the display 110. … In other embodiments, the subject 104 may be displayed in a static, nonmoving orientation within the display 110, *while a visual cue may be provided within the user interface as to a position and orientation of the scanner.*

Id. (emphasis added) (citing Ex. 1005 ¶ 60; Ex. 1003 ¶ 226).

Petitioner further contends that Serra also teaches an ultrasound scanner system comprising a first computer and a main monitor, and an external box system comprising a second computer with 3D graphics capabilities and a second monitor. *Id.* at 43 (citing Ex. 1006, Fig. 8, ¶¶ 75–76). Petitioner explains that in the combination, the position indication relative to the 3D environment provided by Kriveshko would be displayed on the second monitor of Serra (which is used specifically "as an input the ultrasound image (either as a standard video signal or as a digital image), and provides as an output a 3D display"). *Id.* (citing Ex. 1006 ¶ 75; *see also id.* at Fig. 8; Ex. 1003 ¶¶ 225–228).

Petitioner asserts that a POSITA would have understood how and why to modify Kriveshko to include this teaching of Serra to meet this claim because doing so would have been nothing more than the use of known techniques to improve similar devices in the same way. *Id.* (citing *KSR Int'l Co.*, 550 U.S. at 416; Ex. 1003 ¶¶ 228, 245–246).

We are persuaded by Petitioner that claim 16 would have been obvious over the Kriveshko and Serra combination.

Claim 17

Petitioner contends that Kriveshko teaches or suggests, "wherein the first display and/or the second display provides instructions for the operator," as required by dependent claim 17. Pet. 43.

Petitioner contends that Kriveshko teaches that the display 110 is configured to provide guidance (i.e. the instructions) to an operator of the handheld scanning device 102 during a recovery mode. *Id.* at 43–44 (citing Ex. 1005 ¶ 14; Ex. 1003 ¶¶ 229–233). For example, Petitioner states that Kriveshko teaches that

> In the recover mode, the system 100 may seek to reacquire the previous scan by test fitting new scan data to previously acquired data, and *providing visual feedback to a user to assist in navigating back to a scan location on the subject where the re-acquisition is being attempted.*

Id. at 44 (emphasis added) (quoting Ex. 1005 ¶ 59) (citing Ex. 1003 ¶ 231).

We are persuaded by Petitioner that claim 17 would have been obvious over the Kriveshko and Serra combination.

Claim 18

Petitioner asserts that Kriveshko teaches or suggests, "wherein audible information is provided to the operator," as required by dependent claim 18. Pet 44. We agree that Kriveshko teaches providing verbal cues (i.e., the audible information) to the user while the user re-acquires three-dimensional data for an existing three-dimensional model. *Id.* (citing Ex. 1005 ¶ 76 ("It will be appreciated that other techniques may be employed, such as directional arrows or verbal cues, to coach a user back to an appropriate location relative to the subject 104."); Ex. 1003 ¶¶ 234–236).

Additionally, Petitioner contends Kriveshko's image capture system 100 provides audible indicators to a user communicating "whether the image capture system 100 is in a recover mode or a normal acquisition mode." *Id.* (citing Ex. 1005 ¶ 76; Ex. 1003 ¶ 235). Petitioner contends that, as such, Kriveshko's system provides audible information to a user that will assist the user in re-centering the scanning device 102 at the desired position on the subject 104. *Id.* (citing Ex. 1003 ¶¶ 234–236).

We are persuaded by Petitioner that claim 18 would have been obvious over the Kriveshko and Serra combination.

3. Claims 4, 5, 8, and 19

Petitioner states that claim 19 merely recites a system that includes all the limitations of claims 1, 3–5, and 11. Pet. 45–46. We were persuaded by Petitioner's evidence and arguments regarding claims 1, 3, and 11 as addressed above, so we address whether the combination, and in particular whether Serra teaches or suggests a "motion sensor" as recited in claims 4, 5, 8, and 19.

Claim 4 depends from claim 1 and recites "wherein the handheld devices comprises at least one motion sensor." Ex. 1001, 15:50–51. Claim 5 further depends from claim 4 and recites "the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor." *Id.* at 16:1–3. Claim 8 further depends from claim 4 and recites "wherein the user interface is other than the at least one motion sensor." *Id.* at 16:8–9. Claim 19 is independent and recites the limitation, "the view is remotely controlled by at least one motion sensor arranged in the handheld device." *Id.* at 16:35–50. We have reviewed Petitioner's arguments and evidence regarding these limitations, and we find them persuasive and adopt Petitioner's analysis as our own. Pet. 32–34, *see also id.* at 45–46. We address Patent Owner's arguments regarding the recited "motion sensor" below.

a. Does Serra's "3D sensor" constitute a "motion sensor" meeting the limitation of claim 4?

Patent Owner asserts that the combination of Kriveshko and Serra does not teach or suggest a "motion sensor." PO Resp. 15–31. In particular, Patent Owner asserts three reasons for its assertion that Serra does not teach a "motion sensor":

1. Serra teaches a 3D sensor detecting position—not motion.
2. Petitioner and its expert do not provide evidence that Serra's 3D sensor is a motion sensor.
3. Position and motion are fundamentally distinct properties and thus, a person of ordinary skill in the art would understand the 3D sensor of Serra as being a position senor and thus different from the'675 patent claimed motion sensor.

PO Resp. 15–20 (citing Ex. 2011 ¶ 53).

Patent Owner also asserts that Petitioner wrongly relies on Serra's 3D sensor to meet the claimed motion sensor because Serra's tracking of three-dimensional position and orientation does not constitute detection of motion. PO Resp. 16 (citing Pet. 32, 34, 46). Patent Owner contends that Serra teaches that the 3D sensor detects *position*. *Id.* at 16–17 (citing Ex. 1006, Fig. 7 ("3D Sensor attached to Ultrasound Probe or any other way of determining the *position* of the plane of scan" (emphasis added)), ¶ 74 ("the *3D position* of the ultrasound probe *715* can be tracked by 3D tracker *703*, by, for example, 3D sensor *720* which is attached to ultrasound probe *715*" (emphasis added))). Patent Owner asserts that there is no disclosure or suggestion in Serra of detecting "motion" or "movement" of the ultrasound probe. *Id.* (citing Ex. 2011 ¶ 56). According to Patent Owner, this distinction is because Serra's objective is to provide "a system [which] can record both the 3D position and the time of acquisition for each image," so that each image can be correlated with corresponding position data at a given time. *Id.* at 17 (citing Ex. 1006 ¶¶ 36–37; *see also id.* ¶¶ 11–12).

Patent Owner further asserts that Petitioner's declarant Dr. Bajaj, in support of his assertion that Serra's 3D sensor suggests a motion sensor, relies on the teachings of Kerr (Ex. 1011), Touma (Ex. 1028), and Brennan (Ex. 1007). PO Resp. 19–20 (citing Ex. 1003 ¶ 178 ("Kerr, Touma, and Brennan provide additional evidence that a [person of ordinary skill in the art] would have considered Serra's 3D sensor to at least suggest a motion sensor.")). According to Patent Owner none of these references even mention the term "3D sensor," much less explain how tracking position (or tracking position, orientation, and time) constitutes detecting motion. *Id.* at 20.

We are not persuaded by Patent Owner's argument. As we determined above, the claim construction of the term "motion sensor," under the broadest reasonable interpretation in light of the '675 patent specification as well as extrinsic evidence, is properly construed as a motion sensor that detects motion and does not exclude sensors that collect position and orientation data. We further note that there is no *ipsissimis verbis* test for determining whether a reference discloses a claim element, i.e., identity of terminology is not required. *Bond*, 910 F.2d at 832. Thus, it is of no moment that Serra refers to a "3D sensor" rather than a "motion sensor" as long as Serra's "3D sensor" teaches detecting motion by tracking position and orientation.

Here, we find that Petitioner has shown Serra's "3D sensor" senses motion through tracking position and orientation. Pet. Reply 20–21. Specifically, we credit Dr. Bajaj's declaration testimony that Serra teaches "rotating the 3D data presented on the display using tracking information corresponding to the movement of the scanning device." Ex. 1003 ¶ 177 (citing Ex. 1006 ¶ 54); *see also* Pet. 34 (citing Ex. 1003 ¶¶ 185–86; Ex. 1006 ¶¶ 57, 60, Fig. 5).

We further credit Dr. Bajaj's declaration testimony that Serra provides that the tracking information is collected by the 3D sensor attached to scanning device. Ex. 1003 ¶ 177 (citing Ex.1006 ¶¶ 42, 49; *see also id.* at Fig. 7). In addition, we are persuaded by Dr. Bajaj's testimony that a POSITA would have understood that Serra's 3D sensor at least suggests a motion sensor given that Serra's 3D sensor is used to determine the three-dimensional movement of the scanning device. *Id.*

Furthermore, we do not agree with Patent Owner's argument that Serra's 3D sensor does not track position and orientation. PO Resp. 23–25. Although we do not disagree with Dr. Bajaj's additional declaration testimony that Serra's 3D sensor reads a "change of position" or a "change of orientation" and derivatives, Dr. Bajaj's testimony in paragraphs 175–180 of his declaration already adequately supports that Serra's "3D sensor" tracks position and orientation and thus teaches a "motion sensor." Ex. 1003 ¶¶ 175–180.

Accordingly, based on Petitioner's contentions and evidence under the claim construction of the term "motion sensor," as we discussed above, we find that Serra teaches this limitation.

b. *Does Serra teach the limitation of "the view is remotely controlled by at least one motion sensor," as recited in claim 19?*

Patent Owner further argues that Petitioner fails to explain how Serra discloses or suggests that the view is remotely controlled by Serra's 3D sensor attached to the ultrasound probe (which Petitioner alleges corresponds to the claimed "motion sensor"). PO Resp. 29 (citing Ex. 2011 ¶¶ 71–72). Patent Owner asserts that Petitioner's annotated version of Figure 5 of Serra "illustrates changing the viewpoint of the user over the entire three-dimensional scene based on the 3D sensor" using a "zoom operation" and a "rotation operation." *Id.* (citing Pet. 34). Patent Owner explains that although Figure 5 of Serra discloses the words "rotation" and "zoom," Figure 5 does not describe the manner in which the rotation and zoom operations are controlled, much less disclose that a 3D sensor arranged in an ultrasound probe is used to control the rotation and zoom operations. *Id.* at 30. Patent Owner argues that Petitioner cites paragraphs 57 and 60 of Serra, but such disclosures make no mention of a 3D sensor nor do they describe the manner in which the rotation and zoom functions are operated, or that the 3D sensor is used to operate the rotate or zoom functions. *Id.* Patent Owner further asserts that paragraph 57 of Serra discusses the use of a second device ("use the pen or other tracked handheld tool to control the way in which to see the objects"), not the ultrasound probe, and similarly, paragraph 58 of Serra does not disclose that the rotation and zoom operations are done by the handheld scanning device. *Id.* Patent Owner asserts that Petitioner failed to demonstrate where Serra discloses that the view (the way a 3D environment is represented on a display) is remotely controlled by at least one motion sensor as required by claim 19. *Id.* at 31 (citing Ex. 2011 ¶¶ 73–74).

Patent Owner further asserts that paragraph 53 of Serra, cited by Petitioner, does not describe any element of the probe that remotely controls the display to adjust the way in which the 3D environment is represented on the display, much less a motion sensor. *Id.* (citing Pet. 33). That paragraph states: "[A] button can be used to indicate when to use the probe to scan real-time or when to use it to rotate the entire virtual scene." Ex. 1006 ¶ 53. Patent Owner contends this paragraph of Serra does not even mention the 3D sensor, i.e., the element which Petitioner alleges corresponds to the claimed "motion sensor." PO Resp. 31. Patent Owner also asserts that Petitioner cites paragraph 54 of Serra, which discloses using "tracking information in the ultrasound probe" to rotate the scene, but this disclosure does not explain how the tracking information is acquired. *Id.* (citing Pet. 33; Ex. 1006 ¶ 54). Patent Owner also states that this disclosure does not explain how the tracking information is used to rotate the scene. *Id.* Patent Owner repeats that tracking information, which constitutes 3D *positional* information, is not the same as *motion* information, and thus the positional sensor of Serra (Serra's 3D sensor) is not the same as a motion sensor. *Id.* (citing Ex. 2011 ¶ 75).

Petitioner responds that Patent Owner ignores Petitioner's argument that "Serra further discloses that incorporating the 3D user interface into a scanning device provides ergonomic advantages over other scanning systems by permitting the user to both perform a scanning process and examination process *with the same device*." Pet. Reply 11–12 (citing Pet. 26). Petitioner cites to Serra's paragraph 53 for support, which reads in part:

> *Because a user is generally always holding the ultrasound (or other substantially real-time image acquisition) probe, it is ergonomically convenient to allow him to control display parameters by actuating one or more buttons on the probe.* For example, a button can be used to indicate when to use the probe to scan real time or *when to use it to rotate the entire virtual scene*, which is a common a [sic] 3D data set interactive visualization operation. . . .

Id. at 12 (quoting Ex. 1006 ¶ 53).

Petitioner argues that Patent Owner ignores that "Serra's scanning device includes a 3D user interface that rotates a visual representation of 3D data *based on movement of the scanning device determined by a motion sensor*." *Id.* (citing Pet. 26; Ex. 1006 ¶¶ 53–54). Petitioner asserts that Patent Owner focuses on a different Serra embodiment that optionally uses two devices: an acquisition device and a separate handheld tracker. *Id.* (citing PO Resp. 39–40). Petitioner argues that "regardless of the embodiment, as the Petition notes and [Patent Owner] again fails to address, a POSITA would have been motivated and found it obvious to incorporate Serra's 3D user interface into Kriveshko's optical handheld device '[g]iven

Serra's explicit acknowledgement of the ergonomic benefits of modifying a scanning device to include the ability to adjust display parameters.'"
Pet. Reply 12–13 (quoting Pet. 27).

Serra teaches that "*one or more switches*, or other manual actuators, *can be provided on* or for *a handheld probe to enhance 3D interactions.*" Ex. 1006 ¶ 53 (emphasis added). Serra further teaches that a button on the probe can be used to switch between scanning in real-time and a 3D data set interactive visualization operation rotating the entire virtual scene. *See id.* Importantly, Serra elaborates "the user can *release the button on the probe, <u>and use the tracking information in the ultrasound probe to rotate the entire scene</u> (effectively changing the viewpoint of the user over the entire 3D scene).*" *Id.* ¶ 54 (emphasis added). Serra teaches that "*the 3D position of the ultrasound probe 715 can be tracked by 3D tracker 703, by for example, 3D sensor 720 which is attached to ultrasound probe 715.*" *Id.* ¶ 74. (emphasis added). Serra further teaches that the tracking system can track *position and orientation*. *Id.* ¶ 42. We credit Dr. Bajaj's testimony pointing to these findings and explaining the tracking information in relation to the 3D interactions. Ex. 1003 ¶ 177 (citing Ex. 1006 ¶¶ 12, 42, 74, Fig. 7).

Thus, based on the disclosures above, we determine Serra teaches the limitation of "the view is remotely controlled by at least one motion sensor," as recited in claim 19, because Serra teaches tracking a 3D sensor in a device to allow rotation of the entire scene of view based on the position and orientation of the sensor.

Other than its arguments regarding whether Serra teaches a "motion sensor," Patent Owner does not present arguments specific to the additional limitations of claims 4, 5, and 8. *See generally* PO Resp. We find Petitioner has shown Serra teaches those limitations. Pet. 32–35.

For the reasons discussed above, we are persuaded that Petitioner has shown by a preponderance of the evidence that claims 4, 5, 8, and 19 would have been obvious over the Kriveshko and Serra combination.

D. Obviousness over Kriveshko, Serra, and Brennan

Petitioner argues that claims 6, 7, 12, and 13 would have been obvious over Kriveshko, Serra, and Brennan. Pet. 46–54. For the reasons explained below, we are persuaded that Petitioner has demonstrated by a preponderance of the evidence that these claims are unpatentable on this ground.

Petitioner contends that the combination of Kriveshko, Serra, and Brennan teaches or suggests the limitation of "wherein functionality of the user interface comprises a use of gestures," as required by dependent claim 6 and the limitation of "wherein the gestures are detected by the at least one motion sensor," as required by dependent claim 7. Pet. 51–53. Petitioner further contends that the combination teaches the limitations of claims 12 and 13 specifying the handheld instrument as a surgical instrument and a mechanical tool respectively. *Id.* at 53–54. Petitioner provides reasoning why a person of ordinary skill in the art would have combined the teachings of these references. *Id.* at 46–50.

Petitioner asserts that "Brennan describes controlling the functionality of the scanning device via the gestures" and that "Figure 19 depicts exemplary gesture-based alphanumeric input strokes that may be utilized to control various functions of the scanning device." Pet. 51 (citing Ex. 1007, 5:25–36, 17:40–42, 22:31–23:65). Petitioner asserts that Patent Owner does not dispute that Brennan teaches gestures, but rather counters that Brennan's gestures are not for the purpose of claim 1's "controlling the display to adjust the view with which the 3D environment is represented on the display." Pet. Reply 27. In doing so, Petitioner argues that Patent Owner fails to respond to or consider the Petition's arguments as to how these features are taught or suggested by the combination of all three references, again improperly addressing Brennan alone. *Id.*

Patent Owner argues with respect to claims 6 and 7 that Brennan fails to disclose remotely controlling the display to adjust the view by any means. PO Resp. 43–44. Patent Owner further argues that Petitioner's declarant admits that "Kriveshko/Serra does not explicitly teach gestures detected by a motion sensor as recited in claim 7." *Id.* at 45 (citing Ex. 1003 ¶ 256).

It is well settled that "a determination of obviousness based on teachings from multiple references does not require an actual, physical substitution of elements." *In re Mouttet*, 686 F.3d 1322, 1332 (Fed. Cir. 2012) (citations omitted). Nor is the test for obviousness whether a secondary reference's features can be bodily incorporated into the structure of the primary reference. *Keller*, 642 F.2d at 425. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. *Id.*

Here, we agree with Petitioner that one ordinarily skilled in the art would have had reason to combine the teachings of Brennan disclosing handheld scanning devices with well-known user input techniques using gestures for user control of an image capture system, Kriveshko disclosing a scanning device 102 that includes a user input device 116 (e.g., a button, lever, dial, thumb wheel, or switch) for user control of the image capture system 100, and Serra disclosing a scanning device that includes a motion sensor that collects tracking information corresponding to the movement of the scanning device using the motion sensor. Pet. 47 (citing Ex. 1003 ¶¶ 74–85, 248–254, 277–279; Ex. 1005 ¶ 52; Ex. 1006 ¶¶ 49, 53–54, Fig. 7; Ex. 1007, 5:25–36, 22:49–23:21); *see also* Inst. Dec. 28–29.

As we previously stated in the Institution Decision, Petitioner explained that an ordinarily skilled artisan would have been motivated to incorporate the gesture based input techniques of Brennan into the combination of Kriveshko's and Serra's scanning device in order to provide an intuitive means of user input via a motion sensor. Inst. Dec. 29 (citing Pet. 47–48); *see also* Inst. Dec. 27–29. We found that Petitioner's cited section of Brennan refers to making the gesture "R" with the probe to trigger the function of recording, and thus, making the gesture "R" is an intuitive way of triggering the function that starts with the letter "R." *Id.* at 29 (citing Ex. 1007, 22:49–22:59).

We further agree with Petitioner's additional motivation to combine based on Brennan's teaching of combining a scanning device with a surgical instrument to avoid having to constantly swap out surgical instruments within a surgical site. Pet. 48 (citing Ex. 1007, 2:4–8); *see also* Inst. Dec. 29–30. Petitioner explains that Brennan identifies "[t]he need to constantly swap out instruments because of limited access to the surgical site is frequently a problematic and time-consuming distraction to the surgeon." Pet. 48 (citing Ex. 1007, 1:46–49).

Petitioner states that Kriveshko teaches that its scanner has applications in the medical space, such as use by a dentist who often performs different surgical procedures, including tooth extractions, tooth implants, wisdom teeth removal, that require the use of surgical tools. *Id.* at 49 (citing Ex. 1003 ¶ 282). Petitioner contends that one ordinarily skilled in the art would have recognized that incorporating a surgical instrument into Kriveshko's scanning device would have permitted a dentist to perform a scanning process and a surgical process at a surgical site without having to use multiple devices. *Id.* (citing Ex. 1003 ¶¶ 281–283). Additionally, Petitioner explains that a person of ordinary skill in the art would have recognized the importance of reducing distractions for a medical practitioner performing a dental procedure on a patient, like that disclosed by Kriveshko. *Id.* (citing Ex. 1003 ¶¶ 281–283).

We agree with Petitioner that a person of ordinary skill in the art would have been motivated and found it obvious to enhance the combination of Kriveshko-Serra by incorporating a surgical instrument, given that Brennan explicitly teaches the efficiency benefits of combining a scanning device with other devices having diagnostic and/or therapeutic functions. *Id.*

Patent Owner's arguments to the contrary are not persuasive because it is of no moment that Brennan fails alone to disclose remotely controlling the display to adjust the view by any means and the Kriveshko/Serra combination does not explicitly teach gestures detected by a motion sensor. Instead, it is the Petitioner's proposed combination of Kriveshko, Serra, and Brennan that teaches the limitations of claims 6, 7, 12, and 13 as discussed *supra*.

For the reasons discussed above, we determine that Petitioner has shown by a preponderance of the evidence that claims 6, 7, 12, and 13 are unpatentable as obvious over Kriveshko, Serra, and Brennan.

III. CONCLUSION

On this record, Petitioner has shown by a preponderance of the evidence that claims 1–19 of the ’675 patent are unpatentable.

IV. ORDER

Accordingly, it is

ORDERED that

1. Claims 1–2, 9–11, and 18 of the ’675 patent are unpatentable on the ground of anticipation by Kriveshko;
2. Claims 1–5, 8–11, and 14–19 of the ’675 patent are unpatentable on the ground of obviousness over Kriveshko and Serra; and
3. Claims 6, 7, 12, and 13 of the ’675 patent are unpatentable on the ground of obviousness over Kriveshko, Serra, and Brennan; and

FURTHER ORDERED that because this Final Written Decision is final, a party to the proceeding seeking judicial review of the Decision must comply with the notice and service requirements of 37 C.F.R. § 90.2.

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Paper 7
Entered: May 30, 2018

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

ALIGN TECHNOLOGY, INC.
Petitioner,

v.

3SHAPE A/S
Patent Owner.

Case IPR2018-00197
Patent 9,329,675 B2

Before ELENI MANTIS MERCADER, MICHELLE N. WORMMEESTER, and JESSICA C. KAISER, *Administrative Patent Judges*.

MANTIS MERCADER, *Administrative Patent Judge*.

DECISION
Institution of *Inter Partes* Review
35 U.S.C. § 314(a)

I. INTRODUCTION

Petitioner filed a Petition for *inter partes* review of claims 1–19 of U.S. Patent No. 9,329,675 B2 (Ex. 1001, "the '675 patent"). Paper 2 ("Pet."). Patent Owner filed a Preliminary Response. Paper 5 ("Prelim. Resp.").

Upon consideration of the Petition, the Preliminary Response, and the associated evidence, we are persuaded that Petitioner has demonstrated a reasonable likelihood of prevailing in establishing unpatentability of at least one claim of the '675 patent. Accordingly, we institute an *inter partes* review.

A. Related Matters

Petitioner states that the '675 patent has not been involved in any litigation proceedings. Pet. 55. Petitioner identifies *inter partes* review proceeding IPR2018-00198 that also challenges the '675 patent. *Id.*

Patent Owner submits that the following is a list of judicial and administrative matters that would affect, or be affected by, a decision in this proceeding: *Align Technology, Inc. v. 3Shape A/S*, IPR2018-00198, Petition for *Inter Partes* Review of U.S. Patent No. 9,329,675 B2, filed on November 22, 2017; U.S. Provisional Application No. 61/420,138, filed on December 6, 2010; and PCT International Application No. PCT/DK2011/050461, filed on December 5, 2011. Paper 4, 1.

B. The '675 Patent

The '675 patent relates to handheld intraoral scanner device 100 and computer screen 101. Ex. 1001, Fig. 1, 11:29–31. An operator 102 uses the intraoral scanner 100 to record some intraoral 3D geometry and the user interface functionality to rotate, pan, and zoom displayed 3D model 105 of the scanned data on computer screen 101. *Id.* at 11:31–37. The integration of the user interface functionality in device 100 is provided by motion sensors (not visible), which can be accelerometers inside scanner 100, whose readings determine the orientation of 3D model 105 of the teeth acquired by scanner 100 on computer screen 101. *Id.* at 11:37–42. Figure 1 of the '675 patent is reproduced below.

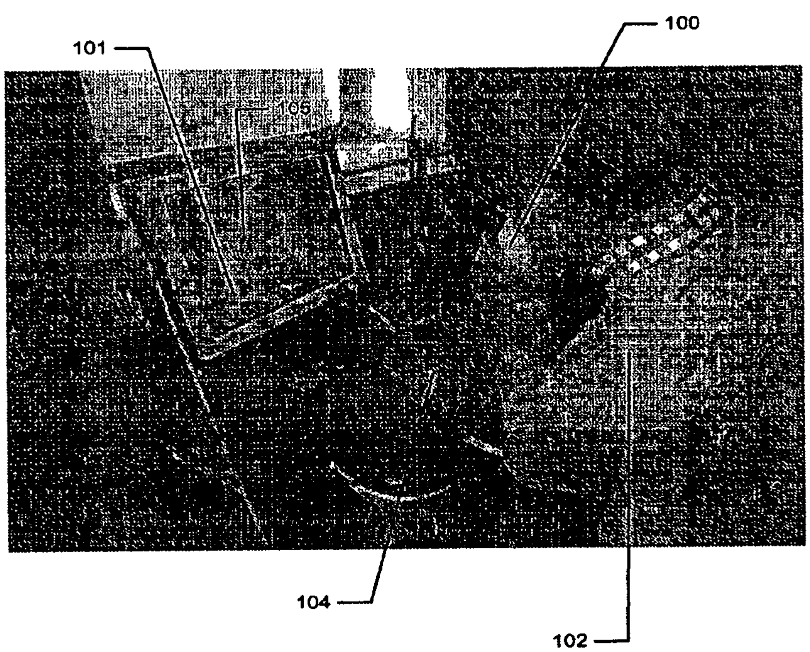

Figure 1 above shows operator 102 using intraoral scanner 100 to record some intraoral 3D geometry and displayed 3D model 105 of the scanned data on computer screen 101. Ex. 1001, Fig. 1, 11:31–37.

Additional functionality to start/stop scanning is provided by button 103 as seen in Figure 3. *Id.* at Fig. 3, 11:42–45. Figure 3 of the '675 patent is reproduced below.

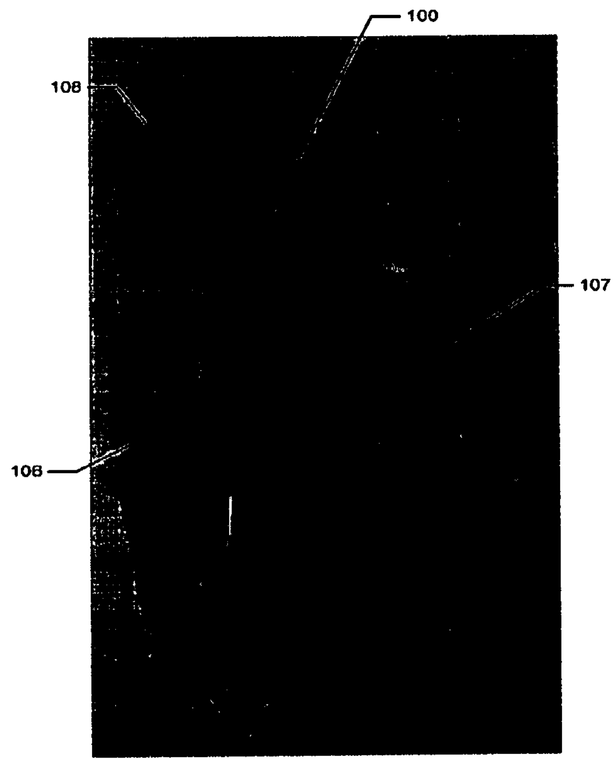

Figure 3 above shows button 103 being located where the user's index finger can reach it conveniently. *Id.* at 11:44–46. When the button is pressed quickly the handheld device is prepared for scanning, e.g., it is set for performing at least one action, the scanning procedure, in the physical 3D environment. *Id.* at 3:58–61. The scanning is stopped when the button is pressed quickly a second time. *Id.* at 3:61–63. While the scanning is performed, a virtual 3D representation is visually built on the display and the user can press and hold the button. *Id.* at 3:61–66. This action puts the handheld device in a controller mode, where the handheld device is adapted for remotely controlling the view with which the 3D environment, such as scanned teeth, is represented on the display. *Id.* at 3:66–4:3. While the button is pressed, the system will use signals from a motion sensor in the handheld device to determine how to present the view of the virtual 3D environment on the computer screen 101. *Id.* at 4:3–5.

C. Illustrative Claim

Petitioner challenges claims 1–19 of the '675 patent. Claims 1 and 19 are independent. Claim 1 is illustrative of the claimed subject matter:

> 1. A scanning system for scanning a 3D environment, the scanning system comprising:
>
> a handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment; and
>
> at least one display remotely connected to the handheld device,
>
> wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment, and the at least one display is adapted for visually representing the physical 3D environment; and
>
> the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display.

Ex. 1001, 15:29–42.

D. References

Petitioner relies on the following references. Pet. 5.

Reference	Number	Date	Ex. No.
Kriveshko	US 2007/0171220 A1	July 26, 2007	Ex. 1005
Serra	US 2006/0020204 A1	Jan. 26, 2006	Ex. 1006
Brennan	US 8,903,476 B2	Dec. 2, 2014	Ex. 1007

E. Asserted Grounds of Unpatentability

Petitioner contends that claims 1–19 of the '675 patent are unpatentable based on the following grounds:

Reference(s)	Basis	Challenged Claims
Kriveshko	§ 102	1, 2, 9–11, and 18
Kriveshko and Serra	§ 103	1–5, 8–11, and 14–19
Kriveshko, Serra, and Brennan	§ 103	6, 7, 12, and 13

Id. Petitioner further relies on the declaration of Chandrajit L. Bajaj, Ph.D. for support (Ex. 1003).

II. CLAIM CONSTRUCTION

Petitioner provides proposed constructions of the claim terms "3D geometry," "3D environment," "view," "handheld device," "3D scanner," "motion sensor," and "means for manually switching between performing the at least one scanning action and remotely controlling the view." Pet. 9–12. Patent Owner provides a proposed construction of the claim term "user interface." Prelim. Resp. 6–9. We determine that no claim term requires express construction to resolve the issues before us other than as discussed below in our analysis of Petitioner's asserted grounds of unpatentability and Patent Owner's preliminary response. *See Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999) ("[O]nly those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy.").

III. DISCUSSION

A. Asserted Anticipation by Kriveshko

Petitioner argues that Kriveshko anticipates claims 1, 2, 9–11, and 18. Pet. 15–24. For the reasons explained below, we are persuaded that Petitioner has demonstrated a reasonable likelihood of prevailing on this asserted ground.

1. Overview of Kriveshko (Ex. 1005)

Kriveshko's Figure 1 shows system 100 including scanning device 102 with input device 116. Ex. 1005 ¶¶ 51, 72. Kriveshko discloses "scanner 102 is *a handheld, freely positionable probe having at least one user input device, such as a button, lever, dial, thumb wheel, switch, or the like*, for user control of the image capture system 100 such as starting and stopping scans." *Id.* ¶ 52 (emphasis added). The scanning device 102 acquires three-dimensional data. *Id.* Kriveshko's scanning system 100 includes computer 108 having display 110. *Id.* ¶ 51.

Kriveshko's Figure 1 is reproduced below:

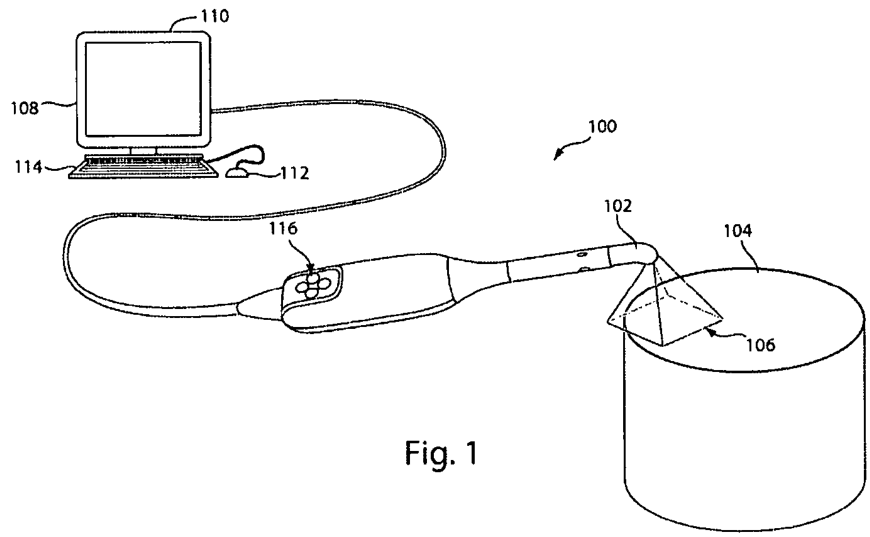

Fig. 1

Figure 1 shows handheld scanner 102 having input device 116 located on scanner 102 wherein scanner 102 is remotely connected to display 110. Ex. 1005, Fig. 1.

Kriveshko's Figure 4 shows "[w]ithin the window 402, a video image may be displayed including a field of view of a scanner, such as the scanner 102 of FIG. 1. Within the field of view, a subject 404, such as the subject 104 of Figure 1 may be displayed, along with one or more user controls 406." *Id.* ¶ 90. Kriveshko discloses:

> user controls 406 may generally include one or more controls for manipulating the three-dimensional model (e.g., rotating, scaling, panning, and the like), selecting a landing target, controlling operation of the image capture system (e.g., starting or stopping an acquisition), and so forth. The one or more controls may be manipulated, for example, using any of the user input devices described above with reference to FIG. 1.

Id. ¶ 91.

Kriveshko's Figure 4 is reproduced below:

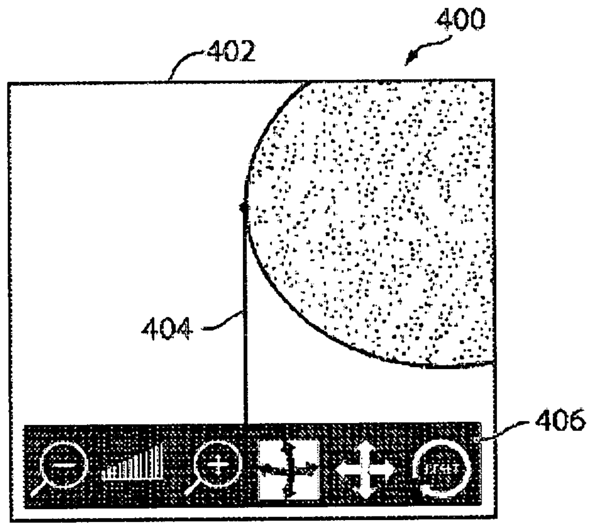

Fig. 4

Figure 4 shows user controls 406 which can be manipulated by any of the user input devices. *Id.* ¶¶ 90–91.

2. Claim 1

To establish anticipation, each and every element in a claim, arranged as recited in the claim, must be found in a single prior art reference. *See Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008); *Karsten Mfg. Corp. v. Cleveland Golf Co.*, 242 F.3d 1376, 1383 (Fed. Cir. 2001). Although the elements must be arranged or combined in the same way as in the claim, "the reference need not satisfy an *ipsissimis verbis* test," i.e., identity of terminology is not required. *In re Gleave*, 560 F.3d 1331, 1334 (Fed. Cir. 2009); *accord In re Bond*, 910 F.2d 831, 832 (Fed. Cir. 1990).

Petitioner relies on Kriveshko as disclosing the limitations of independent claim 1. Pet. 15–20. In particular, Petitioner provides mappings of Kriveshko's disclosure to claim 1 as further supported by Dr. Bajaj's declaration. *Id.* We have reviewed the information provided by Petitioner, including the relevant portions of Dr. Bajaj's supporting declaration (Ex. 1003). Based on the current record, we are persuaded that Petitioner has demonstrated a reasonable likelihood of prevailing on its anticipation challenge to claim 1.

For example, for the preamble (i.e., "[a] scanning system for scanning a 3D environment"), Petitioner relies on Kriveshko's disclosure of system 100 (e.g., the scanning system) for "scan[ning] complex surfaces . . . by maintaining a continuous three-dimensional scan across separated subsections of the surface." Pet. 15 (citing Ex. 1005 ¶ 8). Scanning device 102 is passed over a surface of the subject 104. *Id.* at 15–16 (citing Ex. 1005 ¶ 58). The scanning device 102 captures images of the subject 104 within the image plane 106. *Id.* at 16 (citing Ex. 1005 ¶ 51). Based on the record before us, we are persuaded that Kriveshko discloses the recited "scanning system."

Claim 1 further recites "a handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment." For this limitation, Petitioner points us to Kriveshko's scanning device 102, which is disclosed as a "handheld, freely positionable probe" and includes an "optical scanner" optically acquiring three-dimensional data. Pet. 16 (citing Ex. 1005 ¶¶ 51–52; Ex. 1003 ¶ 95). Petitioner explains that, in Kriveshko, the 3D environment to be scanned is selected by freely positioning (e.g., pointing) scanning device 102 over the surface of subject 104 (e.g., the 3D environment) and capturing images of the subject within image plane 106.

Id. at 17 (citing Ex. 1003 ¶¶ 94–96). Petitioner provides an annotated version of Kriveshko's Figure 1, reproduced below, to further support its contentions:

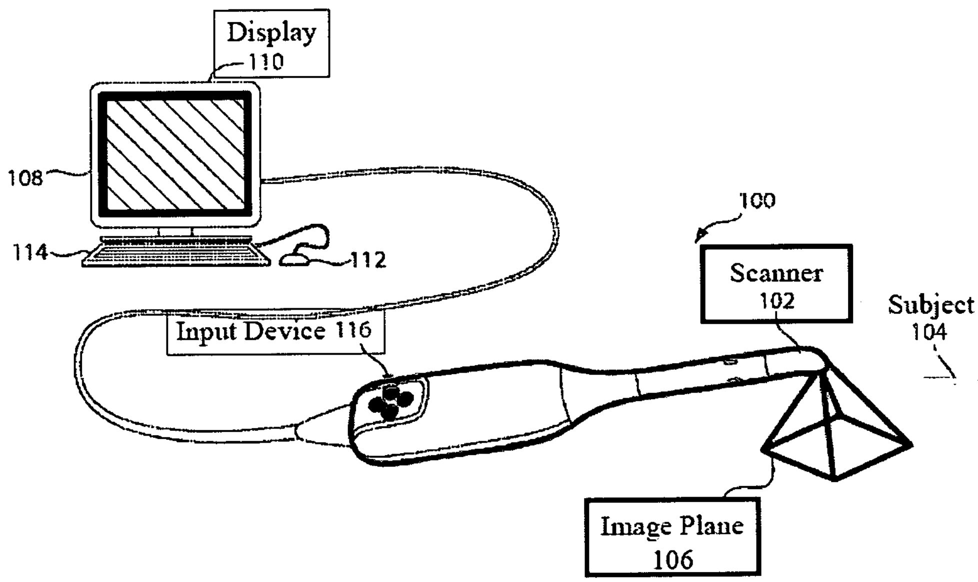

Fig. 1

Annotated Figure 1 (reproduced above) shows pointing freely positionable handheld optical scanner 102 over 3D environment 104 to be scanned. *See* Pet. 16–17. Based on the record before us, we are persuaded that Kriveshko discloses the recited "handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment."

Claim 1 further recites "at least one display remotely connected to the handheld device." Regarding this limitation, Petitioner points us to Kriveshko's Figure 1 (annotated version reproduced above) showing scanning system 100 with computer 108 that includes display 110 (e.g., the at least one display). Pet. 17 (citing Ex. 1005 ¶ 51, Fig. 1; Ex. 1003 ¶ 98).

In Kriveshko, display 110 is remotely connected to handheld optical scanning device 102. Ex. 1005 ¶ 51, Fig. 1. Petitioner explains that similar to the '675 patent's wired scanning device 100 remotely connecting to display 101 (Ex. 1001, Fig. 3), Kriveshko's scanner 102 is remotely connected to display 110 by a wire. *Id.* at 17–18 (citing Ex. 1005, Fig. 1; Ex. 1003 ¶¶ 98–99). Petitioner concludes that Kriveshko's display 110 is remotely connected to its handheld scanner 102 in the same way that the '675 patent's display 101 is remotely connected to the scanning device 100. *Id.* at 18 (citing Ex. 1003 ¶¶ 97–100). Petitioner adds that when handheld scanning device 102 performs a scan of subject 104, computer 108 presents images of the scan on display 110 for viewing by an operator of scanning device 102. *Id.* (citing Ex. 1005 ¶¶ 60, 90, Fig. 1; Ex. 1003 ¶¶ 97–100). Based on the record before us, we are persuaded that Kriveshko discloses the recited "at least one display remotely connected to the handheld device."

Claim 1 further recites "wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment." For this limitation, Petitioner relies on Kriveshko's handheld scanning device 102 capturing images of subject 104 in an image plane 106 while the handheld scanning device 102 is passed over subject 104. Pet. 18 (citing Ex. 1005 ¶¶ 51, 56, 58). Based on the record before us, we are persuaded that Kriveshko discloses that the recited "handheld device" performs a scanning action in a physical 3D environment.

Claim 1 also recites "the at least one display is adapted for visually representing the physical 3D environment." Petitioner relies on Kriveshko as disclosing that display 110 presents a virtual representation of the subject 104 in its environment, which Petitioner asserts is an example of "visually representing the physical 3D environment," as claimed. Pet. 19 (citing Ex. 1005 ¶¶ 60, 90, Fig. 4; Ex. 1003 ¶¶ 76, 105–108). Petitioner points us to an annotated version of Kriveshko's Figure 4 wherein the visual representation of subject 104 is being rendered within window 402 of user interface 400 on display 110. *Id.* (citing Ex. 1005 ¶¶ 60, 90).

The annotated version of Kriveshko's Figure 4 provided by Petitioner is reproduced below:

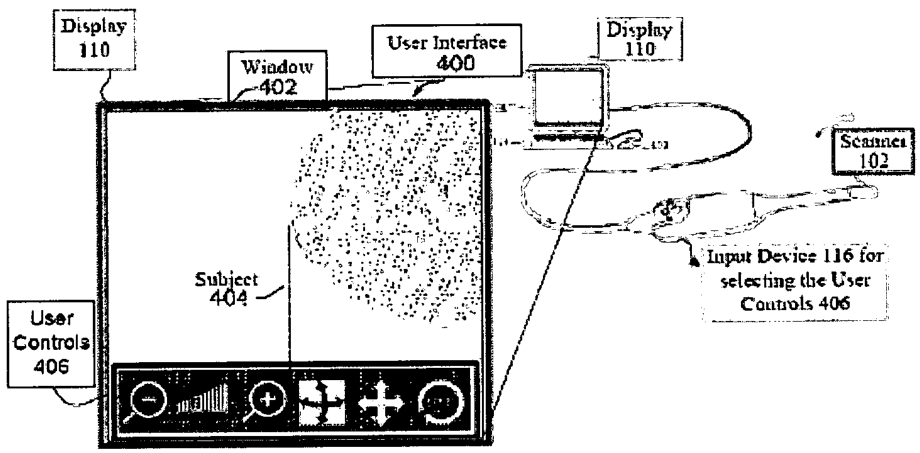

Fig. 4

The annotated Figure 4 includes display 110 visually representing subject 404. Petitioner contends this figure shows:

> [w]ithin the window 402, a video image may be displayed including a field of view of a scanner, such as the scanner 102 of FIG. 1. Within the field of view, a subject 404, such as the subject 104 of Figure 1 may be displayed, along with one or more user controls 406.

Pet. 19 (citing Ex. 1005 ¶ 90). Based on the record before us, we are persuaded that Kriveshko discloses that the recited "display" visually represents a physical 3D environment.

Finally, claim 1 recites "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." For this limitation, Petitioner relies on Kriveshko's handheld scanning device 102 including user input device 116 (e.g., a button, lever, dial, thumb wheel, or switch) for user control of image capture system 100. Pet. 20 (citing Ex. 1005 ¶ 52). Petitioner explains that Kriveshko's user interface of user input device 116 is used to select one or more controls that are presented on display 110, resulting in the manipulation of a three-dimensional model from a scan of the 3D environment. *Id.* (citing Ex. 1005 ¶¶ 90–91; Ex. 1003 ¶¶ 76, 109–111). According to Petitioner, such manipulation includes adjusting the view, which in the 3D environment is represented on the display by rotating, scaling, or panning the view of the three-dimensional model. *Id.*

Petitioner's contentions are further supported by Dr. Bajaj's testimony that Kriveshko's user controls for manipulating the three-dimensional model are selected via a user input element of the scanning device. Ex. 1003 ¶ 76. Dr. Bajaj explains that as illustrated in Figure 1, Kriveshko discloses that scanner 102 includes user input device 116, such as a button, lever, dial, thumb wheel, or switch, for user control of image capture system 100. *Id.* ¶ 110 (citing Ex. 1005 ¶ 52). Furthermore, Dr. Bajaj, referring to Figures 4–9, states that Kriveshko discloses presenting one or more user controls 406 on display 110 for manipulating a three-dimensional model, e.g., rotating, scaling, and panning. *Id.* ¶¶ 76, 110 (citing Ex. 1005 ¶¶ 90, 91). Additionally, Dr. Bajaj explains that in Kriveshko, user controls may be selected using user input devices. *Id.* ¶ 111 (citing Ex. 1005 ¶¶ 90–91).

Dr. Bajaj concludes that a person of ordinary skill in the art would have understood that in Kriveshko, the user input device of scanner 102 would have been used to manipulate the user controls to adjust the view of the display as illustrated in Petitioner's combined annotated version of Figures 1 and 4 as reproduced below. *See id.*

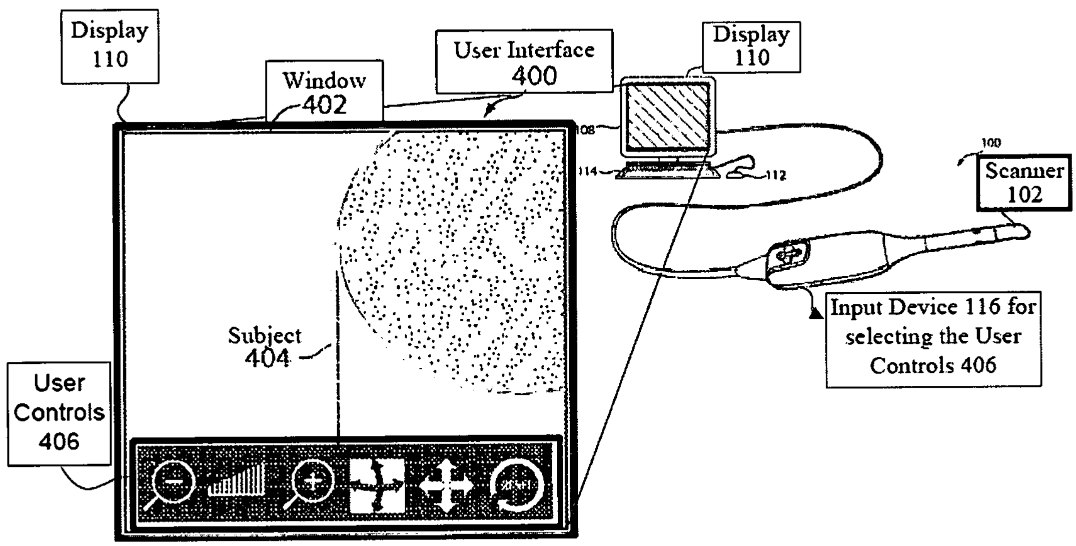

Fig. 4

The annotated Figures 1 and 4 of Kriveshko show user input device 116 for remotely selecting user controls 406. *See* Ex. 1003 ¶ 111.

Based on the record before us, we are persuaded that Kriveshko discloses "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display," as recited in claim 1.

Patent Owner contends Petitioner has not adequately shown Kriveshko discloses the limitation of "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." Prelim. Resp. 11. Patent

Owner contends that Kriveshko discloses a list of potential functions that can be controlled by the user controls 406 which "may generally include one or more controls for manipulating the three-dimensional model (e.g., rotating, scaling, panning, and the like), selecting a landing target, controlling operation of the image capture system (e.g., starting or stopping an acquisition), and so forth." *Id.* at 13–14 (citing Ex. 1005 ¶ 91). Patent Owner points us to Kriveshko's disclosure that "[t]he one or more controls may be manipulated, for example, by using any of the user input devices *described above with reference to Fig. 1*." *Id.* at 14 (citing Ex. 1005 ¶ 91). According to Patent Owner, Figure 1 of Kriveshko depicts a number of potential user input devices, including a keyboard 114, a mouse 112, a display 110, and an input device 116 of a scanner 102. *Id.* (citing Ex. 1005 ¶ 72).

Based on these disclosures, Patent Owner contends that "Kriveshko does not unequivocally disclose the specific *combination* of, on the one hand, manipulating the 3D model, and, on the other hand, the input device 116 of the scanner 102." *Id.* According to Patent Owner, "[o]ne would have to pick and choose (1) 'manipulation of the 3D model' from the variety of potential controls contemplated by Kriveshko, and (2) the input device 116 on the scanner 102 from the variety of potential input devices, to arrive at the claimed combination, while ignoring the fact that Kriveshko's input device 116 is only mentioned in paragraphs [52 and 72] in connection with starting and stopping scans." *Id.* Patent Owner contends that the Petition is devoid of any analysis as to why the disclosure of a list of potential functions and a list of potential user input devices by Kriveshko constitutes anticipation of the specifically claimed combination in claim 1. *Id.* at 14–15.

Thus, Patent Owner alleges Petitioner failed to demonstrate that Kriveshko unequivocally discloses the elements "arranged or combined in the same way as recited in the claim." *Id.* (citing *Net MoneyIN, Inc. v. VeriSign, Inc.*, 545 F.3d 1359, 1369 (Fed. Cir. 2008) ("unless a reference discloses within the four corners of the document not only all of the limitations claimed but also all of the limitations arranged or combined in the same way as recited in the claim, it . . . cannot anticipate under 35 U.S.C. § 102")). Patent Owner further states that such picking and choosing does not constitute an anticipation. *Id.* (citing *In re Arkley*, 455 F.2d 586, 587–88 (CCPA 1972) ("Such picking and choosing has no place in the making of a 102, anticipation rejection.")).

We disagree with Patent Owner's arguments. As discussed above, Kriveshko discloses display controls 406 activated by an input device. Ex. 1005 ¶¶ 90, 91. Kriveshko also discloses that the input device can be any of these devices including a keyboard 114, a mouse 112, a display 110, and an input device 116 of a scanner 102. *Id.* ¶ 72. Kriveshko further discloses that the controls 406 include a number of options including manipulation of the 3D image. *Id.* ¶ 91. Petitioner relies on input device 116 on scanner 102 to select control 406 for the manipulation of the 3D image to meet claim 1's limitation of "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." Pet. 20.

Thus, Patent Owner's citation to *Arkley* is misplaced. Petitioner is not combining embodiments that are not directly related, but rather the relied upon disclosures are from a single embodiment of an input device used to select a control 406 to trigger an appropriate function. *See Arkley*, 455 F.2d at 587 ("without *any* need for picking, choosing, and combining various disclosures not directly related to each other by the teachings of the cited reference"). We determine that Petitioner has not engaged in improper picking and choosing from Kriveshko. In particular, paragraph 91 of Kriveshko states "[t]he one or more controls may be manipulated, for example, using any of the user input devices described above with reference to FIG. 1." Ex. 1005 ¶ 91. Petitioner relies on one such input device, namely input device 116 on scanner 102. *Id.* ¶ 72. With respect to Patent Owner's contention that there is no specific combination of "manipulation of the 3D model" from a variety of potential controls contemplated by Kriveshko with input device 116, paragraph 91 of Kriveshko further discloses that user controls 406 include "one or more controls for manipulating the three-dimensional model (e.g. rotating, scaling, panning, and the like) . . . using any of the user input devices." *See* Pet. 13–14, 20; Ex. 1005 ¶ 91. In other words, the relied upon disclosure of user controls for manipulating an image is *directly related* to input device 116 on scanner 102 because there is *a selection of a particular control 406* by *an input device to trigger a particular function* (e.g., this is a single embodiment of selecting a control 406 for manipulating a displayed image by input 116). *See* Ex. 1005 ¶ 91.

Patent Owner further alleges that Petitioner and its expert concede that Kriveshko discloses 2D input devices, and not a 3D user interface. Prelim. Resp. 11–12. According to Patent Owner, Petitioner failed to demonstrate that Kriveshko discloses the user interface of claim 1 which requires a 3D user interface. *Id.* at 12. Patent Owner's argument is based on its proposed construction of "user interface." Prelim. Resp. 11–12. Specifically, Patent

Owner proposes a construction of "user interface" as a 3D user interface for two reasons: (1) Patent Owner contends the '675 patent repeatedly and consistently describes the invention as employing a 3D user interface (*id.* at 7 (citing Ex. 1001, 1:58–60)), and (2) Patent Owner contends the Specification discloses that the 3D user interface functionality is integrated in the central device and constitutes an advantage of the present system (*id.* (citing Ex. 1001, 2:39–41)). Patent Owner concludes that in light of the fact that the system of the '675 patent is repeatedly and consistently described in the Specification as employing a 3D user interface, the term "user interface" should be construed as requiring a 3D user interface. *Id.* (citing *Virnetx, Inc. v. Cisco Sys., Inc.*, 767 F.3d 1308 (Fed. Cir. 2014) ("The fact that [a feature] is 'repeatedly and consistently' used to characterize the invention strongly suggests that it should be read as part of the claim.")). Patent Owner notes that Petitioner did not provide a proposed construction of the term "user interface." *Id.* at 6.

We do not agree that the recited "user interface" is limited to a 3D user interface at this stage of the proceeding. In particular, we observe that the '675 patent does not consistently refer to the "user interface" as being a 3D user interface as Patent Owner contends. *See, e.g.*, Ex. 1001, 3:15–17, 22–27, 4:15–28. In addition, the patent drafter chose the term "user interface" instead of "3D user interface" in drafting claim 1.

Patent Owner also contends that the Specification of the '675 patent disclaims the use of prior art 2D user interfaces. Prelim. Resp. 8–9. In support, Patent Owner points to a portion of the Specification discussing disadvantages of physically touching a user interaction device in a medical environment. *Id.* at 8 (citing Ex. 1001, 1:28–31). Patent Owner also points to another portion of the '675 Specification that states "prior art user interface devices can be inconvenient, awkward and difficult to use, and they can be labor-intensive, and thus costly to sterilize or disinfect." *Id.* (quoting Ex. 1001, 4:39–42).[1] At this stage of the proceeding, we are not persuaded that the disclosures in the Specification to which Patent Owner points evidence a disavowal of the full scope of the claim. *See Thorner v. Sony Comp. Entm't Am. LLC*, 669 F.3d 1362, 1365 (Fed. Cir. 2012). We are mindful that "the claims must 'not be read restrictively unless the patentee has demonstrated a clear intention to limit the claim scope using words or expressions of manifest exclusion or restriction.'" *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1347 (Fed. Cir. 2015).

For the reasons discussed above, we are not persuaded that the recited "user interface" is limited to a 3D interface.

Accordingly, at this stage of the proceeding and on the current record, we find that Petitioner has adequately shown that Kriveshko discloses the recited "user interface."

Patent Owner further argues that Petitioner fails to provide any explanation as to how Kriveshko constitutes an enabling disclosure of the purported handheld scanner having the ability to perform manipulation of the 3D model. Prelim. Resp. 15–16. On the current record and at this stage of the proceeding, we are not persuaded because of the well-established principle that prior art patents are presumed to be operable. *See In re Sasse*, 629 F.2d 675, 681 (CCPA 1980).

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[1] Patent Owner also cites Exhibit 2001 as further evidence of disadvantages of using 2D input devices for manipulating objects in 3D space. *See* Prelim. Resp. 8 (citing Ex. 2001 ¶ 3).

Lastly, Patent Owner argues that the Petition does not specify where the "remotely controlling" claim element is found in the prior art. Prelim. Resp. 17–18. As stated *supra*, Petitioner relies on Kriveshko's handheld scanning device 102 including user input device 116 (e.g., a button, lever, dial, thumb wheel, or switch) for selecting one or more controls presented at the display 110 (e.g., display 110 being remotely located from user input device 116). *See* Pet. 20 (citing Ex. 1005 ¶¶ 52, 90–91). Petitioner explains that Kriveshko's user interface of user input device 116 is used to select one or more controls that are presented on display 110, resulting in the manipulation of a three-dimensional model from a scan of the 3D environment. *Id.* (citing Ex. 1005 ¶¶ 90–91; Ex. 1003 ¶¶ 76, 109–111). According to Petitioner, such manipulation includes adjusting the view, which in the 3D environment is represented on the display by rotating, scaling, or panning the view of the three-dimensional model. *Id.* Thus, we determine the input device 116 remotely controls one or more controls on display 110.

Based on the foregoing discussion, we are persuaded that Petitioner has provided sufficient evidence that establishes a reasonable likelihood of prevailing in its challenge to claim 1 under 35 U.S.C. § 102 as anticipated by Kriveshko.

3. Claims 2, 9–11, and 18

Claims 2, 9–11, and 18 depend from claim 1. Petitioner contends Kriveshko discloses the additionally recited limitations of claims 2, 9–11, and 18. Pet. 20–24. Petitioner provides detailed explanations and specific citations to Kriveshko indicating where in the reference the claimed features are disclosed. *Id.* (citing Ex. 1005 ¶¶ 52, 54, 60–61, 76, 90–91, 103).

Patent Owner does not respond specifically to Petitioner's challenge to claims 2, 9–11, and 18 beyond Patent Owner's arguments advanced with respect to claim 1 discussed above. *See* Prelim. Resp. 18.

At this stage of the proceeding, for purposes of this Decision, we are satisfied that Petitioner has cited sufficient disclosure to show that Kriveshko discloses the additionally recited limitations of claims 2, 9–11, and 18. On this record, we are persuaded Petitioner has provided sufficient evidence that establishes a reasonable likelihood of prevailing in its challenge to claims 2, 9–11, and 18 under 35 U.S.C. § 102 as anticipated by Kriveshko.

B. Asserted Obviousness over Kriveshko and Serra

Petitioner argues that claims 1–5, 8–11, and 14–19 would have been obvious over Kriveshko and Serra. Pet. 24–46. For the reasons explained below, we are persuaded that Petitioner has demonstrated a reasonable likelihood of prevailing on this asserted ground.

1. Serra

Serra teaches switches or manual actuators on a handheld probe to allow user control of display parameters by actuating one or more buttons on a probe. Ex. 1006 ¶ 53. Serra further teaches that a button can be used to use the probe to scan an image or to use it to rotate the entire virtual scene, which is a common 3D data set interactive visualization operation. *Id.* The handheld scanning device collects tracking information corresponding to the movement of the scanning device and the user interface of the scanning device "rotate[s] the entire scene (effectively changing the viewpoint of the user over the entire 3D scene)." *Id.* ¶ 54.

2. Claim 1

A claim is unpatentable under 35 U.S.C. § 103(a) if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when in the record, objective evidence of nonobviousness. *See Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966). In that regard, an obviousness analysis "need not seek out precise teachings directed to the specific subject matter of the challenged claim, for a court can take account of the inferences and creative steps that a person of ordinary skill in the art would employ." *KSR*, 550 U.S. at 418.

As discussed above with respect to anticipation by Kriveshko, Petitioner argues that Kriveshko teaches all the limitations recited in claim 1. Regarding the limitation "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display," however, Petitioner relies alternatively on Serra. Pet. 24–25. Specifically, Petitioner directs us to where Serra teaches a handheld scanning device that includes a button that can be used to rotate the entire visual scene. *Id.* at 25 (citing Ex. 1006 ¶ 54).

Petitioner further asserts that incorporating Serra's 3D user interface into a scanning device provides *ergonomic advantages* over other scanning systems by permitting the user to both perform a scanning process and examination process with the same device. Pet. 26 (citing Ex. 1006 ¶ 53). Petitioner explains that a person of ordinary skill would have been motivated and would have found it obvious to incorporate Serra's 3D user interface into Kriveshko's optical handheld device in order to provide an ergonomic handheld scanning device with a user interface that is adapted to control the display of three-dimensional imaging data displayed from an optical scan of 3D environment. *Id.* at 27 (citing Ex. 1006 ¶¶ 11, 53; Ex. 1003 ¶¶ 153–164, 239–244).

Based on the record before us, we are persuaded that the combination of Kriveshko and Serra teaches the recited "user interface." We also are persuaded that Petitioner's proffered reasoning for modifying Kriveshko's handheld device to include Serra's user interface, namely, to provide an ergonomic handheld scanning device, is sufficient at this stage of the proceeding. *See In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) ("there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness").

Patent Owner responds that the "ergonomic advantages" attained by employing a button on the probe for switching between scan and rotate settings would not have led a person of ordinary skill in the art to incorporate Serra's 3D sensor into Kriveshko's handheld device. Prelim. Resp. 26. Patent Owner further argues that Petitioner failed to provide an analysis of how the ultrasound technology of Serra is analogous to the optical scanner of the invention. *Id.* at 28.

We find that Patent Owner's arguments are not persuasive at this stage of the proceeding. Claim 1 does not require a 3D sensor, and therefore Patent Owner's argument is not commensurate in scope with the claim language. *See* Ex. 1001, claim 1. We also note that the test for obviousness is not whether a secondary reference's feature (e.g. 3D sensor) can be bodily incorporated into the structure of the primary reference. *In re Keller*, 642 F.2d 413, 425 (CCPA 1981). Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. *Id.* Petitioner's analysis is supported by its expert's testimony, and we find it sufficient at this stage of the proceeding. Pet. 27 (citing Ex. 1003 ¶¶ 153–164, 239–244).

Lastly, we disagree with the argument that Serra is not analogous art. A reference qualifies as analogous art if either: (1) the art is from the same field of endeavor, regardless of the problem addressed and, (2) if the reference is not within the field of the inventor's endeavor, the reference still is reasonably pertinent to the particular problem with which the inventor is involved. *In re Bigio*, 381 F.3d 1320, 1325 (Fed. Cir. 2004). On the current record, we find that Serra is from the same field of endeavor (i.e., imaging technology for guiding scanning and viewing of an image) and thus qualifies as analogous art.

Thus, we are persuaded Petitioner has provided sufficient evidence that establishes a reasonable likelihood of prevailing in its challenge to claim 1 under 35 U.S.C. § 103 as obvious over Kriveshko and Serra.

3. Claims 2–5, 8–11, and 14–19

Claims 2–5, 8–11, and 14–18 depend from claim 1. Independent claim 19 is similar to claim 1, but further recites, among other things, an actuator for switching between one action and remotely controlling the view. *See* Ex. 1001, claims 1 and 19. Petitioner contends Kriveshko and Serra teach the additionally recited limitations of claims 2–5, 8–11, and 14–19. Pet. 30–46. Petitioner provides detailed explanations and specific citations to Kriveshko and Serra indicating where in the respective references the claimed features are taught. *Id.* (citing Ex. 1005 ¶¶ 14, 52, 54, 60–61, 75, 76, 90–91; Ex. 1006 ¶¶ 36, 42, 49, 53–54, 57–60, 75–76, Figs. 5, 7, 8).

Patent Owner responds to Petitioner's challenge to the claims primarily with similar arguments which we do not find persuasive as discussed above. *See* Prelim. Resp. 31–42. Furthermore, we do not agree with Patent Owner's specific argument with respect to claim 4 that Serra's motion sensor *itself* does not detect motion. Prelim. Resp. 32–37. Patent Owner's argument is not commensurate in scope with claim 4, which does not require the term "itself." *See* claim 4. Petitioner's contention that Serra's use of a 3D sensor to collect tracking information corresponding to movement is sufficient to show that Serra's 3D sensor detects motion. *See* Pet. 32 (citing Ex. 1006 ¶¶ 36, 42, 49, 54, Fig. 7; Ex. 1003 ¶¶ 78, 174–179).

We also do not agree with Patent Owner's assertion with respect to claim 5 that Serra does not teach the limitation of "wherein the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor." Prelim. Resp. 37–40. Based on the current record, we are persuaded by Petitioner's reliance on Serra's handheld scanning device, which includes a motion sensor that collects tracking information corresponding to the scanning device's position and results in a view of the 3D environment on its display. Pet. 33–34 (citing

Ex. 1006 ¶¶ 53, 54; Ex. 1003, ¶¶ 174–184; Petitioner's annotated Fig. 5); *also see* Pet. 32 (citing Ex. 1006 ¶¶ 36, 42, 49, 54; Ex. 1003 ¶¶ 78, 174–179, Fig. 7). Patent Owner appears to repeat similar arguments with respect to claim 19. *See* Prelim. Resp. 41–42. In addition, Patent Owner asserts that Petitioner did not account for "the view is remotely controlled by," as recited in claim 19. *Id.* at 41. At this stage of the proceeding, we do not agree because Petitioner pointed us to the corresponding claim 1 limitation (addressed at Pet. 20), namely "the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display." *See* Pet. 45–46, 20. Petitioner further referred us to the alternative grounds of unpatentability based on the Kriveshko-Serra combination which was also relied upon to teach this limitation as addressed *supra*. *See* Pet. 45.

Based on the record before us, we are persuaded Petitioner has provided sufficient evidence that establishes a reasonable likelihood of prevailing in its challenge to claims 2–5, 8–11, and 14–19 under 35 U.S.C. § 103 as obvious over Kriveshko and Serra.

C. Asserted Obviousness over Kriveshko, Serra, and Brennan

Petitioner argues that claims 6, 7, 12, and 13 would have been obvious over Kriveshko, Serra, and Brennan. Pet. 46–54. For the reasons explained below, we are persuaded that Petitioner has demonstrated a reasonable likelihood of prevailing on this asserted ground.

Claims 6, 7, 12, and 13 depend from claim 1. Petitioner contends the combination of Kriveshko, Serra, and Brennan teaches the additionally recited limitations of these dependent claims. Pet. 46–54. Petitioner provides detailed explanations and specific citations to Brennan indicating where in the reference the claimed features are taught. *Id.* Brennan is primarily relied upon for the teaching of using gestures for user control of an image capture system by using a motion sensor. *See id.* at 47, 52 (citing Ex. 1007, 5:20–60, 22:49–23:21, 22:33–37).

Patent Owner responds with similar arguments as those already addressed *supra* with respect to claims 1, 4, and 5 and further argues against the proposed combination on the basis of lack of ability to bodily incorporate the taught features. *See* Prelim. Resp. 43–50. In particular, Patent Owner argues that Petitioner fails to explain (1) how Brennan's sensor that is responsive to movement and/or handling would have worked in conjunction with the systems of Serra without having the ability to provide positional information, and (2) what additional modifications (if any) would have been necessary to the Kriveshko-Serra combination to accommodate the Brennan sensor that is responsive to movement and/or handling. *Id.* at 45.

It is well settled that "a determination of obviousness based on teachings from multiple references does not require an actual, physical substitution of elements." *In re Mouttet*, 686 F.3d 1322, 1332 (Fed. Cir. 2012) (citations omitted). Nor is the test for obviousness whether a secondary reference's features can be bodily incorporated into the structure of the primary reference. *Keller*, 642 F.2d at 425. Rather, the test is what the combined teachings of the references would have suggested to those of ordinary skill in the art. *Id.*

In that regard, Petitioner argues that one skilled in the art would have combined the teachings of Brennan disclosing handheld scanning devices with well-known user input techniques using gestures for user control of an image capture system, Kriveshko disclosing a scanning device 102 that includes a user input device 116 (e.g., a button, lever, dial, thumb wheel, or switch) for user control of the image capture system 100, and Serra disclosing a scanning device that includes a motion sensor that collects tracking information corresponding to the movement of the scanning device using the motion sensor. Pet. 47 (citing Ex. 1003 ¶¶ 74–85, 248–254, 277–279; Ex. 1005 ¶ 52; Ex. 1006 ¶¶ 49, 53–54, Fig. 7; Ex. 1007, 5:25–36, 22:49–23:21).

Petitioner explains that a skilled artisan would have been motivated to incorporate the gesture based input techniques of Brennan into the combination of Kriveshko's and Serra's scanning device in order to provide an intuitive means of user input via a motion sensor. Pet. 47–48 (citing Ex. 1007, 22:49–23:21; Ex. 1003 ¶ 280). Patent Owner argues that Petitioner did not explain why the use of gesture-based input strokes disclosed by Brennan would have been "an intuitive means of user input." Prelim. Resp. 46–47. We note that Petitioner's cited section of Brennan refers to making the gesture "R" with the probe to trigger the function of recording, and thus, making the gesture "R" is an intuitive way of triggering the function that starts with the letter "R." *See* Ex. 1007, 22:49–22:59.

Petitioner provides an additional motivation to combine based on Brennan's teaching of combining a scanning device with a surgical instrument to avoid having to constantly swap out surgical instruments within a surgical site. Pet. 48 (citing Ex. 1007, 2:4–8). Petitioner explains that Brennan identifies "[t]he need to constantly swap out instruments because of limited access to the surgical site is frequently a problematic and time-consuming distraction to the surgeon." *Id.* (citing Ex. 1007, 1:46–49). Petitioner states that Kriveshko teaches that its scanner has applications in the medical space, such as use by a dentist who often performs different surgical procedures, e.g., tooth extractions, tooth implants, wisdom teeth removal, etc., that require the use of surgical tools. *Id.* at 49 (citing Ex. 1003 ¶ 282). Petitioner proffers that one skilled in the art would have recognized that incorporating a surgical instrument into Kriveshko's scanning device would have permitted a dentist to perform a scanning process and a surgical process at a surgical site without having to use multiple devices. *Id.* (citing Ex. 1003 ¶¶ 281–283). Additionally, Petitioner explains that a person of ordinary skill in the art would have recognized the importance of reducing distractions for a medical practitioner performing a dental procedure on a patient, like that disclosed by Kriveshko. *Id.* (citing Ex. 1003 ¶¶ 281–283). According to Petitioner, a person of ordinary skill in the art would have been motivated and found it obvious to enhance the combination of Kriveshko-Serra by incorporating a surgical instrument, given that Brennan explicitly teaches the efficiency benefits of combining a scanning device with other devices having diagnostic and/or therapeutic functions. *Id.*

We determine Petitioner has provided sufficient reasoning for combining the teachings of these references at this stage of the proceeding.

For purposes of this proceeding we are persuaded Petitioner has provided sufficient evidence that establishes a reasonable likelihood of prevailing in its challenge to claims 6, 7, 12, and 13 under 35 U.S.C. § 103 as obvious over Kriveshko, Serra, and Brennan.

IV. CONCLUSION

On April 24, 2018, the Supreme Court held that a final written decision under 35 U.S.C. § 318(a) must decide the patentability of all claims challenged in the petition. *SAS Inst., Inc. v. Iancu,* 2018 WL 1914661, at *10 (U.S. Apr. 24, 2018). After considering the evidence and arguments presented in the Petition and Preliminary Response, we determine that Petitioner has demonstrated a reasonable likelihood of success in proving that at least one claim of the '675 patent is unpatentable. Specifically, we conclude that Petitioner has demonstrated a reasonable likelihood of prevailing with respect to claims 1–19 of the '675 patent challenged in the Petition. Therefore, we institute an *inter partes* review on all asserted grounds as to all challenged claims.

V. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that, pursuant to 35 U.S.C. § 314(a), an *inter partes* review of claims 1–19 of the '675 patent is instituted with respect to all grounds set forth in the Petition; and

FURTHER ORDERED that, pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4(b), *inter partes* review of the '675 patent shall commence on the entry date of this Order, and notice is hereby given of the institution of a trial.

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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	05/03/2016	9329675	0079124-000070	9282

21839 7590 04/13/2016

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ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 249 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

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APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Henrik Öjelund, Lyngby, DENMARK;
David Fischer, Stenlose, DENMARK;
Karl-Josef Hollenbeck, Kobenhavn O, DENMARK;

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

TITLE OF INVENTION: SYSTEM WITH 3D USER INTERFACE INTEGRATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	~~SMALL~~ UNDISCOUNTED	~~$480~~ $960	$0	$0	~~$480~~ $960	04/20/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
CHOW, VAN NGUYEN	2695	345-156000

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Authorized Signature William C Rowland   Date March 23, 2016

Typed or printed name William C. Rowland   Registration No. 30,888

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Electronic Patent Application Fee Transmittal

Application Number:	13991513
Filing Date:	04-Jun-2013
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Filer:	William C. Rowland/David Avila
Attorney Docket Number:	0079124-000070

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
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Patent-Appeals-and-Interference:				
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EFS ID:	25286357
Application Number:	13991513
International Application Number:	
Confirmation Number:	9282
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Customer Number:	21839
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Receipt Date:	23-MAR-2016
Filing Date:	04-JUN-2013
Time Stamp:	17:02:46
Application Type:	U.S. National Stage under 35 USC 371

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EXAMINER	ART UNIT	CLASS-SUBCLASS
CHOW, VAN NGUYEN	2695	345-156000

03/24/2016 MBLANCO1 00000061 024800 13991513
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☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 02-4800 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

☐ Applicant asserting small entity status. See 37 CFR 1.27

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

☐ Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature William C Rowland

Date March 23, 2016

Typed or printed name William C. Rowland

Registration No. 30,888

The PTO did not receive the following listed item(s) CC Form

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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NOTICE OF ALLOWANCE AND FEE(S) DUE

21839 7590 01/20/2016

BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

EXAMINER	
CHOW, VAN NGUYEN	
ART UNIT	PAPER NUMBER
2695	

DATE MAILED: 01/20/2016

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

TITLE OF INVENTION: SYSTEM WITH 3D USER INTERFACE INTEGRATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	04/20/2016

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

21839 7590 01/20/2016

BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

TITLE OF INVENTION: SYSTEM WITH 3D USER INTERFACE INTEGRATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	04/20/2016

EXAMINER	ART UNIT	CLASS-SUBCLASS
CHOW, VAN NGUYEN	2695	345-156000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ____________________
   2 ____________________
   3 ____________________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies ____________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number ________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29
- ❑ Applicant asserting small entity status. See 37 CFR 1.27
- ❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature ______________________ Date ______________________

Typed or printed name ______________________ Registration No. ______________________

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

21839 7590 01/20/2016

BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

EXAMINER	
CHOW, VAN NGUYEN	
ART UNIT	**PAPER NUMBER**
2695	

DATE MAILED: 01/20/2016

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 13991513	Applicant(s) Ojelund et al.	
	Examiner Van Chow	Art Unit 2695	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *12/28/2015*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on______.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *53-55,57-72*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   Certified copies:
   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.
   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)
1. ☐ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/VAN CHOW/
Primary Examiner, Art Unit 2695

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 12/28/2015 has been entered.

Allowable Subject Matter

The following is an examiner’s statement of reasons for allowance:

Claims 53-55, 57-72 are allowed.

Paley et al. (US 7813591) discloses a scanning system comprising: a handheld device including an optical scanner (fig. 1, handheld 116) and at least one display (see fig. 1, display 110), wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment (see figs. 4, 5, 8, 9), the at least one display is adapted for visually representing the physical 3D environment (see figs. 4, 5, 8, 9). Moreover, Paley et al. discloses a the scanner 102 is a handheld, freely positionable probe having at least one user input device, such as a button, lever, dial, thumb wheel, switch, or the like, for user control of the image capture system 100 such as starting and stopping scans. Furthermore, the handheld includes the input 116, but the details are not described.

Kagermeier et al. (US 20090217207), fig. 2, discloses the handheld device includes a user interface for remotely controlling the view with which the 3D environment is represented on the display.

Boilot (US 20080111710) discloses a sensor device (100) and method (300) for touchless finger signing and recognition is provided. The method can include detecting (304) a first pause of a finger in a touchless sensory space (101), tracking (306) a movement (140) of the finger, detecting (308) a second pause of the finger, creating (310) a trace (145) of the finger movement from the tracking, and recognizing (312) a pattern (146) from the trace. The pattern can be an alphanumeric character or a finger gesture. A user can accept or reject the recognized pattern via touchless finger control.

None of the references cited in record disclose or suggest a scanning system for scanning a 3D environment, the scanning system comprising: a handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment; and at least one display remotely connected to the handheld device, wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment, and the at least one display is adapted for visually representing the physical 3D environment; and the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to VAN CHOW whose telephone number is (571)272-7590. The examiner can normally be reached on Tuesday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Joseph Feild can be reached on 571-272-4090. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/VAN CHOW/
Primary Examiner, Art Unit 2695

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991513	ÖJELUND ET AL.
	Examiner	**Art Unit**
	VAN CHOW	2695

CPC						
Symbol					**Type**	**Version**
G06F		3	/	01	F	2013-01-01
A61C		9	/	004	I	2013-01-01
G01B		11	/	24	I	2013-01-01
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CPC Combination Sets								
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

NONE (Assistant Examiner) (Date)	**Total Claims Allowed:** 19	
/VAN CHOW/ Primary Examiner.Art Unit 2695 01/11/2016 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office

Part of Paper No. 20160111

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991513	ÖJELUND ET AL.
	Examiner	**Art Unit**
	VAN CHOW	2695

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
345	156	G	0	6	F	3 / 01 (2006.01.01)						

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				

NONE (Assistant Examiner) (Date)		**Total Claims Allowed:** 19
/VAN CHOW/ Primary Examiner.Art Unit 2695 01/11/2016 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

U.S. Patent and Trademark Office Part of Paper No. 20160111

Issue Classification

Application/Control No.	Applicant(s)/Patent Under Reexamination
13991513	ÖJELUND ET AL.
Examiner	**Art Unit**
VAN CHOW	2695

☐ **Claims renumbered in the same order as presented by applicant** ☒ **CPA** ☐ **T.D.** ☐ **R.1.47**

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	53	16	69												
2	54	17	70												
3	55	18	71												
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13	66														
14	67														
15	68														

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 19	
/VAN CHOW/ Primary Examiner.Art Unit 2695 (Primary Examiner)	01/11/2016 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 1

Search Notes	Application/Control No. 13991513	Applicant(s)/Patent Under Reexamination ÖJELUND ET AL.
	Examiner VAN CHOW	Art Unit 2695

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner
G06F1/1601 OR G06F1/1613	01/11/2016	VC

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
east and text search	01/11/2016	VC

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	east and text search	01/11/2016	VC

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**		
	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1					

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number3	Country Code2 i	Kind Code4	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T5
	1	2007084727	WO		2007-07-26	3M Innovative Properties Company		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.N.C/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

	1	Second Office Action issued in corresponding Chinese Patent Application No. 201180066956.6, dated November 18, 2015, with English translation (27 pages)	☐
If you wish to add additional non-patent literature document citation information please click the Add button			

EXAMINER SIGNATURE			
Examiner Signature	/VAN N CHOW/	Date Considered	01/11/2016
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.N.C/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/WCRowland/	Date (YYYY-MM-DD)	2015-12-09
Name/Print	William C. Rowland	Registration Number	30,888

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.N.C/

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.N.C/

PTO/SB/30 (07-14)
Approved for use through 07/31/2016 OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	13/991,513
Filing Date	2013-06-04
First Named Inventor	Henrik Ojelund
Art Unit	2695
Examiner Name	Van Nguyen Chow
Attorney Docket Number	0079124-000070

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, to any international application that does not compy with the requirements of 35 U.S.C 371, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO on page 2.)

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☑ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on ____________

      ii. ☐ Other ____________

   b. ☐ Enclosed

      i. ☐ Amendment/Reply

      ii. ☐ Affidavit(s)/ Declaration(s)

      iii. ☐ Information Disclosure Statement (IDS)

      iv. ☐ Other ____________

2. Miscellaneous

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of ________ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other ____________

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 02-4800.

      i. ☐ RCE fee required under 37 CFR 1.17(e)

      ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17)

      iii. ☐ Other ____________

   b. ☐ Check in the amount of $ ____________ enclosed

   c. ☑ Payment by credit card (Form PTO-2038 enclosed)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/WCRowland/	Date	December 28, 2015
Name (Print/Type)	William C. Rowland	Registration No.	30,888

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the U.S. Patent and Trademark Office on the date shown below.

Signature			
Name (Print/Type)		Date	

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Patent Application Fee Transmittal

Application Number:	13991513
Filing Date:	04-Jun-2013
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Filer:	William C. Rowland/Stacey Pflieger
Attorney Docket Number:	0079124-000070

Filed as Small Entity

Filing Fees for **U.S. National Stage under 35 USC 371**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for Continued Examination	2801	1	600	600
	Total in USD ($)			**600**

Electronic Acknowledgement Receipt

EFS ID:	24454549
Application Number:	13991513
International Application Number:	
Confirmation Number:	9282
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Customer Number:	21839
Filer:	William C. Rowland/Stacey Pflieger
Filer Authorized By:	William C. Rowland
Attorney Docket Number:	0079124-000070
Receipt Date:	28-DEC-2015
Filing Date:	04-JUN-2013
Time Stamp:	09:49:03
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$600
RAM confirmation Number	10399
Deposit Account	024800
Authorized User	ROWLAND, WILLIAM C

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 CFR 1.19 (Document supply fees)

Charge any Additional Fees required under 37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Request for Continued Examination (RCE)	070rce.pdf	110735 68bc495b62c02653060f9392279c8ebe0552b8de	no	1
Warnings:					
This is not a USPTO supplied RCE SB30 form.					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	31080 038f6b615821edfefae0c7ca94bf84bae5e2ba4a	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	141815	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

21839 7590 12/15/2015

BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

EXAMINER	
CHOW, VAN NGUYEN	

ART UNIT	PAPER NUMBER
2695	

NOTIFICATION DATE	DELIVERY MODE
12/15/2015	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ADIPDOC1@BIPC.com

PTOL-90A (Rev. 04/07)

Advisory Action Before the Filing of an Appeal Brief	Application No. 13/991,513	Applicant(s) ÖJELUND ET AL.	
	Examiner VAN CHOW	Art Unit 2695	AIA (First Inventor to File) Status No

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 09 December 2015 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☒ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:
   - a) ☒ The period for reply expires 4 months from the mailing date of the final rejection.
   - b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   - c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection. The current period for reply expires months from the mailing date of *the prior Advisory Action* or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.

   Examiner Note: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANT'S FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☒ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   - a) ☒ They raise new issues that would require further consideration and/or search (see NOTE below);
   - b) ☐ They raise the issue of new matter (see NOTE below);
   - c) ☒ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   - d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.

   NOTE: *See Continuation Sheet*. (See 37 CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☒ For purposes of appeal, the proposed amendment(s): (a) ☒ will not be entered, or (b) ☐ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
9. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
10. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
11. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

12. ☒ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: Applicant's request for entry into AFCP 2.0 is acknowledged, but it is denied because the response cannot be reviewed and a search conducted in the limited amount of time authorized for this pilot program. Therefore the response is being reviewed under pre-pilot practice..
13. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
14. ☐ Other: _____.

STATUS OF CLAIMS

15. The status of the claim(s) is (or will be) as follows:

Claim(s) allowed: .
Claim(s) objected to: .
Claim(s) rejected: 53-55, 57-72

/VAN CHOW/
Primary Examiner, Art Unit 2695

Continuation of 3. NOTE: The amendments of claims 53 and 72 change scope of claims 54, 55. 57-71 they raise new issies that would require further condideration and/or search .

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)	**MAIL STOP: AF**
Henrik ÖJELUND et al.	)	Group Art Unit: 2695
Application No.: 13/991,513	)	Examiner: Van Nguyen Chow
Filed: June 4, 2013	)	Confirmation No.: 9282
For: SYSTEM WITH 3D USER INTERFACE INTEGRATION	)	

AMENDMENT AFTER FINAL

SUBMITTED UNDER THE

AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DO NOT ENTER: /V.N.C/

Commissioner:

In response to the Office Action dated August 27, 2015, kindly amend the application as follows.

Doc Code: A.NE.AFCP
Document Description: After Final Consideration Pilot Program Request

PTO/SB/434 (05-13)

CERTIFICATION AND REQUEST FOR CONSIDERATION UNDER THE AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0

Practitioner Docket No.:	Application No.:	Filing Date:
0079124-000070	13/991,513	June 4, 2013
First Named Inventor: Henrik ÖJELUND	Title: SYSTEM WITH 3D USER INTERFACE INTEGRATION	

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS CONSIDERATION UNDER THE AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0 (AFCP 2.0) OF THE ACCOMPANYING RESPONSE UNDER 37 CFR 1.116.

1. The above-identified application is (i) an original utility, plant, or design nonprovisional application filed under 35 U.S.C. 111(a) [a continuing application (*e.g.*, a continuation or divisional application) is filed under 35 U.S.C. 111(a) and is eligible under (i)], or (ii) an international application that has entered the national stage in compliance with 35 U.S.C. 371(c).
2. The above-identified application contains an outstanding final rejection.
3. Submitted herewith is a response under 37 CFR 1.116 to the outstanding final rejection. The response includes an amendment to at least one independent claim, and the amendment does not broaden the scope of the independent claim in any aspect.
4. This certification and request for consideration under AFCP 2.0 is the only AFCP 2.0 certification and request filed in response to the outstanding final rejection.
5. Applicant is willing and available to participate in any interview requested by the examiner concerning the present response.
6. This certification and request is being filed electronically using the Office's electronic filing system (EFS-Web).
7. Any fees that would be necessary consistent with current practice concerning responses after final rejection under 37 CFR 1.116, *e.g.*, extension of time fees, are being concurrently filed herewith. [There is no additional fee required to request consideration under AFCP 2.0.]
8. By filing this certification and request, applicant acknowledges the following:

- Reissue applications and reexamination proceedings are not eligible to participate in AFCP 2.0.
- The examiner will verify that the AFCP 2.0 submission is compliant, *i.e.*, that the requirements of the program have been met (see items 1 to 7 above). For compliant submissions:
  - The examiner will review the response under 37 CFR 1.116 to determine if additional search and/or consideration (i) is necessitated by the amendment and (ii) could be completed within the time allotted under AFCP 2.0. If additional search and/or consideration is required but cannot be completed within the allotted time, the examiner will process the submission consistent with current practice concerning responses after final rejection under 37 CFR 1.116, *e.g.*, by mailing an advisory action.
  - If the examiner determines that the amendment does not necessitate additional search and/or consideration, or if the examiner determines that additional search and/or consideration is required and could be completed within the allotted time, then the examiner will consider whether the amendment places the application in condition for allowance (after completing the additional search and/or consideration, if required). If the examiner determines that the amendment does not place the application in condition for allowance, then the examiner will contact the applicant and request an interview.
    - The interview will be conducted by the examiner, and if the examiner does not have negotiation authority, a primary examiner and/or supervisory patent examiner will also participate.
    - If the applicant declines the interview, or if the interview cannot be scheduled within ten (10) calendar days from the date that the examiner first contacts the applicant, then the examiner will proceed consistent with current practice concerning responses after final rejection under 37 CFR 1.116.

Signature	Date
/WCRowland/	December 9, 2015
Name (Print/Typed) William C. Rowland	Practitioner Registration No. 30,888

***Note**: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.*

☐ * Total of ________ forms are submitted.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)	**MAIL STOP: AF**
Henrik ÖJELUND et al.	)	Group Art Unit: 2695
Application No.: 13/991,513	)	Examiner: Van Nguyen Chow
Filed: June 4, 2013	)	Confirmation No.: 9282
For: SYSTEM WITH 3D USER INTERFACE INTEGRATION	)	

AMENDMENT AFTER FINAL

SUBMITTED UNDER THE

AFTER FINAL CONSIDERATION PILOT PROGRAM 2.0

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

In response to the Office Action dated August 27, 2015, kindly amend the application as follows.

AMENDMENTS TO THE CLAIMS:

The following listing of claims will replace all prior versions and listings of claims in this application.

LISTING OF CLAIMS:

1 – 52. (Cancelled)

53. (Currently Amended) A scanning system for scanning a 3D environment, the scanning system comprising:

a handheld device including an optical scanner, wherein the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment; and

at least one display remotely connected to the handheld device,

wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment, and the at least one display is adapted for visually representing the physical 3D environment; and

the handheld device includes a user interface for remotely controlling the display to adjust the view with which the 3D environment is represented on the display.

54. (Previously Presented) A system according to Claim 53, wherein the handheld device is adapted to record the 3D geometry of the 3D environment.

55. (Previously Presented) A system according to Claim 53, wherein the user interface includes means for manually switching between performing the at least one scanning action and remotely controlling the view.

56. (Cancelled)

57. (Previously Presented) The system according to Claim 53, wherein the handheld device comprises at least one motion sensor.

58. (Previously Presented) The system according to Claim 57, wherein the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor.

59. (Previously Presented) The system according to Claim 57, wherein functionality of the user interface comprises a use of gestures.

60. (Previously Presented) The system according to Claim 59, wherein the gestures are detected by the at least one motion sensor.

61. (Previously Presented) The system according to Claim 57, wherein the user-interface is other than the at least one motion sensor.

62. (Previously Presented) The system according to Claim 53, wherein the handheld device is adapted to change a viewing angle with which the 3D environment is represented on the at least one display.

63. (Previously Presented) The system according to Claim 53, wherein the handheld device is adapted to change a magnification factor with which the 3D environment is represented on the at least one display.

64. (Previously Presented) The system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner.

65. (Previously Presented) The system according to Claim 53, wherein the handheld device includes a surgical instrument.

66. (Previously Presented) The system according to Claim 53, wherein the handheld device includes a mechanical tool.

67. (Previously Presented) The system according to Claim 53, wherein the handheld device is an in-ear 3D scanner.

68. (Previously Presented) The system according to Claim 53, wherein the at least one display is defined as a first display, and where the system further comprises a second display.

69. (Previously Presented) The system according to Claim 68, wherein the second display indicates where the handheld device is positioned relative to the 3D environment.

70. (Previously Presented) The system according to Claim 68, wherein the first display and/or the second display provides instructions for the operator.

71. (Previously Presented) The system according to Claim 53, wherein audible information is provided to the operator.

72. (Currently Amended) A system comprising:

a handheld device and at least one display;

wherein the handheld device is adapted for switching between performing at least one action in a physical 3D environment, wherein the at least one display is adapted for visually representing the physical 3D environment; and remotely controlling the display to adjust the view with which the 3D environment is represented on the display;

wherein the handheld device is an intra-oral 3D scanner and the at least one action performed in the physical 3D environment is scanning and that the view is remotely controlled by at least one motion sensor arranged in the handheld device, and wherein an actuator provided on the handheld device switches between performing the at least one action and remotely controlling the view.

REMARKS

The Examiner is thanked for the examination of the application. In view of the foregoing amendments and the remarks that follow, the Examiner is respectfully requested to reconsider and review the rejections.

Art Rejections:

Claims 53 – 55, 57, 58, 61 – 69, and 72 have been rejected under 35 USC 103(a) as being allegedly unpatentable over USP 7,813,591, hereinafter *Paley*, in view of US 2009/0217207, hereinafter *Kagermeier*. Claims 59 and 60 (and presumably 70 and 71) have been rejected under 35 USC 103(a) as being allegedly unpatentable over *Paley*, in view of *Kagermeier*, and further in view of US 2008/0111710, hereinafter *Boilot*.

Claim 1, as now amended, recites that the handheld device includes a user interface for remotely controlling the display ***to adjust the view*** with which the 3D environment is represented on the display, and wherein ***the 3D environment to be scanned is selected by pointing the optical scanner at the 3D environment***.

The Office Action alleges that *Paley* teaches all of (pre-amended) claim 53, except for remotely controlling the view on the display. In particular, the Office Action notes the input 116 of *Paley*, but recognizes that no details are described about it.

For remotely controlling the view on the display, the Examiner now relies on Figure 2 of *Kagermeier*. However, in *Kagermeier*, the handheld device is merely a remote control 10 for controlling the displayed image information B3(PI) and initiating functions of the imaging system 4. The remote control 10 does not include any imaging equipment, such as an optical scanner.

Accordingly, in both the *Paley* and *Kagermeier* devices, the operator must use two different devices to control both the object of the scanning and the display thereof. Specifically, in *Paley*, the operator controls the scanning with the hand held scanner. However, controlling the display to adjust the view displayed thereon must be done with a separate device, such as the mouse 112 or keyboard 114. Similarly, in *Kagermeier*, the 3D environment to be scanned must be controlled at the imaging device 4, it cannot be set by the remote control 10.

Thus, neither reference teaches a handheld device which can control the environment to be scanned and the display thereof.

Accordingly, *Kagermeier* does not overcome the acknowledged deficiency of *Paley*.

The dependent claims are allowable at least for the reasons set forth above with respect to claim 53.

Claim 72 has been similarly amended. Claim 72 is also patentable for substantially the same reasons set forth above with respect to claim 53.

Should any questions arise in connection with this application, it is respectfully requested that the undersigned be contacted at the number indicated below.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: December 9, 2015

By: /WCRowland/
William C. Rowland
Registration No. 30888

Customer No. 21839
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)	Docket Number (Optional) **0079124-000070**
Application Number **13/991,513**	Filed **June 4, 2013**
For **System with 3D User Interface Integration**	
Art Unit **2695**	Examiner **CHOW, VAN NGUYEN**

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Large Fee	Small Fee	Micro Fee	
☒ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$ 100.00
☐ Two month (37 CFR 1.17(a)(2))	$600	$300	$150	$
☐ Three month (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐ Four month (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five month (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☒ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number **02-4800**.

☒ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the
☐ applicant.
☒ attorney or agent of record. Registration number **30,888.**
☐ attorney or agent acting under 37 CFR 1.34. Registration number **30,888.**

/WCRowland/
Signature

December 9, 2015
Date

William C. Rowland
Type or printed name

703-836-6620
Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required. See below*.

☐ Total of ___ forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(**Not for submission under 37 CFR 1.99)**

Application Number	13991513
Filing Date	2013-06-04
First Named Inventor	Henrik Ojelund et al.
Art Unit	2695
Examiner Name	Van Nguyen Chow
Attorney Docket Number	0079124-000070

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
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	1	2007084727	WO		2007-07-26	3M Innovative Properties Company		☐

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

	1	Second Office Action issued in corresponding Chinese Patent Application No. 201180066956.6, dated November 18, 2015, with English translation (27 pages)	☐

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EXAMINER SIGNATURE

Examiner Signature		Date Considered	

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/WCRowland/	Date (YYYY-MM-DD)	2015-12-09
Name/Print	William C. Rowland	Registration Number	30,888

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

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(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 July 2007 (26.07.2007)

PCT

(10) International Publication Number
WO 2007/084727 A1

(51) International Patent Classification:
G06Q 10/00 (2006.01)

(21) International Application Number:
PCT/US2007/001547

(22) International Filing Date: 19 January 2007 (19.01.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/761,078 20 January 2006 (20.01.2006) US

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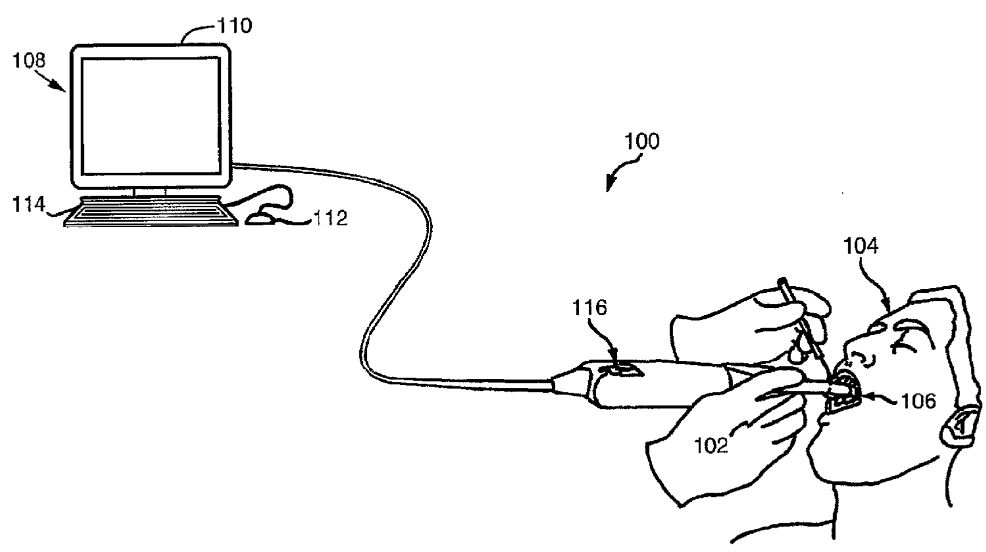
(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

[Continued on next page]

(54) **Title:** DIGITAL DENTISTRY



(57) **Abstract:** The systems and methods disclosed herein employ a scanning system for capturing highly detailed digital dental models. These models may be used within a dentist's office for a wide array of dental functions including quality control, restoration design, and fitting. These models may also, or instead, be transmitted to dental laboratories that may, alone or in collaboration with the originating dentist or other dental professionals, transform the digital model into a physical realization of a dental hardware item.

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GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

DIGITAL DENTISTRY

RELATED APPLICATIONS

[0001] This application claims priority to U.S. App. No. 60/761,078, filed on January 20, 2006.

BACKGROUND

1. Field of the Invention.

[0002] The invention relates to dentistry, and more particularly for dental applications of digital, three-dimensional representations of dentition.

2. Description of the Related Art.

[0003] Dentistry today largely continues in the mold of the past, using techniques pioneered by ancient Egyptians. One basic technique for manufacturing a dental restoration, the so-called lost wax method, employs a wax pattern from which a metal casting is made. A mold of the wax pattern is made using a high-heat investment material. The mold is then heated in a furnace, the pattern is then burned out, and the investment ring is cast or filled with some type of alloy or some other substance to provide a final version of a dental restoration. A dentist bonds this prosthetic to a site in a patient's mouth that has been hand-prepared to match the prosthetic. As a significant disadvantage, a substantial burden is placed on practicing dentists to physically match restorations and tooth surfaces. Further complicating this process, the wax model itself is typically created from a physical cast of the patient's mouth. The casting process can introduce errors into a final restoration, as can material handling in the multiple steps carried out by a dental laboratory to go from the original dental impression to the final restoration.

[0004] In theory, digital dentistry offers manifest advantages of quality, portability, and durability as compared to cast models of physical impressions. However, advances in dentistry have been muted, at least in part due to the inability to easily capture adequate three-dimensional data for teeth and surrounding soft tissue. In addition, dentistry has achieved only limited gains from general improvements in manufacturing technologies because each dental patient and restoration presents a unique, one-off product.

[0005] There remains a need for dentistry tools that capture high-quality digital dental models, as well as tools that permit the design and manufacture of dental hardware from such models.

SUMMARY

[0006] The systems and methods disclosed herein employ a scanning system for capturing highly detailed digital dental models. These models may be used within a dentist's office for a wide array of dental functions including quality control, restoration design, and fitting. These models may also, or instead, be transmitted to dental laboratories that may, alone or in collaboration with the originating dentist or other dental professionals, transform the digital model into a physical realization of a dental hardware item.

[0007] A method disclosed herein includes acquiring a three-dimensional representation of one or more intraoral structures of a dental patient using an intraoral scanner; and providing the three-dimensional representation to a dental fabrication facility.

[0008] The method may further include fabricating a dental restoration at the dental fabrication facility using the three-dimensional representation. The dental fabrication facility may include a dental laboratory. The one or more intraoral structures may include at least one dental implant, at least one tooth, at least one tooth surface prepared for a dental restoration, at least one previously restored tooth, and/or at least one area of soft tissue. The method may further include fabricating a dental prosthesis at the dental fabrication facility using the three-dimensional representation.

[0009] The method may further include transmitting the three-dimensional representation to a dental laboratory and, in response, receiving an assessment of quality for the three-dimensional representation from the dental laboratory. The assessment of quality may be received before the dental patient leaves a dentist's office. The assessment of quality may include an assessment of acceptability of the three-dimensional representation. The method may further include transmitting the three-dimensional representation to a dental laboratory and, in response, receiving an assessment of quality of the at least one prepared tooth surface. Transmitting the three-dimensional representation to a dental fabrication facility may include transmitting to a remote dental laboratory for fabrication of a dental restoration for the one or more intraoral structures. The method may further include transmitting the three-dimensional representation to a dental data hub. The method may further include transmitting a prescription for the dental restoration with the three-dimensional representation. The method may further include transmitting the three-dimensional representation to a model production laboratory. The model production laboratory may be a milling facility, a manufacturing facility, or a three-dimensional rapid prototyping facility. Transmitting the three-dimensional representation to a dental fabrication facility may include providing the three-dimensional representation to an in-office dental laboratory for fabrication of a dental restoration for the one or more intraoral structures.

[0010] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, may perform the steps of: acquiring one or more images of one or more intraoral structures of a dental patient from an intraoral scanner; converting the one or more images into a three-dimensional representation of the one or more intraoral structures; and transmitting the three-dimensional representation to a dental fabrication facility.

[0011] The computer program may further include computer code that performs the step of comparing quality of the three-dimensional representation to predefined quality criteria. The predefined quality criteria may include acceptability of the three-dimensional representation for fabrication. The computer program may further include computer code that performs the steps of: retrieving a prescription for at least one of a prosthesis or an appliance by a dentist; and combining the prescription with the three-dimensional representation prior to transmitting the three-dimensional representation. The one or more intraoral structures may include at least one dental implant, one tooth, or one tooth surface prepared for a dental restoration. The computer program may further include computer code that performs the step of comparing quality of the at least one prepared tooth surface to predefined quality criteria. The one or more intraoral structures may include at least one area of soft tissue.

[0012] A system disclosed herein includes an intraoral scanner for acquiring a three-dimensional representation of one or more intraoral structures of a dental patient; and a transmission means for transmitting the three-dimensional representation to a dental fabrication facility.

[0013] The system may further include a first fabrication means for fabricating a dental restoration at the dental fabrication facility using the three-dimensional representation. The one or more intraoral structures may include at least one dental implant, one tooth, least one tooth surface prepared for a dental restoration, or one area of soft tissue. The system may further include a second fabrication means for fabricating a dental prosthesis at the dental fabrication facility using the three-dimensional representation. The system may further include a quality assessment means for assessing quality of the three-dimensional representation. The quality assessment means may include a means for determining acceptability of the three-dimensional representation for use with the first fabrication means. The quality assessment means may include a means for determining acceptability of the three-dimensional representation for use with the second fabrication means. The one or more intraoral structures may include at least one tooth surface prepared for a dental restoration, wherein the quality assessment means includes a means for determining quality of the at least one prepared tooth surface.

[0014] In another aspect, a method disclosed herein includes receiving a three-dimensional representation of a tooth, the tooth prepared for a dental restoration; specifying a cementation void between the tooth surface and the dental restoration; and fabricating the dental restoration such that the dental restoration, when mated to the tooth surface, defines an empty space corresponding to the cementation void.

[0015] The method may include adjusting the cementation void, such as according to a dentist's preferences or according to the type of cement to be used in the cementation void. The cementation void may be specified by a dentist. The dentist may send the specification to a dental laboratory. The cementation void may be specified by a dental laboratory. The method may include three-dimensionally printing a die including the cementation void. The method may include fabricating a die including the cementation void with a stereo lithography apparatus. The method may include three-dimensionally printing a wax-up including the cementation void. The method may include milling a die including the cementation void. The method may include integrating the cementation void into a digital surface representation of the tooth. The method may include integrating the cementation void into a dental model. The three-dimensional representation may include a digital surface representation of the tooth. Fabricating the dental restoration may include fabricating the dental restoration in an in-house laboratory in a dentist's office. The method may further include fabricating an opposing arch for an arch including the tooth, the opposing arch including a die spacer having a predetermined thickness.

[0016] In another aspect, a computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring one or more images of a tooth of a dental patient from an intraoral scanner, the tooth including a tooth surface prepared for a dental restoration; converting the one or more images into a three-dimensional representation of the tooth; specifying a cementation void between the tooth surface and the dental restoration; combining the specification for the cementation void with the three-dimensional representation into a fabrication specification; and transmitting the fabrication specification to a dental fabrication facility.

[0017] A dentist may specify the cementation void. The computer program product may include code that performs the step of receiving a specification of the cementation void from the dental fabrication facility. The computer program product may include code for three-dimensionally printing the cementation void to a die. The computer program product may include code for three-dimensionally printing the cementation void to a wax up. The computer program product may include code that performs the step of integrating the cementation void into a digital surface representation of the tooth.

[0018] In another aspect, a system disclosed herein includes a first means for three-dimensionally representing a tooth, the tooth prepared for a dental restoration; a second means for specifying a cementation void, the cementation void representing an empty space between the tooth surface and the dental restoration; and a fabrication means for fabricating the dental restoration such that the dental restoration, when mated to the tooth surface, defines an empty space corresponding to the cementation void.

[0019] The system may include an adjustment means for adjusting the cementation void. The adjustment means may include means for incorporating a dentist's preferences. The adjustment means may include means for adjusting the cementation void according to a type of cement. The system may include a first printing means for three-dimensionally printing a die including the cementation void. The system may include a second printing means for three-dimensionally printing a wax-up including the cementation void. The system may include a milling means for milling a die including the cementation void. The system may include a milling means for milling an investment chamber for casting including the cementation void. The system may include a model means for integrating the cementation void into a model of a dental impression. The three-dimensional representation of a tooth may include a digital surface representation of the tooth.

[0020] In another aspect, a method disclosed herein includes fabricating a dental object; acquiring a first three-dimensional representation of the object; and measuring a dimensional accuracy of the first three-dimensional representation. The first three-dimensional representation may include a digital surface representation. The dental object may include a dental prosthesis, a dental implant, a dental appliance, a dental restoration, a restorative component, or an abutment. The method may include acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy may include evaluating a fit between the item of the first three-dimensional representation and the at least one tooth surface of the second three-dimensional representation. The method may further include acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy may include evaluating one or more contact points between the item of the first three-dimensional representation and the one or more teeth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface. The method may further include acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object and at least one opposing tooth, wherein measuring a dimensional accuracy may include evaluating one or more contact points between the item of the first three-dimensional representation and the at least one opposing tooth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface. The second three-dimensional representation may be acquired as a plurality of separate scans. The second three-dimensional representation may be acquired as a continuous scan of the at least one tooth surface and the at least one opposing tooth in occlusion. A dentist may specify tightness of fit of the dental object. Measuring a dimensional accuracy may include quantifying tightness of fit of the dental object. Measuring a dimensional accuracy includes measuring quality of a margin.

[0021] A computer program product may include computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring one or more images of a dental object; converting the one or more images of the dental object into a first three-dimensional representation of the item; and measuring a dimensional accuracy of the first three-dimensional representation. The first three-dimensional representation may include a digital surface representation.

[0022] The dental object may include a dental prosthesis, a dental implant, a dental appliance, a dental restoration, a restorative component, or an abutment. The computer program product may include code that performs the steps of: acquiring one or more images of one or more teeth including at least one tooth surface prepared for the dental object; and converting the one or more images of the one or more teeth into a second three-dimensional representation of the one or more teeth, wherein measuring a dimensional accuracy includes evaluating a fit between the item of the first three-dimensional representation and the at least one tooth surface of the second three-dimensional representation. The computer program product may include code that performs the steps of: acquiring one or more images of one or more teeth including at least one tooth surface prepared for the dental object; converting the one or more images of the one or more teeth into a second three-dimensional representation of the one or more teeth; and generating one or more contact points between the item of the first three-dimensional representation and the one or more teeth of the second three-dimensional representation by virtually affixing the item to the at least one tooth surface, wherein measuring includes evaluating one or more contact points.

[0023] The computer program product may further include computer code that performs the steps of: acquiring one or more images of one or more teeth including at least one tooth surface prepared for the dental object and at least one opposing tooth; converting the one or more images of the one or more teeth and the at least one opposing tooth into a second three-dimensional representation of the one or more teeth and the at least one opposing tooth; and generating one or more contact points between the item of the first three-dimensional representation and the at least one opposing tooth of the second three-dimensional representation by virtually affixing the item to the at least one tooth surface, wherein measuring includes evaluating one or more contact points. Measuring a dimensional accuracy may include quantifying tightness of fit of the dental object. Measuring a dimensional accuracy may include measuring quality of a margin.

[0024] A system disclosed herein includes a fabrication means for fabricating a dental object; a first means for acquiring a first three-dimensional representation of the item; and a measurement means for measuring a dimensional accuracy of the first three-dimensional representation. The first three-dimensional representation may include a digital surface representation.

[0025] The dental object may include a dental prosthesis, a dental implant, a dental appliance, a dental restoration, a restorative component, or an abutment. The system may further include a second means for acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy may include evaluating a fit between the item of the first three-dimensional representation and the at least one tooth surface of the second three-dimensional representation. The system may further include a second means for acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy may include evaluating one or more contact points between the item of the first three-dimensional representation and the one or more teeth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface. The system may further include a second means for acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object and at least one opposing tooth, wherein measuring a dimensional accuracy may include evaluating one or more contact points between the item of the first three-dimensional representation and the at least one opposing tooth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface. A dentist may specify tightness of fit of the dental object. Measuring a dimensional accuracy may include quantifying tightness of fit of the dental object. Measuring a dimensional accuracy includes measuring quality of a margin.

[0026] A method disclosed herein includes acquiring a three-dimensional representation including three-dimensional surface data for at least two independent dental structures; and acquiring motion data characterizing a relative motion of the at least two independent dental structures with respect to one another within a mouth.

[0027] The method may include deriving TMJ condyle paths of rotation and translation from the motion data and the three-dimensional surface data. The method may include providing input to a virtual dental articulator. The method may include providing specifications for a physical dental articulator. The method may include providing specifications for a disposable dental articulator. Acquiring the three-dimensional representation may include acquiring the three-dimensional representation using an intraoral scanner. Acquiring motion data may include acquiring motion data from a video source.

[0028] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, may perform the steps of: acquiring one or more images of at least two independent dental structures of a dental patient from an intraoral scanner; converting the one or more images into a three-dimensional representation of the at least two independent dental structures; acquiring motion data characterizing a relative motion of the at least two independent dental structures with respect to one another; and combining the three-dimensional representation with the motion data to derive TMJ condyle paths of rotation and translation.

[0029] The computer program may include code that performs the steps of: generating an image sequence of the combined three-dimensional representation and the motion data; generating a display signal of the image sequence. Acquiring motion data may include acquiring motion data from a video source.

[0030] A system disclosed herein includes a first means for acquiring one or more images of at least two independent dental structures of a dental patient; a conversion means for converting the one or more images into a three-dimensional representation of the at least two independent dental structures; and a second means for acquiring motion data characterizing a relative motion of the at least two independent dental structures with respect to one another. The system may include an analysis means for deriving TMJ condyle paths of rotation and translation using the three-dimensional representation and the motion data.

[0031] The system may include an action means for combining the three-dimensional representation and the motion data to generate an articulation input. The system may include a first model means for virtually articulating the articulation input. The system may include a second model means for physically articulating the articulation input. The system may include a disposable model means for physically articulating the articulation input. The first means may include a means for acquiring the one or more images using an intraoral scanner. The second means may include a means for acquiring the motion data from a video source.

[0032] In another aspect, a method disclosed herein includes receiving an electronic dental prescription including prescription data, a first three-dimensional representation of one or more intraoral structures including at least one tooth surface prepared for an artificial dental object, and a second three-dimensional representation of the at least one tooth surface prior to preparation for the artificial dental object; and fabricating the artificial dental object for the one or more intraoral structures using the electronic dental prescription.

[0033] Receiving an electronic dental prescription may include receiving a three-dimensional representation from a dental data hub or from a dentist. Receiving a three-dimensional representation may include receiving a prescription for a dental restoration for the tooth surface. At least one of the first and second three-dimensional representations may include a digital surface representation of a full arch. The electronic dental prescription may include a prescription for an appliance, a prosthesis, or an item of dental hardware. Fabricating an artificial dental object may include fabricating a dental restoration in an in-house laboratory in a dentist's office.

[0034] A system disclosed herein includes a communication means for receiving a prescription data, a first three-dimensional representation of one or more intraoral structures including at least one tooth surface prepared for an artificial dental object, and a second three-dimensional representation of the at least one tooth surface prior to preparation for the artificial dental object; and a fabrication means for fabricating a dental restoration for the one or more intraoral structures using the three-dimensional representation.

[0035] The communication means may include a means for receiving the electronic dental prescription from a dental data hub or a dentist. The electronic dental prescription may include a prescription for a dental restoration. At least one of the first and second three-dimensional representations may include a digital surface representation of a full arch. The electronic dental prescription may include a prescription for one or more of an appliance, a prosthesis, and an item of dental hardware. The fabrication means may include in an in-house laboratory in a dentist's office.

[0036] In another aspect, a method disclosed herein includes a single dental visit, the steps of: acquiring a three-dimensional representation of one or more intraoral structures from a dental patient, the intraoral structures may include at least one tooth surface prepared for an artificial dental object; and processing the three-dimensional representation to provide feedback to a dentist concerning the at least one tooth surface.

[0037] The feedback may identify corrective action. The corrective action may include acquiring an additional three-dimensional representation of the one or more intraoral structures. The corrective action may include additional surface preparation of the at least one tooth. The feedback may identify a margin for fitting the dental restoration to the at least one tooth surface. The margin for fitting may be edited. The feedback may include a visual display of one or more regions of inadequate margin for fitting the dental restoration to the at least one tooth surface. The feedback may include a visual display recommending additional preparatory work required for the at least one tooth surface. The feedback may include a visual display recommending acquiring additional three-dimensional representations of one or more regions of the one or more intraoral structures. The feedback may include identifying an incomplete three-dimensional representation. The feedback may include identifying errors in the three-dimensional representation. The feedback may include visual highlighting of a margin line on a display of the three-dimensional representation.

[0038] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring one or more images of one or more intraoral structures of a dental patient, the intraoral structures including at least one tooth surface prepared for an artificial dental object; converting the one or more images into a three-dimensional representation of the one or more intraoral structures; analyzing the at least one tooth surface within the three-dimensional representation; generating a feedback signal, the feedback signal representative of the result of analyzing the at least one tooth surface; and outputting the feedback signal to provide feedback to a dentist.

[0039] The feedback signal may identify corrective action. The corrective action may include acquiring an additional one or more images of the one or more intraoral dental structures. The corrective action may include additional surface preparation of the at least one tooth. The feedback signal may identify a margin for fitting the dental restoration to the at least one tooth surface. The margin for fitting may be edited.

[0040] In another aspect, a system disclosed herein includes a scanning device configured to intraorally capture surface image data from a surface within a mouth of a dental patient; a computer coupled to the scanning device and receiving the surface image data therefrom, the computer configured to resolve the surface image data into a digital surface reconstruction, the computer further configured to generate a visualization of the digital surface reconstruction and provide the visualization as a display signal; and a display coupled to the computer and receiving the display signal therefrom, the display converting the display signal into a viewable image of the visualization. The surface may include dentition.

[0041] The scanning device may capture surface image data at a video frame rate. The system may include a user interface controlled by the computer and rendered on the display. The user interface may provide at least one tool for analyzing the surface. The user interface may include a tool that may provide real time feedback to the user. The real time feedback may include visual cues within the rendered image. The at least one tool may include a distance measurement tool, a tool that may evaluate adequacy of tooth structure removal from a dental restoration surface preparation, a tool that may evaluate adequacy of margin preparations, a tool that evaluates taper, a tool that evaluates undercut, or a tool that identifies scan deficiencies. The scan deficiencies may include holes in the surface. The at least one tool may include a tool that evaluates adequacy of removal path in multiple unit preparation. The at least one tool may include a tool that identifies irregularities in one or more occlusal surfaces requiring further preparation. Analyzing the surface may include an evaluation of suitability for three-dimensional printing, of suitability for milling, or of suitability for manual fabrication.

[0042] The computer may be further configured to automatically annotate the visualization with a visual indication of an evaluation. The visual indication includes an evaluation of contour of a surface preparation. The surface image data may include at least two tooth surfaces in occlusion. The visual indication may include an evaluation of margin of a surface preparation. The visual indication includes an evaluation of occlusal clearance of a surface preparation. The surface may include at least one surface prepared for a dental restoration, the evaluation including an evaluation of an adequacy of the at least one surface for receiving the dental restoration. The visual indication may include display of a contour of an actual tooth and a computer-generated surface preparation. The computer-generated surface preparation may be based upon intact configuration of the actual tooth prior to preparation.

[0043] In another aspect, a method disclosed herein includes receiving a three-dimensional representation that may include three-dimensional surface data from an intraoral structure including at least one tooth having a tooth surface prepared for a dental restoration; and presenting the three-dimensional representation in a user interface, the user interface may include a first tool for identifying a margin line for the dental restoration on the at least one tooth and a second tool for recessing a region of the three-dimensional representation below the margin line.

[0044] The first tool may provide automated identification of the margin line. The method may include removing a portion of the three-dimensional representation below the margin line with the second tool. The method may include removing a portion of the three-dimensional representation below the margin line with the second tool to provide a virtual ditched die, and three-dimensionally printing the ditched die.

[0045] A system disclosed herein includes a means for receiving a three-dimensional representation including three-dimensional surface data from an intraoral structure that may include at least one tooth having a tooth surface prepared for a dental restoration; and a user interface means for presenting the three-dimensional representation to a user, the user interface means may include a first tool means for identifying a margin line for the dental restoration on the at least one tooth and a second tool means for recessing a region of the three-dimensional representation below the margin line.

[0046] The first tool means may include a means for providing automated identification of the margin line. The system may include a means for removing a portion of the three-dimensional representation below the margin line. The system may include a means for removing a portion of the three-dimensional representation below the margin line to provide a virtual ditched die, and a means for three-dimensionally printing the ditched die.

[0047] In another aspect, a method disclosed herein includes acquiring a digital dental impression that may include three-dimensional surface data for at least two independent dental structures; and acquiring orientation data that may define a relative position of at least a portion of each of the at least two independent dental structures while in occlusion.

[0048] The orientation data may include three-dimensional surface data that spans the at least two independent dental structures while in occlusion. The orientation data may include three-dimensional surface data from each of the at least two independent dental structures while in occlusion. The occlusion may include a centric occlusion. The method may include applying the orientation data to position a virtual model of the at least two independent dental structures in a virtual articulator. The method may include fabricating models of each of the at least two independent dental structures and may apply the orientation data to position the models within a dental articulator. Acquiring orientation data may include acquiring three-dimensional data of a buccal side of dentition. Acquiring orientation data may include acquiring three-dimensional data of a labial side of dentition.

[0049] A system disclosed herein includes a first acquisition means for acquiring a digital dental impression including three-dimensional surface data for at least two independent dental structures; and a second acquisition means for that may acquire orientation data defining a relative position of at least a portion of each of the at least two independent dental structures while in occlusion.

[0050] The orientation data may include three-dimensional surface data that spans the at least two independent dental structures while in occlusion. The orientation data may include three-dimensional surface data from each of the at least two independent dental structures while in occlusion. The occlusion may include a centric occlusion. The system may include a model means for virtually articulating the at least two independent dental structures. The system may include a fabrication means for fabricating models of each of the at least two independent dental structures; and a model means for physically articulating the fabricated models. The orientation data may include three-dimensional data of a buccal side of dentition. The orientation data may include three-dimensional data of a labial side of dentition.

[0051] In another aspect, a method disclosed herein includes providing an intraoral three-dimensional scanning device; and scanning a plurality of teeth in an arch with the device in a scan path that may include a motion that begins at a first lingual point, traverses laterally over a first occlusal point and a first buccal point, translates to a second buccal point adjacent to the first buccal point, and then traverses laterally over a second occlusal point adjacent to the first occlusal point and a second lingual point adjacent to the first lingual point.

[0052] The method may include scanning the plurality of teeth in the arch with the device using a motion that translates to a third lingual point, and then may traverse laterally over a third occlusal point adjacent to the second occlusal point and a third buccal point adjacent to the second buccal point. The first lingual point and the second lingual point may be spaced apart such that a field of view of the scanning device includes at least one overlapping portion of the plurality of teeth when the scanning device is positioned to image the first and second lingual points respectively. The scan path may begin at a third buccal point, a third palatal point, or a third labial point.

[0053] In another aspect, a method disclosed herein includes within a single dental visit, the steps of: acquiring a three-dimensional representation of one or more intraoral structures including at least one tooth prepared for a dental restoration; and processing the three-dimensional representation that may provide feedback to a dentist concerning the at least one tooth.

[0054] The feedback may include a physical dimension, a dimension of the at least one tooth prior to preparation for the dental restoration, a contour of the at least one tooth, a clearance relative to one or more adjacent teeth for a dental restoration associated with the at least one tooth, or a position of the at least one tooth. The feedback may include a clearance relative to one or more teeth in an opposing occluded arch.

[0055] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring a three-dimensional representation of one or more intraoral structures that may include at least one tooth prepared for a dental restoration; analyzing the three-dimensional representation; generating a feedback signal, the feedback signal may represent the analysis of the three-dimensional representation; and outputting the feedback signal to a dentist.

[0056] The feedback signal may include a physical dimension, a dimension of the at least one tooth prior to preparation for the dental restoration, a contour of the at least one tooth, a clearance relative to one or more adjacent teeth for a dental restoration associated with the at least one tooth, or a position of the at least one tooth.

The feedback may include a clearance relative to one or more teeth in an opposing occluded arch.

[0057] A system disclosed herein includes an acquisition means for acquiring a three-dimensional representation of one or more intraoral structures including at least one tooth prepared for a dental restoration; an analysis means for analyzing the three-dimensional representation; a means for generating a feedback signal, the feedback signal representing the analysis of the three-dimensional representation; and a signal means for providing the feedback signal to a dentist.

[0058] The feedback signal may include a physical dimension, a dimension of the at least one tooth prior to preparation for the dental restoration, a contour of the at least one tooth, a clearance relative to one or more adjacent teeth for a dental restoration associated with the at least one tooth, or a position of the at least one tooth. The feedback may include a clearance relative to one or more teeth in an opposing occluded arch.

[0059] In another aspect, a method disclosed herein includes acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures; and providing a visual display of the three-dimensional representation in real time. The visual display of the three-dimensional representation may be superimposed on a real time two-dimensional video image of the one or more intraoral structures.

[0060] The one or more intraoral structures may include at least one tooth, at least one tooth surface prepared for a dental restoration, at least one restored tooth, at least one implant, or at least one area of soft tissue. The method may include processing the three-dimensional representation to generate user feedback concerning the one or more intraoral structures, and may provide a visual display of the user feedback. The feedback may include highlighting areas in the three-dimensional representation requiring additional attention.

[0061] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring one or more images of one or more intraoral structures; processing the one or more images into a three-dimensional representation including a digital surface representation of the one or more intraoral structures; and generating a first visual display signal of the three-dimensional representation in real time.

[0062] The computer program product may include computer code that performs the step of generating a second visual display signal wherein the three-dimensional representation is superimposed on a real time two-dimensional video image of the one or more intraoral structures. The one or more intraoral structures may include at least one tooth, at least one tooth surface prepared for a dental restoration, at least one restored tooth, at least one implant, or at least one area of soft tissue. The computer program product may include computer code that performs the steps of: analyzing the three-dimensional representation; may generate a feedback signal representative of the analysis of the three-dimensional representation; generate a third visual display signal including the feedback signal. The third visual display signal may include highlighted areas of the three-dimensional representation requiring additional attention.

[0063] A system disclosed herein includes: an acquisition means for acquiring a three-dimensional representation from a dental patient, the three-dimensional representation may include a digital surface representation of one or more intraoral structures; and a display means for visually displaying the three-dimensional representation in real time.

[0064] The display means may include a means for superimposing the three-dimensional representation on a real time two-dimensional video image of the one or more intraoral structures. The one or more intraoral structures may include at least one tooth, at least one tooth surface prepared for a dental restoration, at least one restored tooth, at least one implant, or at least one area of soft tissue. The system may include: an analysis means for analyzing the three-dimensional representation; a feedback means for generating a feedback signal representative of the analysis of the three-dimensional representation, wherein the display means includes a means for visually displaying the feedback signal. The feedback means may include a means for highlighting areas in the three-dimensional representation requiring additional attention.

[0065] In another aspect, a handheld imaging device for a three-dimensional imaging system disclosed herein includes: an elongated body including a first end, a second end, and a central axis; a video rate three-dimensional scanning device within the elongated body, the video rate three-dimensional scanning device may have an optical axis for receiving images, the optical axis substantially perpendicular to the central axis at a position near the first end of the elongated body; and the second end adapted for gripping by a human hand, and the second end may include a user input responsive to user manipulation to generate control signals for transmission to a processor associated with the imaging system. The user input may include a mouse, track ball, button, switch, mini joystick, touchpad, keypad, or thumb wheel. The control signals may be transmitted to the processor through a wireless communication medium. The user input may control a user interface associated with the imaging system.

[0066] A handheld imaging device for a three-dimensional imaging system disclosed herein includes: an elongated body including a central axis, a first end, and a second end, the second end adapted for gripping by a human hand and a central axis; a video rate three-dimensional scanning device within the elongated body, the video rate three-dimensional scanning device having an optical axis for receiving images, the optical axis substantially perpendicular to the central axis at a position near the first end of the elongated body; and a physical offset shaped and sized to maintain a desired distance of the first end from an imaging subject along the optical axis. The physical offset may include one or more wheels for slidably engaging a surface of the imaging subject.

[0067] In another aspect, a method disclosed herein includes: acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures, the intraoral structures may include a dental arch; processing the three-dimensional representation that may provide a digital dental model including one or more alignment guides to aid in positioning an orthodontic fixture; and fabricating a physical model from the digital dental model.

[0068] The method may include constructing the orthodontic fixture on the physical model using the alignment guides. The method may include constructing a support for the orthodontic fixture on the digital dental model. The alignment guides may include visual markings. The alignment guides may include at least one substantially horizontal shelf for the orthodontic fixture. Processing may include virtually placing a plurality of orthodontic brackets onto the three-dimensional representation, and adding a plurality of bracket supports to the digital dental model to support a physical realization of the plurality of orthodontic brackets on the physical model. The method may include fabricating the physical realization of the plurality of orthodontic brackets, positioning each one of the plurality of orthodontic brackets onto the physical model, and vacuum forming an appliance over the plurality of orthodontic brackets, the appliance maintaining the plurality of orthodontic brackets in fixed relation to one another. The method may include applying the appliance with the plurality of orthodontic brackets to the dental arch. The appliance may be formed of a soft, clear material. The method may include transmitting the digital dental model to a remote dental laboratory. Processing may include virtually placing a plurality of orthodontic brackets onto the three-dimensional representation in a bracket arrangement, and generating a digital model of a bracket guide adapted to position a physical realization of the plurality of orthodontic brackets in the bracket arrangement on the dental arch. The method may include three-dimensionally printing the bracket guide. The physical model may include fabricating the physical model in an in-house dental laboratory in a dentist's office.

[0069] In another aspect, a method disclosed herein includes: acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures, the intraoral structures may include a dental arch; adding a plurality of virtual brackets to the three-dimensional representation to provide a bracket model; processing the bracket model to generate a bracket guide model, the bracket guide model adapted to maintain a physical realization of the plurality of virtual brackets in a fixed orientation with respect to one another, the fixed orientation corresponding to a desired orientation of the physical realization on the dental arch; fabricating a bracket guide from the bracket guide model; and attaching the physical realization of the plurality of virtual brackets to the bracket guide model.

[0070] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring one or more images of one or more intraoral structures, the intraoral structures may include a dental arch; processing the one or more images into a three-dimensional representation of the one or more intraoral structures; transforming the three-dimensional representation into a digital dental model, the digital dental model including one or more orthodontic fixture alignment guides; and generating a virtual orthodontic fixture using the alignment guides.

[0071] The computer program product may include code that performs the step of constructing a support for the virtual orthodontic fixture on the digital dental model. The alignment guides may include visual markings. The alignment guides may include at least one substantially horizontal shelf for the virtual orthodontic fixture. Transforming may include virtually placing a plurality of orthodontic brackets onto the dental arch of the three-dimensional representation, and adding a plurality of bracket supports to the digital dental model. The computer program product may include code that performs the step of transmitting the digital dental model to a remote dental laboratory.

[0072] A system disclosed herein includes: an acquisition means for acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures, the intraoral structures may include a dental arch; a processing means for processing the three-dimensional representation that may provide a digital dental model including one or more alignment guides to aid in positioning an orthodontic fixture; and a first fabrication means for fabricating a physical model from the digital dental model.

[0073] The system may include a means for constructing the orthodontic fixture on the physical model using the alignment guides. The processing means may include a means for constructing a support for the orthodontic fixture on the digital dental model. The alignment guides may include visual markings. The alignment guides may include at least one substantially horizontal shelf for the orthodontic fixture. The processing means may include a means for virtually placing a plurality of orthodontic brackets onto the three-dimensional representation, and adding a plurality of bracket supports to the digital dental model to support a physical realization of the plurality of orthodontic brackets on the physical model. The system may include a second fabrication means for fabricating the physical realization of the plurality of orthodontic brackets, a positioning means for positioning each one of the plurality of orthodontic brackets onto the physical model, and a forming means for vacuum forming an appliance over the plurality of orthodontic brackets, the appliance maintaining the plurality of orthodontic brackets in fixed relation to one another. The system may include a means for applying the appliance with the plurality of orthodontic brackets to the dental arch. The appliance may be formed of a soft, clear material. The system may include a communication means for transmitting the digital dental model to a remote dental laboratory. The processing means may include a means for virtually placing a plurality of orthodontic brackets onto the three-dimensional representation in a bracket arrangement, and a model means for generating a digital model of a bracket guide adapted to position a physical realization of the plurality of orthodontic brackets in the bracket arrangement on the dental arch. The system may include a printing means for three-dimensionally printing the bracket guide. The fabrication means may include a means for fabricating the physical model in an in-house dental laboratory in a dentist's office.

[0074] A three-dimensional data acquisition system adapted for intraoral acquisition of dental data from one or more intraoral structures, as disclosed herein, may include a first operating mode for capturing scan data and rendering a low-quality three-dimensional image from the scan data in real time, and a second operating mode for generating a high-quality three dimensional image from the scan data after exiting the first operating mode, the high-quality three-dimensional image may have greater spatial resolution than the low-quality three-dimensional image.

[0075] The system may further including a display that renders the low-quality three-dimensional image superimposed on a video image of the one or more intraoral structures. Rendering a low-quality three-dimensional image may include rendering the low-quality three-dimensional image at a frame rate of the video image. The system may include a communications interface for transmitting the high-quality three-dimensional image to a dental laboratory.

[0076] In another aspect, a system disclosed herein includes: a scanning device configured to intraorally capture surface image data from a surface within a mouth of a dental patient; a computer coupled to the scanning device and receiving the surface image data therefrom, the computer configured to resolve the surface image data into a three-dimensional representation, the computer may be further configured to generate a visualization of the three-dimensional representation and to provide the visualization as a display signal; and a display coupled to the computer and receiving the display signal therefrom, the display adapted to convert the display signal into a viewable image, the display being a touch-screen display adapted to receive a user input through direct contact with a surface of the display, wherein the user input is interpreted by the computer to affect manipulation of the three-dimensional representation. The user input may affect rotational orientation of the visualization on the display.

[0077] The display may include areas for one or more user controls accessible through the touch-screen display. The user controls may include a zoom control, a pan control, or case management controls. The case management controls may include a control to transmit the three-dimensional representation to a dental lab, a control to evaluate quality of the three-dimensional representation, a tool to edit the three-dimensional representation, or a control to create a dental prescription.

[0078] The user controls may include a control to define a cementation void, a control to define a margin line, a control to infer a margin line from the three-dimensional representation, a control to recess a region of the three-dimensional representation below a margin line, a control to virtually fit a dental restoration to a prepared tooth surface, include a virtual dental articulator, or include a tool to design a dental restoration fitted to the surface within the mouth of the dental patient.

[0079] The three-dimensional model may include two arches; the display may include an area for one or more user controls accessible through the touch-screen display to permit positioning the two arches within a virtual articulator. The system may include a user interface displayed on the display and controlled by the computer. The user interface may be accessible through the touch-screen.

[0080] A system disclosed herein includes: a digital dental impression that may include three-dimensional digital surface data for one or more intraoral structures, the digital dental impression may be captured using a three-dimensional intraoral scanning device and stored in a computer readable medium; a first computer may be configured to render the digital dental impression from a point of view; and a second computer at a remote location may be configure to simultaneously render the digital dental impression from the point of view.

[0081] The system may include a control for passing control of the point of view between the first computer and the second computer. The system may include the first computer and the second computer including a collaborative tool for manipulating the model, for sectioning the model, or for rearranging one or more sections of the model. The system may include the first computer and the second computer including a collaborative cursor control tool. The system may include the first computer and the second computer connected by a communication channel. The communication channel may include one or more of VoIP, IRC, video conferencing, or instant messaging. The second computer may be operated by a consulting dentist, a dental technician, in a dental laboratory, or by an oral surgeon. The second computer may be operated by a dental specialist including one or more of a periodontist, a prosthodontist, a pedodontist, an orthodontic specialist, an oral and maxillofacial surgery specialist, an oral and maxillofacial radiology specialist, an endodontist, and an oral and maxillofacial pathologist.

[0082] A method disclosed herein includes: seating a dental patient in a clinical office; acquiring a digital dental impression that may include three-dimensional digital surface data for one or more intraoral structures from an intraoral scan of the dental patient; transmitting the digital dental impression to a dental laboratory before the patient leaves the office; receiving an evaluation of the digital dental impression from the dental laboratory before the patient leaves the office; and if the evaluation is unfavorable, repeating the step of acquiring the digital dental impression.

[0083] If the evaluation includes an identification of at least one region of the one or more intraoral structures requiring additional preparation, the method may include preparing the one or more intraoral structures according to the evaluation. The evaluation may include an evaluation of surface continuity, an evaluation of data density, or an evaluation of feature detail. The one or more intraoral structures may include a tooth surface prepared for a dental restoration. The digital dental impression may include a case plan for the restoration. The case plan may include a type of restoration, a design of restoration, or a list of restoration components. The list of restoration components may include a full ceramic component. The list of restoration components may include a PFM component. The case plan may include a specification of one or more restoration materials.

[0084] A system disclosed herein includes: a means for acquiring a digital dental impression, the digital dental impression may include three-dimensional digital surface data for one or more intraoral structures from an intraoral scan of a dental patient seated in a clinical office; a request means for transmitting the digital dental impression to a dental laboratory before the patient leaves the office; an evaluation means for determining if the digital dental impression must be reacquired before the patient leaves the office; and a response means for transmitting the determination to the clinical office.

[0085] The evaluation means may include a means for evaluating surface continuity, a means for evaluating data density, or a means for evaluating feature detail. The one or more intraoral structures may include a tooth surface prepared for a dental restoration. The digital dental impression may include a case plan for the restoration, a type of restoration, a design of restoration, or a list of restoration components. The list of restoration components may include a full ceramic component. The list of restoration components may include a PFM component. The case plan may include a specification of one or more restoration materials.

[0086] A system disclosed herein includes: a scanning device for real time capture of three-dimensional surface data; a monitor that may render the three-dimensional surface data in real time; a processor that may be configure to evaluate quality of the three-dimensional surface data, and may generate a signal representative of a data quality during a scan; and a feedback device that may be responsive to the signal to produce a user alert concerning the data quality when the data quality degrades below a predetermined threshold.

[0087] The scanning device may resolve the three-dimensional surface data from a plurality of two-dimensional image sets, and wherein the evaluation of quality may include evaluation of ability to determine spatial relationships from the plurality of two-dimensional image sets. The evaluation of quality may include evaluation of point cloud density. The evaluation of quality may include evaluation of scanning device motion. The feedback device may include an LED, a speaker, a buzzer, a vibrator, or a wand. The feedback device may be positioned on the wand. The feedback device may be further responsive to the signal to produce a second user alert when the data quality is within an acceptable range.

[0088] In another aspect, a method disclosed in herein may include: scheduling a preparation visit for a dental restoration for a patient; obtaining a digital surface representation of one or more intraoral structures of the patient, this may include at least one tooth associated with the dental restoration; and fabricating a temporary restoration based upon the digital surface representation.

[0089] Fabricating a temporary restoration may include transmitting the digital surface representation to a dental laboratory. Fabricating a temporary restoration may include applying the digital surface representation to prepare a design for the temporary restoration and transmitting the design to a dental laboratory. The method may include three-dimensionally printing the temporary restoration. The method may include three-dimensionally printing the temporary restoration at a dentist's office where the preparation visit is scheduled. The method may include milling the temporary restoration. The method may include milling the temporary restoration at a dental office where the preparation visit is scheduled. Obtaining a digital surface representation may include three-dimensionally scanning the one or more intraoral structures on a day of the preparation visit. Obtaining a digital surface representation may include retrieving the digital surface representation from prior dental data for the patient. Fabricating the temporary restoration may include fabricating the temporary restoration prior to the preparation visit, the temporary restoration may include one or more characteristics of the at least one tooth. The method may include, on the day of the preparation visit, adapting a surface of the at least one tooth to receive the temporary restoration. The method may include, on the day of the preparation visit, adapting the temporary restoration to fit a prepared surface of the at least one tooth. The step of fabricating may be performed at an in-house dental laboratory at a dentist's office.

[0090] A method disclosed herein includes: acquiring a digital dental impression including three-dimensional digital surface data for one or more intraoral structures, the intraoral structures may include at least one tooth surface prepared for a dental restoration; and acquiring additional three-dimensional data with greater spatial resolution around the at least one tooth surface prepared for the dental restoration.

[0091] The acquiring additional three-dimensional data may include acquiring additional data from the at least one tooth surface, post-processing source data for the digital dental impression, or post-processing the three-dimensional digital surface data.

[0092] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, may perform the steps of: acquiring one or more images of one or more intraoral structures, the intraoral structures may include at least one tooth surface prepared for a dental restoration; and generating a digital dental impression that may include three-dimensional digital surface data from the one or more images.

[0093] The computer program product may include code that performs the step of post-processing source data for the digital dental impression to generate additional three-dimensional data with greater spatial resolution. The computer program product may include code that performs the step of post-processing the three-dimensional digital surface data to generate additional three-dimensional data with greater spatial resolution.

[0094] A system disclosed herein includes: a first means for acquiring a digital dental impression that may include three-dimensional digital surface data for one or more intraoral structures, the intraoral structures may include at least one tooth surface prepared for a dental restoration; and a second means for acquiring additional three-dimensional data with greater spatial resolution around the at least one tooth surface prepared for the dental restoration.

[0095] The second means may include a means for acquiring additional data from the at least one tooth surface, a means for post-processing source data for the digital dental impression, or a means for post-processing the three-dimensional digital surface data.

[0096] A method disclosed herein includes: acquiring a digital surface representation for one or more intraoral structures, the intraoral structures may include at least one tooth surface prepared for a dental restoration; fabricating a kit from the digital surface representation, the kit may include two or more components suitable for use in fabrication of the dental restoration; and sending the kit to a dental laboratory for fabrication of the dental restoration. The kit may include one or more of a die, a quad model, an opposing quad model, an opposing model, a base, a pre-articulated base, and a waxup.

[0097] The method may include transmitting the digital surface representation to a production facility. The step of fabricating may be performed at the production facility. The kit may include one or more components selected from the group of pre-cut components, pre-indexed components, and pre-articulated components. The step of fabricating may be performed at a dentist's office.

[0098] An artificial dental object disclosed herein includes an exposed surface, the exposed surface finished with a texture to enhance acquisition of three dimensional image data from the exposed surface with a multi-aperture three-dimensional scanning device. The texture may include pseudo-random three-dimensional noise.

[0099] The artificial dental object may include an impression coping, a fixture, a healing abutment, or a temporary impression coping. The artificial dental object may include a dental prosthesis, a dental restoration, a dental appliance, or an item of dental hardware.

[00100] In another aspect, a method disclosed herein includes acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface suitable for an artificial dental object; transmitting the three-dimensional representation to a dental insurer; and

receiving authorization from the dental insurer to perform a dental procedure including the artificial dental object.

[00101] The artificial dental object may include one or more of an implant, a crown, an impression coping, a bridge, a fixture, and an abutment. The intraoral surface may include at least one edentulous space. The intraoral surface may include at least one tooth surface.

[00102] A computer program product disclosed herein may include code that, when executed on one or more computer devices, performs the steps of: acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface suitable for an artificial dental object; transmitting the three-dimensional representation to a dental insurer; and receiving authorization from the dental insurer to perform a dental procedure including the artificial dental object.

[00103] The artificial dental object may include one or more of an implant, a crown, an impression coping, a fixture, a bridge, and an abutment. The intraoral surface may include at least one edentulous space. The intraoral surface may include at least one tooth surface.

[00104] A system disclosed herein includes a means for acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface suitable for an artificial dental object; a first communication means for transmitting the three-dimensional representation to a dental insurer; and a second communication means for receiving authorization from the dental insurer to perform a dental procedure including the artificial dental object.

[00105] The artificial dental object may include one or more of an implant, a crown, an impression coping, a fixture, a bridge and an abutment. The at least one intraoral surface may include an edentulous space. The at least one intraoral surface includes a tooth surface.

[00106] In another aspect, a method disclosed herein includes acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface related to a dental procedure; and transmitting the three-dimensional representation to a dental insurer as a record of the dental procedure.

[00107] The dental procedure may relate to one or more of an implant, a crown, an impression coping, a fixture, a bridge, and an abutment. The method may include receiving a payment from the insurer for a procedure involving the artificial dental object. The intraoral surface may include an edentulous space. The intraoral surface may include a tooth surface prepared for an artificial dental object. The intraoral surface may include a restored tooth.

[00108] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of: acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at one intraoral surface related to a dental procedure; and transmitting the three-dimensional representation to a dental insurer as a record of the dental procedure.

[00109] The dental procedure may relate to one or more of an implant, a crown, an impression coping, a bridge, and an abutment. The code may further include code that performs the step of receiving a record of payment from the insurer for the dental procedure. The intraoral surface may include an edentulous space. The intraoral surface may include a tooth surface prepared for an artificial dental object. The intraoral surface may include a restored tooth.

[00110] A system disclosed herein may include a means for acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface related to a dental procedure; and a communication means for transmitting the three-dimensional representation to a dental insurer as a record of the dental procedure.

[00111] The dental procedure may to one or more of an implant, a crown, an impression coping, a bridge, and an abutment. The communication means may include a means for receiving a payment from the insurer for the dental procedure.

[00112] In another aspect, a method disclosed herein includes receiving a three-dimensional representation of one or more intraoral structures from a dentist; receiving a proposed dental procedure from the dentist; determining whether the proposed dental procedure is appropriate for the one or more intraoral structures; and transmitting a reply to the dentist. The reply may include an approval to perform the dental procedure. The reply may include a denial to perform the dental procedure. The method may include authorizing payment for the dental procedure.

[00113] A computer program product disclosed herein includes computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, may perform the steps of: receiving a three-dimensional representation of one or more intraoral structures from a dentist; receiving a proposed dental procedure from the dentist; comparing the proposed dental procedure to a predetermined list of appropriate procedures for the one or more intraoral structures; and transmitting a reply to the dentist. The reply may include an approval to perform the dental procedure. The reply may include a denial to perform the dental procedure. The computer program product may include computer code that performs the step of authorizing payment for the dental procedure.

[00114] A system disclosed herein includes: a first means for receiving a three-dimensional representation of one or more intraoral structures from a dentist; a second means for receiving a proposed dental procedure from the dentist; an evaluation means for determining whether the proposed dental procedure is appropriate for the one or more intraoral structures; and a reply means for transmitting a reply to the dentist. The reply may include an approval to perform the dental procedure. The reply may include a denial to perform the dental procedure. The system may include a means for authorizing payment for the dental procedure.

[00115] A system disclosed herein includes: a dental data repository coupled to a communications network, the dental data repository may be adapted to receive dental data including three-dimensional representations of intraoral structures and prescriptions for dental procedures from a plurality of dentists.

[00116] The dental data repository may be adapted to transmit prescriptions and three-dimensional representations to a plurality of dental laboratories. The at least one of the prescriptions may identify a specific one of the plurality of dental laboratories. The dental data repository may be further adapted to communicate with one or more dental insurers for authorization of dental procedures. The dental data repository may be further adapted to communicate with one or more dental insurers to coordinate payment for dental procedures. The system may include a dental laboratory interface for the plurality of dental laboratories to provide status on work in progress. The system may include a dental laboratory interface for the plurality of dental laboratories to receive work assignments. The system may include a dentist interface for the plurality of dentists to monitor work in progress. The system may include a dentist interface for the plurality of dentists to submit prescriptions and three-dimensional representations. The system may include a transaction engine for transmitting payments among two or more of one of the plurality of dentists, one of the plurality of dental laboratories, and one of the one or more dental insurers. The system may include a collaboration interface for two or more of the plurality of dentists to collaborate on a dental matter.

BRIEF DESCRIPTION OF THE FIGURES

[00117] The invention and the following detailed description of certain embodiments thereof may be understood by reference to the following figures.

[00118] Fig. 1 shows a dental image capture system.

[00119] Fig. 2 shows entities participating in a digital dentistry network.

[00120] Fig. 3 shows a user interface that may be used in a digital dental system.

[00121] Fig. 4 depicts a quality control procedure for use in a digital dental system.

[00122] Fig. 5 shows a dental laboratory procedure using a digital dental model.

[00123] Fig. 6 illustrates a scan path that may be used with a three-dimensional image capture system.

[00124] Figs. 7A and 7B show a modeling environment for creating alignment guides for orthodontic hardware.

DETAILED DESCRIPTION

[00125] Described are a wide array of systems and methods for digital dentistry. However, it will be appreciated that the inventive concepts disclosed herein are not limited to the specific embodiments disclosed. For example, the general techniques disclosed herein may be usefully employed in any environment where precise, three-dimensional data might be usefully captured and processed, including orthopedics, digital animation, and customized manufacturing. In addition, while numerous variations and implementations of digital dentistry techniques are described, it will be appreciated that other combinations of the specific scanning, processing, and manufacturing techniques described herein may be used, and that such variations are intended to fall within the scope of this disclosure.

[00126] In the following description, the term "image" generally refers to a two-dimensional set of pixels forming a two-dimensional view of a subject within an image plane. The term "image set" generally refers to a set of related two dimensional images that might be resolved into three-dimensional data. The term "point cloud" generally refers to a three-dimensional set of points forming a three-dimensional view of the subject reconstructed from a number of two-dimensional views. In a three-dimensional image capture system, a number of such point clouds may also be registered and combined into an aggregate point cloud constructed from images captured by a moving camera. Thus it will be understood that pixels generally refer to two-dimensional data and points generally refer to three-dimensional data, unless another meaning is specifically indicated or clear from the context.

[00127] The terms "three-dimensional surface representation", "digital surface representation", "three-dimensional surface map", and the like, as used herein, are intended to refer to any three-dimensional surface map of an object, such as a point cloud of surface data, a set of two-dimensional polygons, or any other data representing all or some of the surface of an object, as might be obtained through the capture and/or processing of three-dimensional scan data, unless a different meaning is explicitly provided or otherwise clear from the context.

[00128] A "three-dimensional representation" may include any of the three-*dimensional surface representations* described above, as well as volumetric and other representations, unless a different meaning is explicitly provided or otherwise clear from the context.

[00129] In general, the terms "render" or "rendering" refer to a two-dimensional visualization of a three-dimensional object, such as for display on a monitor. However, it will be understood that three-dimensional rendering technologies exist, and may be usefully employed with the systems and methods disclosed herein. As such, rendering should be interpreted broadly unless a narrower meaning is explicitly provided or otherwise clear from the context.

[00130] The term "dental object", as used herein, is intended to refer broadly to subject matter specific to dentistry. This may include intraoral structures such as dentition, and more typically human dentition, such as individual teeth, quadrants, full arches, pairs of arches which may be separate or in occlusion of various types, soft tissue (e.g., gingival and mucosal surfaces of the mouth, or perioral structures such as the lips, nose, cheeks, and chin), and the like, as well bones and any other supporting or surrounding structures. As used herein, the term "intraoral structures" refers to both natural structures within a mouth as described above and artificial structures such as any of the dental objects described below. While the design and fabrication of artificial dental structures is the subject of much of the following discussion, it will be understood that any of these artificial structures might be present in the mouth during a scan, either as a result of prior dental work (e.g., a previously restored tooth) or during an evaluation of fit and other aspects of a current procedure. Dental objects may include "restorations", which may be generally understood to include components that restore the structure or function of existing dentition, such as crowns, bridges, veneers, inlays, onlays, amalgams, composites, and various substructures such as copings and the like, as well as temporary restorations for use while a permanent restoration is being fabricated. Dental objects may also include a "prosthesis" that replaces dentition with removable or permanent structures, such as dentures, partial dentures, implants, retained dentures, and the like. Dental objects may also include "appliances" used to correct, align, or otherwise temporarily or permanently adjust dentition, such as removable orthodontic appliances, surgical stents, bruxism appliances, snore guards, indirect bracket placement appliances, and the like. Dental objects may also include "hardware" affixed to dentition for an extended period, such as implant fixtures, implant abutments, orthodontic brackets, and other orthodontic components. Dental objects may also include "interim components" of dental manufacture such as dental models (full and/or partial), wax-ups, investment molds, and the like, as well as trays, bases, dies, and other components employed in the fabrication of restorations, prostheses, and the like. As suggested above, dental objects may also be categorized as natural dental objects such as the teeth, bone, and other intraoral structures described above or as artificial dental objects such as the restorations, prostheses, appliances, hardware, and interim components of dental manufacture as described above. It will be understood that any of the foregoing, whether natural or artificial, may be an intraoral structure when present within the mouth. Thus, for example, a previous restoration or an implant for a crown might be present within the mouth, and may be an intraoral structure scanned during an intraoral scan.

[00131] Terms such as "digital dental model", "digital dental impression" and the like, are intended to refer to three-dimensional representations of dental objects that may be used in various aspects of acquisition, analysis, prescription, and manufacture, unless a different meaning is otherwise provided or clear from the context. Terms such as "dental model" or "dental impression" are intended to refer to a physical model, such as a cast, printed, or otherwise fabricated physical instance of a dental object. Unless specified, the term "model", when used alone, may refer to either or both of a physical model and a digital model.

[00132] Fig. 1 shows an image capture system. In general, the system 100 may include a scanner 102 that captures images from a surface 106 of a subject 104, such as a dental patient, and forwards the images to a computer 108, which may include a display 110 and one or more user input devices such as a mouse 112 or a keyboard 114. The scanner 102 may also include an input or output device 116 such as a control input (e.g., button, touchpad, thumbwheel, etc.) or a status indicator (e.g., LCD or LED display or light, a buzzer, or the like) to provide status information.

[00133] The scanner 102 may include any camera or camera system suitable for capturing images from which a three-dimensional point cloud may be recovered. For example, the scanner 102 may employ a multi-aperture system as disclosed, for example, in U.S. Pat. Pub. No. 20040155975 to Hart et al., the entire contents of which is incorporated herein by reference. While Hart discloses one multi-aperture system, it will be appreciated that any multi-aperture system suitable for reconstructing a three-dimensional point cloud from a number of two-dimensional images may similarly be employed. In one multi-aperture embodiment, the scanner 102 may include a plurality of apertures including a center aperture positioned along a center optical axis of a lens and any associated imaging hardware. The scanner 102 may also, or instead, include a stereoscopic, triscopic or other multi-camera or other configuration in which a number of cameras or optical paths are maintained in fixed relation to one another to obtain two-dimensional images of an object from a number of slightly different perspectives. The scanner 102 may include suitable processing for deriving a three-dimensional point cloud from an image set or a number of image sets, or each two-dimensional image set may be transmitted to an external processor such as contained in the computer 108 described below. In other embodiments, the scanner 102 may employ structured light, laser scanning, direct ranging, or any other technology suitable for acquiring three-dimensional data, or two-dimensional data that can be resolved into three-dimensional data.

[00134] In one embodiment, a second scanner such as a PMD[vision] camera from PMD Technologies, may be employed to capture real-time, three-dimensional data on dynamic articulation and occlusion. While this scanner employs different imaging technology (time-of-flight detection from an array of LEDs) than described above, and produces results with resolution generally unsuitable for reconstruction of dental models, such a scanner may be employed to infer motion of, e.g., opposing dental arches with sufficient resolution to select an axis for articulation or otherwise capture dynamic information that can be applied to two or more rigid bodies of a dental object scan. This data may be supplemented with more precise alignment data statically captured from digital or manual bite registration to provide reference or calibration points for continuous, dynamic motion data.

[00135] In one embodiment, the scanner 102 is a handheld, freely positionable probe having at least one user input device 116, such as a button, lever, dial, thumb wheel, switch, track ball, mini joystick, touchpad, keypad, or the like, for user control of the image capture system 100 such as starting and stopping scans, or interacting with a user interface on the display 110. In an embodiment, the scanner 102 may be shaped and sized for dental scanning. More particularly, the scanner 102 may be shaped and sized for intraoral scanning and data capture, such as by insertion into a mouth of an imaging subject and passing over an intraoral surface 106 at a suitable distance to acquire surface data from teeth, gums, and so forth. This may include a shape resembling an electric toothbrush or a dental tool, and including an elongated body with an optical port on one end that receives scan data, and user controls on (or near) the other end.

[00136] A physical offset may be provided for the optical port that physically maintains an appropriate distance from scanning subject matter. More particularly, the physical offset may prevent the optical port from getting too near the scanned subject matter, which permits a user to maintain proper distance through a steady application of pressure toward the subject matter. The physical offset may be adapted for particular subject matter and may include a simple rod or other rigid form extending toward the optical path of the scanner, or the physical offset may include contoured forms for mating with more complex surfaces. The physical offset may include wheels or plates for slidably engaging a surface of scanned subject matter, or other structures or surface treatments to improve operation in various applications.

[00137] The scanner 102 may, through a continuous acquisition process, capture a point cloud of surface data having sufficient spatial resolution and accuracy to prepare dental objects such as restorations, hardware, appliances, and the like therefrom, either directly or through a variety of intermediate processing steps. In other embodiments, surface data may be acquired from a dental model such as a dental restoration, to ensure proper fitting using a previous scan of corresponding dentition, such as a tooth surface prepared for the restoration.

[00138] Although not shown in Fig. 1, it will be appreciated that a number of supplemental lighting systems may be usefully employed during image capture. For example, environmental illumination may be enhanced with one or more spotlights illuminating the subject 104 to speed image acquisition and improve depth of field (or spatial resolution depth). The scanner 102 may also, or instead, include a strobe, flash, or other light source to supplement illumination of the subject 104 during image acquisition.

[00139] The subject 104 may be any object, collection of objects, portion of an object, or other subject matter. More particularly with respect to the dental fabrication techniques discussed herein, the object 104 may include human dentition captured intraorally from a dental patient's mouth. A scan may capture a three-dimensional representation of some or all of the dentition according to particular purpose of the scan. Thus the scan may capture a digital model of a tooth, a quadrant of teeth, or a full collection of teeth including two opposing arches, as well as soft tissue or any other relevant intraoral and/or extraoral structures. In other embodiments where, for example, a completed fabrication is being virtually test fit to a surface preparation, the scan may include a dental restoration such as an inlay or a crown, or any other artificial dental object. The subject 104 may also, or instead, include a dental model, such as a plaster cast, wax-up, impression, or negative impression of a tooth, teeth, soft tissue, or some combination of these.

[00140] Although not depicted, it will be understood that the scanner 102 may have a two-dimensional field of view or image plane where optical data is acquired. It will be appreciated that the term "image plane" as used in this paragraph, refers to a plane in the imaging environment rather than a plane within an optical sensor (such as film or sensors) where an image is captured. The image plane may form any number of two-dimensional shapes according to the construction of the scanner 102, such as a rectangle, a square, a circle, or any other two-dimensional geometry. In general, the scanner 102 will have a depth of field or range of depth resolution for image acquisition within the image plane determined by the physical construction of the scanner 102 and environmental conditions such as ambient light.

[00141] The computer 108 may be, for example, a personal computer or other processing device. In one embodiment, the computer 108 includes a personal computer with a dual 2.8GHz Opteron central processing unit, 2 gigabytes of random access memory, a TYAN Thunder K8WE motherboard, and a 250 gigabyte, 10,000 rpm hard drive. This system may be operated to capture approximately 1,500 points per image set in real time using the techniques described herein, and store an aggregated point cloud of over one million points. As used herein, the term "real time" means generally with no observable latency between processing and display. In a video-based scanning system, real time more specifically refers to processing within the time between frames of video data, which typically vary according to specific video technologies between about fifteen frames per second and about thirty frames per second. However, it will also be understood that terms such as "video" or "video rate" imply a wide range of possible frame rates associated with such video. While most modern video formats employ a frame rate of 25 to 30 frames per second, early video employed frame rates as low as 8 frames per second, and movies of the early 1900's varied from 12 to 18 frames per second. In addition, it is common for specialized imaging equipment to employ a rate adapted to the computational demands of particular imaging and rendering techniques, and some video systems operate with frame rates anywhere from 4 frames per second (for computationally extensive imaging systems) to 100 frames per second or higher (for high-speed video systems). As used herein, the terms video rate and frame rate should be interpreted broadly. Notwithstanding this broad meaning, it is noted that useful and visually pleasing three-dimensional imaging systems may be constructed as described herein with frame rates of at least ten frames per second, frame rates of at least twenty frames per second, and frame rates between 25 and 30 frames per second.

[00142] More generally, processing capabilities of the computer 108 may vary according to the size of the subject 104, the speed of image acquisition, and the desired spatial resolution of three-dimensional points. The computer 108 may also include peripheral devices such as a keyboard 114, display 110, and mouse 112 for user interaction with the camera system 100. The display 110 may be a touch screen display capable of receiving user input through direct, physical interaction with the display 110.

[00143] Communications between the computer 108 and the scanner 102 may use any suitable communications link including, for example, a wired connection or a wireless connection based upon, for example, IEEE 802.11 (also known as wireless Ethernet), BlueTooth, or any other suitable wireless standard using, e.g., a radio frequency, infrared, or other wireless communication medium. In medical imaging or other sensitive applications, wireless image transmission from the scanner 102 to the computer 108 may be secured. The computer 108 may generate control signals to the scanner 102 which, in addition to image acquisition commands, may include conventional camera controls such as focus or zoom. In addition, the computer 108 may include a network communications interface for connecting to a network such as the dental network described below.

[00144] In an example of general operation of a three-dimensional image capture system 100, the scanner 102 may acquire two-dimensional image sets at a video rate while the scanner 102 is passed over a surface of the subject. The two-dimensional image sets may be forwarded to the computer 108 for derivation of three-dimensional point clouds. The three-dimensional data for each newly acquired two-dimensional image set may be derived and fitted or "stitched" to existing three-dimensional data using a number of different techniques. Such a system employs camera motion estimation to avoid the need for independent tracking of the position of the scanner 102. One useful example of such a technique is described in commonly-owned U.S. App. No. 11/270,135, filed on November 9, 2005, the entire contents of which is incorporated herein by reference. However, it will be appreciated that this example is not limiting, and that the principles described herein may be applied to a wide range of three-dimensional image capture systems.

[00145] The display 110 may include any display suitable for video or other rate rendering at a level of detail corresponding to the acquired data. Suitable displays include cathode ray tube displays, liquid crystal displays, light emitting diode displays and the like. In addition, where three-dimensional visualization is desired, the display 110 may include a three-dimensional display using a wide variety of techniques including stereo pair imaging, holographic imaging, and multiplanar or volumetric imaging, each with a number of rendering modalities that may be usefully employed with the systems described herein.

[00146] In some embodiments, the display may include a touch screen interface using, for example capacitive, resistive, or surface acoustic wave (also referred to as dispersive signal) touch screen technologies, or any other suitable technology for sensing physical interaction with the display 110.

[00147] The touch screen may be usefully employed in a dental office or other context to provide keyboardless processing and manipulation of scanning and any resulting three-dimensional representations. For example, the touch screen may be employed to permit user manipulation of a displayed model, such as panning, zooming, and rotating, through direct physical interaction with the displayed model and any corresponding controls within a user interface. For example, a user may touch a "rotate" button on the display 110, after which placing a finger on the screen and dragging may cause three-dimensional rotation of the displayed model around a corresponding axis (typically perpendicular to the direction of finger motion).

[00148] The touch screen may also provide tools for manipulating the digital model. For example, a user may define or specify a cementation void or die spacer. A user may define, edit, or annotate a margin line, such as a computer-generated margin line. A user may define a die and/or ditch a die by recessing one or more regions below the margin line. A user may place arches of a digital dental model into a virtual articulator and articulate the arches. The touch screen may provide one or more tools for virtually designing a dental restoration fitted to a dental model, including fitting to a prepared surface, adjacent teeth, and/or teeth of an opposing arch.

[00149] The touch screen may also provide case management controls providing functions such as transmitting a digital model to a dental laboratory, evaluating quality of a digital model or performing other quality control functions as described below, or creating a dental prescription as described, for example, below with reference to Fig. 3.

[00150] The image capture system 100 may generally be adapted for real time acquisition and display, e.g., at a video rate, of three-dimensional data, which may be rendered, for example, as a point cloud superimposed on a video image from the scanner 102. For certain types of data acquisition, there may be a significant difference in the processing time required for resolution of a three-dimensional image adequate for two-dimensional perspective rendering (faster) and maximum or optimum resolution that might be achieved with post-processing. In such circumstances, the image capture system 100 may include two different operating modes. In a first operating mode, a relatively low-quality three-dimensional representation may be obtained and rendered in real time, such as within the display 110. In a second operating mode, a relatively high-quality three-dimensional representation may be generated for the source scan data using any desired degree of processing. The second operating mode may recover, through additional post-processing steps, three-dimensional data having greater spatial resolution and/or accuracy. It will be understood that, while two different modes are described, it is not required that the two modes be mutually exclusive. For example, both modes may execute simultaneously on a computer as separate processes or threads, or the data from the first operating mode may be employed to seed the second operating mode with a model for refinement for post-processing. All such variations as would be apparent to one of ordinary skill in the art may be employed with the systems described herein. Either the high-quality representation or the low-quality representation, or both, may be transmitted to a dental laboratory for subsequent steps such as quality control and model fabrication, examples of which are provided below.

[00151] In another aspect, the system 100 may provide different levels of accuracy or spatial resolution, each associated with, for example, different degrees of post-processing, computing power, or rate of movement by the scanner 102 over a subject 104. Thus, for example, an entire dental arch may be scanned at a relatively low accuracy, while a surface preparation or other area of diagnostic or treatment significance may be scanned at a relatively higher accuracy which may, for example, require a slower scanning motion or additional post-processing delays. Similarly, certain areas such as the surface preparation may be designated for supplemental post-processing to achieve enhanced accuracy or spatial resolution.

[00152] The input or output device 116 may include a feedback device that provides warnings or indicators to an operator of the image capture system 100 with respect to scan quality or progress. The device 116 may include, for example, a buzzer, speaker, light emitting diode, an incandescent light, or any other acoustic, haptic, tactile, or visual signal to notify the operator of an event without requiring the operator to look at the display 110. For example, data quality may be continuously monitored by the system 100, and an alert may be generated when the data quality drops below a quantitative threshold, or data acquisition is lost completely (or different alerts may be provided for each of these events). The evaluation of data quality may depend, for example, on an ability of the system 100 to fit a new data set to existing three-dimensional data, or the ability to resolve two-dimensional image sets into three-dimensional data, or the density of acquired data, or any other objective criterion, either alone or in combination. The evaluation of data quality may also, or instead, be inferred from other parameters such as motion of the scanner 102 or distance from the subject 104. It will be understood that while a data quality indicator may be positioned on the scanner 102 as shown, the device 116 may also, or instead, be positioned at any other location suitable for alerting an operator, which may depend on the type of alert generated (i.e., a visual alert may have different positioning parameters than an audio alert or a tactile alert). In another aspect, the input or output device 116 may provide feedback when data quality is within an acceptable range. In another aspect, the input our output device 116 may provide both positive feedback (good data quality) and negative feedback (poor data quality) so that continuous feedback is available to the operator concerning an ongoing scan.

[00153] Fig. 2 shows entities participating in a digital dentistry network. As depicted, a network 200 may include a plurality of clients 202 and servers 204 connected via an internetwork 210. Any number of clients 202 and servers 204 may participate in such a system 200. The network 200 may include one or more local area networks ("LANs") 212 interconnecting clients 202 through a hub 214 (in, for example, a peer network such as a wired or wireless Ethernet network) or a local area network server 214 (in, for example, a client-server network). The LAN 212 may be connected to the internetwork 210 through a gateway 216, which provides security to the LAN 212 and ensures operating compatibility between the LAN 212 and the internetwork 210. Any data network may be used as the internetwork 210 and the LAN 212.

[00154] The internetwork 210 may include, for example, the Internet, with the World Wide Web providing a system for interconnecting clients 202 and servers 204 in a communicating relationship through the internetwork 210. The internetwork 210 may also, or instead, include a cable network, a satellite network, the Public Switched Telephone Network, a WiFi network, a WiMax network, cellular networks, and any other public, private, and/or dedicated networks, either alone or combination, that might be used to interconnect devices for communications and transfer of data.

[00155] An exemplary client 202 may include a processor, a memory (e.g. RAM), a bus which couples the processor and the memory, a mass storage device (e.g. a magnetic hard disk or an optical storage disk) coupled to the processor and the memory through an I/O controller, and a network interface coupled to the processor and the memory, such as modem, digital subscriber line ("DSL") card, cable modem, network interface card, wireless network card, or other interface device capable of wired, fiber optic, or wireless data communications. One example of such a client 202 is a personal computer equipped with an operating system such as Microsoft

Windows XP, UNIX, or Linux, along with software support for Internet and other communication protocols. The personal computer may also include a browser program, such as Microsoft Internet Explorer, Netscape Navigator, or FireFox to provide a user interface for access to the internetwork 210. Although the personal computer is a typical client 202, the client 202 may also be a workstation, mobile computer, Web phone, VOIP device, television set-top box, interactive kiosk, personal digital assistant, wireless electronic mail device, or other device capable of communicating over the Internet. As used herein, the term "client" is intended to refer to any of the above-described clients 202 or other client devices, and the term "browser" is intended to refer to any of the above browser programs or other software or firmware providing a user interface for navigating through an internetwork 210 such as the Internet. The client 202 may also include various communications capabilities such as instant messaging, electronic mail, syndication (such as RSS 2.0), Web-based conferencing, Web-based application sharing, Web-based videoconferencing, Voice over IP ("VoIP"), and any other standards-based, proprietary, or other communication technologies, either in hardware, software, or a combination of these, to enable communications with other clients 202 through the internetwork 210.

[00156] An exemplary server 204 includes a processor, a memory (e.g. RAM), a bus which couples the processor and the memory, a mass storage device (e.g. a magnetic or optical disk) coupled to the processor and the memory through an I/O controller, and a network interface coupled to the processor and the memory. Servers may be clustered together to handle more client traffic, and may include separate servers for different functions such as a database server, an application server, and a Web presentation server. Such servers may further include one or more mass storage devices 206 such as a disk farm or a redundant array of independent disk ("RAID") system for additional storage and data integrity. Read-only devices, such as compact disk drives and digital versatile disk drives, tape drives, and the like may also be connected to the servers. Suitable servers and mass storage devices are manufactured by, for example, IBM, and Sun Microsystems. Generally, a server 204 may operate as a source of content, a hub for interactions among various clients, and platform for any back-end processing, while a client 202 is a participant in the dental activities supported by the digital dentistry systems described herein. However, it should be appreciated that many of the devices described above may be configured to respond to remote requests, thus operating as a server, and the devices described as servers 204 may participate as a client in various digital dentistry applications.

[00157] Focusing now on the internetwork 210, one embodiment is the Internet. The structure of the Internet 210 is well known to those of ordinary skill in the art and includes a network backbone with networks branching from the backbone. These branches, in turn, have networks branching from them, and so on. The backbone and branches are connected by routers, bridges, switches, and other switching elements that operate to direct data through the internetwork 210. For a more detailed description of the structure and operation of the Internet 210, one may refer to "The Internet Complete Reference," by Harley Hahn and Rick Stout, published by McGraw-Hill, 1994. However, one may practice the present invention on a wide variety of communication networks. For example, the internetwork 210 can include interactive television networks, telephone networks, wireless voice or data transmission systems, two-way cable systems, customized computer networks, Asynchronous Transfer Mode networks, and so on. Clients 202 may access the internetwork 210 through an Internet Service Provider ("ISP", not shown) or through a dedicated DSL service, ISDN leased lines, T1 lines, OC3 lines, digital satellite service, cable modem service, or any other connection, or through an ISP providing same. Further, the internetwork 210 may include a variety of network types including wide-area networks, local area networks, campus area networks, metropolitan area networks, and corporate area networks.

[00158] In an exemplary embodiment, a browser, executing on one of the clients 202, retrieves a Web document at an address from one of the servers 204 via the internetwork 210, and displays the Web document on a viewing device, e.g., a screen. A user can retrieve and view the Web document by entering, or selecting a link to, a URL in the browser. The browser then sends an http request to the server 204 that has the Web document associated with the URL. The server 204 responds to the http request by sending the requested Web document to the client 202. The Web document is an HTTP object that includes plain text (ASCII) conforming to the HyperText Markup Language ("HTML"). Other markup languages are known and may be used on appropriately enabled browsers and servers, including the Dynamic HyperText Markup Language ("DHTML"), the Extensible Markup Language ("XML"), the Extensible Hypertext Markup Language ("XHML"), and the Standard Generalized Markup Language ("SGML").

[00159] Each Web document usually contains hyperlinks to other Web documents. The browser displays the Web document on the screen for the user and the hyperlinks to other Web documents are emphasized in some fashion such that the user can identify and select each hyperlink. To enhance functionality, a server 204 may execute programs associated with Web documents using programming or scripting languages, such as Perl, C, C++, C#, or Java, or a Common Gateway Interface ("CGI") script to access applications on the server. A server 204 may also use server-side scripting languages such as ColdFusion from MacroMedia or PHP. These programs and languages may perform "back-end" functions such as order processing, database management, and content searching. A Web document may also contain, or include references to, small client-side applications, or applets, that are transferred from the server 204 to the client 202 along with a Web document and executed locally by the client 202. Java is one popular example of a programming language used for applets. The text within a Web document may further include (non-displayed) scripts that are executable by an appropriately enabled browser, using a scripting language such as JavaScript or Visual Basic Script. Browsers may further be enhanced with a variety of helper applications to interpret various media including still image formats such as JPEG and GIF, document formats such as PS and PDF, motion picture formats such as AVI and MPEG, animated media such as Flash media, and sound formats such as MP3 and MIDI. These media formats, along with a growing variety of proprietary media formats, may be used to enrich a user's interactive and audio-visual experience as each Web document is presented through the browser. In addition, user interaction may be supplemented with technologies such as RSS (for syndication), OPML (for outlining), AJAX (for dynamic control of a web page), and so forth. The term "page" as used herein is intended to refer to the Web document described above, as well as any of the above-described functional or multimedia content associated with the Web document. A page may be employed to provide a user interface to the digital dentistry systems described herein. In addition, one or more applications running on a client 202 may provide a user interface for local and/or networked digital dentistry functions as described herein.

[00160] In Fig. 2, each client 202 represents a computing device coupled to the internetwork 210. It will be understood that a client 202 may be present at a location associated with digital dentistry such as a dental laboratory, a rapid manufacturing facility, a dental office, and/or a dental data center. Each of these potential participants in a digital dentistry system will now be described in greater detail.

[00161] One of the clients 202 may reside at a dental office. The dental office may include any office or other physical facility that provides dental care including individual dentist offices, dental group offices, retail dental centers, university dental schools, and the like. A dental patient may visit the dental office for a routine check up or cleaning, or for a visit scheduled due to oral discomfort, dental injury, or the like.

[00162] During the dental visit, a dentist may examine the dental patient and provide a dental assessment, such as the need for a restoration, tooth extraction, or the like. The dental office may include a three-dimensional scanner, such as any of the scanners described above, which the dentist may use to capture a three-dimensional digital representation of the dental patient's dentition including scans both before and after one or more tooth surfaces have been prepared for a dental object such as a restoration or the like. While a scan may be performed in the context of a specific dental issue, such as a planned restoration, the dentist may also capture scans during routine visits so that a dental history for the dental patient is accumulated over time. Using the client 202, which may include the image capture system 100 described above, the dentist may obtain one or more three-dimensional representations and, after discussing treatment with the dental patient, input any relevant dental prescription information. The dentist may then electronically transmit the three-dimensional representations, along with the prescription, to a dental laboratory or other fabrication facility using a network such as the internetwork 210 described above. In general, an electronic dental prescription, as used herein, includes a dental prescription in electronic form along with any three-dimensional data such as tooth surfaces before and after surface preparation, teeth in occlusion, and so forth. Additional data, such as x-ray, digital radiographic, or photograph data may be incorporated into the electronic dental prescription, or otherwise used with the systems and methods described herein. In certain instances, an electronic dental prescription may instead refer exclusively to the prescription data. In general, the meaning should be clear from the context, however, in the absence of explicit guidance, the broadest possible meaning is intended.

[00163] As a significant advantage, a practicing dentist may maintain a history of three-dimensional representations of dentition and surrounding soft tissue for each dental patient. Where a new procedure, such as a restoration, is scheduled for the patient, the dentist may pre-fabricate a temporary restoration using historic dental data. The temporary restoration may be fabricated for example, at the dental office where the procedure is scheduled using a three-dimensional printer and/or a copy milling machine, or at a remote facility such as the dental laboratory or rapid manufacturing facility described below. In one aspect, a scan may be obtained of a prepared surface during the scheduled visit, and the temporary restoration (or a final restoration) may be fabricated, such as at the dental office during the visit, by combining historical three-dimensional data with a three-dimensional representation of the prepared surface. In another embodiment, a treating dentist may shape the surface preparation to receive a pre-fabricated temporary restoration.

[00164] More generally, the client 202 at the dental office may be coupled in a communicating relationship with a client 202 at one or more of a dental laboratory, another dental office, a rapid manufacturing facility, and/or a dental data center for communication of three-dimensional representations of dental subject matter and related information. This dental network may be usefully employed in diagnosis, case planning, consultation, evaluation, and the like. Participation may include, for example, consultation, online or distance collaboration, approval, payment authorization, or any other collaborative or unilateral participation, examples of which are provided throughout this description. Thus there is disclosed herein methods and systems for sharing digital dental data, such as digital dental impressions captured using the techniques described above. This may permit a wide array of collaborative communications using a shared view of dentition or related digital models. For example, a dentist may collaborate with another dentist, a dental technician at a dental laboratory, an oral surgeon, a technician at a rapid manufacturing facility, or any other participant in a dental network at a remote location using a shared view of a patient's dentition. Various dental specialists may participate from remote (or local) locations, such as a periodontist, a prosthodontist, a pedodontist, an orthodontic specialist, an oral and maxillofacial surgery specialist, an oral and maxillofacial radiology specialist, an endodontist, and/or an oral and maxillofacial pathologist. Tools may be provided, such as collaborative tools, for sharing control of model manipulation, sectioning, rearranging, marking, and visualizing or simulating proposed clinical procedures. Each participant may view a rendering of the three-dimensional representation of dentition from a common or shared point of view. Control of the view and any modeling tools may be passed among participants, as well as a cursor or command prompt shared by participants within a user interface. In one aspect, this system forms a collaborative dental environment in which a three-dimensional representation of a dental patient's dentition is shared among participants. Communications among participants may include any network-supported communications protocol including electronic mail, instant messaging, Internet Relay Chat, Voice-over-IP, and the like, as well as conventional teleconferencing.

[00165] Turning next to the dental laboratory, a dental laboratory may provide a fabrication resource for dental practitioners. A conventional dental laboratory may have a number of production departments specializing in various dental objects such as complete dentures, partial dentures, crowns and bridges, ceramics, and orthodontic appliances. A dental laboratory may employ trained technicians to perform various tasks associated with filling a dental prescription such as preparing dental models, dies, articulated models, and the like from impressions and occlusal registrations received from dentists. Typically, a dentist submits an order with specific instructions (a prescription) to a dental laboratory, and the laboratory fabricates the corresponding dental object(s) for use by the dentist. A client 202 at a dental laboratory may be coupled in a communicating relationship with a client 202 at one or more of a dental office, another dental laboratory, a rapid manufacturing facility, and/or a dental data center for communication of three-dimensional representations of dental subject matter and related information. This dental network may be usefully employed in diagnosis, case planning, consultation, evaluation, and the like.

[00166] Dental laboratories may for example create restorative products such as crowns and bridges. A traditional crown formed of gold, other metal alloys, or ceramic may replace all visible areas of a tooth. An onlay is a partial crown that does not fully cover the visible tooth. Crowns may include a precision attachment incorporated into the design that may receive and connect a removable partial denture. Inlays are restorations fabricated to fit a prepared tooth cavity and then cemented into place. A bridge is a restoration of one or more missing teeth, such as a fixed partial, a three unit bridge, or the like. A bridge may be permanently attached to the natural teeth or attached to custom-made or prefabricated posts and cores that are first cemented into the roots.

[00167] Another major area of dental objects includes reconstructive products, most typically dentures. Partial dentures are a removable dental prosthesis that replaces missing teeth and associated structures. Full dentures substitute for the total loss of teeth and associated structures. Some dental labs also make precision attachments that connect a crown to an artificial prosthesis. Implants are fixtures anchored securely in the bone of the mouth to which an abutment, crown or other dental object can be attached using screws, clips, or the like. This may include, for example, a titanium root replacement integrated with the bone, an abutment or transfer coping, and an implant secured to the abutment. Implant procedures also typically involve a healing abutment to assist with healing of affected soft tissue and to maintain positioning of teeth while the root replacement attaches to the bone (which may take several months). An additional impression may be taken of the implant using an impression coping or abutment after it has attached to the bone for preparation of a final restoration.

[00168] A dental laboratory may also manufacture cosmetic products such as ceramic or composite resin veneers and crowns. Veneers are thin coverings cemented to the front of the tooth for aesthetic affect. Crowns are designed to cover the entire tooth preparation and will resemble natural teeth. Composite or ceramic inlays and onlays may be manufactured to replace amalgams and give teeth a more natural appearance. Orthodontic appliances move existing teeth to enhance function and/or appearance.

[00169] In general, the procedures described above involve transfer of a dental impression to a laboratory for fabrication of the final dental object. In some cases, such as implants, a number of impressions may be taken over the course of treatment. Using a scanner such as that described above, a dentist may capture an accurate three-dimensional representation of dentition and surrounding tissue and transmit this digital version of the dental impression to a dental laboratory using a network such as the internetwork 210 described above. The dental laboratory may receive the data and proceed with any appropriate fabrication. In various procedures, the three-dimensional representation may include data from two or more scans, such as an initial three-dimensional representation of dentition prior to any dental work, and a prepared three-dimensional representation of the dentition after one or more tooth surfaces have been prepared for the dental object(s). The surface preparation may provide guidance to the laboratory concerning fit of the restoration or other dental object to the tooth surface, and the initial scan may provide valuable information concerning the appropriate dimensions for the final dental object and its relationship to surrounding teeth. A dentist may also optionally specify a number of parameters for the dental laboratory as described in various examples below.

[00170] Where a particular dental object is temporary, or will be covered by another dental object at a subsequent dental visit, the object may be fabricated with one or more characteristics that improve scanning of any exposed surfaces once the object is placed within a dental patient's mouth. For example, an object such as an impression coping, fixture, or healing abutment may be fabricated with scanning-optimized surfaces such as an optical or textured finish. An optical finish may, for example, include randomly (or pseudo-randomly) distributed coloration such as black or other high-contrast dots. A textured finish may, for example, include a pseudo-random texture or one or more discrete landmarks.

[00171] It will be appreciated that in certain embodiments the dental laboratory may be an in-office dental laboratory physically located within or near a dental office where a dental patient is receiving treatment. In various embodiments, the in-office dental laboratory may provide facilities for a subset of dental objects described above, such as those most commonly used by a particular dentist.

[00172] Rapid manufacturing facilities may also be employed with the systems described herein. A rapid manufacturing facility may include equipment for designing and/or fabricating dental objects for use in dental procedures. A client 202 at a rapid manufacturing facility may be coupled in a communicating relationship with a client 202 at one or more of a dental office, another dental laboratory, a rapid manufacturing facility, and/or a dental data center for communication of three-dimensional representations of dental subject matter and related information. This dental network may be usefully employed in diagnosis, case planning, consultation, evaluation, and the like.

[00173] Rapid manufacturing facilities may include, for example one or more stereo lithography apparatuses, three-dimensional printers, computerized milling machines, or other three-dimensional rapid prototyping facilities or similar resources. A particular facility may include one or more of a number of different types of machines which may be scheduled for various fabrication jobs received through the internetwork 210. In one embodiment, a single facility may provide a large number of machines along with suitably trained technical personal to provide a centralized fabrication facility. In another embodiment, machines may be distributed at various locations, including one or more machines within dental offices and dental laboratories. Where copings, crowns, or the like are to be finished at the rapid manufacturing facility rather than, for example, a dental laboratory, the rapid manufacturing facility may also include machinery such as pressing machines and electroplating machines.

[00174] More generally, a dental fabrication facility may include one or more of the rapid manufacturing facilities, dental laboratory facilities, or in-office dental laboratories described above, either alone or in combination.

[00175] A dental data center may provide a hub for a digital dentistry network. A server 204 at a dental laboratory may be coupled in a communicating relationship with a client 202 at one or more of a dental office, a dental laboratory, a rapid manufacturing facility, and/or another dental data center for communication of three-dimensional representations of dental subject matter and related information. This dental network may be usefully employed in diagnosis, case planning, consultation, evaluation, and the like. The dental data center may, for example operate as an intermediary between dentists, laboratories, and fabrication facilities to provide a common repository for new dental jobs from a dental office, which may be distributed to available resources at one or more dental laboratories and/or rapid fabrication facilities. In addition to scheduling and workload allocation, the dental data center may provide various value-added services such as quality control for incoming three-dimensional representation, financial transaction management, insurance authorization and payment, and the like.

[00176] The dental data center may coordinate a number of transactions within a digital dentistry network. For example, the dental data center may engage in continuous bidding for fabrication work in order to ensure competitive pricing for fabrication facility and dental laboratory work sourced from the dental data center. As another example, the dental data center may provide status updates concerning a fabrication job to a dentist or other participant, including up-to-date information such as job received, job at fabrication facility, job at dental laboratory, model completed, waxing completed, investing completed, casting completed, porcelain build-up completed, restoration completed, finishing, shipping, and so forth. The dental data center may provide a web-based work-in-progress interface through which a dentist may monitor progress. Other known systems, such as electronic mail alerts or RSS updates, may be used to provide status updates to dentists or other interested parties. While a dental data center may be usefully employed with the digital dentistry systems described herein, it will also be understood that various dental networks may operate independently between parties, such as between a dental office and a dental laboratory or between a dental laboratory and a rapid manufacturing facility, or between a number of dental offices and a rapid manufacturing facility, without a centralized server at a dental data center. All such embodiments are intended to fall within the scope of this disclosure. Further, it will be understood that a wide array of software platforms, communications protocols, security protocols, user interfaces, and the like are known, and may be suitably adapted to a web-based, web-services based, or other dental data center as described herein.

[00177] A digital dentistry network may include other participants, such as a consulting dentist, and oral surgeon, an insurer, a federal or state regulator or oversight entity, or any other dental entity. Each of these participants may communicate with other participants in the digital dentistry network through use of a client 202. Through this digital dentistry network, various methods and systems may be deployed. For example, in one aspect a three-dimensional representation and a dental prescription may be electronically transmitted to an insurer through the network, and the insurer may respond with authorization to perform the specified dental procedure (or a denial, which may include any reasons for the denial), including fabrication of any related dental objects. The insurer may maintain an electronic copy of three-dimensional representations relevant to the authorization, such as an image of the tooth surface prepared for the procedure. The insurer may also render payment, or authorize payment, to a treating dentist. The insurer may also, or instead, render payment to related entities, such as a dental laboratory or rapid manufacturing facility, for fabrication services provided. In one common practice, the insurer makes a single payment to the treating dentist who may in turn contract desired vendors for fabrication services. However, the insurer may render payments separately to one or more parties involved including a dentist, a dental patient, a dental laboratory, a rapid manufacturing facility, and so on.

[00178] In one aspect, dental laboratory procedures may be improved by fabricating a kit of components for use by a dental laboratory in subsequent fabrication of a final restoration, prosthesis, or the like. For example, a kit may include one or more of a die, a quad model, an opposing quad model, a full arch model, an opposing arch model, a base, a pre-articulated base, a waxup, and so forth. More generally, the kit may include one or more pre-cut components, pre-indexed components, and pre-articulated components for assembly into a dental model, such as a model adapted for use with an articulator. The kit may also, or instead, include various interim components of dental manufacture, such as required or commonly used components for particular procedures, e.g., the PFM crown kit, the bridge kit, and so on. All or some of these components may be automatically fabricated as a kit by a production facility specializing in high-throughput such as the rapid manufacturing facility described above, and the kit may be forwarded to a dental laboratory specializing in creation of final restorations and the like. This approach leverages the relative expertise of these two participants in a digital dentistry network, and may achieve significant decreases in cost and time to a final restoration or other dental object. Alternatively, a dentist may determine and directly fabricated any required kit components using, for example, an in-house three-dimensional printer. In one aspect, a group of different kits may be established for different dental work, so that a dental prescription automatically triggers fabrication of the corresponding kit.

[00179] Fig. 3 shows a user interface that may be used in a digital dental system. The user interface may be presented, for example, as a Web page viewed using a Web browser, or as an application executing on one of the clients 202 described above, or as a remotely hosted application, or as a combination of these.

[00180] The interface 300 may include navigation features such as a home control 302, a name directory control 304, a toolbox control 306, and a security control 308. Each of these features may direct the interface 300 to a different functional area. For example, the home control 302 may access a top level menu that provides access to, for example, system login, data source selection, hardware/software configuration, administrative tools, and so forth. The name directory control 304 may access a directory of patients, physicians, dental laboratories, rapid manufacturing facilities and like, and permit searching, data input, and so forth. The directory may, for example, provide access to patient dental records and history, contact information, and the like. The toolbox control 306 may provide access to tools for scanning, case planning and management, scheduling, and the like. The security control 308 may provide access to account management, communications configuration, and other security-oriented features and functions of a digital dentistry system.

[00181] Within each main area of top-level navigation, the interface 300 may provide a number of tabs, such as the scanning tab 310, the prescription tab 312, and the status tab 314 depicted in Fig. 3. The scanning tab 310 may, for example, invoke an interface for controlling operation of an image capture system 100 such as that described above in reference to Fig. 1. The prescription tab 312 may, for example, invoke an interface that permits specification of a restoration or other dental object, including a specification of teeth being treated, treatment type, manufacturer, and details of the dental object including color, material, texture, and so forth. The interface of the prescription tab 312 may also include tools for transmitting a prescription, along with any three-dimensional data obtained from scans of a patient, to a dental laboratory, dental data center, rapid manufacturing facility, or the like. The status tab 314 may, for example, invoke an interface for obtaining or updating status information on a case such as the fabrication status of a prescription (e.g., prescription and scan received, scan evaluated and approved, models complete, object fabricated, object shipped to dentist, and so forth).

[00182] Fig. 3 depicts in more detail a prescription window of the interface 300, as accessed by selecting the prescription tab 312. This window may show current data for a prescription within a text window 320. A scroll bar 322 or other control may be provided for selecting options relating to a prescription. In operation, and by way of example only, a feature of the prescription, such as the material or manufacturer, may be highlighted within the text window 320, and options for that feature may selected from the scroll bar 322. The window may also include additional navigational or process controls such as a next button 324, a back button 326, and a finish button 328, which may be used to navigate through one or more different windows of a prescription and/or case planning interface. This may include, for example, input of patient data, selection of a dental laboratory, scheduling of dental visits, and the like. It will be understood that the above interface 300 is an example only and that other hierarchical arrangements of functions, and/or arrangements of data and controls within a particular interface, are possible and may be employed with a digital dental system as described herein. For example, the interface may control scanning, marking or annotation of scanned models, case planning, access to databases of patient records and dental data, preparation of prescriptions, analysis of dentition, scheduling, management of patient data, communications with remote fabrication facilities, and so forth. Any user interface or

combination of user interfaces and user interface technologies suitable for a digital dental system as described herein may be employed without departing from the scope of this disclosure. As such, a user interface 300 should be understood more generally with reference to the systems and methods described herein, and not by specific reference to the example interface shown in Fig. 3.

[00183] Having described a number of aspects of a digital dentistry system and network, along with various participants in such a network, specific uses of the system will now be discussed in greater detail.

[00184] Fig. 4 depicts a quality control procedure for use in a digital dental system. The process 400 may start 402 by obtaining a digital model, such as a three-dimensional representation of dental subject matter as described generally above.

[00185] The digital model may include a single model, such as a digital model of dentition prior to any dental work, such as for archival or comparison purposes. This may also, or instead, be a digital model of dentition including one or more prepared surfaces, such as a single tooth surface prepared for a crown, or a number of tooth surfaces prepared for a multi-unit bridge. This may also include a scan of bite registration. For example, a scan may be obtained of the teeth of a dental patient in centric relation, centric occlusion, or with maximum intercuspation, in protrusion (e.g., for sleep apnea guards), in lateral excursions, or in any other static orientation useful for any of the dental procedures described herein. As a significant advantage, the upper and lower arches may be treated as rigid bodies, thus permitting relative three-dimensional orientation for a full bite registration to be obtained from a scan of a relatively small region of the upper and lower arches while in occlusion, such as centric occlusion. Thus for example, a three-dimensional scan that spans the two arches, such as a scan of the exterior surfaces of one or two teeth in a buccal or labial area, may be used to register bite. In addition, the digital model may include motion information describing the relative motion of, e.g., an upper and lower jaw throughout one or more jaw motions such as opening and closing the mouth or simulated chewing. Such motion data may, for example, be obtained through a variety of techniques suitable for tracking three-dimensional motion, which may include extrapolation from video data, use of transmitters on the moving jaws, mechanical or electromechanical sensors and/or transmitters, and so forth. Motion data may also be inferred by capturing orientation data for the jaws in a variety of positions. Motion data may be employed, for example, to derive the position of TMJ condyle paths of rotation and translation, or to provide input to a virtual or conventional dental articulator.

[00186] In addition, dynamic three-dimensional data may be obtained and used. As noted elsewhere herein, some systems permit direct three-dimensional video capture. However, other techniques may be employed to capture dynamic data. For example, in one example process, two opposing arches may be brought into natural occlusion. The dental patient may then slide the arches forward and back and from side to side, during which the scanner may capture relative motion of the two rigid bodies defined by the two opposing arches. The captured data may be used to characterize and animate a three-dimensional transformation that captures the full excursion of the dentition. This data may, in turn, be registered to detailed scans of the opposing arches. As a further use of this type of data, the excursion data may be used in combination with detailed arch data to provide a cutting tool or path for occlusal surfaces of a restoration. Thus, occlusal surfaces may be measured or otherwise determined during a scan, and applied to define surfaces of a restoration. Using various CAD modeling tools, the restoration may be further refined, such as by shaping side walls of the restoration, adding visually appealing and/or functional cusps to the occlusal surfaces, and so forth. Thus in one aspect there is disclosed herein a method for determining one or more occlusal surfaces of a dental restoration using dynamic three-dimensional data acquired during a scan. The method may include obtaining a three dimensional model of two opposing arches of a patient's dentition, obtaining excursion data for the two opposing arches, preparing a tooth surface of the dentition for a restoration, and determining an occlusal surface of the restoration using the excursion data and the three-dimensional model.

[00187] More generally, any digital model or other data useful in dental procedures, restorations, and the like as described herein may be obtained in step 404.

[00188] Once a digital model (or models) is obtained in step 404, the process 400 may proceed to one or more quality control steps as depicted in steps 406-410.

[00189] This may include automated quality control, as shown in step 406, which may be simple quantitative analysis such as measures of accuracy, variability, or density of three-dimensional surface data for a digital model. This may also, or instead, include more sophisticated, automated analyses such as adequacy and/or suitability of margins and prepared surfaces for an anticipated restoration. For example, an automated quality control tool may examine a prepared tooth surface to ensure that a margin line is present all the way around a preparation, or examine the prepared surface to ensure that adequate material has been removed to accommodate a restoration. Similarly, an automated process may locate areas of potential problems, such as occlusal high spots, occlusal clearance, occlusal irregularities, areas of poor margin preparation, areas of inadequate tooth removal, improper taper, improper draw path or removal path for a multiple unit preparation, inappropriate contour, and so forth.

[00190] In one aspect, quality control may include real time feedback during a scan, or between successive scans. The feedback may be rendered with suitable visualizations on a display to permit immediate observation and correction by a dentist. Thus it will be appreciate that, while depicted in Fig. 4 as a post-scanning operation, quality control may be implemented at any time in a digital dentistry process, or throughout the entire process. Real time feedback may include for example, textual annotations identifying teeth as they are recognized within a scan, and providing one or more dimensions of a tooth, or an analysis of contour, clearance relative to adjacent teeth, or a position of the tooth relative to other teeth or relative to a global coordinate system. By providing this information in real time within the context of a single dental visit, treatment may be generally improved by reducing or eliminating a need for follow up scans.

[00191] In another aspect, quality control may include an evaluation of suitability of a surface preparation, or a restoration or other dental object prepare for the restoration, for manufacturing using one or more techniques, including three-dimensional printing, milling, stereo lithography, and or conventional dental fabrication, or various combinations of these.

[00192] Although not depicted in Fig. 4, it will be appreciated that quality control may be semi-automated. Thus, for example, a user interface may provide a number interactive, three-dimensional tools such as markup tools that a dentist or other dental professional may use to measure, mark, annotate, or otherwise manipulate a digital model to evaluate suitability for subsequent processing and the creation of a physical dental object such as a restoration.

[00193] As shown in step 408, quality control may include manual quality control. For example, a dentist may inspect a scan in an interactive, three-dimensional environment to visually identify, e.g., holes or areas of incomplete scan needed for an intended dental procedure. The dentist may employ various features, such as rotation, zooming, and panning to inspect various surfaces of the three-dimensional digital representation from a scan.

[00194] As shown in step 410, quality control may include remote quality control. For example, after completing a scan, a dental office may transmit a digital model to a dental laboratory or a fabrication facility for evaluation of adequacy of the scan. As a significant advantage, the recipient, such as a dental laboratory may provide immediate feedback to a dentist while a dental patient is still in the dental office, or still in a dentist's chair at a dental office, thus avoiding a need to schedule repeat visits for additional surface scanning or surface preparation. A dental laboratory may inspect a prepared surface to ensure that a restoration can be fit to the prepared surface, or that there is adequate space (especially thickness) for a restoration or other dental object. The dental laboratory may also evaluate color and suggest shade matching for a dentist. The dental laboratory may request manual marking of a margin by a dentist where the margin is not visible on a prepared tooth surface. The dental laboratory may also apply separate standards for data quality (density, accuracy, surface continuity, feature detail, etc.), and may request additional or new scan data consistent with its own specifications. The dental office may transmit a case plan prior to (or during) transmission of a scan, which may permit more detailed analysis of the scan data by the recipient. Thus, for example, a dental laboratory may evaluate suitability of the scan and/or surface preparation for a type of restoration and any prescribed components (e.g., full ceramic, porcelain-fused-to-metal, etc.). Where the dental laboratory can quickly generate an accurate or rough model for a restoration or other dental object according to any fabrication or end use constraints, the rough model may, in digital form, be virtually fit to the prepared surface, and feedback may be provided to a dentist such as an identification of regions requiring further reduction.

[00195] Quality control, whether automated or manual, and whether local or remote, may include a variety of different dental evaluations. For example, a prepared tooth in an arch that will receive a restoration may be evaluated to determine whether there is adequate space for cement to bond the restoration to the prepared tooth surface. As another example, a dentist may visually confirm accuracy of a scan by inspection for gross errors or omissions such as holes, gaps, distortions, twists, and the like. The dentist may also visually inspect margin lines on surface preparations, and may annotate margins for identification by a dental laboratory or other fabrication facility. Similarly, a dental laboratory may, during a quality control evaluation, request that the dentist identify the margins on a surface preparation where the margin lines are not self-evident.

[00196] Feedback from a quality control step, whether automated or manual, and whether remote or local, may include various forms of feedback. For example, an evaluation may conclude with an identification of regions of a prepared tooth surface requiring additional preparation or reduction, or regions of a digital model requiring additional or supplemental scanning due to incomplete, erroneous, or potentially erroneous data, which may be identified, for example, by comparison to models of expected shape for dentition, surface preparations, and the like. An evaluation from a dental laboratory may request new data, or additional shaping of a prepared surface. An evaluation from a dental laboratory may include a request for an oral consultation. In addition other dental professionals such as a consulting dentist, an oral surgeon, a dental specialist, or a laboratory technician may be called upon for evaluation, approval, and/or recommendations. Feedback may be presented to a dentist in a number of forms. For example, the feedback may include text or audible narrative concerning additional scanning, additional surface preparation, or requests for confirmation. The feedback may be graphical feedback provided by highlighting questionable or erroneous areas of a preparation within a rendered display of scan data. The feedback may identify corrective action on a scan or a surface preparation. The feedback may identify a margin line which may be displayed on a two-dimensional rendering of a three-dimensional representation, and a user interface may permit the margin line to be edited or confirmed. The feedback may include a visual display with regions of inadequate margin highlighted, such as through use of color, texture, or explicit annotations, arrows, callouts, or the like, and any combination of these.

[00197] It will be understood that the quality control steps indicated in Fig. 4 are not mutually exclusive. That is each of the quality control steps 406-410 may be performed during the process 400, such as in sequence or in parallel (as where a dentist and a laboratory evaluate a scan simultaneously), and all such variations are intended to fall within the scope of this disclosure.

[00198] Any of the quality control steps above may advantageously be performed while a dental patient is still present at a dental office, or while the patient is still in a dental chair, thus reducing or eliminating the need for follow up dental visits for additional scanning.

[00199] After one or more quality control steps 406-410, a determination may be made as to whether a scan and/or surface preparations are satisfactory. If the data is not satisfactory, the process 400 may proceed to step 414 where the digital model may be supplemented or replaced with new scan data. This may include, for example, new scanning to replace apparently erroneous or inadequate scan data, or a new scan of the dental subject matter following, e.g., additional surface preparation consistent with errors identified during quality control. The process 400 may then return to step 404 where a new digital model is obtained.

[00200] If it is determined in step 412 that the data is satisfactory, the process 400 may proceed to step 416 where a dentist may prepare a prescription. The prescription may include, for example, a dental patient identification, an identification of one or more teeth being treated, a type of treatment (e.g., for a restoration, one or more of a bridge, a crown, an inlay, a laminate veneer, an onlay, or a temporary), an identification of missing teeth (if appropriate), a material or fabrication technology (e.g., full ceramic, cast metal, PFM, etc.), an alloy type (e.g., for a PFM crown), a manufacturer (e.g., Cercon, Cerec, Empress, Everest, Lava, Procera, etc.), limited occlusal clearance (e.g., enamalplasty, reduction coping, etc.), a shade guide (e.g., Vita 3D Master, Vita Classical, etc.), a surface texture, a surface glaze, an opacity, an occlusal staining, dental notes, and any other information relevant to identification or preparation of the dental object. For example, for a crown the specification may include a material type, a design (such as metal band, 360-degree facial butt porcelain shoulder, facial butt porcelain shoulder, metal occlusal surface, or no metal showing), a return (e.g., biscuit bake, finish, metal try-in, etc.). Each specification may include subspecifications. For example, a metal band crown may be specified as having the metal band located at a buccal location, a lingual location, or 360-degree.

[00201] As shown in step 418, once the prescription has been completed, the digital model and prescription may be uploaded to a dental laboratory or other fabrication facility using, for example, the dental network described above. The process 400 may then end, as shown in step 420.

[00202] It will be understood that numerous variations and modifications to the above process 400 may be used. For example, the prescription may be prepared at a different point in the process, such as before scanning so that the prescription data may be used to evaluate sufficiency of the scan data. As another example, each digital model (e.g., native tooth surfaces, bit registration, prepared tooth surfaces) may be separately presented to one or more quality control steps, or the entire digital model may be obtained prior to any quality control analysis. All such variations and modifications are intended to fall within the scope of the methods and systems described herein.

[00203] Fig. 5 shows a dental laboratory procedure using a digital dental model. While described as a dental laboratory procedure, it will be understood that the fabrication and quality control procedures described with reference to Fig. 5 may be performed by any fabrication facility including a dental fabrication facility such as a dental laboratory equipped to receive digital dental data, a model production laboratory (such as a rapid fabrication facility, milling facility, and the like), an in-office dental laboratory at a dental office, or any other dental fabrication facility. The fabrication facility may include a remote facility accessible through the dental network, and digital dental data may be communicated to the fabrication facility directly or through a hub for dental data such as the dental data center described above.

[00204] As shown in step 504, the process 500 may start 502 by receiving a digital model from a dentist or other source. This may include, for example, a digital model, such as a digital surface representation obtained using the image capture system 100 described above, of a surface prepared for a restoration such as a crown, or any other dental object.

[00205] As shown in step 506, the dental laboratory may design and/or fabricate a restoration or other dental object based upon the digital model received in step 504. This may include a variety of fabrication techniques, including working from a physical cast of a dental impression created using conventional dentistry techniques, or three-dimensional printing or other fabrication techniques to manufacture various interim components of dental manufacture such as dies, casts, and the like, or direct fabrication of a virtually designed restoration, such as through computerized milling of the restoration from ceramic.

[00206] In one aspect, designing the restoration may include a step of virtually adding a die spacer to a digital model. It is known in dentistry to employ a die spacer – a thin layer painted onto regions of dental models – to improve the final fit between a prepared tooth surface in a dental patient's mouth and a restoration or other dental object. The die spacer may for example provide a small void between a cast of the prepared surface and a restoration constructed for the cast which may provide a void for cement used with the final fitting, or to account for size changes in the restoration fabrication process. The die spacer may be virtually added to a digital model of a prepared surface to achieve a similar effect with a restoration that is to be directly fabricated from the digital model, or an interim component such as a fabricated cast of a dental impression used to create the restoration. Similarly, where a cast dental model is to be fabricated from a digital model, the die spacer may be added to appropriate regions of the prepared surface and any other suitable surfaces to remove or reduce the need for use of die spacers in subsequent fabrication steps. More generally, a virtual die spacer may be added to a digital model of a conventional dental model, a die, a waxup, or any other interim component of dental manufacture to account for a cementation void or other physical variations in the design of a final restoration. This cementation void or virtual die spacer may be fabricated directly into a die, waxup, or other interim component that may be three-dimensionally printed or otherwise manufactured from the digital model.

[00207] Thus in one aspect, disclosed herein is a virtual die spacer. In fabricating a dental restoration, a virtual dies spacer or cementation void may be specified, either by an originating dental office or a dental laboratory, and this void may be automatically or manually added to appropriate regions of a digital model to provide a corresponding cementation void in a final restoration. As a significant advantage, the thickness of the virtual die spacer may be explicitly specified, and may be adjusted according to, for example, a dentist's preference or according to a type of cement to be used with the restoration. Dentist preferences concerning die spacer thickness may also be stored for reuse, and dentist feedback (e.g., "too tight" or "inadequate void") may be recorded to provide sizing for a final restoration or other dental object that more closely meets and individual dentist's expectations.

[00208] In another aspect, designing the restoration may include virtually ditching a die for a restoration. In conventional dentistry, a material may be cut away from a die below the margin line (which would otherwise include bone, soft tissue, and the like) prior to use as a restoration model. This operation may be performed virtually within a user interface that includes interactive tools for manipulating a three-dimensional representation of dentition. Initially, this may include an automated, semi-automated, or manual step of defining a die in three-dimensional space by identifying a plane, a point, or a line used to separate a die from a model in an operation analogous to physically cutting a die from a conventional dental model. This may be followed by additional steps such as separate steps of explicitly identifying a margin line with a first tool and then manipulating the digital model "below" the margin line, i.e., away from the tooth surface fitted to a restoration, with a second tool to remove unwanted or unneeded areas from a volume bounded by the digital surface representation. This process may be semi-automated or automated, such as by automatic identification of the margin line and removal of a predetermined amount of sub-margin volume. The ditched die may then be directly fabricated using techniques described above.

[00209] Regardless of the interim modeling and fabrication steps, this step may result in a restoration in physical form, such as a crown, bridge, inlay, onlay, or other dental object intended for use by a dental patient.

[00210] As shown in step 508, the restoration may be scanned using, for example, an image capture system 100 such as the system described above with reference to Fig. 1, to obtain a scanned restoration.

[00211] As shown in step 510, the scanned restoration may be test fit to the digital model received in step 504, such as by virtually superimposing the scanned restoration to the digital model. This may permit evaluation of a variety of fit criteria prior to an attempt to fit the physical restoration to a prepared surface in the dental patient's mouth. This includes, for example, an evaluation of margin fit, an evaluation of void space for cement used to affix the restoration to the prepared surface, and any other evaluation relating the prepared surface directly to the restoration or abutting tooth surfaces. This may also include an evaluation of bite, occlusions, lateral excursions and any other evaluation relating to jaw motion or the mating of lower and upper arches with the restoration in place.

[00212] In another aspect, test fitting may include measuring dimensional accuracy of the scanned restoration. For example, the restoration in this context may include a prosthesis, an implant, an appliance, a restorative component, an abutment, a fixture, or any other dental object. The scanned restoration may be measured for fit between adjacent teeth, or for evaluation of contact points with teeth of an opposing arch when the restoration is fitted to a prepared surface (or more specifically, when the scanned restoration is virtually fitted to a scan of the prepared surface), or a fit to the prepared surface, possibly including an allowance for die spacing on one or more surfaces. A dentist may specify a desired tightness of fit, which may be quantified objectively (e.g., in millimeters or microns) or subjectively (e.g., loose, average, tight, etc.).

[00213] In one aspect, feedback from specific dentists may be monitored, so that subsequent restorations may more closely meet each dentist's expectations for a desired tightness of fit.

[00214] In another aspect, measuring dimensional accuracy may include evaluating a quality of margin fit between a scanned restoration and a scanned surface preparation, in order to avoid fitting difficulties at the time of fitting the physical restoration to a patient's dentition.

[00215] As shown in step 512, the test fit of step 510 may be followed by a determination of whether the physical restoration is satisfactory. If the physical restoration is not satisfactory, the process 500 may proceed to step 514 where the physical restoration is reworked, or a new restoration prepared. If the physical restoration is satisfactory, the physical model may be sent to a dental office for a final fitting procedure in the dental patient's mouth. It may also be advantageous to also forward the scan of the restoration to the originating dental office in order to begin preparation for the final fitting procedure. The process 500 may then end 518.

[00216] It will be understood that numerous variations and modifications to the above process 500 may be used. For example, although not depicted in Fig. 5, in certain instances where it appears that a physical restoration cannot be properly fabricated to fit the restoration site, e.g., the prepare surface and surrounding dentition, the dental laboratory may contact the originating dental office to request additional preparation of the target surface. All such variations and modifications are intended to fall within the scope of the methods and systems described herein.

[00217] It will further be appreciated that, even in a system where the digital surface representation is used directly to fabricate a cast dental model to which subsequent, conventional dental laboratory techniques are applied, significant advantages may be realized through elimination or mitigation of physical handling and shipping of a dental impression. Thus in one aspect, there is disclosed herein a technique for acquiring a digital model, such as a digital surface representation, of a prepared surface and/or surrounding dentition, and transmitting the digital model to a dental laboratory or rapid manufacturing facility for preparation of a restoration or other dental object.

[00218] Fig. 6 illustrates a scan path that may be used with a three-dimensional image capture system. In a system that operates to continuously acquire three-dimensional data in real time, and fits or registers incremental three-dimensional data to an aggregate three-dimensional model, it may be advantageous to scan in a manner that increases registration to the aggregate model. Thus, for example, a scan path that runs adjacent to edges of the aggregate model may provide additional registration or fit information and improve overall accuracy, particularly over large surfaces. With respect to scans of human dentition, this general approach suggests an s-shaped scan that traces from interior to exterior (or exterior to interior) surfaces of one tooth, and then reverses direction to trace an exterior-to-interior path immediately adjacent to the initial path, which may reduce overall spatial error between extremities of the arch. Without loss of generality, a more detailed example of this approach is set out below.

[00219] A scan path 600 for obtaining three-dimensional data from a dental arch 602 using a scanner such as the scanner 102 described above with reference to Fig. 1 may begin at a first lingual point 604. The scan path may then traverse laterally over an occlusal point 606 or surface of a molar to a first buccal point 608, translate to a second buccal point 610 by moving forward along the gum line, and then traverse laterally over a second occlusal point to a second lingual point. The scan path may then translate forward once again to a third lingual point, traverse laterally over a third occlusal point to a third buccal point, and once again translate forward. By scanning in this s-shaped manner, each successive pass over occlusal surfaces may be fit to data from an adjacent pass over the occlusal surfaces, as well as to one or more immediately prior frames of data. While the remainder of a scan path is not illustrated in Fig. 6, it will be understood that the scan may continue along the entire arch in this manner, finally reaching a molar 612 at the opposite extremity of the arch.

[00220] It will be understood that the spacing of adjacent passes may be greater or less than illustrated. For example, a buccal-to-lingual pass may cover a portion of a tooth, an entire tooth, or a number of teeth depending upon, for example, the field of view for data acquisition with the scanner. It will also be understood that the starting and ending points of the generally s-shaped scan are somewhat arbitrary. A scan may begin, for example at a lingual point, at an occlusal point, or at a buccal point. Further, the scan may begin at a molar, or the scan may begin at an incisor, with two consecutive scans performed from this central location to each molar extremity of the arch. All such variations are intended to fall within the scope of the scan path described herein. In general, regardless of the starting point, a generally s-shaped scan may move along adjacent buccal-to-lingual passes in the manner described above. In one aspect, real-time feedback may be provided to a user by displaying on a display a next appropriate direction of motion for a scan that follows the generally s-shaped path.

[00221] Figs. 7A and 7B show a modeling environment for creating alignment guides for orthodontic hardware. A three-dimensional representation 702 of dentition and surrounding soft tissue may be acquired from a dental patient as described generally above, and rendered within a user interface 704 on a computer such as the image capture system 100 described above, or more generally, the client 202 described above. In various embodiments, orthodontic hardware may be virtually placed on the three-dimensional representation 702, which may be used to determine appropriate positions for one or more alignment guides, or brackets may themselves be virtually positioned on the three-dimensional representation 702 with corresponding alignment guides being generated by computer, or the alignment guides may be directly positioned on the three-dimensional representation 702. The user interface may include interactive tools for virtually positioning orthodontic hardware and/or brackets for orthodontic hardware and/or alignment guides onto the three-dimensional representation 702 within the user interface 704. The design of orthodontic hardware and any corresponding positioning of brackets or the like, may be performed by a dentist at a dental office and transmitted to a dental laboratory or other fabrication facility, or the unmodified three-dimensional representation may be transmitted to the dental laboratory along with a prescription for orthodontic hardware.

[00222] Fig. 7A shows a three-dimensional representation 702 with visual markings 706 that serve as alignment guides. This marked three-dimensional representation 702, or digital dental model, may serve as a basis for subsequent fabrication of custom orthodontic hardware. The markings 706 may be fabricated directly into a physical realization of the digital dental model, such as using pigmented printing techniques, or the markings 706 may be added to the physical realization after fabrication using additional computerized or manual marking techniques.

[00223] Fig. 7B shows a three-dimensional representation 702 with supports 708 that serve as a physical alignment guide. This three-dimensional representation 702, or digital dental model, may serve as a basis for subsequent fabrication of custom orthodontic hardware. As depicted, each support 708 may include a horizontal top surface or shelf for supporting an orthodontic fixture or other hardware. However, it will be understood that any physical form capable of supporting or engaging the intended hardware may suitable by employed, and fabricated into a physical model. The supports 708 may be fabricated directly into a physical realization of the digital dental model using techniques such as three-dimensional printing, stereo lithography, or computerized milling.

[00224] The alignment guides may serve to guide positioning of an orthodontic fixture onto the physical realization of the digital dental model to assist in fabricating custom orthodontic hardware. In an additional processing step, once the corresponding orthodontic hardware, such as brackets, is positioned onto the physical model, the position of a number of brackets may be captured in a physical template such as a foam, a vacuum-formed appliance, or the like, for direct transfer to an arch within a dental patient's mouth. The appliance may, for example, be formed of a soft, clear material for easy handling by a dentist and/or greater comfort for a dental patient. In such a process, a treating dentist may perform an additional scan of the patient's dentition immediately prior to affixing the brackets to ensure that the natural dentition still corresponds closely to the model used for virtual bracket positioning.

[00225] In another embodiment, additional modeling may be employed to create a virtual bracket carrier model – a device to carry brackets in a specific relative orientation – that can be physically realized as a bracket positioning appliance through direct fabrication using any of the techniques described above. The bracket carrier model may include one or more alignment guides for brackets such as those described generally above. Brackets may then be attached to the bracket positioning appliance for transfer to an arch within a dental patient's mouth. The treating dentist may perform an additional scan of the patient's dentition immediately prior to affixing the brackets to ensure that the natural dentition still corresponds closely to the model used to create the bracket positioning appliance.

[00226] It will be appreciated that the processes and methods disclosed herein may be realized in hardware, software, or any combination of these suitable for the three-dimensional imaging and modeling techniques described herein. This includes realization in one or more microprocessors, microcontrollers, embedded microcontrollers, programmable digital signal processors or other programmable device, along with internal and/or external memory. The may also, or instead, include one or more application specific integrated circuits, programmable gate arrays, programmable array logic components, or any other device or devices that may be configured to process electronic signals. It will further be appreciated that a realization may include computer executable code created using a structured programming language such as C, an object oriented programming language such as C++, or any other high-level or low-level programming language (including assembly languages, hardware description languages, and database programming languages and technologies) that may be stored, compiled or interpreted to run on one of the above devices, as well as heterogeneous combinations of processors, processor architectures, or combinations of different hardware and software. At the same time, processing may be distributed across devices such as a camera and/or computer in a number of ways or all of the functionality may be integrated into a dedicated, standalone image capture device. All such permutations and combinations are intended to fall within the scope of the present disclosure.

[00227] It will also be appreciated that means for performing the steps associated with the processes described above may include any suitable components of the image capture system 100 described above with reference to Fig. 1, along with any software and/or hardware suitable for controlling operation of same. The user interfaces described herein may, for example, be rendered within the display 110 of the image capture system 100 of Fig. 1.

[00228] While the invention has been disclosed in connection with certain preferred embodiments, other embodiments will be recognized by those of ordinary skill in the art, and all such variations, modifications, and substitutions are intended to fall within the scope of this disclosure. Thus, the invention is to be understood with reference to the following claims, which are to be interpreted in the broadest sense allowable by law.

CLAIMS:

What is claimed is:

1. A method comprising:

acquiring a three-dimensional representation of one or more intraoral structures of a dental patient using an intraoral scanner; and

providing the three-dimensional representation to a dental fabrication facility.

2. The method of claim 1, further comprising fabricating a dental restoration at the dental fabrication facility using the three-dimensional representation.

3. The method of claim 1, wherein the dental fabrication facility includes a dental laboratory.

4. The method of claim 1, wherein the one or more intraoral structures include at least one dental implant.

5. The method of claim 1, wherein the one or more intraoral structures include at least one tooth.

6. The method of claim 1, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration.

7. The method of claim 1, wherein the one or more intraoral structures include at least one area of soft tissue.

8. The method of claim 1, wherein the one or more intraoral structures include at least one previously restored tooth.

9. The method of claim 1, further comprising fabricating a dental prosthesis at the dental fabrication facility using the three-dimensional representation.

10. The method of claim 1, further comprising transmitting the three-dimensional representation to a dental laboratory and, in response, receiving an assessment of quality for the three-dimensional representation from the dental laboratory.

11. The method of claim 10, wherein the assessment of quality is received before the dental patient leaves a dentist's office.

12. The method of claim 10, wherein the assessment of quality includes an assessment of acceptability of the three-dimensional representation.

13. The method of claim 6, further comprising transmitting the three-dimensional representation to a dental laboratory and, in response, receiving an assessment of quality of the at least one prepared tooth surface.

14. The method of claim 1, wherein providing the three-dimensional representation to a dental fabrication facility includes transmitting to a remote dental laboratory for fabrication of a dental restoration for the one or more intraoral structures.

15. The method of claim 14, further comprising transmitting the three-dimensional representation to a dental data hub.

16. The method of claim 14, further comprising transmitting a prescription for the dental restoration with the three-dimensional representation.

17. The method of claim 14, further comprising transmitting the three-dimensional representation to a model production laboratory.

18. The method of claim 17, wherein the model production laboratory is a milling facility.

19. The method of claim 17, wherein the model production laboratory is a manufacturing facility.

20. The method of claim 17, wherein the model production laboratory is a three-dimensional rapid prototyping facility.

21. The method of claim 1, wherein providing the three-dimensional representation to a dental fabrication facility includes providing the three-dimensional representation to an in-office dental laboratory for fabrication of a dental restoration for the one or more intraoral structures.

22. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of one or more intraoral structures of a dental patient from an intraoral scanner;

converting the one or more images into a three-dimensional representation of the one or more intraoral structures; and

transmitting the three-dimensional representation to a dental fabrication facility.

23. The computer program product of claim 22, further comprising computer code that performs the step of comparing quality of the three-dimensional representation to predefined quality criteria.

24. The computer program product of claim 23, wherein the predefined quality criteria includes acceptability of the three-dimensional representation for fabrication.

25. The computer program product of claim 22, further comprising computer code that performs the steps of:

retrieving a prescription for at least one of a prosthesis or an appliance prepared by a dentist; and

combining the prescription with the three-dimensional representation prior to transmitting the three-dimensional representation.

26. The computer program product of claim 22, wherein the one or more intraoral structures include at least one dental implant.

27. The computer program product of claim 22, wherein the one or more intraoral structures include at least one tooth.

28. The computer program product of claim 22, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration.

29. The computer program product of claim 28, further comprising computer code that performs the step of comparing quality of the at least one prepared tooth surface to predefined quality criteria.

30. The computer program product of claim 22, wherein the one or more intraoral structures include at least one area of soft tissue.

31. A system comprising:

an intraoral scanner for acquiring a three-dimensional representation of one or more intraoral structures of a dental patient; and

a transmission means for transmitting the three-dimensional representation to a dental fabrication facility.

32. The system of claim 31, further comprising a first fabrication means for fabricating a dental restoration at the dental fabrication facility using the three-dimensional representation.

33. The system of claim 31, wherein the one or more intraoral structures include at least one dental implant.

34. The system of claim 31, wherein the one or more intraoral structures include at least one tooth.

35. The system of claim 31, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration.

36. The system of claim 31, wherein the one or more intraoral structures include at least one area of soft tissue.

37. The system of claim 31, further comprising a second fabrication means for fabricating a dental prosthesis at the dental fabrication facility using the three-dimensional representation.

38. The system of claim 31, further comprising a quality assessment means for assessing quality of the three-dimensional representation.

39. The system of claim 38, wherein the quality assessment means includes a means for determining acceptability of the three-dimensional representation for use with the first fabrication means.

40. The system of claim 38, wherein the quality assessment means includes a means for determining acceptability of the three-dimensional representation for use with the second fabrication means.

41. The system of claim 38, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration, and wherein the quality assessment means includes a means for determining quality of the at least one prepared tooth surface.

42. A method comprising:

receiving a three-dimensional representation of a tooth, the tooth prepared for a dental restoration;

specifying a cementation void between the tooth surface and the dental restoration; and

fabricating the dental restoration such that the dental restoration, when mated to the tooth surface, defines an empty space corresponding to the cementation void.

43. The method of claim 42, further comprising adjusting the cementation void.

44. The method of claim 43, wherein adjusting the cementation void includes adjusting the cementation void according to a dentist's preferences.

45. The method of claim 43, wherein adjusting the cementation void includes:

specifying a type of cement to be used in the cementation void; and

adjusting the cementation void according to the type of cement to be used in the cementation void.

46. The method of claim 42, wherein the cementation void is specified by a dentist.

47. The method of claim 46, wherein the dentist sends the specification of the cementation void to a dental laboratory.

48. The method of claim 47, wherein the cementation void is specified by a dental laboratory.

49. The method of claim 42, further comprising three-dimensionally printing a die including the cementation void.

50. The method of claim 42, further comprising fabricating a die including the cementation void using a stereo lithography apparatus.

51. The method of claim 42, further comprising three-dimensionally printing a wax-up including the cementation void.

52. The method of claim 42, further comprising milling a die including the cementation void.

53. The method of claim 42, further comprising integrating the cementation void into a digital surface representation of the tooth.

54. The method of claim 42, further comprising integrating the cementation void into a dental model.

55. The method of claim 42, wherein the three-dimensional representation includes a digital surface representation of the tooth.

56. The method of claim 42, wherein fabricating the dental restoration includes fabricating the dental restoration in an in-house laboratory in a dentist's office.

57. The method of claim 42, further comprising fabricating an opposing arch for an arch including the tooth, the opposing arch including a die spacer having a predetermined thickness.

58. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of a tooth of a dental patient from an intraoral scanner, the tooth including a tooth surface prepared for a dental restoration;

converting the one or more images into a three-dimensional representation of the tooth;

specifying a cementation void between the tooth surface and the dental restoration;

combining the specification for the cementation void with the three-dimensional representation into a fabrication specification; and

transmitting the fabrication specification to a dental fabrication facility.

59. The computer program product of claim 58, wherein a dentist specifies the cementation void.

60. The computer program product of claim 58, further comprising computer code that performs the step of receiving a specification of the cementation void from the dental fabrication facility.

61. The computer program product of claim 58 further comprising code for three-dimensionally printing the cementation void to a die.

62. The computer program product of claim 58 further comprising code for three-dimensionally printing the cementation void to a wax up.

63. The computer program product of claim 58, further comprising computer code that performs the step of integrating the cementation void into a digital surface representation of the tooth.

64. A system comprising:

a first means for three-dimensionally representing a tooth, the tooth prepared for a dental restoration;

a second means for specifying a cementation void, the cementation void representing an empty space between the tooth surface and the dental restoration; and

a fabrication means for fabricating the dental restoration such that the dental restoration, when mated to the tooth surface, defines an empty space corresponding to the cementation void.

65. The system of claim 64, further comprising an adjustment means for adjusting the cementation void.

66. The system of claim 65, wherein the adjustment means includes means for incorporating a dentist's preferences.

67. The system of claim 65, wherein the adjustment means includes means for adjusting the cementation void according to a type of cement.

68. The system of claim 64, further comprising a first printing means for three-dimensionally printing a die including the cementation void.

69. The system of claim 64, further comprising a second printing means for three-dimensionally printing a wax-up including the cementation void.

70. The system of claim 64, further comprising a milling means for milling a die including the cementation void.

71. The system of claim 64, further comprising a milling means for milling an investment chamber for casting including the cementation void.

72. The system of claim 64, further comprising a model means for integrating the cementation void into a model of a dental impression.

73. The system of claim 64, wherein the three-dimensional representation of a tooth includes a digital surface representation of the tooth.

74. A method comprising:
fabricating a dental object;
acquiring a first three-dimensional representation of the dental object; and
measuring a dimensional accuracy of the first three-dimensional representation.

75. The method of claim 74, wherein the first three-dimensional representation includes a digital surface representation.

76. The method of claim 74, wherein the dental object includes a dental prosthesis.

77. The method of claim 74, wherein the dental object includes a dental implant.

78. The method of claim 74, wherein the dental object includes a dental appliance.

79. The method of claim 74, wherein the dental object includes a restorative component.

80. The method of claim 74, wherein the dental object includes a dental restoration.

81. The method of claim 74, wherein the dental object includes an abutment.

82. The method of claim 74, further comprising acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy includes evaluating a fit between the item of the first three-dimensional representation and the at least one tooth surface of the second three-dimensional representation.

83. The method of claim 74, further comprising acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy includes evaluating one or more contact points between the item of the first three-dimensional representation and the one or more teeth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface.

84. The method of claim 74, further comprising acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object and at least one opposing tooth, wherein measuring a dimensional accuracy includes evaluating one or more contact points between the item of the first three-dimensional representation and the at least one opposing tooth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface.

85. The method of claim 74 wherein the second three-dimensional representation is acquired as a plurality of separate scans.

86. The method of claim 74 wherein the second three-dimensional representation is acquired as a continuous scan of the at least one tooth surface and the at least one opposing tooth in occlusion.

87. The method of claim 74, wherein a dentist specifies tightness of fit of the dental object.

88. The method of claim 74, wherein measuring a dimensional accuracy includes quantifying tightness of fit of the dental object.

89. The method of claim 74, wherein measuring a dimensional accuracy includes measuring quality of a margin.

90. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of a dental object;

converting the one or more images of the dental object into a first three-dimensional representation of the item; and

measuring a dimensional accuracy of the first three-dimensional representation.

91. The computer program product of claim 90, wherein the first three-dimensional representation includes a digital surface representation.

92. The computer program product of claim 90, wherein the dental object includes a dental prosthesis.

93. The computer program product of claim 90, wherein the dental object includes a dental implant.

94. The computer program product of claim 90, wherein the dental object includes a dental appliance.

95. The computer program product of claim 90, wherein the dental object includes a restorative component.

96. The computer program product of claim 90, wherein the dental object includes an abutment.

97. The computer program product of claim 90, wherein the dental object includes a restoration.

98. The computer program product of claim 90, further comprising computer code that performs the steps of:

acquiring one or more images of one or more teeth including at least one tooth surface prepared for the dental object; and

converting the one or more images of the one or more teeth into a second three-dimensional representation of the one or more teeth, wherein measuring a dimensional accuracy includes evaluating a fit between the item of the first three-dimensional representation and the at least one tooth surface of the second three-dimensional representation.

99. The computer program product of claim 90, further comprising computer code that performs the steps of:

acquiring one or more images of one or more teeth including at least one tooth surface prepared for the dental object;

converting the one or more images of the one or more teeth into a second three-dimensional representation of the one or more teeth; and

generating one or more contact points between the item of the first three-dimensional representation and the one or more teeth of the second three-dimensional representation by virtually affixing the item to the at least one tooth surface, wherein measuring includes evaluating one or more contact points.

100. The computer program product of claim 90, further comprising computer code that performs the steps of:

acquiring one or more images of one or more teeth including at least one tooth surface prepared for the dental object and at least one opposing tooth;

converting the one or more images of the one or more teeth and the at least one opposing tooth into a second three-dimensional representation of the one or more teeth and the at least one opposing tooth; and

generating one or more contact points between the item of the first three-dimensional representation and the at least one opposing tooth of the second three-dimensional representation by virtually affixing the item to the at least one tooth surface, wherein measuring includes evaluating one or more contact points.

101. The computer program product of claim 90, wherein measuring a dimensional accuracy includes quantifying tightness of fit of the dental object.

102. The computer program product of claim 90, wherein measuring a dimensional accuracy includes measuring quality of a margin.

103. A system comprising:

a fabrication means for fabricating a dental object;

a first means for acquiring a first three-dimensional representation of the item; and

a measurement means for measuring a dimensional accuracy of the first three-dimensional representation.

104. The system of claim 103, wherein the first three-dimensional representation includes a digital surface representation.

105. The system of claim 103, wherein the dental object includes a dental prosthesis.

106. The system of claim 103, wherein the dental object includes a dental implant.

107. The system of claim 103, wherein the dental object includes a dental appliance.

108. The system of claim 103, wherein the dental object includes a restorative component.

109. The system of claim 103, wherein the dental object includes a dental restoration.

110. The system of claim 103, wherein the dental object includes an abutment.

111. The system of claim 103, further comprising a second means for acquiring a second three-dimensional representation of one or more teeth including at least one tooth

surface prepared for the dental object, wherein measuring a dimensional accuracy includes evaluating a fit between the item of the first three-dimensional representation and the at least one tooth surface of the second three-dimensional representation.

112. The system of claim 103, further comprising a second means for acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object, wherein measuring a dimensional accuracy includes evaluating one or more contact points between the item of the first three-dimensional representation and the one or more teeth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface.

113. The system of claim 103, further comprising a second means for acquiring a second three-dimensional representation of one or more teeth including at least one tooth surface prepared for the dental object and at least one opposing tooth, wherein measuring a dimensional accuracy includes evaluating one or more contact points between the item of the first three-dimensional representation and the at least one opposing tooth of the second three-dimensional representation when the item is virtually affixed to the at least one tooth surface.

114. The system of claim 103, wherein a dentist specifies tightness of fit of the dental object.

115. The system of claim 103, wherein measuring a dimensional accuracy includes quantifying tightness of fit of the dental object.

116. The system of claim 103, wherein measuring a dimensional accuracy includes measuring quality of a margin.

117. A method comprising:

acquiring a three-dimensional representation including three-dimensional surface data for at least two independent dental structures; and acquiring motion data characterizing a relative motion of the at least two independent dental structures with respect to one another within a mouth.

118. The method of claim 117, further comprising deriving TMJ condyle paths of rotation and translation from the motion data and the three-dimensional surface data.

119. The method of claim 117, further comprising providing input to a virtual dental articulator.

120. The method of claim 117, further comprising providing specifications for a physical dental articulator.

121. The method of claim 117, further comprising providing specifications for a disposable dental articulator.

122. The method of claim 117, wherein acquiring the three-dimensional representation includes acquiring the three-dimensional representation using an intraoral scanner.

123. The method of claim 117, wherein acquiring motion data includes acquiring motion data from a video source.

124. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of at least two independent dental structures of a dental patient from an intraoral scanner;

converting the one or more images into a three-dimensional representation of the at least two independent dental structures; and

acquiring motion data characterizing a relative motion of the at least two independent dental structures with respect to one another.

125. The computer program product of claim 124 further comprising code that performs the step of combining the three-dimensional representation with the motion data to derive TMJ condyle paths of rotation and translation.

126. The computer program product of claim 124, further comprising computer code that performs the steps of:

generating an image sequence of the combined three-dimensional representation and the motion data; and

generating a display signal of the image sequence.

127. The computer program product of claim 124, wherein acquiring motion data includes acquiring motion data from a video source.

128. A system comprising:

a first means for acquiring one or more images of at least two independent dental structures of a dental patient;

a conversion means for converting the one or more images into a three-dimensional representation of the at least two independent dental structures; and

a second means for acquiring motion data characterizing a relative motion of the at least two independent dental structures with respect to one another.

129. The system of claim 128, further comprising an analysis means for deriving TMJ condyle paths of rotation and translation using the three-dimensional representation and the motion data.

130. The system of claim 128, further comprising an action means for combining the three-dimensional representation and the motion data to generate an articulation input.

131. The system of claim 130, further comprising a first model means for virtually articulating the articulation input.

132. The system of claim 130, further comprising a second model means for physically articulating the articulation input.

133. The system of claim 130, further comprising a disposable model means for physically articulating the articulation input.

134. The system of claim 128, wherein the first means includes a means for acquiring the one or more images using an intraoral scanner.

135. The system of claim 128, wherein the second means includes a means for acquiring the motion data from a video source.

136. A method comprising:

receiving an electronic dental prescription including prescription data, a first three-dimensional representation of one or more intraoral structures including at least one tooth surface prepared for an artificial dental object, and a second three-dimensional representation of the at least one tooth surface prior to preparation for the artificial dental object; and

fabricating the artificial dental object for the one or more intraoral structures using the electronic dental prescription.

137. The method of claim 136, wherein an electronic dental prescription includes receiving a three-dimensional representation from a dental data hub.

138. The method of claim 136, wherein an electronic dental prescription includes receiving a three-dimensional representation from a dentist.

139. The method of claim 136, wherein the electronic dental prescription includes a prescription for a dental restoration for the tooth surface.

140. The method of claim 136, wherein at least one of the first and second three-dimensional representations includes a digital surface representation of a full arch.

141. The method of claim 136, wherein the electronic dental prescription includes a prescription for one or more of an appliance, a prosthesis, or an item of dental hardware.

142. The method of claim 136, wherein fabricating an artificial dental object includes fabricating a dental restoration in an in-house laboratory in a dentist's office.

143. A system comprising:

a communication means for receiving an electronic dental prescription including prescription data, a first three-dimensional representation of one or more intraoral structures including at least one tooth surface prepared for an artificial dental object, and a second three-dimensional representation of the at least one tooth surface prior to preparation for the artificial dental object; and

a fabrication means for fabricating an artificial dental object for the one or more intraoral structures using the three-dimensional representation.

144. The system of claim 143, wherein the communication means includes a means for receiving the electronic dental prescription from a dental data hub.

145. The system of claim 143, wherein the communication means includes a means for receiving the electronic dental prescription from a dentist.

146. The system of claim 143, wherein the electronic dental prescription includes a prescription for a dental restoration.

147. The system of claim 143, wherein the three-dimensional representation includes a digital surface representation of a full arch.

148. The system of claim 143, wherein the electronic dental prescription includes a prescription for one or more of an appliance, a prosthesis, and an item of dental hardware.

149. The system of claim 143, wherein the fabrication means includes an in-house laboratory in a dentist's office.

150. A method comprising, within a single dental visit, the steps of:

acquiring a three-dimensional representation of one or more intraoral structures from a dental patient, the intraoral structures including at least one tooth surface prepared for an artificial dental object; and

processing the three-dimensional representation to provide feedback to a dentist concerning the at least one tooth surface.

151. The method of claim 150, wherein the feedback identifies corrective action.

152. The method of claim 151, wherein the corrective action includes acquiring an additional three-dimensional representation of the one or more intraoral structures.

153. The method of claim 151, wherein the corrective action includes additional surface preparation of the at least one tooth.

154. The method of claim 150, wherein the feedback identifies a margin for fitting the dental restoration to the at least one tooth surface.

155. The method of claim 154, wherein the margin for fitting can be edited.

156. The method of claim 150, wherein the feedback includes a visual display of one or more regions of inadequate margin for fitting the dental restoration to the at least one tooth surface.

157. The method of claim 150, wherein the feedback includes a visual display recommending additional preparatory work required for the at least one tooth surface.

158. The method of claim 150, wherein the feedback includes a visual display recommending acquiring additional three-dimensional representations of one or more regions of the one or more intraoral structures.

159. The method of claim 150, wherein the feedback includes identifying an incomplete three-dimensional representation.

160. The method of claim 150, wherein the feedback includes identifying errors in the three-dimensional representation.

161. The method of claim 150, wherein the feedback includes visual highlighting of a margin line on a display of the three-dimensional representation.

162. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of one or more intraoral structures of a dental patient, the intraoral structures including at least one tooth surface prepared for an artificial dental object;

converting the one or more images into a three-dimensional representation of the one or more intraoral structures;

analyzing the at least one tooth surface within the three-dimensional representation;

generating a feedback signal, the feedback signal representative of the result of analyzing the at least one tooth surface; and

outputting the feedback signal to provide feedback to a dentist.

163. The computer program product of claim 162, wherein the feedback signal identifies corrective action.

164. The computer program product of claim 163, wherein the corrective action includes acquiring an additional one or more images of the one or more intraoral dental structures.

165. The computer program product of claim 163, wherein the corrective action includes additional surface preparation of the at least one tooth.

166. The computer program product of claim 162, wherein the feedback signal identifies a margin for fitting the dental restoration to the at least one tooth surface.

167. The computer program product of claim 162, wherein the margin for fitting can be edited.

168. A system comprising:

a scanning device configured to intraorally capture surface image data from a surface within a mouth of a dental patient, the scanning device adapted to provide real time feedback during a scan by superimposing surface image data onto a video image of the surface;

a computer coupled to the scanning device and receiving the surface image data therefrom, the computer configured to resolve the surface image data into a digital surface reconstruction, the computer further configured to generate a visualization of the digital surface reconstruction and provide the visualization as a display signal; and

a display coupled to the computer and receiving the display signal therefrom, the display converting the display signal into a viewable image of the visualization.

169. The system of claim 168, wherein the surface includes dentition.

170. The system of claim 168, further comprising a user interface controlled by the computer and rendered on the display, the user interface providing at least one tool for analyzing the surface.

171. The user interface of the system of claim 170, further comprising a tool that provides real time feedback to the user.

172. The user interface of the system of claim 171, wherein the real time feedback includes visual cues within the rendered image.

173. The system of claim 170, wherein the scanning device captures surface image data at a video frame rate.

174. The system of claim 170, wherein the at least one tool includes a distance measurement tool.

175. The system of claim 170, wherein the at least one tool includes a tool that evaluates adequacy of tooth structure removal from a dental restoration surface preparation.

176. The system of claim 170, wherein the at least one tool includes a tool that evaluates adequacy of margin preparations.

177. The system of claim 170, wherein the at least one tool includes a tool that evaluates taper.

178. The system of claim 170, wherein the at least one tool includes a tool that evaluates undercut.

179. The system of claim 170, wherein the at least one tool includes a tool that identifies scan deficiencies.

180. The system of claim 179, wherein the scan deficiencies include holes in the surface.

181. The system of claim 170, wherein the at least one tool includes a tool that evaluates adequacy of removal path in multiple unit preparation.

182. The system of claim 170, wherein the at least one tool includes a tool that identifies irregularities in one or more occlusal surfaces requiring further preparation.

183. The system of claim 170, wherein analyzing the surface includes an evaluation of suitability for three-dimensional printing.

184. The system of claim 170, wherein analyzing the surface includes an evaluation of suitability for milling.

185. The system of claim 170, wherein analyzing the surface includes an evaluation of suitability for manual fabrication.

186. The system of claim 168, wherein the computer is further configured to automatically annotate the visualization with a visual indication of an evaluation.

187. The system of claim 186, wherein the visual indication includes an evaluation of contour of a surface preparation.

188. The system of claim 186, wherein the surface image data includes at least two tooth surfaces in occlusion.

189. The system of claim 186, wherein the visual indication includes an evaluation of margin of a surface preparation.

190. The system of claim 186, wherein the visual indication includes an evaluation of occlusal clearance of a surface preparation.

191. The system of claim 186, wherein the surface includes at least one surface prepared for a dental prosthesis, the evaluation including an evaluation of an adequacy of the at least one surface for receiving the dental prosthesis.

192. The system of claim 186, wherein the visual indication includes display of a contour of an actual tooth and a computer-generated surface preparation.

193. The system of claim 192, wherein the computer-generated surface preparation is based upon intact configuration of the actual tooth prior to preparation.

194. A method comprising:

receiving a three-dimensional representation including three-dimensional surface data from an intraoral structure including at least one tooth having a tooth surface prepared for a dental restoration; and

presenting the three-dimensional representation in a user interface, the user interface including a first tool for identifying a margin line for the dental restoration on the at least one tooth and a second tool for recessing a region of the three-dimensional representation below the margin line.

195. The method of claim 194, wherein the first tool provides automated identification of the margin line.

196. The method of claim 194, further comprising removing a portion of the three-dimensional representation below the margin line with the second tool.

197. The method of claim 194, further comprising removing a portion of the three-dimensional representation below the margin line with the second tool to provide a virtual ditched die, and three-dimensionally printing the ditched die.

198. A system comprising:

a means for receiving a three-dimensional representation including three-dimensional surface data from an intraoral structure including at least one tooth having a tooth surface prepared for a dental restoration; and

a user interface means for presenting the three-dimensional representation to a user, the user interface means including a first tool means for identifying a margin line for the dental restoration on the at least one tooth and a second tool means for recessing a region of the three-dimensional representation below the margin line.

199. The system of claim 198, wherein the first tool means includes a means for providing automated identification of the margin line.

200. The system of claim 198, further comprising a means for removing a portion of the three-dimensional representation below the margin line.

201. The system of claim 198, further comprising a means for removing a portion of the three-dimensional representation below the margin line to provide a virtual ditched die, and a means for three-dimensionally printing the ditched die.

202. A method comprising:

acquiring a digital dental impression including three-dimensional surface data for at least two independent dental structures; and

acquiring orientation data defining a relative position of at least a portion of each of the at least two independent dental structures while in occlusion.

203. The method of claim 202, wherein the orientation data includes three-dimensional surface data that spans the at least two independent dental structures while in occlusion.

204. The method of claim 202, wherein the orientation data includes three-dimensional surface data from each of the at least two independent dental structures while in occlusion.

205. The method of claim 202, wherein the occlusion includes a centric occlusion.

206. The method of claim 202, further comprising applying the orientation data to position a virtual model of the at least two independent dental structures in a virtual articulator.

207. The method of claim 202, further comprising fabricating models of each of the at least two independent dental structures and applying the orientation data to position the models within a dental articulator.

208. The method of claim 202, wherein acquiring orientation data includes acquiring three-dimensional data of a buccal side of dentition.

209. The method of claim202, wherein acquiring orientation data includes acquiring three-dimensional data of a labial side of dentition.

210. A system comprising:

a first acquisition means for acquiring a digital dental impression including three-dimensional surface data for at least two independent dental structures; and

a second acquisition means for acquiring orientation data defining a relative position of at least a portion of each of the at least two independent dental structures while in occlusion.

211. The system of claim 210, wherein the orientation data includes three-dimensional surface data that spans the at least two independent dental structures while in occlusion.

212. The system of claim 210, wherein the orientation data includes three-dimensional surface data from each of the at least two independent dental structures while in occlusion.

213. The system of claim 210, wherein the occlusion includes a centric occlusion.

214. The system of claim 210, further comprising a model means for virtually articulating the at least two independent dental structures.

215. The system of claim 210, further comprising:

a fabrication means for fabricating models of each of the at least two independent dental structures; and

a model means for physically articulating the fabricated models.

216. The system of claim 210, wherein the orientation data includes three-dimensional data of a buccal side of dentition.

217. The system of claim210, wherein the orientation data includes three-dimensional data of a labial side of dentition.

218. A method comprising:

providing an intraoral three-dimensional scanning device; and

scanning a plurality of teeth in an arch with the device in a scan path that includes a motion that begins at a first lingual point, traverses laterally over a first occlusal point and a first buccal point, translates to a second buccal point adjacent to the first buccal point, and then traverses laterally over a second occlusal point adjacent to the first occlusal point and a second lingual point adjacent to the first lingual point.

219. The method of claim 218, further comprising scanning the plurality of teeth in the arch with the device using a motion that translates to a third lingual point, and then

traverses laterally over a third occlusal point adjacent to the second occlusal point and a third buccal point adjacent to the second buccal point.

220. The method of claim 218, wherein the first lingual point and the second lingual point are spaced apart such that a field of view of the scanning device includes at least one overlapping portion of the plurality of teeth when the scanning device is positioned to image the first and second lingual points respectively.

221. The method of claim 218, wherein the scan path begins at a third buccal point.

222. The method of claim 218, wherein the scan path begins at a third palatal point.

223. The method of claim 218, wherein the scan path begins at a third labial point.

224. A method comprising, within a single dental visit, the steps of:

acquiring a three-dimensional representation of one or more intraoral structures including at least one tooth prepared for a dental restoration; and

processing the three-dimensional representation to provide feedback to a dentist concerning the at least one tooth.

225. The method of claim 224, wherein the feedback includes a physical dimension.

226. The method of claim 224, wherein the feedback includes a dimension of the at least one tooth prior to preparation for the dental restoration.

227. The method of claim 224, wherein the feedback includes a contour of the at least one tooth.

228. The method of claim 224, wherein the feedback includes a clearance relative to one or more adjacent teeth for a dental restoration associated with the at least one tooth.

229. The method of claim 224, wherein the feedback includes a clearance relative to one or more teeth in an opposing occluded arch.

230. The method of claim 224, wherein the feedback includes a position of the at least one tooth.

231. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring a three-dimensional representation of one or more intraoral structures including at least one tooth prepared for a dental restoration;

analyzing the three-dimensional representation;

generating a feedback signal, the feedback signal representing the analysis of the three-dimensional representation; and

outputting the feedback signal to a dentist.

232. The computer program product of claim 231, wherein the feedback signal includes a physical dimension.

233. The computer program product of claim 231, wherein the feedback signal includes a dimension of the at least one tooth prior to preparation for the dental restoration.

234. The computer program product of claim 231, wherein the feedback signal includes a contour of the at least one tooth.

235. The computer program product of claim 231, wherein the feedback signal includes a clearance relative to one or more adjacent teeth for a dental restoration associated with the at least one tooth.

236. The computer program product of claim 231, wherein the feedback signal includes a clearance relative to one or more teeth of an opposing occluded arch.

237. The computer program product of claim 231, wherein the feedback signal includes a position of the at least one tooth.

238. A system comprising:

an acquisition means for acquiring a three-dimensional representation of one or more intraoral structures including at least one tooth prepared for a dental restoration;

an analysis means for analyzing the three-dimensional representation;

a means for generating a feedback signal, the feedback signal representing the analysis of the three-dimensional representation; and

a signal means for providing the feedback signal to a dentist.

239. The system of claim 238, wherein the feedback signal includes a physical dimension.

240. The system of claim 238, wherein the feedback signal includes a dimension of the at least one tooth prior to preparation for the dental restoration.

241. The system of claim 238, wherein the feedback signal includes a contour of the at least one tooth.

242. The system of claim 238, wherein the feedback signal includes a clearance relative to one or more adjacent teeth for a dental restoration associated with the at least one tooth.

243. The system of claim 238, wherein the feedback signal includes a clearance relative to one or more teeth in an opposing occluded arch.

244. The system of claim 238, wherein the feedback signal includes a position of the at least one tooth.

245. A method comprising:

acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures; and

providing a visual display of the three-dimensional representation in real time.

246. The method of claim 245, wherein the visual display of the three-dimensional representation is superimposed on a real time two-dimensional video image of the one or more intraoral structures.

247. The method of claim 245, wherein the one or more intraoral structures include at least one tooth.

248. The method of claim 245, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration.

249. The method of claim 245, wherein the one or more intraoral structures include at least one restored tooth.

250. The method of claim 245, wherein the one or more intraoral structures include at least one implant.

251. The method of claim 245, wherein one or more intraoral structures include at least one area of soft tissue.

252. The method of claim 245, further comprising processing the three-dimensional representation to generate user feedback concerning the one or more intraoral structures, and providing a visual display of the user feedback.

253. The method of claim 252 wherein the feedback includes highlighting areas in the three-dimensional representation requiring additional attention.

254. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of one or more intraoral structures;

processing the one or more images into a three-dimensional representation including a digital surface representation of the one or more intraoral structures; and

generating a first visual display signal of the three-dimensional representation in real time.

255. The computer program product of claim 254, further comprising computer code that performs the step of generating a second visual display signal wherein the three-dimensional representation is superimposed on a real time two-dimensional video image of the one or more intraoral structures.

256. The computer program product of claim 254, wherein the one or more intraoral structures include at least one tooth.

257. The computer program product of claim 254, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration.

258. The computer program product of claim 254, wherein the one or more intraoral structures include at least one area of soft tissue.

259. The computer program product of claim 254, wherein the one or more intraoral structures include at least one implant.

260. The computer program product of claim 254, wherein the one or more intraoral structures include at least one restored tooth.

261. The computer program product of claim 254, further comprising computer code that performs the steps of:

analyzing the three-dimensional representation;

generating a feedback signal representative of the analysis of the three-dimensional representation; and

generating a third visual display signal including the feedback signal.

262. The computer program product of claim 261, wherein the third visual display signal includes highlighted areas of the three-dimensional representation requiring additional attention.

263. A system comprising:

an acquisition means for acquiring a three-dimensional representation from a dental patient, the three-dimensional representation including a digital surface representation of one or more intraoral structures; and

a display means for visually displaying the three-dimensional representation in real time.

264. The system of claim 263, wherein the display means includes a means for superimposing the three-dimensional representation on a real time two-dimensional video image of the one or more intraoral structures.

265. The system of claim 263, wherein the one or more intraoral structures include at least one tooth.

266. The system of claim 263, wherein the one or more intraoral structures include at least one tooth surface prepared for a dental restoration.

267. The system of claim 263, wherein the one or more intraoral structures include at least one area of soft tissue.

268. The system of claim 263, wherein the one or more intraoral structures include at least one implant.

269. The system of claim 263, wherein the one or more intraoral structures include at least one restored tooth.

270. The system of claim 263, further comprising:

an analysis means for analyzing the three-dimensional representation;

a feedback means for generating a feedback signal representative of the analysis of the three-dimensional representation, wherein the display means includes a means for visually displaying the feedback signal.

271. The system of claim 270, wherein the feedback means includes a means for highlighting areas in the three-dimensional representation requiring additional attention.

272. A handheld imaging device for a three-dimensional imaging system comprising:

an elongated body including a first end, a second end, and a central axis;

a video rate three-dimensional scanning device within the elongated body, the video rate three-dimensional scanning device having an optical axis for receiving images, the optical axis substantially perpendicular to the central axis at a position near the first end of the elongated body; and

the second end adapted for gripping by a human hand, and the second end including a user input responsive to user manipulation to generate control signals for transmission to a processor associated with the imaging system.

273. The device of claim 272, wherein the user input includes a mouse, track ball, button, switch, mini joystick, touchpad, keypad, or thumb wheel.

274. The device of claim 272, wherein the control signals are transmitted to the processor through a wireless communication medium.

275. The device of claim 272, wherein the user input controls a user interface associated with the imaging system.

276. A handheld imaging device for a three-dimensional imaging system comprising:

an elongated body including a central axis, a first end, and a second end, the second end adapted for gripping by a human hand and a central axis;

a video rate three-dimensional scanning device within the elongated body, the video rate three-dimensional scanning device having an optical axis for receiving images, the optical axis substantially perpendicular to the central axis at a position near the first end of the elongated body; and

a physical offset shaped and sized to maintain a desired distance of the first end from an imaging subject along the optical axis.

277. The device of claim 276, wherein the physical offset includes one or more wheels for slidably engaging a surface of the imaging subject.

278. A method comprising:

acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures, the intraoral structures including a dental arch;

processing the three-dimensional representation to provide a digital dental model including one or more alignment guides to aid in positioning an orthodontic fixture; and

fabricating a physical model from the digital dental model.

279. The method of claim 278, further comprising constructing the orthodontic fixture on the physical model using the alignment guides.

280. The method of claim 278, further comprising constructing a support for the orthodontic fixture on the digital dental model.

281. The method of claim 278, wherein the alignment guides include visual markings.

282. The method of claim 278, wherein the alignment guides include at least one substantially horizontal shelf for the orthodontic fixture.

283. The method of claim 278, wherein processing includes virtually placing a plurality of orthodontic brackets onto the three-dimensional representation, and adding a plurality of bracket supports to the digital dental model to support a physical realization of the plurality of orthodontic brackets on the physical model.

284. The method of claim 283, further comprising fabricating the physical realization of the plurality of orthodontic brackets, positioning each one of the plurality of orthodontic brackets onto the physical model, and vacuum forming an appliance over the plurality of orthodontic brackets, the appliance maintaining the plurality of orthodontic brackets in fixed relation to one another.

285. The method of claim 284, further comprising applying the appliance with the plurality of orthodontic brackets to the dental arch.

286. The method of claim 284, wherein the appliance is formed of a soft, clear material.

287. The method of claim 278, further comprising transmitting the digital dental model to a remote dental laboratory.

288. The method of claim 278, wherein processing includes virtually placing a plurality of orthodontic brackets onto the three-dimensional representation in a bracket arrangement, and generating a digital model of a bracket guide adapted to position a physical realization of the plurality of orthodontic brackets in the bracket arrangement on the dental arch.

289. The method of claim 288, further comprising three-dimensionally printing the bracket guide.

290. The method of claim 278, wherein fabricating the physical model includes fabricating the physical model in an in-house dental laboratory in a dentist's office.

291. A method comprising:

acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures, the intraoral structures including a dental arch;

adding a plurality of virtual brackets to the three-dimensional representation to provide a bracket model;

processing the bracket model to generate a bracket guide model, the bracket guide model adapted to maintain a physical realization of the plurality of virtual brackets in a fixed orientation with respect to one another, the fixed orientation corresponding to a desired orientation of the physical realization on the dental arch;

fabricating a bracket guide from the bracket guide model; and

attaching the physical realization of the plurality of virtual brackets to the bracket guide model.

292. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of one or more intraoral structures, the intraoral structures including a dental arch;

processing the one or more images into a three-dimensional representation of the one or more intraoral structures;

transforming the three-dimensional representation into a digital dental model, the digital dental model including one or more orthodontic fixture alignment guides; and

generating a virtual orthodontic fixture using the alignment guides.

293. The computer program product of claim 292, further comprising computer code that performs the step of constructing a support for the virtual orthodontic fixture on the digital dental model.

294. The computer program product of claim 292, wherein the alignment guides include visual markings.

295. The computer program product of claim 292, wherein the alignment guides include at least one substantially horizontal shelf for the virtual orthodontic fixture.

296. The computer program product of claim 292, wherein transforming includes virtually placing a plurality of orthodontic brackets onto the dental arch of the three-dimensional representation, and adding a plurality of bracket supports to the digital dental model.

297. The computer program product of claim 292, further comprising computer code that performs the step of transmitting the digital dental model to a remote dental laboratory.

298. A system comprising:

an acquisition means for acquiring a three-dimensional representation from a dental patient including a digital surface representation of one or more intraoral structures, the intraoral structures including a dental arch;

a processing means for processing the three-dimensional representation to provide a digital dental model including one or more alignment guides to aid in positioning an orthodontic fixture; and

a first fabrication means for fabricating a physical model from the digital dental model.

299. The system of claim 298, further comprising a means for constructing the orthodontic fixture on the physical model using the alignment guides.

300. The system of claim 298, wherein the processing means includes a means for constructing a support for the orthodontic fixture on the digital dental model.

301. The system of claim 298, wherein the alignment guides include visual markings.

302. The system of claim 298, wherein the alignment guides include at least one substantially horizontal shelf for the orthodontic fixture.

303. The system of claim 298, wherein the processing means includes a means for virtually placing a plurality of orthodontic brackets onto the three-dimensional representation, and adding a plurality of bracket supports to the digital dental model to support a physical realization of the plurality of orthodontic brackets on the physical model.

304. The system of claim 303, further comprising a second fabrication means for fabricating the physical realization of the plurality of orthodontic brackets, a positioning means for positioning each one of the plurality of orthodontic brackets onto the physical model, and a forming means for vacuum forming an appliance over the plurality of orthodontic brackets, the appliance maintaining the plurality of orthodontic brackets in fixed relation to one another.

305. The system of claim 304, further comprising a means for applying the appliance with the plurality of orthodontic brackets to the dental arch.

306. The system of claim 304, wherein the appliance is formed of a soft, clear material.

307. The system of claim 298, further comprising a communication means for transmitting the digital dental model to a remote dental laboratory.

308. The system of claim 298, wherein the processing means includes a means for virtually placing a plurality of orthodontic brackets onto the three-dimensional representation in a bracket arrangement, and a model means for generating a digital model of a bracket guide adapted to position a physical realization of the plurality of orthodontic brackets in the bracket arrangement on the dental arch.

309. The system of claim 308, further comprising a printing means for three-dimensionally printing the bracket guide.

310. The system of claim 298, wherein the fabrication means includes a means for fabricating the physical model in an in-house dental laboratory in a dentist's office.

311. A three-dimensional data acquisition system adapted for intraoral acquisition of dental data from one or more intraoral structures, the system including a first operating mode for capturing scan data and rendering a low-quality three-dimensional image from the scan data in real time, and a second operating mode for generating a high-quality three dimensional image from the scan data after exiting the first operating mode, the high-quality three-dimensional image having greater spatial resolution than the low-quality three-dimensional image.

312. The system of claim 311, further including a display that renders the low-quality three-dimensional image superimposed on a video image of the one or more intraoral structures.

313. The system of claim 312, wherein rendering a low-quality three-dimensional image includes rendering the low-quality three-dimensional image at a frame rate of the video image.

314. The system of claim 311, further including a communications interface for transmitting the high-quality three-dimensional image to a dental laboratory.

315. A system comprising:

a scanning device configured to intraorally capture surface image data from a surface within a mouth of a dental patient;

a computer coupled to the scanning device and receiving the surface image data therefrom, the computer configured to resolve the surface image data into a three-dimensional representation, the computer further configured to generate a visualization of the three-dimensional representation and to provide the visualization as a display signal; and

a display coupled to the computer and receiving the display signal therefrom, the display converting the display signal into a viewable image, the display being a touch-screen display adapted to receive a user input through direct contact with a surface of the display, wherein the user input is interpreted by the computer to affect manipulation of the three-dimensional representation.

316. The system of claim 315, wherein the user input affects rotational orientation of the visualization on the display.

317. The system of claim 315, wherein the display includes areas for one or more user controls accessible through the touch-screen display.

318. The system of claim 317, wherein the user controls include a zoom control.

319. The system of claim 317, wherein the user controls include a pan control.

320. The system of claim 317, wherein the user controls include case management controls.

321. The system of claim 320, wherein the case management controls include a control to transmit the three-dimensional representation to a dental lab.

322. The system of claim 320, wherein the case management controls include a control to evaluate quality of the three-dimensional representation.

323. The system of claim 320, wherein the case management controls include a tool to edit the three-dimensional representation.

324. The system of claim 320, wherein the case management controls include a control to create a dental prescription.

325. The system of claim 317, wherein the user controls include a control to define a cementation void.

326. The system of claim 317, wherein the user controls include a control to define a margin line.

327. The system of claim 317, wherein the user controls include a control to infer a margin line from the three-dimensional representation.

328. The system of claim 317, wherein the user controls include a control to recess a region of the three-dimensional representation below a margin line

329. The system of claim 317, wherein the user controls include a control to virtually fit a dental restoration to a prepared tooth surface.

330. The system of claim 317, wherein the user controls include a virtual dental articulator.

331. The system of claim 317, wherein the user controls include a tool to design a dental restoration fitted to the surface within the mouth of the dental patient.

332. The system of claim 315, wherein the three-dimensional model includes two arches; the display including an area for one or more user controls accessible through the touch-screen display to permit positioning the two arches within a virtual articulator.

333. The system of claim 315, further comprising a user interface displayed on the display and controlled by the computer.

334. The system of claim 333, wherein the user interface is accessible through the touch-screen.

335. A system comprising:

a digital dental impression including three-dimensional digital surface data for one or more intraoral structures, the digital dental impression captured using a three-dimensional intraoral scanning device and stored in a computer readable medium;

a first computer configured to render the digital dental impression from a point of view; and

a second computer at a remote location configured to simultaneously render the digital dental impression from the point of view.

336. The system of claim 335, further including a control for passing control of the point of view between the first computer and the second computer.

337. The system of claim 335, further including the first computer and the second computer including a collaborative tool for manipulating the model.

338. The system of claim 335, further including the first computer and the second computer including a collaborative tool for sectioning the model.

339. The system of claim 335, further including the first computer and the second computer including a collaborative tool for rearranging one or more sections of the model.

340. The system of claim 335, further including the first computer and the second computer including a collaborative cursor control tool.

341. The system of claim 335, further including the first computer and the second computer connected by a communication channel.

342. The system of claim 341, wherein the communication channel includes one or more of VoIP, IRC, video conferencing, or instant messaging.

343. The system of claim 335, wherein the second computer is operated by a consulting dentist.

344. The system of claim 335, wherein the second computer is operated by a dental technician.

345. The system of claim 335, wherein the second computer is operated in a dental laboratory.

346. The system of claim 335, wherein the second computer is operated by an oral surgeon.

347. The system of claim 335, wherein the second computer is operated by a dental specialist including one or more of a periodontist, a prosthodontist, a pedodontist, an orthodontic specialist, an oral and maxillofacial surgery specialist, an oral and maxillofacial radiology specialist, an endodontist, and an oral and maxillofacial pathologist.

348. A method comprising:

seating a dental patient in a clinical office;

acquiring a digital dental impression including three-dimensional digital surface data for one or more intraoral structures from an intraoral scan of the dental patient;

transmitting the digital dental impression to a dental laboratory before the patient leaves the office;

receiving an evaluation of the digital dental impression from the dental laboratory before the patient leaves the office; and

if the evaluation is unfavorable, repeating the step of acquiring the digital dental impression.

349. The method of claim 348, wherein the evaluation includes an identification of at least one region of the one or more intraoral structures requiring additional preparation, the method including preparing the one or more intraoral structures according to the evaluation.

350. The method of claim 348, wherein the evaluation includes an evaluation of surface continuity.

351. The method of claim 348, wherein the evaluation includes an evaluation of data density.

352. The method of claim 348, wherein the evaluation includes an evaluation of feature detail.

353. The method of claim 348, wherein one or more intraoral structures includes a tooth surface prepared for a dental restoration.

354. The method of claim 353, wherein the digital dental impression includes a case plan for the restoration.

355. The method of claim 354, wherein the case plan includes a type of restoration.

356. The method of claim 354, wherein the case plan includes a design of restoration.

357. The method of claim 354, wherein the case plan includes a list of restoration components.

358. The method of claim 357, wherein the list of restoration components includes a full ceramic component.

359. The method of claim 357, wherein the list of restoration components includes a PFM component.

360. The method of claim 354, wherein the case plan includes a specification of one or more restoration materials.

361. The method of claim 348 wherein the evaluation includes an evaluation of a margin around a tooth prepared for a restoration.

362. A system comprising:

a means for acquiring a digital dental impression, the digital dental impression including three-dimensional digital surface data for one or more intraoral structures from an intraoral scan of a dental patient seated in a clinical office;

a request means for transmitting the digital dental impression to a dental laboratory before the patient leaves the office;

an evaluation means for determining if the digital dental impression must be reacquired before the patient leaves the office; and

a response means for transmitting the determination to the clinical office.

363. The system of claim 362, wherein the evaluation means includes a means for evaluating surface continuity.

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364. The system of claim 362, wherein the evaluation means includes a means for evaluating data density.

365. The system of claim 362, wherein the evaluation means includes a means for evaluating feature detail.

366. The system of claim 362, wherein one or more intraoral structures includes a tooth surface prepared for a dental restoration.

367. The system of claim 366, wherein the digital dental impression includes a case plan for the restoration.

368. The system of claim 367, wherein the case plan includes a type of restoration.

369. The system of claim 367, wherein the case plan includes a design of restoration.

370. The system of claim 367, wherein the case plan includes a list of restoration components.

371. The system of claim 370, wherein the list of restoration components includes a full ceramic component.

372. The system of claim 370, wherein the list of restoration components includes a PFM component.

373. The system of claim 367, wherein the case plan includes a specification of one or more restoration materials.

374. A system comprising:

a scanning device for real time capture of three-dimensional surface data;

a monitor that renders the three-dimensional surface data in real time;

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a processor configured to evaluate quality of the three-dimensional surface data, and to generate a signal representative of a data quality during a scan; and

a feedback device responsive to the signal to produce a user alert concerning the data quality when the data quality degrades below a predetermined threshold.

375. The system of claim 374, wherein the scanning device resolves the three-dimensional surface data from a plurality of two-dimensional image sets, and wherein the evaluation of quality includes evaluation of ability to determine spatial relationships from the plurality of two-dimensional image sets.

376. The system of claim 374, wherein the evaluation of quality includes evaluation of point cloud density.

377. The system of claim 374, wherein the evaluation of quality includes evaluation of scanning device motion.

378. The system of claim 374, wherein the feedback device includes an LED.

379. The system of claim 374, wherein the feedback device includes a speaker.

380. The system of claim 374, wherein the feedback device includes a buzzer.

381. The system of claim 374, wherein the feedback device includes a vibrator.

382. The system of claim 374, wherein the scanning device includes a wand, the feedback device positioned on the wand.

383. The system of claim 374, wherein the feedback device is further responsive to the signal to produce a second user alert when the data quality is within an acceptable range.

384. A method comprising:

scheduling a preparation visit for a dental restoration for a patient;

obtaining a digital surface representation of one or more intraoral structures of the patient, including at least one tooth associated with the dental restoration; and

fabricating a temporary restoration based upon the digital surface representation.

385. The method of claim 384, wherein fabricating a temporary restoration includes transmitting the digital surface representation to a dental laboratory.

386. The method of claim 384, wherein fabricating a temporary restoration includes applying the digital surface representation to prepare a design for the temporary restoration and transmitting the design to a dental laboratory.

387. The method of claim 384, further including three-dimensionally printing the temporary restoration.

388. The method of claim 384, further including three-dimensionally printing the temporary restoration at a dentist's office where the preparation visit is scheduled.

389. The method of claim 384, further including milling the temporary restoration.

390. The method of claim 384, further including milling the temporary restoration at a dental office where the preparation visit is scheduled.

391. The method of claim 384, wherein obtaining a digital surface representation includes three-dimensionally scanning the one or more intraoral structures on a day of the preparation visit.

392. The method of claim 384, wherein obtaining a digital surface representation includes retrieving the digital surface representation from prior dental data for the patient.

393. The method of claim 384, wherein fabricating the temporary restoration includes fabricating the temporary restoration prior to the preparation visit, the temporary restoration including one or more characteristics of the at least one tooth.

394. The method of claim 393, further comprising, on the day of the preparation visit adapting a surface of the at least one tooth to receive the temporary restoration.

395. The method of claim 393, further comprising, on the day of the preparation visit, adapting the temporary restoration to fit a prepared surface of the at least one tooth.

396. The method of claim 384, wherein the step of fabricating is performed at an in-house dental laboratory at a dentist's office.

397. A method comprising:

acquiring a digital dental impression including three-dimensional digital surface data for one or more intraoral structures, the intraoral structures including at least one tooth surface prepared for an artificial dental object; and

acquiring additional three-dimensional data with greater spatial resolution around the at least one tooth surface prepared for the artificial dental object.

398. The method of claim 397, wherein acquiring additional three-dimensional data includes acquiring additional data from the at least one tooth surface.

399. The method of claim 397, wherein acquiring additional three-dimensional data includes post-processing source data for the digital dental impression.

400. The method of claim 397, wherein acquiring additional three-dimensional data includes post-processing the three-dimensional digital surface data.

401. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring one or more images of one or more intraoral structures, the intraoral structures including at least one tooth surface prepared for an artificial dental object; and

generating a digital dental impression including three-dimensional digital surface data from the one or more images.

402. The computer program product of claim 401, further comprising computer code that performs the step of post-processing source data for the digital dental impression to generate additional three-dimensional data with greater spatial resolution.

403. The computer program product of claim 401, further comprising computer code that performs the step of post-processing the three-dimensional digital surface data to generate additional three-dimensional data with greater spatial resolution.

404. A system comprising:

a first means for acquiring a digital dental impression including three-dimensional digital surface data for one or more intraoral structures, the intraoral structures including at least one tooth surface prepared for an artificial dental object; and

a second means for acquiring additional three-dimensional data with greater spatial resolution around the at least one tooth surface prepared for the artificial dental object.

405. The system of claim 404, wherein the second means includes a means for acquiring additional data from the at least one tooth surface.

406. The system of claim 404, wherein the second means includes a means for post-processing source data for the digital dental impression.

407. The method of claim 404, wherein the second means includes a means for post-processing the three-dimensional digital surface data.

408. A method comprising:

acquiring a digital surface representation for one or more intraoral structures, the intraoral structures including at least one tooth surface prepared for a dental prosthesis;

fabricating a kit from the digital surface representation, the kit including two or more components suitable for use in fabrication of the dental prosthesis; and

sending the kit to a dental laboratory for fabrication of the dental prosthesis.

409. The method of claim 408, wherein the kit includes one or more of a die, a quad model, an opposing quad model, an opposing model, a base, a pre-articulated base, and a waxup.

410. The method of claim 408, further comprising transmitting the digital surface representation to a production facility, the step of fabricating being performed at the production facility.

411. The method of claim 408, wherein the kit includes one or more components selected from the group of pre-cut components, pre-indexed components, and pre-articulated components.

412. The method of claim 408, where in the step of fabricating is performed at a dentist's office.

413. An artificial dental object including an exposed surface, the exposed surface having a texture integrated therein adapted to enhance acquisition of three dimensional image data from the exposed surface with a multi-aperture three-dimensional scanning device.

414. The artificial dental object of claim 413 wherein the texture includes pseudo-random three-dimensional noise.

415. The artificial dental object of claim 413 wherein the artificial dental object includes an impression coping.

416. The artificial dental object of claim 413 wherein the artificial dental object includes a fixture.

417. The artificial dental object of claim 413 wherein the artificial dental object includes a healing abutment.

418. The artificial dental object of claim 413 wherein the artificial dental object includes a temporary impression coping.

419. The artificial dental object of claim 413 wherein the artificial dental object includes a dental prosthesis.

420. The artificial dental object of claim 413 wherein the artificial dental object includes a dental appliance.

421. The artificial dental object of claim 413 wherein the artificial dental object includes an item of dental hardware.

422. The artificial dental object of claim 413 wherein the artificial dental object includes a dental restoration.

423. A method comprising:

acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface suitable for an artificial dental object;

transmitting the three-dimensional representation to a dental insurer; and

receiving authorization from the dental insurer to perform a dental procedure including the artificial dental object.

424. The method of claim 423, wherein the artificial dental object includes one or more of an implant, a crown, an impression coping, a bridge, a fixture, and an abutment.

425. The method of claim 423, wherein the intraoral surface includes at least one edentulous space.

426. The method of claim 423, wherein the intraoral surface includes at least one tooth surface.

427. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface suitable for an artificial dental object;

transmitting the three-dimensional representation to a dental insurer; and

receiving authorization from the dental insurer to perform a dental procedure including the artificial dental object.

428. The method of claim 427, wherein the artificial dental object includes one or more of an implant, a crown, an impression coping, a fixture, a bridge, and an abutment.

429. The method of claim 427, wherein the intraoral surface includes at least one edentulous space.

430. The method of claim 427, wherein the intraoral surface includes at least one tooth surface.

431. A system comprising:

a means for acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface suitable for an artificial dental object;

a first communication means for transmitting the three-dimensional representation to a dental insurer; and

a second communication means for receiving authorization from the dental insurer to perform a dental procedure including the artificial dental object.

432. The system of claim 431, wherein the artificial dental object includes one or more of an implant, a crown, an impression coping, a fixture, a bridge and an abutment.

433. The system of claim 431, wherein the at least one intraoral surface includes an edentulous space.

434. The system of claim 431, wherein the at least one intraoral surface includes a tooth surface.

435. A method comprising:

acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface related to a dental procedure; and

transmitting the three-dimensional representation to a dental insurer as a record of the dental procedure.

436. The method of claim 435, wherein the dental procedure relates to one or more of an implant, a crown, an impression coping, a fixture, a bridge, and an abutment.

437. The method of claim 435, further comprising receiving a payment from the insurer for a procedure involving the artificial dental object.

438. The method of claim 435 wherein the intraoral surface includes an edentulous space.

439. The method of claim 435 wherein the intraoral surface includes a tooth surface prepared for an artificial dental object.

440. The method of claim 437 wherein the intraoral surface includes a restored tooth.

441. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at one intraoral surface related to a dental procedure; and

transmitting the three-dimensional representation to a dental insurer as a record of the dental procedure.

442. The computer program product of claim 441, wherein the dental procedure relates to one or more of an implant, a crown, an impression coping, a bridge, and an abutment.

443. The computer program product of claim 441, further comprising computer code that performs the step of receiving a record of payment from the insurer for the dental procedure.

444. The computer program product of claim 441, wherein the intraoral surface includes an edentulous space.

445. The computer program product of claim 441, wherein the intraoral surface includes a tooth surface prepared for an artificial dental object.

446. The computer program product of claim 441, wherein the intraoral surface includes a restored tooth.

447. A system comprising:

a means for acquiring a three-dimensional representation of one or more intraoral structures, the intraoral structures including at least one intraoral surface related to a dental procedure; and

a communication means for transmitting the three-dimensional representation to a dental insurer as a record of the dental procedure.

448. The system of claim 447, wherein the dental procedure relates to one or more of an implant, a crown, an impression coping, a bridge, and an abutment.

449. The system of claim 447, wherein the communication means includes a means for receiving a payment from the insurer for the dental procedure.

450. A method comprising:

receiving a three-dimensional representation of one or more intraoral structures from a dentist;

receiving a proposed dental procedure from the dentist;

determining whether the proposed dental procedure is appropriate for the one or more intraoral structures; and

transmitting a reply to the dentist.

451. The method of claim 450, wherein the reply includes an approval to perform the dental procedure.

452. The method of claim 450, wherein the reply includes a denial to perform the dental procedure.

453. The method of claim 450, further comprising authorizing payment for the dental procedure.

454. A computer program product comprising computer executable code embodied in a computer readable medium that, when executed on one or more computer devices, performs the steps of:

receiving a three-dimensional representation of one or more intraoral structures from a dentist;

receiving a proposed dental procedure from the dentist;

comparing the proposed dental procedure to a predetermined list of appropriate procedures for the one or more intraoral structures; and

transmitting a reply to the dentist.

455. The computer program product of claim 454, wherein the reply includes an approval to perform the dental procedure.

456. The computer program product of claim 454, wherein the reply includes a denial to perform the dental procedure.

457. The computer program product of claim 454, further comprising computer code that performs the step of authorizing payment for the dental procedure.

458. A system comprising:

a first means for receiving a three-dimensional representation of one or more intraoral structures from a dentist;

a second means for receiving a proposed dental procedure from the dentist;

an evaluation means for determining whether the proposed dental procedure is appropriate for the one or more intraoral structures; and

a reply means for transmitting a reply to the dentist.

459. The system of claim 458, wherein the reply includes an approval to perform the dental procedure.

460. The system of claim 458, wherein the reply includes a denial to perform the dental procedure.

461. The system of claim 458, further comprising a means for authorizing payment for the dental procedure.

462. A system comprising:

a dental data repository coupled to a communications network, the dental data repository adapted to receive dental data including three-dimensional representations of intraoral structures and prescriptions for dental procedures from a plurality of dentists.

463. The system of claim 462, wherein the dental data repository is adapted to transmit prescriptions and three-dimensional representations to a plurality of dental laboratories.

464. The system of claim 463, wherein at least one of the prescriptions identifies a specific one of the plurality of dental laboratories.

465. The system of claim 462, wherein the dental data repository is further adapted to communicate with one or more dental insurers for authorization of dental procedures.

466. The system of claim 462, wherein the dental data repository is further adapted to communicate with one or more dental insurers to coordinate payment for dental procedures.

467. The system of claim 462, further comprising a dental laboratory interface for the plurality of dental laboratories to provide status on work in progress.

468. The system of claim 462, further comprising a dental laboratory interface for the plurality of dental laboratories to receive work assignments.

469. The system of claim 462, further comprising a dentist interface for the plurality of dentists to monitor work in progress.

470. The system of claim 462, further comprising a dentist interface for the plurality of dentists to submit prescriptions and three-dimensional representations.

471. The system of claim 462, further comprising a transaction engine for transmitting payments among two or more of one of the plurality of dentists, one of the plurality of dental laboratories, and one of the one or more dental insurers.

472. The system of claim 462, further comprising a collaboration interface for two or more of the plurality of dentists to collaborate on a dental matter.

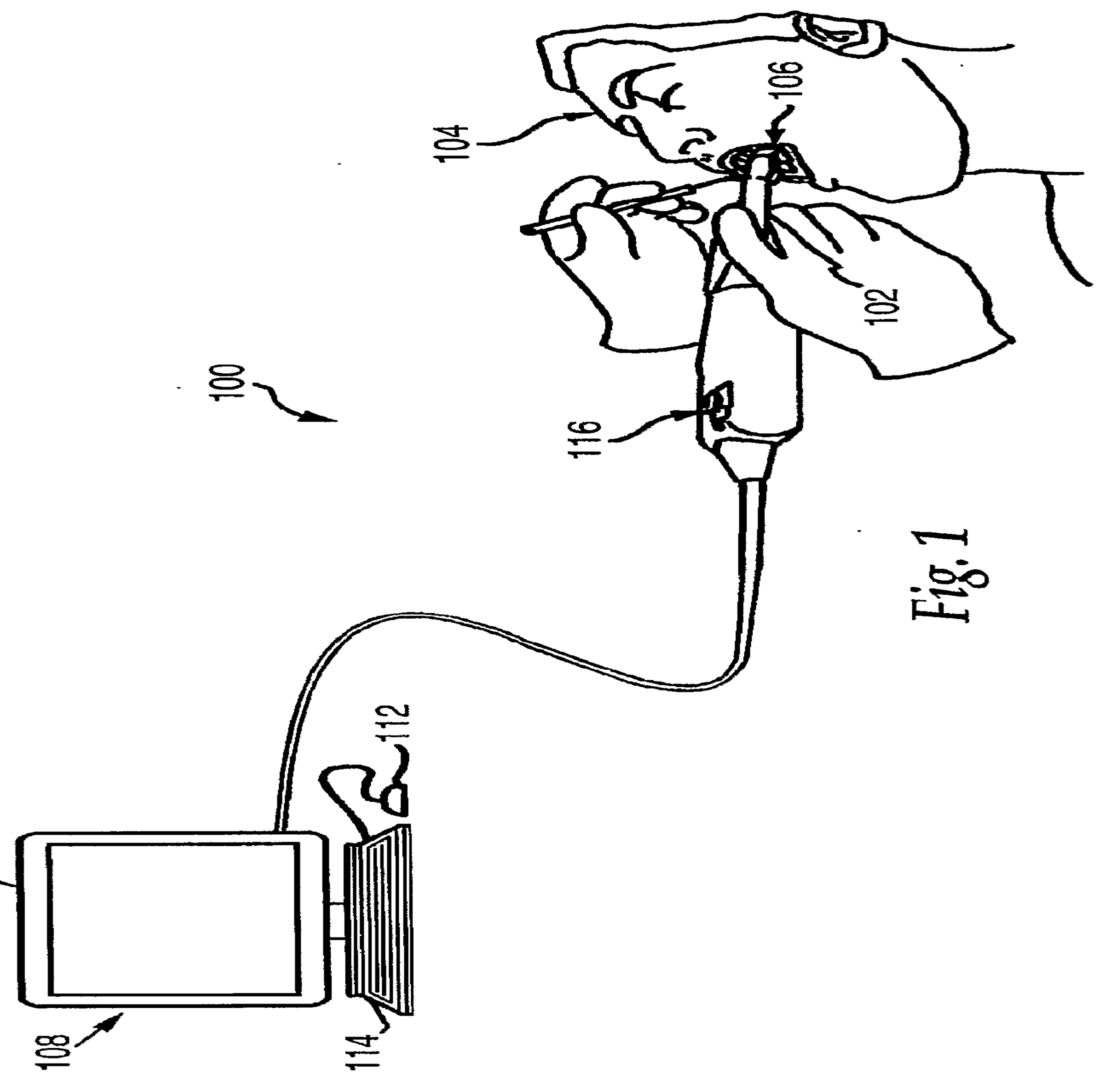


Fig. 1

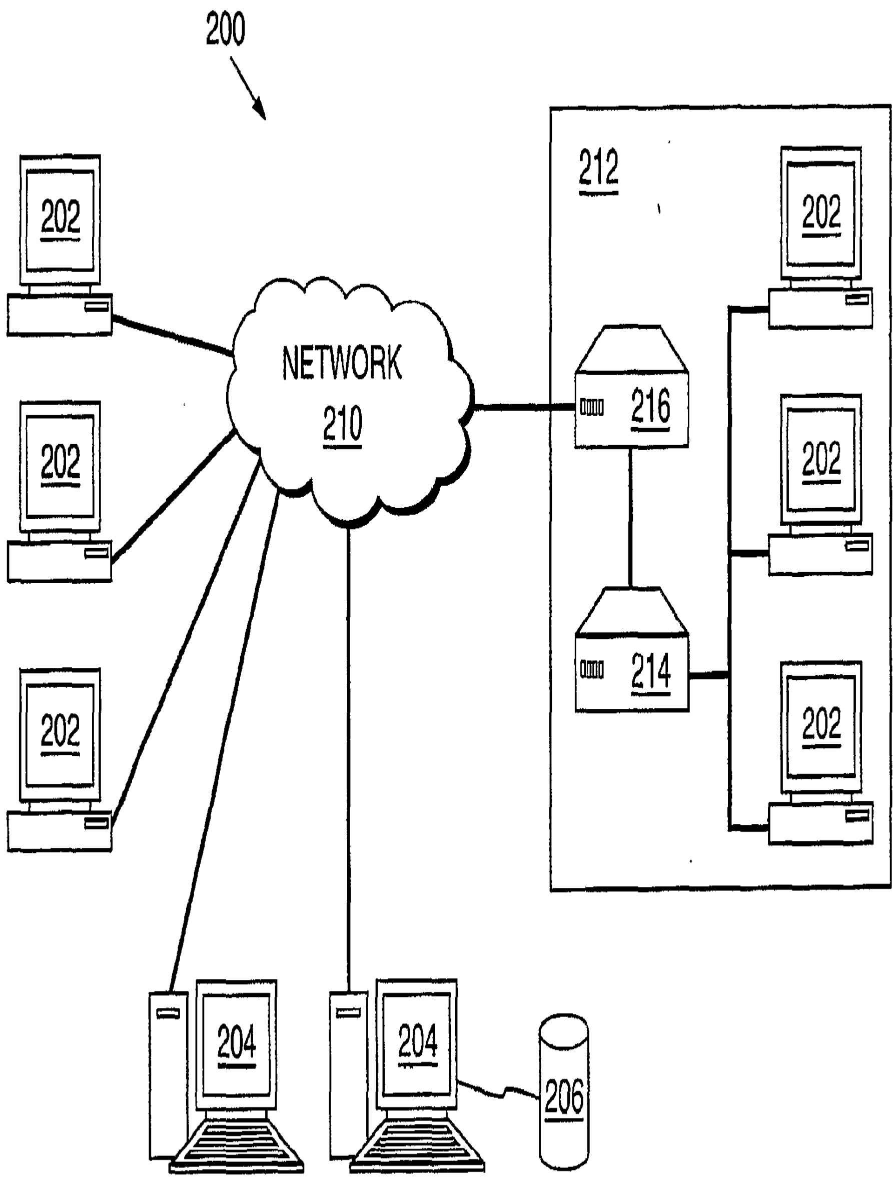
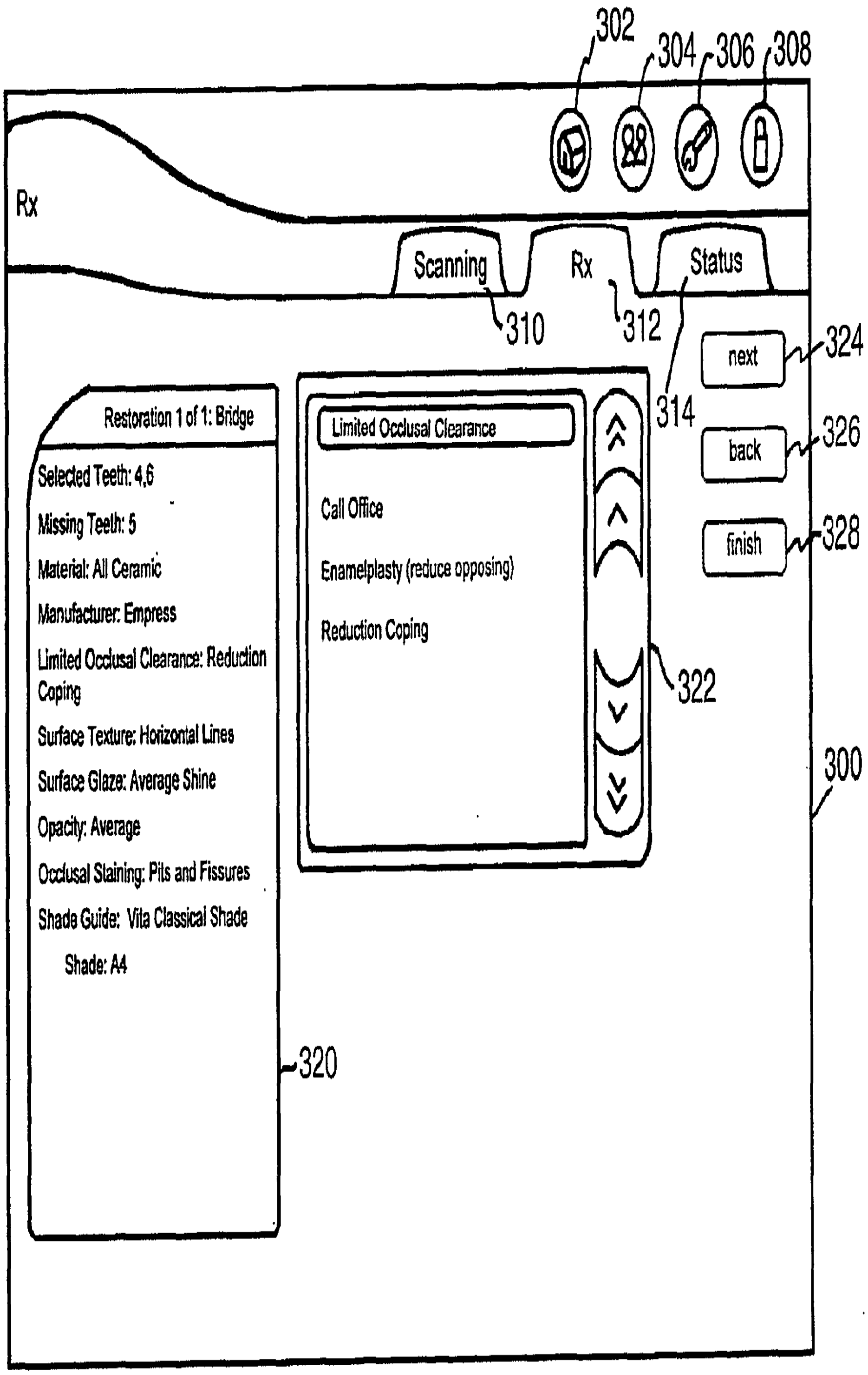


Fig. 2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306
308
Rx
Scanning
Rx
Status
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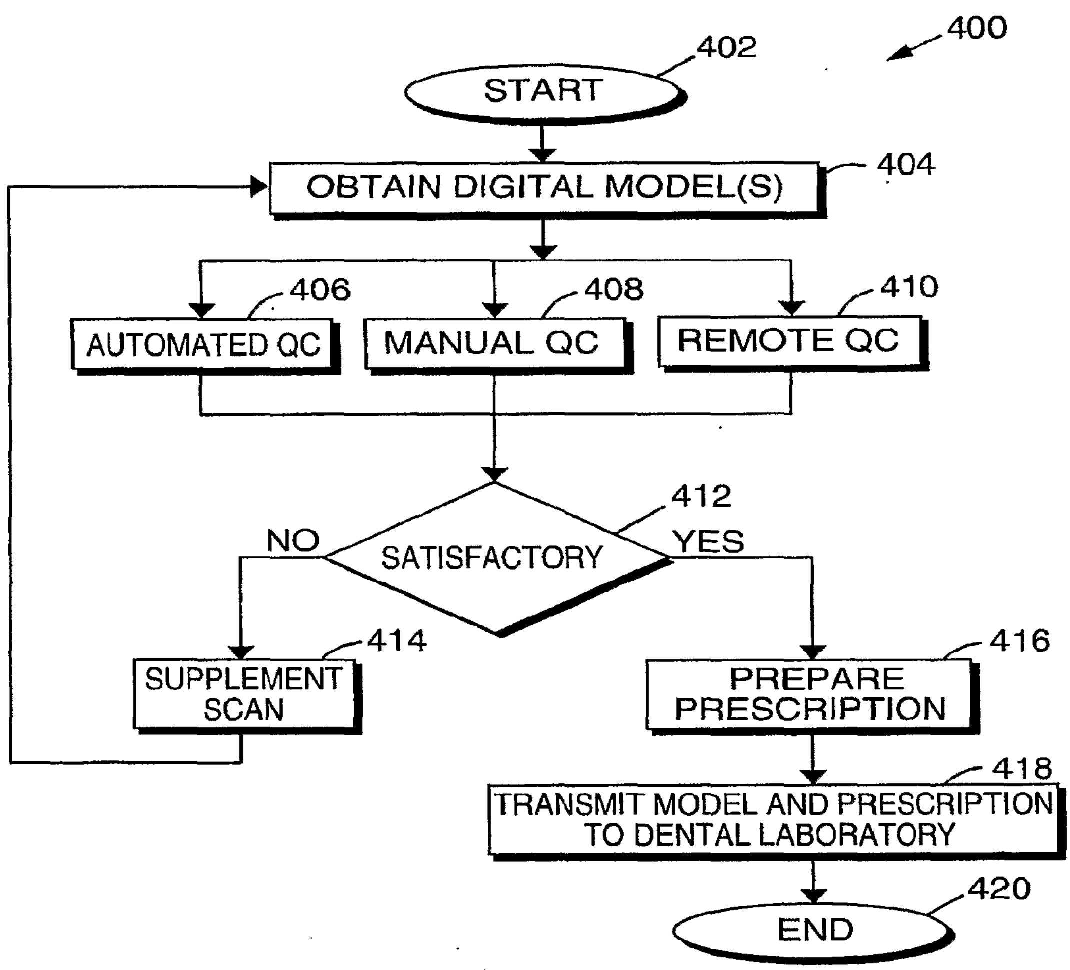
312
314
next
324
back
326
finish
328
Restoration 1 of 1: Bridge
Selected Teeth: 4,6
Missing Teeth: 5
Material: All Ceramic
Manufacturer: Empress
Limited Occlusal Clearance: Reduction Coping
Surface Texture: Horizontal Lines
Surface Glaze: Average Shine
Opacity: Average
Occlusal Staining: Pits and Fissures
Shade Guide: Vita Classical Shade
Shade: A4
Limited Occlusal Clearance
Call Office
Enamelplasty (reduce opposing)
Reduction Coping
322
300
320

Fig. 3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406
AUTOMATED QC
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MANUAL QC
410
REMOTE QC
412
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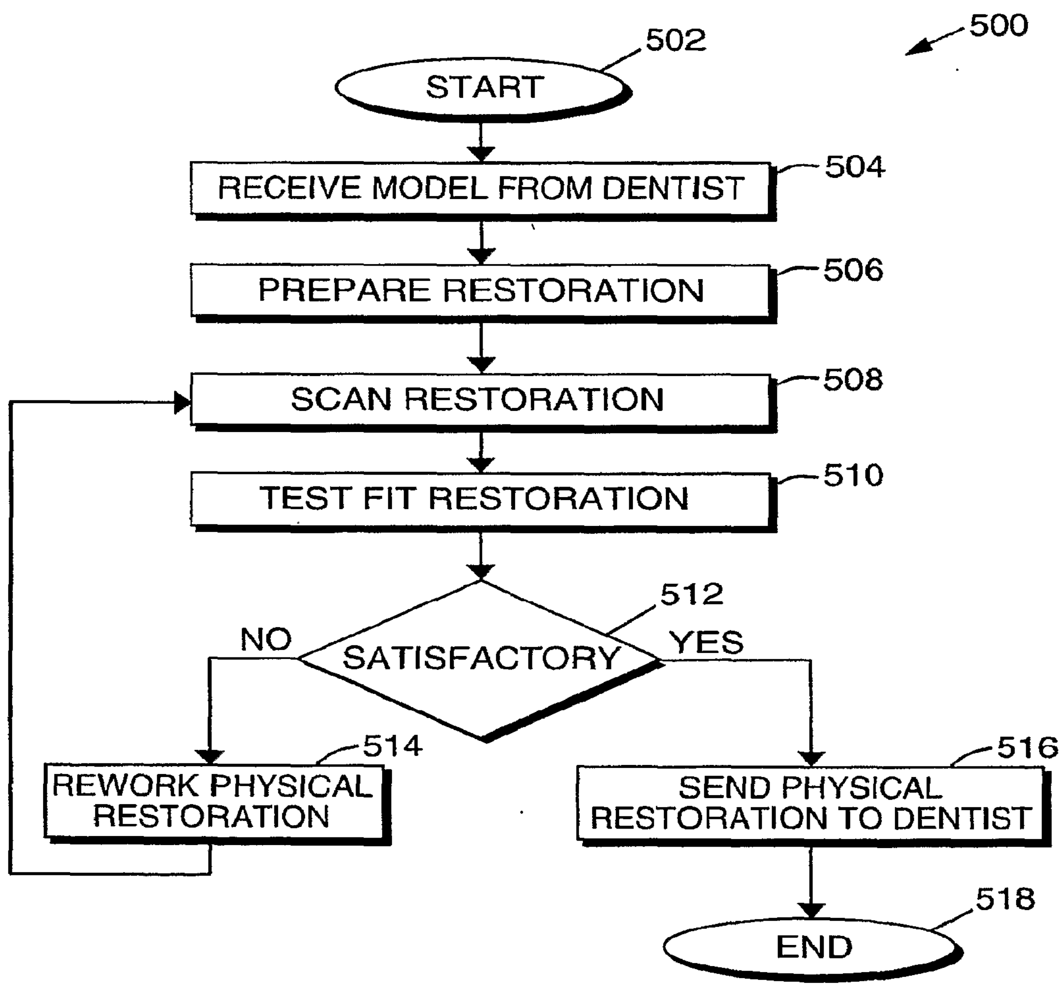
SATISFACTORY
YES
414
SUPPLEMENT SCAN
416
PREPARE PRESCRIPTION
418
TRANSMIT MODEL AND PRESCRIPTION TO DENTAL LABORATORY
420
END

Fig. 4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PREPARE RESTORATION
506
SCAN RESTORATION
508
TEST FIT RESTORATION
510
SATISFACTORY
512
NO
YES
REWORK PHYSICAL RESTORATION
514
SEND PHYSICAL RESTORATION TO DENTIST
516
END
518

Fig. 5

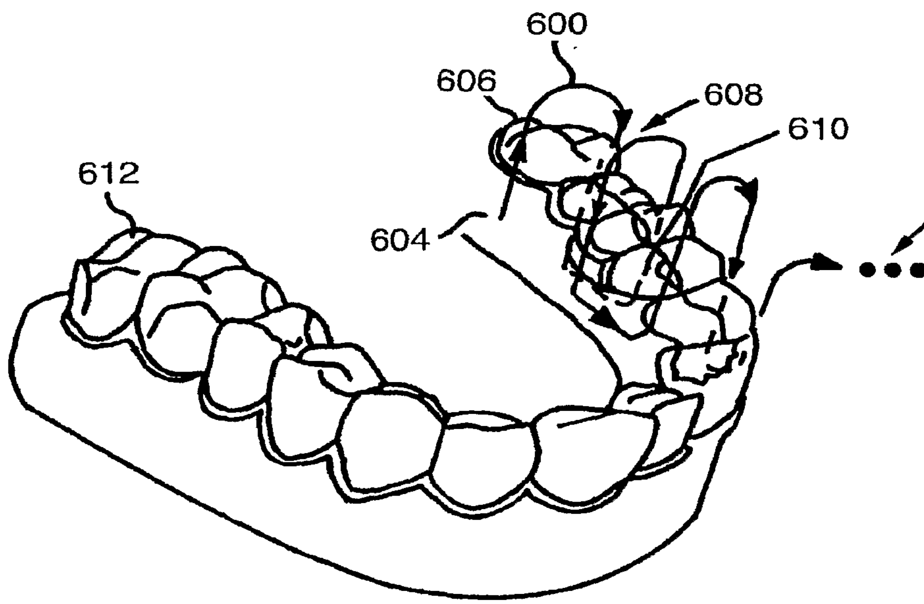

Fig. 6

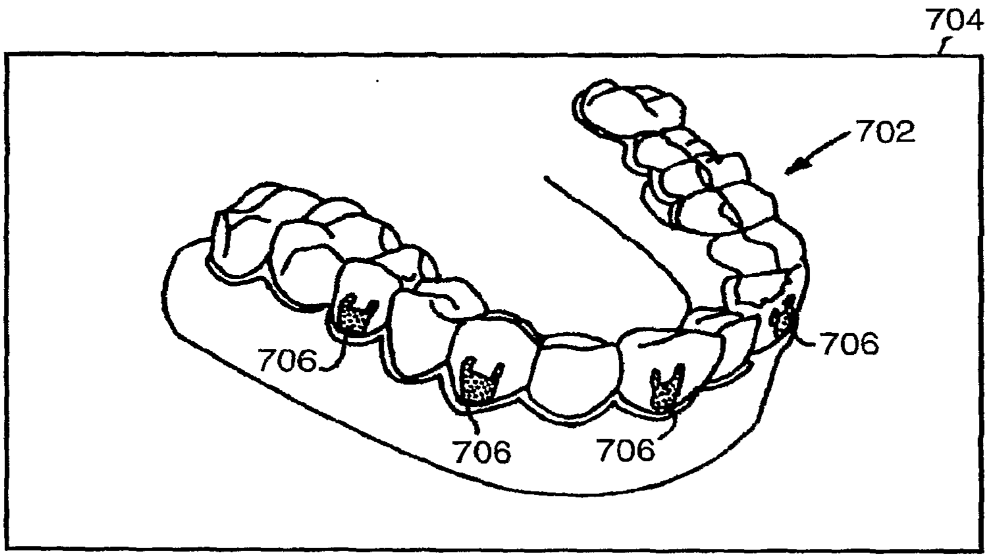

Fig. 7A

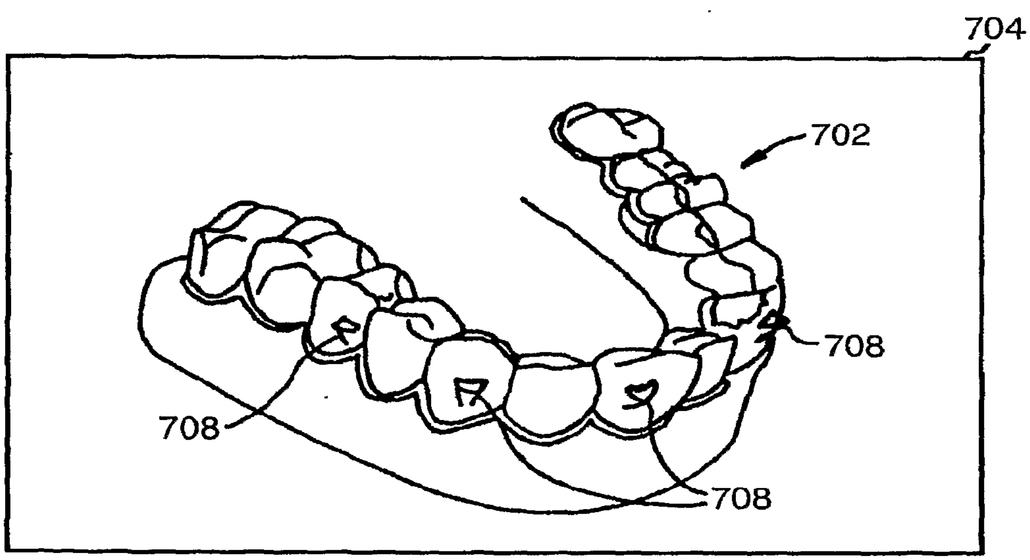

Fig. 7B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/001547

A. CLASSIFICATION OF SUBJECT MATTER

G06Q 10/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC G06Q 10/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models since 1975
Japanese Utility models and applications for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PAJ, FPD, USPAT, eKIPASS "Keyword: dental, intraoral, inter-oral, three-dimensional, fabrication"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2005153257 A (DURBIN DUANE M , DURBIN DENNIS A) 14 JULY 2005 See the abstract; figures 1.	1, 22 31, 245, 254, 263 2-9, 14-15, 17-22, 26-28, 30, 31-37, 74-135, 150-244, 246-253, 255-262, 264-277, 311-347, 384-412
Y	US 06648640 A (Ora Metrix, Inc.) 18 NOVEMBER 2003 See the abstract; claims 1-35; figures 1-120.	1-9, 14-15, 17-22, 26-28, 30, 31-37, 74-135, 150-277, 311-347, 384-412
A	US 2004029078 A (MARSHALL MICHAEL CRAIG) 12 FEBRUARY 2004 See the abstract; figures 1-2.	1-472
A	US 2005170309 A (3M INNOVATIVE PROPERTIES CO) 04 AUGUST 2005 See the abstract; columns 1-2; figures 1-2.	1-472

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
02 JULY 2007 (02.07.2007)

Date of mailing of the international search report
02 JULY 2007 (02.07.2007)

Name and mailing address of the ISA/KR
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Facsimile No. 82-42-472-7140

Authorized officer
KOO, Young Hoi
Telephone No. 82-42-481-8376

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/US2007/001547

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US2005153257A1	14.07.2005	US7118375BB	10.10.2006
US06648640	18.11.2003	US20020015934A1	07.02.2002
		US2002150859A1	17.10.2002
		US2002156652A1	24.10.2002
		US2003021453A1	30.01.2003
		US2003096210A1	22.05.2003
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		US6648640B2	18.11.2003
		US6971873BB	06.12.2005
		US7013191BB	14.03.2006
		US7029275BB	18.04.2006
		US7160110BB	09.01.2007
		US7172417BB	06.02.2007
US2004029078A1	12.02.2004	None	
US2005170309A1	04.08.2005	AU2004316121AA	01.09.2005
		EP1711120A1	18.10.2006
		WO2005079695A1	01.09.2005

Electronic Patent Application Fee Transmittal

Application Number:	13991513
Filing Date:	04-Jun-2013
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Filer:	William C. Rowland/Stacey Pflieger
Attorney Docket Number:	0079124-000070

Filed as Small Entity

Filing Fees for **U.S. National Stage under 35 USC 371**

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 1 month with $0 paid	2251	1	100	100
Miscellaneous:				
Submission- Information Disclosure Stmt	2806	1	90	90
	Total in USD ($)			**190**

Electronic Acknowledgement Receipt

EFS ID:	24303694
Application Number:	13991513
International Application Number:	
Confirmation Number:	9282
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Customer Number:	21839
Filer:	William C. Rowland/Stacey Pflieger
Filer Authorized By:	William C. Rowland
Attorney Docket Number:	0079124-000070
Receipt Date:	09-DEC-2015
Filing Date:	04-JUN-2013
Time Stamp:	09:44:42
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$190
RAM confirmation Number	19964
Deposit Account	024800
Authorized User	ROWLAND, WILLIAM C

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	After Final Consideration Program Request	070afcp.pdf	96695 8a025b5cf777c887f270649c657c446fc594ed7a	no	1

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2		070amd.pdf	34201 f2ba61f5deb07748df662b9bb764c1f2abbba13f	yes	7

Multipart Description/PDF files in .zip description

Document Description	Start	End
Response After Final Action	1	1
Claims	2	5
Applicant Arguments/Remarks Made in an Amendment	6	7

Warnings:

Information:

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3	Extension of Time	070eot.pdf	20814 b2618ccda11f4fe313b32c6bb89b50629872b4da	no	1

Warnings:

Information:

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4	Information Disclosure Statement (IDS) Form (SB08)	070ids.pdf	64025 ed0015db78d1a71581a3f3df7c7df573b95ca364	no	4

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5	Foreign Reference	070wo727.pdf	6841816 17d4e7f781912a0dd0cac8ba91c48f8810cf8bd2	no	138

Warnings:

Information:

6	Non Patent Literature	070cnoa.pdf	546898 1430c2665ff05653e846827aef227396a8b12f70	no	27
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	33012 e0bf52fada6d5eaf574561bd8017833ac144f3f2	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	7637461		

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/991,513	Filing Date 06/04/2013	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	12/09/2015	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0	x $40 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	x $210 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	**0**

AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/ALLYSON PURNELL/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

21839 7590 08/27/2015
BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

EXAMINER	
CHOW, VAN NGUYEN	

ART UNIT	PAPER NUMBER
2695	

NOTIFICATION DATE	DELIVERY MODE
08/27/2015	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ADIPDOC1@BIPC.com

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 13/991,513	Applicant(s) ÖJELUND ET AL.	
	Examiner VAN CHOW	Art Unit 2695	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *08/13/2015*.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *53-55 and 57-72* is/are pending in the application.
5a) Of the above claim(s) _____ is/are withdrawn from consideration.
6)☐ Claim(s) _____ is/are allowed.
7)☒ Claim(s) *all* is/are rejected.
8)☐ Claim(s) _____ is/are objected to.
9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.
11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
Certified copies:
a)☐ All b)☐ Some** c)☐ None of the:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.
3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
4) ☐ Other: _____.

Response to Arguments

1. Applicant's arguments filed on 08/13/2015 have been considered but are moot because the arguments do not apply to any of the references being used in the current rejection.

Claim Rejections - 35 USC § 103

2. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 53-55, 57, 58, 61-69, 72 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Paley et al. (US 7813591) in view of Kagermeier et al. (US 20090217207).

Regarding claim 53, discloses a scanning system comprising: a handheld device including an optical scanner (fig. 1, handheld 116) and at least one display (see fig. 1, display 110), wherein the handheld device is adapted for performing at least one scanning action in a physical 3D environment (see figs. 4, 5, 8, 9), the at least one display is adapted for visually representing the physical 3D environment (see figs. 4, 5, 8, 9).

Moreover, Paley et al. discloses a the scanner 102 is a handheld, freely positionable probe having at least one user input device, such as a button, lever, dial, thumb wheel, switch, or the like, for user control of the image capture system 100 such as starting and stopping scans. Furthermore, the handheld includes the input 116, but the details are not described.

Kagermeier et al. fig. 2, discloses the handheld device includes a user interface for remotely controlling the view with which the 3D environment is represented on the display.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to provide the remote control in Pa et al. as suggested by Kagermeier et al., the motivation being in order to remotely controlling the view with which the 3D environment is represented on the display.

Regarding claim 54, the combination of Paley et al. and Kagermeier et al., discloses a system according to Claim 53, wherein the handheld device is adapted to record the 3D geometry of the 3D environment (see Paley et al. figs. 4, 5, 8, 9, Kagermeier et al. fig. 2).

Regarding claim 55, the combination of Paley et al. and Kagermeier et al., discloses a system according to Claim 53, wherein the user interface includes means for manually switching between performing the at least one scanning action and remotely controlling the view (see Paley et al. figs. 1, col. 4, lines 42-61, Kagermeier et al. fig. 2).

Regarding claims 57, 58, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device comprises at least one motion sensor; and/or wherein the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor (see Paley et al. col. 18, lines 17-50, Kagermeier et al. fig. 3, abstract).

Regarding claim 61, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 57, wherein the user-interface is other than the at least one motion sensor (see Paley et al. figs. 2, 4, 5, 8, 9, Kagermeier et al. fig. 2).

Regarding claim 62, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device is adapted to change a viewing angle with which the 3D environment is represented on the at least one display (see Paley et al. figs. 4, 5, 8, 9, Kagermeier et al. fig. 2).

Regarding claim 63, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device is adapted to change a magnification factor with which the 3D environment is represented on the at least one display (see Paley et al. figs. 4, 5, 8, 9, Kagermeier et al. fig. 2).

Regarding claim 64, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner (see Paley et al. abstract, fig. 1, Kagermeier et al. fig. 2).

Regarding claim 65, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device inludes a surgical instrument (see Paley et al. abstract, fig. 1, Kagermeier et al. fig. 2).

Regarding claim 66, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device is a mechanical tool (see Paley et al. abstract, fig. 1, Kagermeier et al. fig. 2).

Regarding claim 67, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the handheld device is an in-ear 3D scanner (see Paley et al. abstract, figs. 1-9, Kagermeier et al. fig. 2, it is inherently to use the medical device on the other body part).

Regarding claim 68, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 53, wherein the at least one display is defined as a first display, and where the system further comprises a second display (see Paley et al. figs. 4, 5, 8, 9, Kagermeier et al. fig. 2).

Regarding claim 69, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 68, wherein the second display indicates where the handheld device is positioned relative to the 3D environment (see Paley et al. figs. 4, 5, 8, 9, Kagermeier et al. fig. 2).

Regarding claim 72, see rejection above of claim 53.

4. Claims 59, 60 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Paley et al. (US 7813591), Kagermeier et al. (NPL June, 2001 see attachment) in view of Boilot (US 20080111710).

Regarding claims 59, 60, the combination of Paley et al. and Kagermeier et al., discloses the system according to Claim 57.

Boilot discloses a sensor device (100) and method (300) for touchless finger signing and recognition is provided. The method can include detecting (304) a first pause of a finger in a touchless sensory space (101), tracking (306) a movement (140) of the finger, detecting (308) a second pause of the finger, creating (310) a trace (145) of the finger movement from the tracking, and recognizing (312) a pattern (146) from the trace. The pattern can be an alphanumeric character or a finger gesture. A user can accept or reject the recognized pattern via touchless finger control.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to provide the finger gesture in Paley et al., Kagermeier et al. as suggested by Boilot, the motivation being in order to touchless finger control.

Therefore, the combination of Paley et al, Kagermeier et al. and Boilot, discloses wherein functionality of the user interface comprises a use of gestures; and/or the gestures are detected by the at least one motion sensor (see Paley et al. figs. 4, 5, 8, 9, Kagermeier et al. figs. 2, 3, abstract, and Boilot abstract, figs. 1, 2) .

Regarding claim 70 and 71, the combination of Paley et al, Kagermeier et al. and Boilot, discloses the system according to Claim 53 or claim 68, wherein the first display and/or the second display provides instructions for the operator (see Boilot figs. 23, 31, pars. 85, 87, 90-92); and/or audible information is provided to the operator (see Boilot figs. 4, 6, pars. 45, 46, 65, 69).

Conclusion

5. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to VAN CHOW whose telephone number is (571)272-7590. The examiner can normally be reached on Tuesday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Joseph Feild can be reached on 571-272-4090. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/VAN CHOW/
Primary Examiner, Art Unit 2695

Doc code: IDS
Doc description: Information Disclosure Statement (IDS) Filed
PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)		
	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code1	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6135961		2000-10-24	Pflugrath et al.	

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code1	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050057745		2005-03-17	Bontje	
	2	20060025684		2006-02-02	Quistgaard et al.	

If you wish to add additional U.S. Published Application citation information please click the Add button.

FOREIGN PATENT DOCUMENTS

Examiner Initial*	Cite No	Foreign Document Number3	Country Code2 i	Kind Code4	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear	T5
	1	101513350	CN		2009-08-26	Siemens AG	with English Abstract	☐
	2	2009089126	WO		2009-07-16	3M Innovative Properties Company		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99**)	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

	3	2001011193	WO		2011-01-27	Dimensional Photonics International, Inc.		☐

If you wish to add additional Foreign Patent Document citation information please click the Add button

NON-PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T5
	1	First Office Action issued in corresponding Chinese Patent Application No. 201180066956.6, issued April 3, 2015. (13 pages)	☐

If you wish to add additional non-patent literature document citation information please click the Add button

EXAMINER SIGNATURE

Examiner Signature	/VAN CHOW/	Date Considered	08/21/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

[1] See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. [2] Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). [3] For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [4] Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [5] Applicant is to place a check mark here if English language translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /VC/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☐ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

☐ See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/WCRowland/	Date (YYYY-MM-DD)	2015-08-13
Name/Print	William C. Rowland	Registration Number	30888

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1 hour to complete, including gathering, preparing and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these record s.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).

5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /VC/

Index of Claims	Application/Control No. 13991513	Applicant(s)/Patent Under Reexamination ÖJELUND ET AL.
	Examiner VAN CHOW	Art Unit 2695

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/07/2015	08/21/2015							
	53	✓	✓							
	54	✓	✓							
	55	✓	✓							
	56	✓	-							
	57	✓	✓							
	58	✓	✓							
	59	✓	✓							
	60	✓	✓							
	61	✓	✓							
	62	✓	✓							
	63	✓	✓							
	64	✓	✓							
	65	✓	✓							
	66	✓	✓							
	67	✓	✓							
	68	✓	✓							
	69	✓	✓							
	70	✓	✓							
	71	✓	✓							
	72	✓	✓							

Search Notes	**Application/Control No.** 13991513	**Applicant(s)/Patent Under Reexamination** ÖJELUND ET AL.
	Examiner VAN CHOW	**Art Unit** 2695

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner
G06F1/1601 OR G06F1/1613	08/21/2015	VC

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
east and text search	08/21/2015	VC

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)	**MAIL STOP: AMENDMENT**
Henrik ÖJELUND et al.	)	Group Art Unit: 2695
Application No.: 13/991,513	)	Examiner: Van Nguyen Chow
Filed: June 4, 2013	)	Confirmation No.: 9282
For: SYSTEM WITH 3D USER INTERFACE INTEGRATION	)	

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

In response to the Office Action dated May 13, 2015, kindly amend the application as follows.

AMENDMENTS TO THE CLAIMS:

The following listing of claims will replace all prior versions and listings of claims in this application.

LISTING OF CLAIMS:

1 – 52. (Cancelled)

53. (Currently Amended) A scanning system comprising:

a handheld device including an optical scanner; and

at least one display remotely connected to the handheld device,

wherein the handheld device is adapted for ~~switching between~~ performing at least one scanning action in a physical 3D environment, ~~wherein~~ and the at least one display is adapted for visually representing the physical 3D environment; and

the handheld device includes a user interface for remotely controlling the view with which the 3D environment is represented on the display.

54. (Previously Presented) A system according to Claim 53, wherein the handheld device is adapted to record the 3D geometry of the 3D environment.

55. (Currently Amended) A system according to Claim 53, wherein the user interface includes means for manually switching between performing the at least one scanning action and remotely controlling the view ~~is provided on the handheld device~~.

56. (Cancelled)

57. (Previously Presented) The system according to Claim 53, wherein the handheld device comprises at least one motion sensor.

58. (Currently Amended) The system according to Claim **[[**53**]]** 57, wherein the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor.

59. (Currently Amended) The system according to Claim **[[**53**]]** 57, wherein functionality of the user interface ~~functionality~~ comprises **[[**the**]]** a use of gestures.

60. (Currently Amended) The system according to Claim **[[**53**]]** 59, wherein the gestures are detected by the at least one motion sensor.

61. (Currently Amended) The system according to Claim **[[**53**]]** 57, wherein ~~herein~~ the ~~handheld device comprises at least one~~ user-interface ~~element~~ is other than the at least one motion sensor.

62. (Currently Amended) The system according to Claim 53, wherein ~~herein~~ the handheld device is adapted to change a viewing angle with which the 3D environment is represented on the at least one display.

63. (Previously Presented) The system according to Claim 53, wherein the handheld device is adapted to change a magnification factor with which the 3D environment is represented on the at least one display.

64. (Previously Presented) The system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner.

65. (Currently Amended) The system according to Claim 53, wherein the handheld device includes **[[**is**]]** a surgical instrument.

66. (Currently Amended) The system according to Claim 53, wherein the handheld device includes **[[**is**]]** a mechanical tool.

67. (Previously Presented) The system according to Claim 53, wherein the handheld device is an in-ear 3D scanner.

68. (Previously Presented) The system according to Claim 53, wherein the at least one display is defined as a first display, and where the system further comprises a second display.

69. (Currently Amended) The system according to Claim **[[**53**]]** 68, wherein the second display indicates where the handheld device is positioned relative to the 3D environment.

70. (Currently Amended) The system according to Claim **[[**53**]]** 68, wherein the first display and/or the second display provides instructions for the operator.

71. (Currently Amended) The system according to Claim 53, wherein audible information ~~to the operator~~ is provided to the operator.

72. (Currently Amended) A **[[**The**]]** system ~~according to claim 53~~ comprising:

a handheld device and at least one display;

wherein the handheld device is adapted for switching between performing at least one action in a physical 3D environment, wherein the at least one display is adapted for visually representing the physical 3D environment; and

remotely controlling the view with which the 3D environment is represented on the display;

wherein the handheld device is an intra-oral 3D scanner and the at least one action performed in the physical 3D environment is scanning and that the view is remotely controlled by at least one motion sensor arranged in the handheld device, and wherein an actuator provided on the handheld device switches between performing the at least one action and remotely controlling the view.

REMARKS

The Examiner is thanked for the examination of the application. In view of the foregoing amendments and the remarks that follow, the Examiner is respectfully requested to reconsider and review the rejections.

35 USC 112, second paragraph:

In response to the issues identified with respect to 35 USC 112, second paragraph, the relevant claims have been amended to ensure compliance. In the event that the Examiner is of the opinion that additional issues exist, the Examiner is urged to contact the undersigned so that such issues can be promptly resolved.

Art Rejections:

Claims 53 – 58, 61 – 69, and 72 have been rejected under 35 USC 103(a) as being allegedly unpatentable over USP 7,813,591, hereinafter *Paley*, in view of the article by Xia cited by the Examiner, hereinafter *Xia*. Claims 59 and 60 (and presumably 70 and 71) have been rejected under 35 USC 103(a) as being allegedly unpatentable over *Paley*, in view of *Xia*, and further in view of US 2008/0111710, hereinafter *Boilot*.

Claim 1, as now amended, recites a scanning system comprising, among other items,

a handheld device including an optical scanner; and at least one display remotely connected to the handheld device, and the handheld device includes a user interface for ***remotely*** controlling the view with which the 3D environment is represented on the display.

The Office Action alleges that *Paley* teaches all of (pre-amended) claim 53, except for remotely controlling the view on the display. For this feature, the Examiner relies on Figure 2 of *Xia*. However, in *Xia*, the images are created separately and ahead of time, e.g., by a camera and by a CT scanner. See paragraphs B and C on page 99 of *Xia*. In Figure 2, the operator appears to be holding a simulated surgical tool. It is not a scanner for creating the images on the display. Accordingly, *Xia* also does not teach or suggest the concept of remotely controlling the display of an image with a handheld scanner that is creating the image.

Accordingly, *Xia* does not overcome the acknowledged deficiency of *Paley*.

The dependent claims are allowable at least for the reasons set forth above with respect to claim 53.

Claim 72 has been rewritten in independent form without any substantive changes. Claim 72 is also patentable for substantially the same reasons set forth above with respect to claim 53.

Should any questions arise in connection with this application, it is respectfully requested that the undersigned be contacted at the number indicated below.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: August 13, 2015

By: /WCRowland/
William C. Rowland
Registration No. 30888

Customer No. 21839
(703) 836-6620

PTO/SB/08a (01-10)
Approved for use through 07/31/2012. OMB 0651-0031
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT
(Not for submission under 37 CFR 1.99)

Application Number	13991513
Filing Date	2013-06-04
First Named Inventor	Henrik Ojelund et al.
Art Unit	2695
Examiner Name	Van Nguyen Chow
Attorney Docket Number	0079124-000070

U.S.PATENTS

Examiner Initial*	Cite No	Patent Number	Kind Code[1]	Issue Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	6135961		2000-10-24	Pflugrath et al.	

If you wish to add additional U.S. Patent citation information please click the Add button.

U.S.PATENT APPLICATION PUBLICATIONS

Examiner Initial*	Cite No	Publication Number	Kind Code[1]	Publication Date	Name of Patentee or Applicant of cited Document	Pages,Columns,Lines where Relevant Passages or Relevant Figures Appear
	1	20050057745		2005-03-17	Bontje	
	2	20060025684		2006-02-02	Quistgaard et al.	

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	1	101513350	CN		2009-08-26	Siemens AG	with English Abstract	☐
	2	2009089126	WO		2009-07-16	3M Innovative Properties Company		☐

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (**Not for submission under 37 CFR 1.99)**	Application Number: 13991513 Filing Date: 2013-06-04 First Named Inventor: Henrik Ojelund et al. Art Unit: 2695 Examiner Name: Van Nguyen Chow Attorney Docket Number: 0079124-000070

	3	2001011193	WO		2011-01-27	Dimensional Photonics International, Inc.		☐

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	1	First Office Action issued in corresponding Chinese Patent Application No. 201180066956.6, issued April 3, 2015. (13 pages)	☐

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)		
	Application Number	13991513
	Filing Date	2013-06-04
	First Named Inventor	Henrik Ojelund et al.
	Art Unit	2695
	Examiner Name	Van Nguyen Chow
	Attorney Docket Number	0079124-000070

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OR

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☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

☐ A certification statement is not submitted herewith.

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A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/WCRowland/	Date (YYYY-MM-DD)	2015-08-13
Name/Print	William C. Rowland	Registration Number	30888

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PATENT- OG VAREMÆRKESTYRELSEN

Espacenet

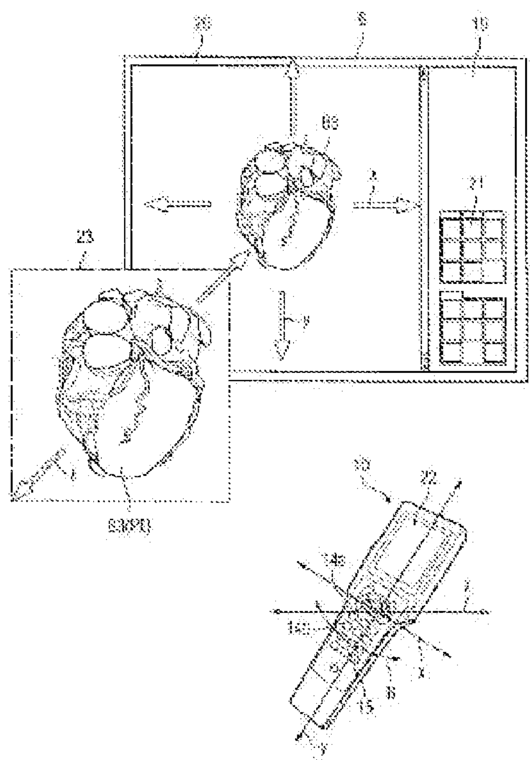
Bibliografiske data: CN101513350 (A) — 2009-08-26

Device and method for displaying medical image and imaging system

Opfinder(e):	ROBERT KAGERMEIER [DE]; EIKE RIETZEL [DE]; STEFFEN SCHROETER [DE]; DIETMAR SIERK [DE] + (KAGERMEIER ROBERT, ; RIETZEL EIKE, ; SCHROETER STEFFEN, ; SIERK DIETMAR)
Ansøger(e):	SIEMENS AG [DE] + (SIEMENS AG)
Klassifikation:	- international: *A61B5/055; A61B6/03; A61B8/13; G06F3/033; G06F3/0346; G06F3/048; G06F3/0484; G09F9/00* - kooperativ: A61B6/548; G06F3/0346; G06F3/04845
Ansøgningsnummer:	CN2009107572 20090223
Prioritetsnummer/-numre:	DE20081010717 20080222
Også publiceret som:	DE102008010717 (A1) US2009217207 (A1)

Sammendrag af CN101513350 (A)

The invention relates to a device (1) for displaying three-dimensional medical image information (B3). The device includes a processing unit (2), a display (3), a remote control (10), a communication interface, and a software module (7). The processing unit (2) is operable to process the medical image information. The display (3) is operable to display the medical image information (B3). The remote control (10) is operable to register a user movement (B) by at least one motion-sensitive sensor (11, 12). The communication interface is operable to transfer the user movement (B) to the processing unit (2). The software module (7) is associated with the processing unit (2). The software module (7) is operable to reconcile the user movement (B) with the medical image information (B3) so that the user movement (B) is reproduced as a virtual movement of the displayed medical image information (B3).



[19] 中华人民共和国国家知识产权局

[51] Int. Cl.
A61B 6/03 (2006.01)
A61B 8/13 (2006.01)
A61B 5/055 (2006.01)
G09F 9/00 (2006.01)

[12] 发明专利申请公布说明书

[21] 申请号 200910007572.1

[43] 公开日 2009 年 8 月 26 日

[11] 公开号 CN 101513350A

[22] 申请日 2009.2.23

[21] 申请号 200910007572.1

[30] 优先权

[32] 2008.2.22 [33] DE [31] 102008010717.4

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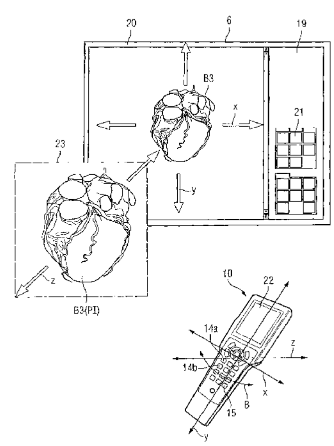
权利要求书 3 页 说明书 8 页 附图 4 页

[54] 发明名称

用于显示医学图像信息的装置和方法以及成像系统

[57] 摘要

本发明涉及一种用于显示三维的医学图像信息(B3)的装置(1)，包括：用于处理图像信息(B3)的处理单元(2)；用于显示图像信息(B3)的显示元件(3)；用于借助至少一个运动敏感的传感器(11，12)采集使用者移动(B)的遥控器(10)；以及将使用者移动(B)传输到处理单元(2)的通信接口。借助所述处理装置(2)配备的软件模块(7)，与图像信息(B3)一起如下计算使用者移动(B)：将使用者移动(B)理解为所显示的图像信息(B3(PI))的虚拟运动。



1. 一种用于显示三维医学图像信息（B3）的装置（1），包括：

- 用于处理图像信息（B3）的处理单元（2），

- 用于显示图像信息（B3）的显示元件（3），

- 用于借助至少一个运动敏感的传感器（11，12）采集使用者移动（B）的遥控器（10），

- 将使用者移动（B）传输到处理单元（2）的通信接口，以及

- 所述处理装置（2）配备的、用于与图像信息（B3）一起如下计算使用者移动（B）的软件模块（7）：将所述使用者移动（B）理解为所显示的图像信息（B3（PI））的虚拟运动。

2. 根据权利要求1所述的装置（1），其中，所述医学图像信息是三维图像信息（B3）。

3. 根据权利要求1或2所述的装置（1），其中，所述传感器是具有一个或多个测量轴线的加速度传感器（11）。

4. 根据权利要求1至3中任一项所述的装置（1），其中，所述传感器是具有一个或多个测量轴线的转动率传感器（12）。

5. 根据权利要求1至4中任一项所述的装置（1），其中，所述遥控器（10）具有至少一个加速度传感器（11）和至少一个转动率传感器（12）。

6. 根据权利要求1至5中任一项所述的装置（1），其中，作为所述通信接口（16）设置了无线电连接。

7. 根据权利要求1至6中任一项所述的装置（1），其中，所述遥控器（10）具有若干用于选择各个显示模式的显示选择转换开关（14），并且其中，根据所选择的显示模式将所述使用者移动（B）转换为虚拟运动。

8. 根据权利要求7所述的装置（1），其中，所述遥控器（10）至少具有一个用于医学诊断或治疗设备（4）的遥控器的操作选择转换开关（15）。

9. 根据权利要求1至8中任一项所述的装置（1），其中，在静止位置设置用于容纳所述遥控器（10）的容纳装置（17）。

10. 根据权利要求9所述的装置（1），其中，所述容纳装置（17）具有弹性支座（18）。

11. 一种用于显示三维医学图像信息（B3）的方法，其中，

- 利用借助至少一个运动敏感的传感器（11，12）的遥控器（10）采集使用者移动（B），

- 将所述使用者移动（B）理解为所显示的图像信息（B3（PI））的虚拟运动。

12. 根据权利要求11所述的方法，其中，借助单轴的或多轴的加速度传感器（11）测量所述使用者移动（B）。

13. 根据权利要求11或12所述的方法，其中，借助单轴的或多轴的转动率传感器（12）测量所述使用者移动（B）。

14. 根据权利要求11至13中任一项所述的方法，其中，借助至少一个加速度传感器（11）和至少一个转动率传感器（12）测量所述使用者移动（B）。

15. 根据权利要求11至14中任一项所述的方法，其中，经过无线电连接进行数据的传输。

16. 根据权利要求11至15中任一项所述的方法，其中，选择显示模式，并且其中，根据所选择的显示模式将所述使用者移动（B）转换为所述虚拟运动。

17. 根据权利要求16所述的方法，其中，显示模式提供了，选择和在至少一个空间方向上移动放大的图像片段。

18. 根据权利要求16或17所述的方法，其中，显示模式提供了，围绕至少一个空间轴转动所显示的图像信息（B3（PI））。

19. 根据权利要求16至18中任一项所述的方法，其中，显示模式提供了，改变所显示的图像信息（B3（PI））的比例。

20. 根据权利要求16至19中任一项所述的方法，其中，显示模式提供了，改变所显示的图像信息（B3（PI））的对比度。

21. 根据权利要求16至20中任一项所述的方法，其中，显示模式共同地考虑利用加速度传感器（11）和利用转动率传感器（12）的测量，用于改变所显示的图像信息（B3（PI））。

22. 根据权利要求16至21中任一项所述的方法，其中，显示模式借助按照计算机鼠标（9）方式的使用者移动（B），允许操作作为工作位计算机运行的处理单元（2）。

23. 根据权利要求16至22中任一项所述的方法，其中，在预定的时间间

隔上重复地采集所述使用者移动（B）。

24. 根据权利要求 16 至 23 中任一项所述的方法，其中，只有在所述使用者移动（B）超过预定的阈值时，才进行所述虚拟运动。

用于显示医学图像信息的装置和方法以及成像系统

技术领域

本发明涉及一种用于显示医学图像信息的装置和方法以及一种具有这样的装置的成像系统。

背景技术

对于医学图像信息的产生来说存在不同的成像系统。在此，例如是计算机断层成像（CT）、正电子发射断层成像（PET）、单光子发射计算机断层成像（SPECT）或者磁共振断层成像（MRT）。借助成像系统可以确定人的身体区域的图像信息。以下将医学图像信息理解为可以用成像系统采集的图像信息。这里通常是二维的（2D）、三维的（3D）或四维的（4D）图像信息。二维的图像信息包括两个空间维。三维的图像信息包括三个空间维或者两个空间维和时间。四维的图像信息包括三个空间维和时间。只有在不同的时刻采集身体区域时，时间作为维才是有意义的。在心脏学中通常是在检查患者的心脏时关于可能的缺陷功能在不同的心跳阶段采集图像信息，对这些心跳阶段的检查具有时间戳。

图像信息在显示单元上、通常是在监视器上被显示。借助所显示的图像信息可以建立医生对相应的身体区域的检查结果。此外，通过在进行医学干预期间在不同的时间用成像系统测量图像信息并接着由医生进行检查，所显示的图像信息使得可以监控医学的干预。

图像信息的准备（Aufbereitung）和显示通过成像系统配备的、通常被构造为计算机系统的处理单元来进行。借助操作元件、如计算机键盘或计算机鼠标，可以改变在显示元件上显示的图像信息。为此，设置了软件模块，该软件模块可以通过计算机键盘或计算机鼠标选择不同的功能，如图像信息的局部放大、图像信息的旋转等等。因此，借助计算机键盘的光标键或借助计算机鼠标的滚动按钮来进行显示的实际修改。对于计算机键盘或对于计算机鼠标需要桌面等作为支撑垫。由此不可能将计算机键盘或计算机鼠标安置在患者支撑装置（如

患者卧榻，其上安置了用于医学检查或干预的患者）的直接的附属区。特别是在执行医学干预时医生由此必须不断地在患者支撑装置和计算机键盘或计算机鼠标的位置之间变换位置，以便可以仔细查看医学干预的进程。

发明内容

由此本发明要解决的技术问题是，提供一种用于显示三维医学图像信息的装置，借助该装置可以按照用户友好的简单方式修改所显示的图像信息。

按照本发明，上述技术问题的解决是通过一种用于显示三维医学图像信息的装置实现的。为此设置了用于处理图像信息的处理单元和用于显示图像信息的显示元件。在此，处理单元特别地被构造为计算机系统，为该计算机系统配备有被构造为监视器的显示元件。此外，还设置了用于借助至少一个运动敏感的传感器采集使用者移动的遥控器。另外设置了将使用者移动传输到处理单元的通信接口。为处理单元配备有用于与图像信息一起计算使用者移动的软件模块。如下进行该计算：将使用者移动理解为在显示元件上所显示的图像信息的虚拟运动。以这种方式将使用者移动按照直观方式转换为在显示元件上的图像信息的类似运动。遥控器的支撑垫（如桌面等）不再是必须的。由此医生可以随身携带遥控器并且从成像系统周围的每个位置对所显示的图像信息进行改变。尤其是在显示元件的足够大尺寸的前提条件下，医生在进行医学干预的情况下不再必须不断地改变其位置，以便根据图像信息评价医学干预的进程。这样明显更快地并且由此对患者来说更体贴地进行医学干预。

在一种优选变形中，传感器是具有一个或多个测量轴线的加速度传感器。这样的加速度传感器例如在 US5540095 中被描述过。借助加速度传感器采集遥控器的平移运动作为使用者移动。如果是具有三个测量轴线的加速度传感器，则可以在三个空间方向上的每一个上采集遥控器的运动。使用者移动被转换为在显示元件上的图像信息的相应的平移运动。

在另一种优选变形中传感器是具有一个或多个测量轴线的转动率传感器（Drehratensensor），按照专业术语也称为陀螺仪（Gyroskop），例如在 US 6505511 B1 中被描述过。借助转动率传感器可以采集遥控器的转动或旋转运动作为使用者移动，其被理解为所显示的图像信息的转动运动或旋转。如果转动率传感器是三轴的转动率传感器，则可以用它采集遥控器的任意转动作为使用者移动并且将其理解为所显示的图像信息的虚拟运动。

在一种具有优势的扩展中，遥控器具有至少一个加速度传感器和至少一个转动率传感器。如果这两个传感器都是三轴的传感器，则借助其可以采集遥控器在空间的任意运动作为使用者移动并且将其理解为所显示的图像信息的虚拟运动。按照这种方式可以完全直观地改变在显示元件上显示的图像信息。

在一种优选扩展中，作为通信接口设置了无线电连接。由此可以将使用者移动无线传输到处理单元。换言之，检查的医生的运动自由不受任何在遥控器和处理单元之间作为通信连接的电缆连接的情况下的限制。

在一种合适的扩展中，遥控器具有若干用于选择各个显示模式的显示选择转换开关。根据所选择的显示模式将使用者移动转换为图像信息的虚拟运动。换言之，当事先操控了相应的显示选择转换开关时，才将使用者移动转换为所显示的图像信息的运动。由此可靠地避免了通过无意的遥控器运动和作为使用者移动的对运动的不期望的配准（Registrierung）引起的所显示的图像信息的错误调整。

在一种优选扩展中，遥控器至少具有一个用于医学诊断或治疗设备的遥控器的操作选择转换开关。换言之，可以借助遥控器来触发医学诊断或治疗设备的功能。例如，可以在医学信息的范围内触发对更新的图像信息的记录，以便将医学干预的进程作为图像信息变得可视。例如，在X射线治疗设备中，为了有针对地照射患者，可以开启或关闭治疗用的射线例如X射线或粒子射线。此外具有优势的是，借助遥控器来触发医学干预。在此，例如可以是注射对比剂或触发热的或电的治疗技术。可以借助遥控器来进行植入物例如近距离治疗（Brachytherapie）中的种子（Seed）、或者在对心脏的干预中的支架的放置。

在一种合适的变形中，在静止位置设置用于容纳遥控器的容纳装置。该容纳装置例如被设置在被构造为患者卧榻的患者支撑装置的扶手上。该容纳装置容纳遥控器，使得医生双手都可以自由地进行干预。因为容纳装置被设置在患者支撑装置上或者在其紧邻处，所以遥控器始终处于医生可到达的范围。

容纳装置优选地具有弹性支座。换言之，还可以（可能受限制地）移动由容纳装置容纳的遥控器。由此对于进行简单的移动不必额外地将遥控器从其容纳装置中取出。医生在进行移动之后可以立即使其双手解放，以便继续进行医学干预。

此外，本发明的技术问题还通过一种用于显示三维医学图像信息的方法解决。为此，用遥控器借助至少一个运动敏感的传感器采集使用者移动。接着借

助通信接口将使用者移动传输到处理单元。使用者被移动理解为所显示的图像信息的虚拟运动。在此，针对用于显示三维的医学图像信息的装置的变形及其优选实施方式可以被对应地转移到所述方法。

优选地，显示模式提供了选择和在至少一个空间方向上移动图像信息的放大的图像片段。为此，合适地借助加速度传感器仅仅采集遥控器的平移运动。在此，例如借助被构造为按键的显示选择转换开关来进行显示模式的选择。在此，在激活显示模式的情况下首先放大地显示图像片段、优选地在显示元件上所显示的图像信息的中间图像片段。接着借助使用者移动可以移动该图像片段，直到图像片段中感兴趣的图像信息以放大的形式被显示。此外合适地的是，连续多次操控相应的显示选择转换开关可以逐渐地改变图像片段和逐渐放大所显示的图像信息。

此外，还可以优选地互相组合不同的功能。在二维的（2D）图像信息情况下遥控器在平面中的运动可以被理解为图像片段的改变，并且从平面出发的向上或向下运动被理解为所显示的图像信息的放大或者缩小。

合适地，显示模式提供了围绕至少一个空间轴转动所显示的图像信息。为此，合适地借助转动率传感器仅采集遥控器的旋转运动。按照这种方式可以将所显示的图像信息一直转动，直到在显示元件上感兴趣的图像信息可以被良好地看清并且由此可以检查。

优选地，显示模式提供了改变所显示的图像信息的比例。换言之，所显示的图像信息通过遥控器的平移运动或通过旋转运动被无级地放大或缩小地显示。

合适地，显示模式提供了改变所显示的图像信息的对比度。换言之，对比度通过遥控器的平移运动或通过遥控器的旋转运动被无级地增大或减小。在以灰度图表示的图像信息中无级地变换通常由255个灰度值组成的灰度级。以这种方式可以按照简单的方式对检查呈现最好可能的对比度。

在一种优选变形中，显示模式共同地考虑用加速度传感器和用转动率传感器的测量，用于改变所显示的图像信息。由此产生用于直观地改变图像信息的多种可能性。

在三维（3D）图像信息的情况下，在平移运动时可以移动所显示的图像片段，并且在遥控器转动时进行所显示的图像信息的放大或缩小。由此，例如遥控器的左旋可以导致所显示的图像的放大以及遥控器的右旋导致所显示的图像

信息的缩小。

如果呈现一个序列的四维（4D）图像信息，则例如又可以将平移运动转换为所显示的图像片段的改变。遥控器的旋转运动可以根据旋转方向而导致选择前面的或后面的图像信息。

在一种优选变形中，显示模式借助按照计算机鼠标方式的使用者移动，使得可以操作作为工作位计算机（Arbeitsplatzrechner）运行的处理单元。为此，合适地在遥控器上附加设置一个或多个操作按键。在操控这样的按键时，特别地仿真计算机鼠标的左键或右键的操控。通过两次直接连续操控操作键模仿如通常双击鼠标左键以开始程序等等那样的双击。换言之，借助遥控器可以遥控工作位计算机，而无需为此改变其位置。

优选地，如下构造在遥控器和计算机系统之间的通信接口：使得该通信接口关于传输到计算机系统上的控制信号与计算机鼠标的标准接口相应。以这种方式可以按照通常的方式按照完全的功能范围使用在计算机系统的操作系统上安装的软件模块。由此，不需要与相应的编程成本相关的软件模块的匹配或者程序改编。

因为为显示图像信息而设置的软件模块通常是为借助计算机鼠标的操作而设置，所以优选也可以用遥控器进行软件模块的完全的操作。由此，用户通过按照计算机鼠标的方式使用遥控器，例如可以选择图像片段。接着可以用已经描述的显示模式例如通过遥控器的平移运动或通过旋转运动进行所显示的图像信息的改变。换言之，在显示元件上显示的图像信息也可以通过多个显示模式的连续切换而被改变。

合适地，在预定的时间间隔上重复地采集使用者移动并且在该时间间隔上求平均。以这种方式缓和了遥控器的突然的和剧烈的运动。

优选地，只有在使用者移动超过预定的阈值时，才将其转换为虚拟的运动。以这种方式避免了在遥控器仅仅微小偏转的情况下就立即进行所显示的图像信息的改变。

此外，本发明的技术问题还通过具有用于显示三维图像信息的装置的医学诊断或治疗设备解决。在此，针对用于显示三维的图像信息的装置的变形及其优选实施方式可以被对应地转移到所述医学诊断或治疗设备。

附图说明

下面结合附图更详细描述本发明的实施例。在附图中：

图 1 示出了用于显示三维医学图像信息的装置的示意图，

图 2 示出了所述装置的第一运行模式，

图 3 示出了所述装置的第二运行模式，以及

图 4 示出了所述装置的第三运行模式。

具体实施方式

图 1 示出了用于显示三维医学图像信息 1 的装置，具有被构造为计算机系统的处理单元 2 和连接到处理单元上的并且被构造为监视器的显示元件 3。装置 1 与医学成像系统 4 相关联，后者例如被构造为计算机断层成像（CT）、正电子发射断层成像（PET）、单光子发射计算机断层成像（SPECT）或者磁共振断层成像（MRT）。借助医学成像系统 4 测量原始数据 R，该原始数据 R 由处理单元 2 所配备的计算单元 5 计算。在此，生成三维医学图像信息 B3 并且在显示元件 3 上显示。在计算机断层成像中作为原始数据 R 测量投影图像，该原始数据 R 由被构造为重建计算机的计算单元 5 转换为三维医学图像信息 B3。软件模块 7 用于准备图像信息 B3。计算机键盘 8 和计算机鼠标 9 作为操作元件分别借助接口 8′、9′连接到处理单元 2。借助操作元件 8、9 通过控制信号 St 访问软件模块 7 并且借助用户界面准备图像信息 B3。按照这种方式可以改变在显示器 6 上显示的图像信息 B3。因此，可以放大图像信息 B3 的一个片段并且借助计算机键盘 8 的光标键或借助计算机鼠标的滚动按钮移动该片段。以类似的方式可以旋转或倾斜（Verkippen）所显示的图像信息 B3。

此外，为装置 1 配备了遥控器 10。遥控器 10 包括三轴的加速度传感器 11 和三轴的转动率传感器 12。借助这两个传感器 11、12 可以采集遥控器 10 的任意的使用者移动 B。为此，由加速度传感器测量位置信息 PI1 并且由转动率传感器 12 测量位置信息 PI2，并且传输到处理单元 13。此外设置了多个显示选择转换开关 14，其开关状态 S1 被传输到处理单元 13。另外设置了多个操作选择转换开关 15，其开关状态 S2 同样被传输到处理单元 13。根据显示选择转换开关 14 的开关状态 S1，处理单元 13 准备由传感器 11、12 测量的位置信息 PI1、PI2 并且借助通信接口 16 将其作为位置信息 PI 传输到处理单元 2。位置信息 PI 与图像信息 B3 一起由软件模块 7 如下计算：将使用者移动 B 理解为所显示的图像信息 B3（PI）的虚拟运动。换言之，根据所显示的图像信息 B3（PI）理

解遥控器 10 的任意的使用者移动 B。这可以非常直观地改变所显示的图像信息 B3（PI）。

操作选择转换开关 15 的开关状态 S2 借助处理单元 13 经过通信接口 16 被传输到处理单元 2 并且从那里被传输到医学成像系统 4。根据医学成像系统 4 的不同的实现，借助遥控器 10 可以远程控制设备功能。例如，借助遥控器 10 在计算机断层成像中可以触发用于产生新的原始数据 R 以及由此产生新的三维医学图像信息 B3 的扫描。如果医学成像系统是医学治疗装置的部分，则可以借助操作选择转换开关 15 开启或者关闭用于放射疗法的微粒辐射。

医学成像系统 4 配备有用于遥控器 10 的容纳装置 17。容纳装置 17 具有弹性支座 18，例如弹簧臂（Federarm）等等，遥控器 10 借助该支座被固定在成像系统 4 的组件上。在此，例如是在图 1 中未示出的患者卧榻的扶手。

总之，主治医生相应地从任意的位置既可以触发成像系统 4 的功能，也可以对所显示的图像信息 B3（PI）进行改变。由此，主治医生不必赶到处理单元 2 处并且借助计算机键盘 8 或计算机鼠标 9 在那里来触发功能。而是他可以集中精神于其医生的任务例如进行医学的干预。根据需要可以触发借助医学成像系统 4 用于产生新的图像信息 B3 的新的测量，以便监控医学干预的进程。借助遥控器修改在显示器 6 上所显示的图像信息 B3（PI），以便可得到最佳的检查结果。接着根据该检查结果继续进行医学的干预。

如果不需要遥控器 10，则将其置于容纳装置 17 中。借助容纳装置 17 的弹性支座 18，主治医生可以进行使用者移动 B，其被转换成图像信息 B3（PI）的虚拟运动，即使也许是受限的移动可能性。

图 2 示出了显示元件 3 的显示器 6，在该显示器 6 上示出了用户界面 19。该用户界面 19 具有菜单列表 20 和若干按键 21，借助其可以访问软件模块 7 的功能。在显示元件 3 的位置上的用户界面 19 的操作借助计算机键盘 8 或计算机鼠标 9，通过访问菜单列表 20 或按键 21 来进行。由此可以从计算机键盘 8 或计算机鼠标 9 的位置改变所显示的图像信息。

借助遥控器 10 进行对软件模块 7 的访问。遥控器 10 具有用于显示目前选择的运行模式的指示区域 22。通过操控显示选择转换开关 14a 可以选择第一显示模式并且在显示器 6 上显示图像信息 B3 的片段 23。此时，借助遥控器 10 的使用者移动 B 一直移动片段，直到所显示的图像信息 B3（PI）显示期望的片段 23。换言之，第一显示模式具有如下功能：仅仅分析借助加速度传感器 11 所测

量的遥控器 10 在所有三个空间方向 x、y、z 上的平移运动并且将其转换为片段 23 在所有三个空间方向 x、y、z 上的移动以显示图像信息 B3（PI）。如果多次连续操纵了显示选择转换开关 14a，则片段 23 被逐步地放大。借助另一个显示选择转换开关 14b 又可以建立最初显示的图像信息 B3 并且再次退出第一显示模式。

图 3 如图 2 那样示出了显示元件 3 的显示器 6 和作为所显示的三维图像信息 B3 的心脏。借助遥控器 10 的显示选择转换开关 14b 可以选择遥控器 10 的第二显示模式。在所选择的第二显示模式中，仅仅分析遥控器 10 的旋转运动以及由此作为使用者移动 B 的遥控器 10 的转动率传感器 12 的测量信号，并且将其转换为所显示的图像信息 B3（PI）的转动或者说旋转。以这种方式，可以作为使用者移动 B 采集围绕空间轴 x、y、z 的任意的转动或者说旋转。换言之，随着遥控器 10 在所有三个空间方向上的转动，图像信息 B3 一直转动，直到用户感兴趣的图像信息 B3（PI）在显示器 6 上被显示。通过操控显示选择转换开关 14c 又可以显示最初的图像信息 B3 并且退出遥控器 10 的第二运行模式。

图 4 示出了处在通过操控显示选择转换开关 14d 所选择的第三显示模式之下的显示器 6。现在，在显示器 6 上不再看得见图像信息 B3。而是此时显示鼠标光标 24，借助该鼠标光标可以通过遥控器 10 在用户界面 19 上选择任意的程序功能。换言之，该第三显示模式对应于按照计算机鼠标 9 的方式操作用户界面 19。为此，如下处理利用加速度传感器 11 所测量的位置信息 PI1：仅仅分析作为使用者移动 B 的在两个空间轴 x、y 的方向上的运动并且将其转换为位置信息 PI。而对鼠标光标 24 的运动不考虑第三空间方向。在所示出的情况下所显示的图像信息 B3（PI）的虚拟运动对应于鼠标光标 24 的运动。此外，设置了两个操作按键 25，其在功能上对应于鼠标左键以及右键。由此遥控器 10 可以模仿计算机鼠标的所有功能。

通过再次操控显示选择转换开关 14d 可以再次退出第三显示模式。

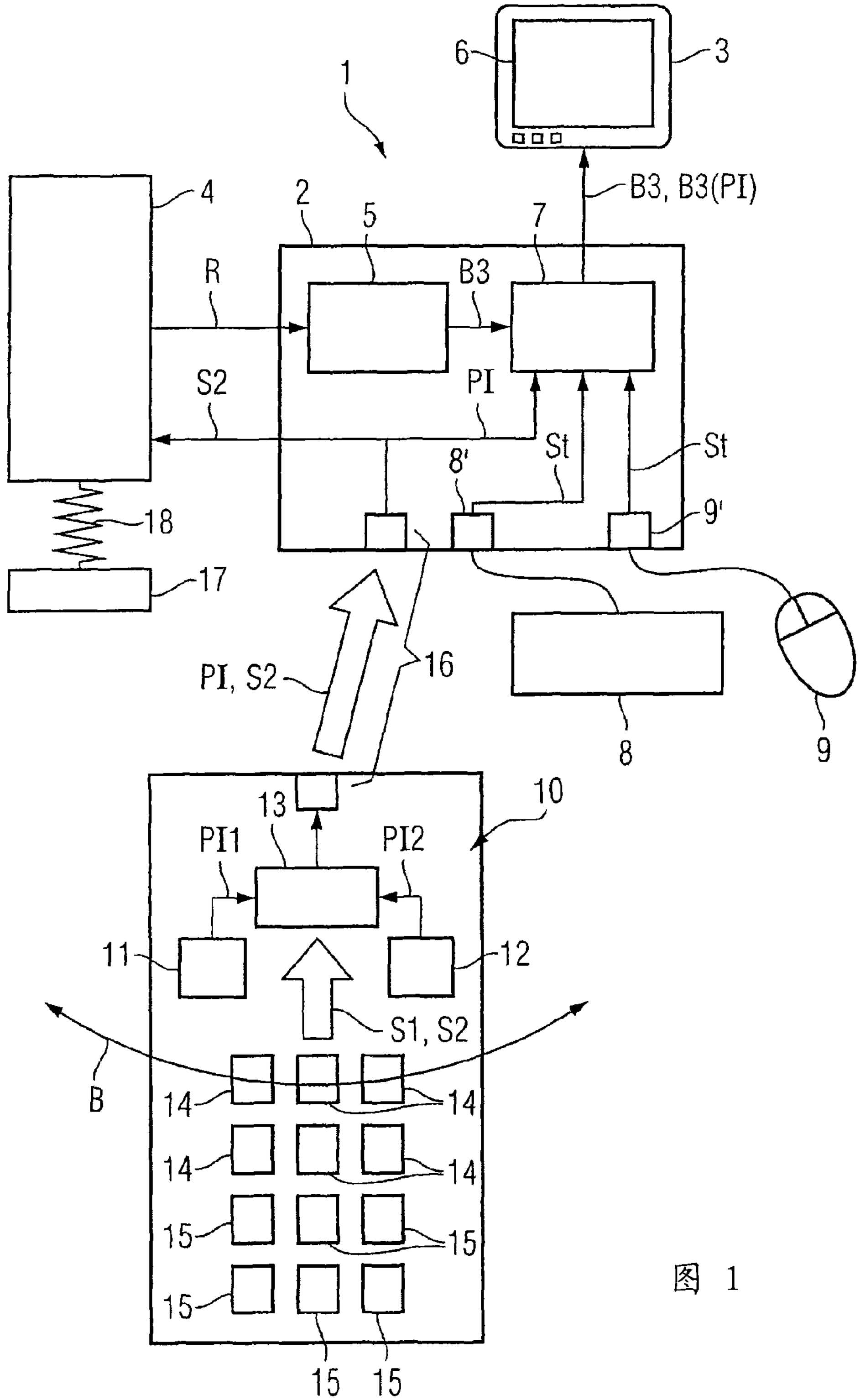

1
6
3
B3, B3(PI)
4
2
5
7
R
B3
S2
PI
St
8'
St
18
9'
17
PI, S2
16
8
9
10
13
PI1
PI2
11
12
S1, S2
B
14
15

图 1

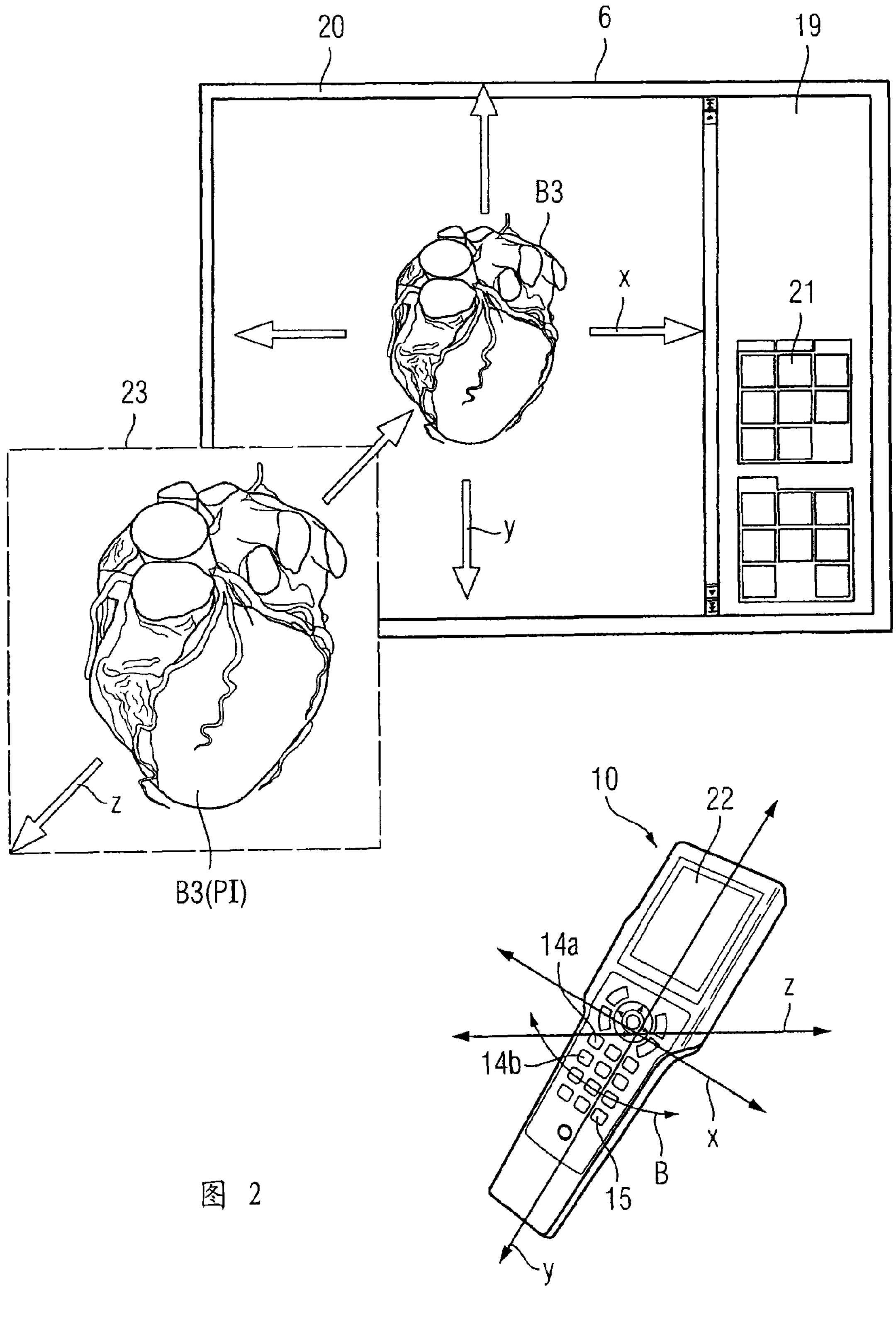


图 2

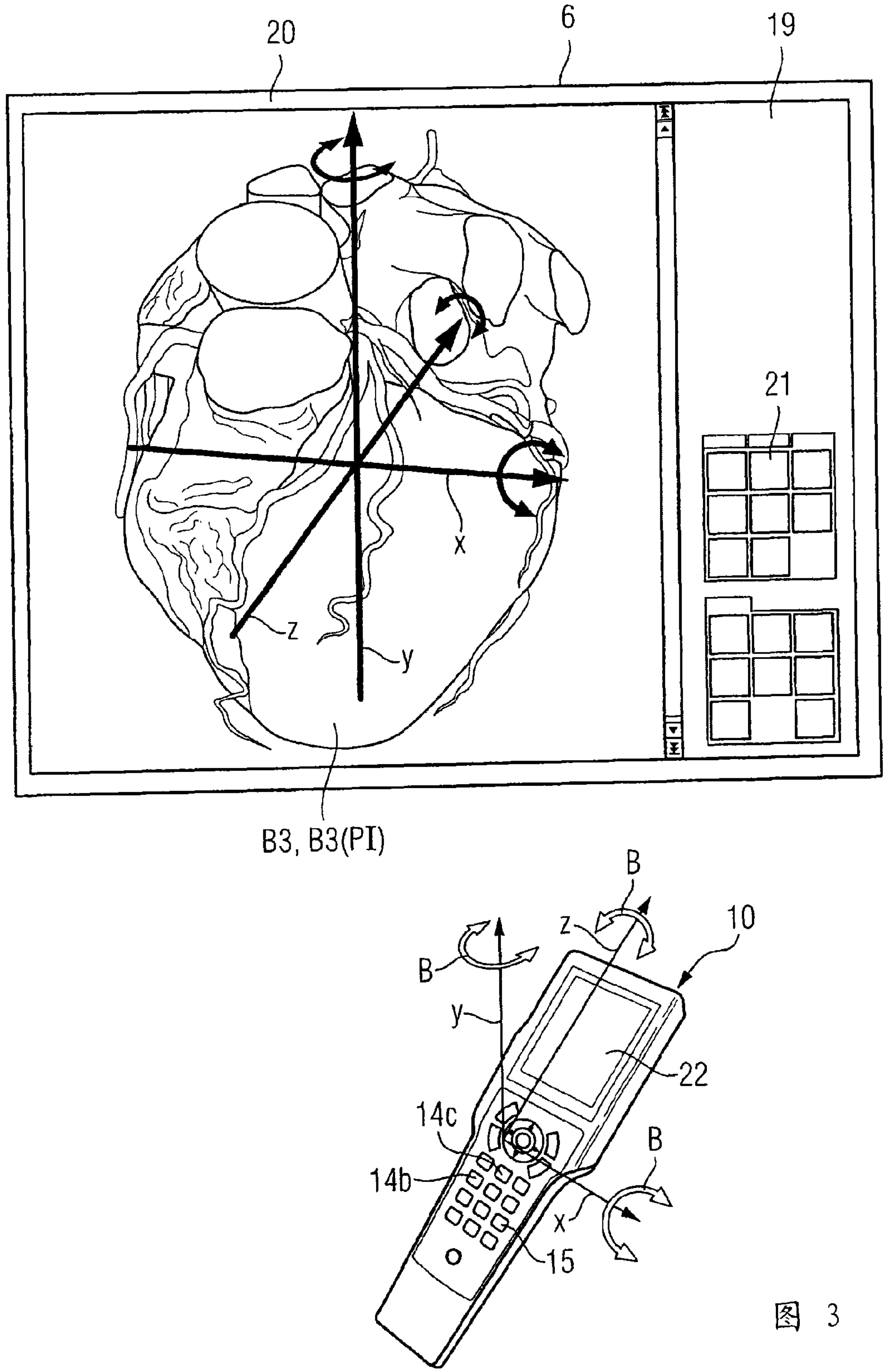
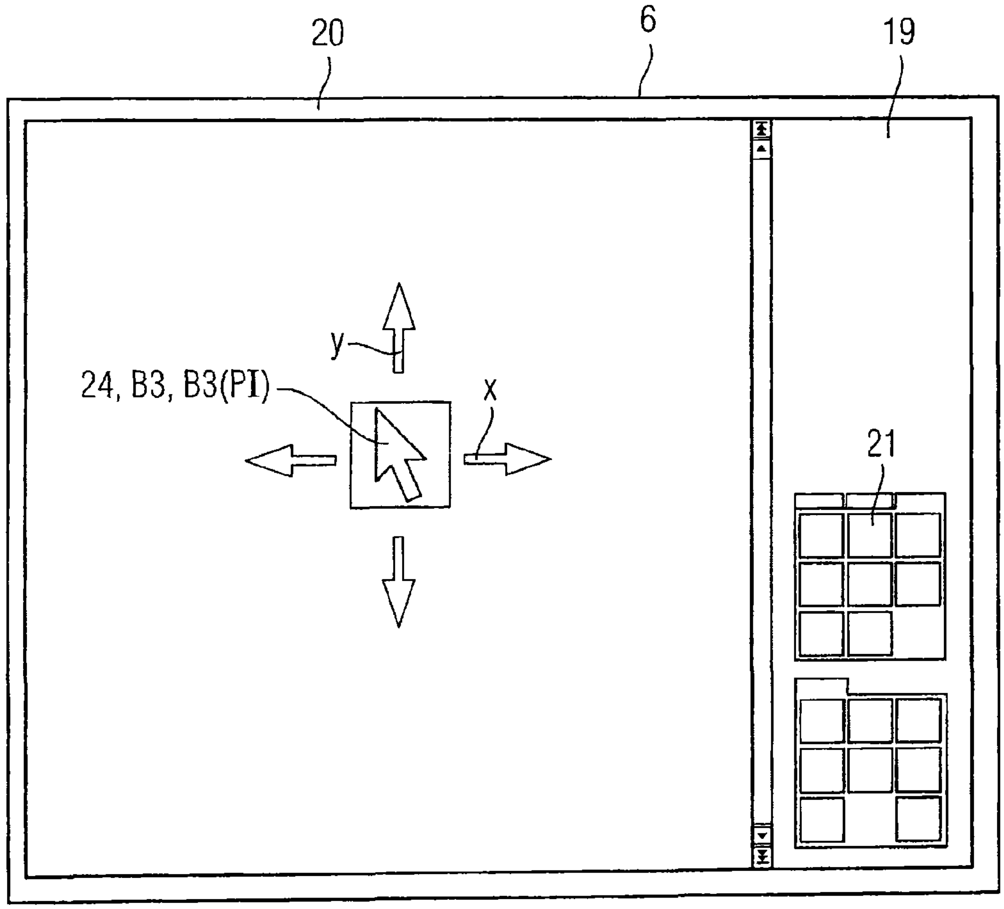


图 3



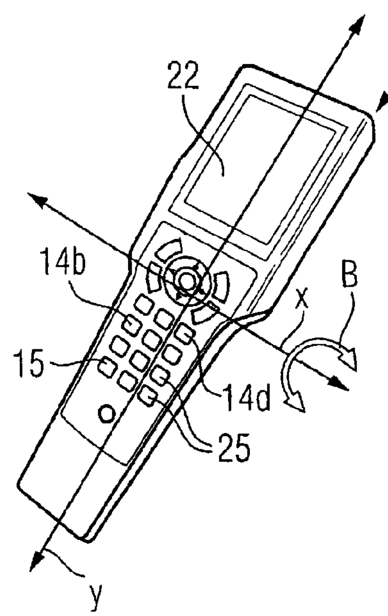


图 4

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 July 2009 (16.07.2009)

PCT

(10) International Publication Number
WO 2009/089126 A1

(51) International Patent Classification:
H04N 13/00 (2006.01) *H04N 13/02* (2006.01)

(21) International Application Number:
PCT/US2009/030065

(22) International Filing Date: 4 January 2009 (04.01.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/019,159 4 January 2008 (04.01.2008) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(54) **Title:** THREE-DIMENSIONAL MODEL REFINEMENT

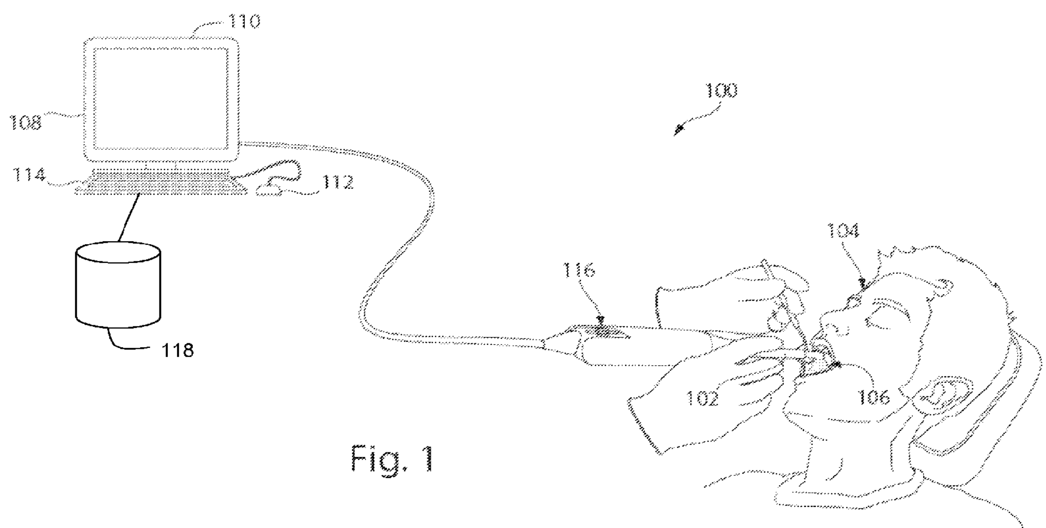

Fig. 1

(57) **Abstract:** A three-dimensional measurement is refined by warping two-dimensional images of an object from offset camera positions according to a three-dimensional model of the object, and applying any resulting discrepancies to refine the three-dimensional model, or to refine one of a number of three-dimensional measurements used to create the three-dimensional model.

WO 2009/089126 A1

THREE-DIMENSIONAL MODEL REFINEMENT

[0001] The present application claims priority from the U.S. Provisional Patent Application No. 61/019,159, filed January 4, 2008, which is hereby incorporated by reference in its entirety.

FIELD OF INVENTION

[0002] This invention relates generally to three-dimensional imaging and more specifically to refinement of three dimensional models reconstructed from a sequence of three-dimensional measurements captured along a camera path.

BACKGROUND

[0003] In one technique for three-dimensional image reconstruction, a number of images or image sets of an object are captured with a camera that travels in a path over the surface of the object. Information from this image catalogue can then be used to reconstruct a three-dimensional model of the object based upon each camera position and three-dimensional measurement captured along the path. While individual measurements from the camera can contain noise from a variety of sources, the resulting three-dimensional model tends to smooth out this noise to recover three-dimensional data points more accurate than the individual measurements.

[0004] There remains a need for post-processing techniques to refine individual three-dimensional measurements based upon the full data set available for a completed three-dimensional scan.

SUMMARY

[0005] A three-dimensional measurement is refined by warping two-dimensional images of an object from offset camera positions according to a three-dimensional model of the object, and applying any resulting discrepancies to refine the three-dimensional model, or to refine one of a number of three-dimensional measurements used to create the three-dimensional model.

[0006] In one aspect, a method of refining a three-dimensional model described herein includes providing a three-dimensional model of an object; obtaining a first two-dimensional image of the object from a first camera pose; obtaining a second two-dimensional image of the object from a second camera pose, wherein the second two-dimensional image includes a common portion of a surface of the object with the first two-dimensional image; deforming the first two-dimensional image based upon a spatial relationship of the first camera pose, the second camera pose, and the three-dimensional model to obtain an expected image from the second camera pose based upon the first camera pose; comparing the second two-dimensional image to the expected image to identify one or more discrepancies; and correcting the three-dimensional model based upon the one or more discrepancies.

[0007] The first camera pose and the second camera pose may be a position and an orientation of a single camera in two dependent positions. The first camera pose and the second camera pose may be a position and an orientation of two offset channels of a multi-aperture camera. The first camera pose and the second camera pose may be a position and an orientation of a single camera in two independent positions. A relationship between the first camera pose and the second camera pose may be calculated based upon a three-dimensional measurement of the surface of the object from each of the first camera pose and the second camera pose. The method may include deriving the three-dimensional model from a plurality of three-dimensional measurements of the surface of the object from a plurality of camera poses including the first camera pose and the second camera pose. The method may include applying the one or more discrepancies to directly refine the three-dimensional model. The method may include applying the one or more discrepancies to refine a three-dimensional measurement from one or more of the first camera pose and the second camera pose to provide a refined measurement. The method may include refining a camera path calculation for a camera path used to create the three-dimensional model using the refined measurement to provide a refined camera path. The method may include using the refined camera path and the refined measurement to refine the three-dimensional model. The three-dimensional model may be a point cloud or a polygonal mesh. The object may be human dentition. The second camera pose may correspond to a center channel of a multi-aperture camera system, the center channel providing a conventional two-dimensional image of the object. The method may include obtaining a third two-dimensional image of the object from a third camera pose corresponding to a second side channel of the multi-aperture system and deforming the third two-dimensional image to an expected image for the center channel for use in further refining the three-dimensional measurement from the multi-aperture camera system.

[0008] In another aspect, computer program product for refining a three-dimensional model of an object described herein includes computer executable code embodied on a computer readable medium that, when executing on one or more computing devices, performs the steps of providing a three-dimensional model of an object; obtaining a first two-dimensional image of the object from a first camera pose; obtaining a second two-dimensional image of the object from a second camera pose, wherein the second two-dimensional image includes a common portion of a surface of the object with the first two-dimensional image; deforming the first two-dimensional image based upon a spatial relationship of the first camera pose, the second camera pose, and the three-dimensional model to obtain an expected image from the second camera pose based upon the first camera pose; comparing the second two-dimensional image to the expected image to identify one or more discrepancies; and correcting the three-dimensional model based upon the one or more discrepancies.

[0009] The first camera pose and the second camera pose may be a position and an orientation of a single camera in two dependent positions. The first camera pose and the second camera pose may be a position and an orientation of two offset channels of a multi-aperture camera. The first camera pose and the second camera pose may be a position and an orientation of a single camera in two independent positions. A relationship between the first camera pose and the second camera pose may be calculated based upon a three-dimensional measurement of the surface of the object from each of the first camera pose and the second camera pose. The computer program produce may include code for performing the step of deriving the three-dimensional model from a plurality of three-dimensional measurements of the surface of the object from a plurality of camera poses including the first camera pose and the second camera pose. The computer program produce may include code for performing the step of applying the one or more discrepancies to directly refine the three-dimensional model. The computer program produce may include code for performing the step of applying the one or more discrepancies to refine a three-dimensional measurement from one or more of the first camera pose and the second camera pose to provide a refined measurement. The computer program produce may include code for performing the step of refining a camera path calculation for a camera path used to create the three-dimensional model using the refined measurement to provide a refined camera path. The computer program produce may include code for performing the step of using the refined camera path and the refined measurement to refine the three-dimensional model. The three-dimensional model may be a point cloud or a polygonal mesh. The object may be human dentition. The second camera pose may correspond to a center channel of a multi-aperture camera system, the center channel providing a conventional two-dimensional image of the object. The computer program product may include code for performing the steps of obtaining a third two-dimensional image of the object from a third camera pose corresponding to a second side channel of the multi-aperture system and deforming the third two-dimensional image to an expected image for the center channel for use in further refining the three-dimensional measurement from the multi-aperture camera system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The invention and the following detailed description of certain embodiments thereof may be understood by reference to the following figures.

[0011] Fig. 1 shows a three-dimensional scanning system.

[0012] Fig. 2 shows a schematic diagram of an optical system for a three-dimensional camera.

[0013] Fig. 3 shows a processing pipeline for obtaining three-dimensional data from a video camera.

[0014] Fig. 4 illustrates a coordinate system for three-dimensional measurements.

[0015] Fig. 5 illustrates a sequence of images captured from a moving camera.

[0016] Fig. 6 is a conceptual representation of a three-dimensional data acquisition process.

[0017] Fig. 7 is a flow chart of a process for refining three-dimensional data.

[0018] Fig. 8 is a flow chart of a global path optimization.

DETAILED DESCRIPTION

[0019] In the following text, references to items in the singular should be understood to include items in the plural, and vice versa, unless explicitly stated otherwise or clear from the text. Grammatical conjunctions are intended to express any and all disjunctive and conjunctive combinations of conjoined clauses, sentences, words, and the like, unless otherwise stated or clear from the context.

[0020] The following description details specific scanning technologies and focuses on dental applications of three-dimensional imaging; however, it will be appreciated that variations, adaptations, and combinations of the methods and systems below will be apparent to one of ordinary skill in the art. For example, while an image-based system is described, non-image based scanning techniques such as infrared time-of-flight techniques or structured light techniques using patterned projections may similarly employ reconstruction based on camera path that may benefit from the improvements described herein. Similarly, while the following description emphasizes a refinement using concurrent images from two offset channels of a multi-aperture camera, it will be understood that the techniques may be similarly applied to refine frame-to-frame data for a camera path of a multi-aperture camera, or different frames of data for a conventional camera. As another example, while digital dentistry is one useful application of the improved accuracy that results from the techniques described herein, the teachings of this disclosure may also usefully be employed to refine three-dimensional animation models, three-dimensional scans for machine vision applications, and so forth. All such variations, adaptations, and combinations are intended to fall within the scope of this disclosure.

[0021] In the following description, the term "image" generally refers to a two-dimensional set of pixels forming a two-dimensional view of a subject within an image plane. The term "image set" generally refers to a set of related two-dimensional images that might be resolved into three-dimensional data. The term "point cloud" generally refers to a three-dimensional set of points forming a three-dimensional view of the subject reconstructed from a number of two-dimensional images. In a three-dimensional image capture system, a number of such point clouds may also be registered and combined into an aggregate point cloud constructed from images captured by a moving camera. Thus it will be understood that pixels generally refer to two-dimensional data and points generally refer to three-dimensional data, unless another meaning is specifically indicated or clear from the context.

[0022] The terms “three-dimensional model”, “three-dimensional surface representation”, “digital surface representation”, “three-dimensional surface map”, and the like, as used herein, are intended to refer to any three-dimensional reconstruction of an object, such as a point cloud of surface data, a set of two-dimensional polygons, or any other data representing all or some of the surface of an object, as might be obtained through the capture and/or processing of three-dimensional scan data, unless a different meaning is explicitly provided or otherwise clear from the context. A “three-dimensional representation” may include any of the three-dimensional surface representations described above, as well as volumetric and other representations, unless a different meaning is explicitly provided or otherwise clear from the context.

[0023] In general, the terms “render” or “rendering” refer to a two-dimensional visualization of a three-dimensional object, such as for display on a monitor. However, it will be understood that a variety of three-dimensional rendering technologies exist, and may be usefully employed with the systems and methods disclosed herein. For example, the systems and methods described herein may usefully employ a holographic display, an autostereoscopic display, an anaglyph display, a head-mounted stereo display, or any other two-dimensional and/or three-dimensional display. As such, rendering as described herein should be interpreted broadly unless a narrower meaning is explicitly provided or otherwise clear from the context.

[0024] The term “dental object”, as used herein, is intended to refer broadly to subject matter related to dentistry. This may include intraoral structures such as dentition, and more typically human dentition, such as individual teeth, quadrants, full arches, pairs of arches (which may be separate or in occlusion of various types), soft tissue, and the like, as well bones and any other supporting or surrounding structures. As used herein, the term “intraoral structures” refers to both natural structures within a mouth as described above and artificial structures such as any of the dental objects described below that might be present in the mouth. Dental objects may include "restorations", which may be generally understood to include components that restore the structure or function of existing dentition, such as crowns, bridges, veneers, inlays, onlays, amalgams, composites, and various substructures such as copings and the like, as well as temporary restorations for use while a permanent restoration is being fabricated. Dental objects may also include a "prosthesis" that replaces dentition with removable or permanent structures, such as dentures, partial dentures, implants, retained dentures, and the like. Dental objects may also include "appliances" used to correct, align, or otherwise temporarily or permanently adjust dentition, such as removable orthodontic appliances, surgical stents, bruxism appliances, snore guards, indirect bracket placement appliances, and the like. Dental objects may also include "hardware" affixed to dentition for an extended period, such as implant fixtures, implant abutments, orthodontic brackets, and other orthodontic components. Dental objects may also include "interim components" of dental manufacture such as dental models (full and/or partial), wax-ups, investment molds, and the like, as well as trays, bases, dies, and other components employed in the fabrication of restorations, prostheses, and the like. Dental objects may also be categorized as natural dental objects such as the teeth, bone, and other intraoral structures described above or as artificial dental objects such as the restorations, prostheses, appliances, hardware, and interim components of dental manufacture as described above.

[0025] Terms such as "digital dental model", "digital dental impression" and the like, are intended to refer to three-dimensional representations of dental objects that may be used in various aspects of acquisition, analysis, prescription, and manufacture, unless a different meaning is otherwise provided or clear from the context. Terms such as "dental model" or "dental impression" are intended to refer to a physical model, such as a cast, printed, or otherwise fabricated physical instance of a dental object. Unless specified, the term "model", when used alone, may refer to either or both of a physical model and a digital model.

[0026] It will further be understood that terms such as "tool" or "control", when used to describe aspects of a user interface, are intended to refer generally to a variety of techniques that may be employed within a graphical user interface or other user interface to receive user input that stimulates or controls processing including without limitation drop-down lists, radio buttons, cursor and/or mouse actions (selections by point, selections by area, drag-and-drop operations, and so forth), check boxes, command lines, text input fields, messages and alerts, progress bars, and so forth. A tool or control may also include any physical hardware relating to the user input, such as a mouse, a keyboard, a display, a keypad, a track ball, and/or any other device that receives physical input from a user and converts the physical input into an input for use in a computerized system. Thus in the following description the terms "tool", "control" and the like should be broadly construed unless a more specific meaning is otherwise provided or clear from the context.

[0027] Fig. 1 depicts a three-dimensional scanning system that may be used with the systems and methods described herein. In general, the system 100 may include a camera 102 that captures images from a surface 106 of an object 104, such as a dental patient, and forwards the images to a computer 108, which may include a display 110 and one or more user-input devices 112, 114 such as a mouse 112 or a keyboard 114. The camera 102 may also include an integrated input or output device 116 such as a control input (e.g., button, touchpad, thumbwheel, etc.) or a display (e.g., LCD or LED display) to provide status information.

[0028] The camera 102 may include any camera or camera system suitable for capturing images from which a three-dimensional point cloud or other three-dimensional data may be recovered. For example, the camera 102 may employ a multi-aperture system as disclosed in U.S. Pat. No. 7,372,642 to Rohály et al., the entire content of which is incorporated herein by reference. While Rohály discloses one multi-aperture system, it will be appreciated that any multi-aperture system suitable for reconstructing a three-dimensional point cloud from a number of two-dimensional images may similarly be employed. In one multi-aperture embodiment, the camera 102 may include a plurality of apertures including a center aperture positioned along a center optical axis of a lens that provides a center channel for the camera 102, along with any associated imaging hardware. In such embodiments, the center channel may provide a conventional video image of the scanned subject matter, while a number of axially offset channels yield image sets containing disparity information that can be employed in three-dimensional reconstruction of a surface. In other embodiments, a separate video camera and/or channel may be provided to achieve the same result, i.e., a video of an object corresponding temporally to a three-dimensional scan of the object, preferably from the same perspective, or from a perspective having a fixed, known relationship to the perspective of the camera 102. The camera 102 may also, or instead, include a stereoscopic, triscopic or other multi-camera or other configuration in which a number of cameras or optical paths are maintained in fixed relation to one another to obtain two-dimensional images of an object from a number of different perspectives. The camera 102 may include suitable processing for deriving a three-dimensional point cloud from an image set or a number of image sets, or each two-dimensional image set may be transmitted to an external processor such as contained in the computer 108 described below. In other embodiments, the camera 102 may employ structured light, laser scanning, direct ranging, or any other technology suitable for acquiring three-dimensional data, or two-dimensional data that can be resolved into three-dimensional data. While the techniques described below can usefully employ video data acquired by a video-based three-dimensional scanning system, it will be understood that any other three-dimensional scanning system may be supplemented with a video acquisition system that captures suitable video data contemporaneously with, or otherwise synchronized with, the acquisition of three-dimensional data.

[0029] In one embodiment, the camera 102 is a handheld, freely-positionable probe having at least one user-input device 116, such as a button, a lever, a dial, a thumb wheel, a switch, or the like, for user control of the image capture system 100 such as starting and stopping scans. In an embodiment, the camera 102 may be shaped and sized for dental scanning. More particularly, the camera 102 may be shaped and sized for intraoral scanning and data capture, such as by insertion into a mouth of an imaging subject and passing over an intraoral surface 106 at a suitable distance to acquire surface data from teeth, gums, and so forth. The camera 102 may, through such a continuous data acquisition process, capture a point cloud of surface data having sufficient spatial resolution and accuracy to prepare dental objects such as prosthetics, hardware, appliances, and the like therefrom, either directly or through a variety of intermediate processing steps. In other embodiments, surface data may be acquired from a dental model such as a dental prosthesis, to ensure proper fitting using a previous scan of corresponding dentition, such as a tooth surface prepared for the prosthesis.

[0030] Although not shown in Fig. 1, it will be appreciated that a number of supplemental lighting systems may be usefully employed during image capture. For example, environmental illumination may be enhanced with one or more spotlights illuminating the object 104 to speed image acquisition and improve depth of field (or spatial resolution depth). The camera 102 may also, or instead, include a strobe, a flash, or some other light source to supplement illumination of the object 104 during image acquisition.

[0031] The object 104 may be any object, collection of objects, portion of an object, or other subject matter. More particularly with respect to the dental techniques discussed herein, the object 104 may include human dentition captured intraorally from a dental patient's mouth. A scan may capture a three-dimensional representation of some or all of the dentition according to a particular purpose of the scan. Thus the scan may capture a digital model of a tooth, a quadrant of teeth, or a full collection of teeth including two opposing arches, as well as soft tissue or any other relevant intraoral structures. The scan may capture multiple representations, such as a tooth surface before and after preparation for a restoration. As will be noted below, this data may be employed for subsequent modeling such as designing a restoration or determining a margin line for same. During the scan, a center channel of the camera 102 or a separate video system may capture video of the dentition from the point of view of the camera 102. In other embodiments where, for example, a completed fabrication is being virtually test fitted to a surface preparation, the scan may include a dental prosthesis such as an inlay, a crown, or any other dental prosthesis, dental hardware, dental appliance, or the like. The object 104 may also, or instead, include a dental model, such as a plaster cast, a wax-up, an impression, or a negative impression of a tooth, teeth, soft tissue, or some combination of these.

[0032] The computer 108 may include, for example, a personal computer or other processing device. In one embodiment, the computer 108 includes a personal computer with a dual 2.8GHz Opteron central processing unit, 2 gigabytes of random access memory, a TYAN Thunder K8WE motherboard, and a 250 gigabyte, 10,000 rpm hard drive. In one current embodiment, the system can be operated to capture more than five thousand points per image set in real time using the techniques described herein, and store an aggregated point cloud of several million points. Of course, this point cloud may be further processed to accommodate subsequent data handling, such as by decimating the point cloud data or generating a corresponding mesh of surface data. As used herein, the term "real time" means generally with no observable latency between processing and display. In a video-based scanning system, real time more specifically refers to processing within the time between frames of video data, which may vary according to specific video technologies between about fifteen frames per second and about thirty frames per second. More generally, processing capabilities of the computer 108 may vary according to the size of the object 104, the speed of image acquisition, and the desired spatial resolution of three-dimensional points. The computer 108 may also include peripheral devices such as a keyboard 114, display 110, and mouse 112 for user interaction with the camera system 100. The display 110 may be a touch screen display capable of receiving user input through direct, physical interaction with the display 110. In another aspect, the display may include an autostereoscopic display or the like capable of displaying stereo images.

[0033] Communications between the computer 108 and the camera 102 may use any suitable communications link including, for example, a wired connection or a wireless connection based upon, for example, IEEE 802.11 (also known as wireless Ethernet), BlueTooth, or any other suitable wireless standard using, e.g., a radio frequency, infrared, or other wireless communication medium. In medical imaging or other sensitive applications, wireless image transmission from the camera 102 to the computer 108 may be secured. The computer 108 may generate control signals to the camera 102 which, in addition to image acquisition commands, may include conventional camera controls such as focus or zoom.

[0034] In an example of general operation of a three-dimensional image capture system 100, the camera 102 may acquire two-dimensional image sets at a video rate while the camera 102 is passed over a surface of the subject. The two-dimensional image sets may be forwarded to the computer 108 for derivation of three-dimensional point clouds. The three-dimensional data for each newly acquired two-dimensional image set may be derived and fitted or "stitched" to existing three-dimensional data using a number of different techniques. Such a system may employ camera motion estimation to avoid the need for independent tracking of the position of the camera 102. One useful example of such a technique is described in commonly-owned U.S. App. No. 11/270,135, filed on November 9, 2005, the entire content of which is incorporated herein by reference. However, it will be appreciated that this example is not limiting, and that the principles described herein may be applied to a wide range of three-dimensional image capture systems.

[0035] The display 110 may include any display suitable for video or other rate rendering at a level of detail corresponding to the acquired data. Suitable displays include cathode ray tube displays, liquid crystal displays, light emitting diode displays and the like. In general, the display 110 may be operatively coupled to, and capable of receiving display signals from, the computer 108. This display may include a CRT or flat panel monitor, a three-dimensional display (such as an anaglyph display), an autostereoscopic three-dimensional display or any other suitable two-dimensional or three-dimensional rendering hardware. In some embodiments, the display may include a touch screen interface using, for example capacitive, resistive, or surface acoustic wave (also referred to as dispersive signal) touch screen technologies, or any other suitable technology for sensing physical interaction with the display 110.

[0036] The system 100 may include a computer-usable or computer-readable medium. The computer-usable medium 118 may include one or more memory chips (or other chips, such as a processor, that include memory), optical disks, magnetic disks or other magnetic media, and so forth. The computer-usable medium 118 may in various embodiments include removable memory (such as a USB device, tape drive, external hard drive, and so forth), remote storage (such as network attached storage), volatile or non-volatile computer memory, and so forth. The computer-usable medium 118 may contain computer-readable instructions for execution by the computer 108 to perform the various processes described herein. The computer-usable medium 118 may also, or instead, store data received from the camera 102, store a three-dimensional model of the object 104, store computer code for rendering and display, and so forth.

[0037] Fig. 2 depicts an optical system 200 for a three-dimensional camera that may be used with the systems and methods described herein, such as for the camera 102 described above with reference to Fig. 1.

[0038] The optical system 200 may include a primary optical facility 202, which may be employed in any kind of image processing system. In general, a primary optical facility refers herein to an optical system having one optical channel. Typically, this optical channel shares at least one lens, and has a shared image plane within the optical system, although in the following description, variations to this may be explicitly described or otherwise clear from the context. The optical system 200 may include a single primary lens, a group of lenses, an object lens, mirror systems (including traditional mirrors, digital mirror systems, digital light processors, or the like), confocal mirrors, and any other optical facilities suitable for use with the systems described herein. The optical system 200 may be used, for example in a stereoscopic or other multiple image camera system. Other optical facilities may include holographic optical elements or the like. In various configurations, the primary optical facility 202 may include one or more lenses, such as an object lens (or group of lenses) 202b, a field lens 202d, a relay lens 202f, and so forth. The object lens 202b may be located at or near an entrance pupil 202a of the optical system 200. The field lens 202d may be located at or near a first image plane 202c of the optical system 200. The relay lens 202f may relay bundles of light rays within the optical system 200. The optical system 200 may further include components such as aperture elements 208 with one or more apertures 212, a refocusing facility 210 with one or more refocusing elements 204, one or more sampling facilities 218, and/or a number of sensors 214a, 214b, 214c.

[0039] The optical system 200 may be designed for active wavefront sampling, which should be understood to encompass any technique used to sample a series or collection of optical data from an object 220 or objects, including optical data used to help detect two-dimensional or three-dimensional characteristics of the object 220, using optical data to detect motion, using optical data for velocimetry or object tracking, or the like. Further details of an optical system that may be employed as the optical system 200 of Fig. 2 are provided in U.S. Pat. No. 7,372,642, the entire content of which is incorporated herein by reference. More generally, it will be understood that, while Fig. 2

depicts one embodiment of an optical system 200, numerous variations are possible. One salient feature of the optical system related to the discussion below is the use of a center optical channel that captures conventional video or still images at one of the sensors 214b concurrent with various offset data (at, e.g., 214a and 214c) used to capture three-dimensional measurements. This center channel image may be presented in a user interface to permit inspection, marking, and other manipulation by a user during a user session as describe below.

[0040] Fig. 3 shows a three-dimensional reconstruction system 300 employing a high-speed pipeline and a high-accuracy pipeline. In general, the high-speed processing pipeline 330 aims to provide three-dimensional data in real time, such as at a video frame rate used by an associated display, while the high-accuracy processing pipeline 350 aims to provide the highest accuracy possible from camera measurements, subject to any external computation or time constraints imposed by system hardware or an intended use of the results. A data source 310 such as the camera 102 described above provides image data or the like to the system 300. The data source 310 may for example include hardware such as LED ring lights, wand sensors, a frame grabber, a computer, an operating system and any other suitable hardware and/or software for obtaining data used in a three-dimensional reconstruction. Images from the data source 310, such as center channel images containing conventional video images and side channels containing disparity data used to recover depth information may be passed to the real-time processing controller 316. The real-time processing controller 316 may also provide camera control information or other feedback to the data source 310 to be used in subsequent data acquisition or for specifying data already obtained in the data source 310 that is needed by the real-time processing controller 316. Full resolution images and related image data may be retained in a full resolution image store 322. The stored images may, for example, be provided to the high-accuracy processing controller 324 during processing, or be retained for image review by a human user during subsequent processing steps.

[0041] The real-time processing controller 316 may provide images or frames to the high-speed (video rate) processing pipeline 330 for reconstruction of three-dimensional surfaces from the two-dimensional source data in real time. In an exemplary embodiment, two-dimensional images from an image set such as side channel images, may be registered by a two-dimensional image registration module 332. Based on the results of the two-dimensional image registration, a three-dimensional point cloud generation module 334 may create a three-dimensional point cloud or other three-dimensional representation. The three-dimensional point clouds from individual image sets may be combined by a three-dimensional stitching module 336. Finally, the stitched measurements may be combined into an integrated three-dimensional model by a three-dimensional model creation module 338. The resulting model may be stored as a high-speed three-dimensional model 340.

[0042] The high-accuracy processing controller 324 may provide images or frames to the high-accuracy processing pipeline 350. Separate image sets may have two-dimensional image registration performed by a two-dimensional image registration module 352. Based on the results of the two-dimensional image registration a three-dimensional point cloud or other three-dimensional representation may be generated by a three-dimensional point cloud generation module 354. The three-dimensional point clouds from individual image sets may be connected using a three-dimensional stitching module 356. Global motion optimization, also referred to herein as global path optimization or global camera path optimization, may be performed by a global motion optimization module 357 in order to reduce errors in the resulting three-dimensional model 358. In general, the path of the camera as it obtains the image frames may be calculated as a part of the three-dimensional reconstruction process. In a post-processing refinement procedure, the calculation of camera path may be optimized – that is, the accumulation of errors along the length of the camera path may be minimized by supplemental frame-to-frame motion estimation with some or all of the global path information. Based on global information such as individual frames of data in the image store 322, the high-speed three-dimensional model 340, and intermediate results in the high-accuracy processing pipeline 350, the high-accuracy model 370 may be processed to reduce errors in the camera path and resulting artifacts in the reconstructed model. As a further refinement, a mesh may be projected onto the high-speed model by a mesh projection module 360. The resulting images may be warped or deformed by a warping module 362. Warped images may be utilized to ease alignment and stitching between images, such as by reducing the initial error in a motion estimation. The warped images may be provided to the two-dimensional image registration module 352. The feedback of the high-accuracy three-dimensional model 370 into the pipeline may be repeated until some metric is obtained, such as a stitching accuracy or a minimum error threshold.

[0043] Various aspects of the system 300 of Fig. 3 are described in greater detail below. In particular, a model refinement process is described that may be used by the high-accuracy processing controller 324 to refine the high accuracy three-dimensional model 370 using measured data in the image store 322. It should be understood that various processing modules, or the steps implied by the modules, shown in this figure are exemplary in nature and that the order of processing, or the steps of the processing sequence, may be modified, omitted, repeated, re-ordered, or supplemented, without departing from the scope of this disclosure.

[0044] Fig. 4 illustrates a coordinate system for three-dimensional measurements using a system such as the optical system 200 described above. The following description is intended to provide useful context, and should not be interpreted as limiting in any sense. In general an object 408 within an image plane 402 of a camera has world coordinates $\{X_w, Y_w, Z_w\}$ in a world coordinate system 410, camera coordinates $\{X_c, Y_c, Z_c\}$ in a camera coordinate system 406, and image set coordinates $\{x_i, y_i, \underline{d}_i(x_i, y_i)\}$ for i = 1 to N points or pixels within a processing mesh of the field of view 402, where $\underline{d}_i$ is a disparity vector 412 containing one or more disparity values that characterize z-axis displacement (Z_c) or depth 404 of a point in the image plane 402 based upon x-axis and/or y-axis displacement in the image plane 402 between a number of physically offset apertures or other imaging channels. The processing mesh may be understood as any overlay or grid for an image or other two-dimensional data that identifies locations where processing will occur. While a processing mesh may be a regular grid of locations in a square, rectangular, triangular, or other pattern, the processing mesh may also, or instead, include irregular patterns selected randomly or according to the specific subject matter being processed. The disparity vector 412 may be expressed, for example, in terms of displacement relative to a center channel, if any, for the camera. In general, the disparity vector 412 encodes depth, and in various other three-dimensional imaging systems, this disparity vector 412 may be replaced by one or more other measured quantities that encode depth. Thus terms such as disparity vector, disparity value, and disparity data and the like should be understood broadly to include any one or more scalar and/or vector quantities measured by a system to capture depth information. Also more generally, a three-dimensional measurement as used herein may refer to any form of data encoding three-dimensional data including without limitation, groups of two dimensional images from which disparity vectors might be obtained, the disparity field (of disparity vectors) itself, or a three-dimensional surface reconstruction derived from the disparity field. In image-based three-dimensional reconstruction, a camera model may be employed to relate disparity vectors to depth within a field of view of a camera. The camera model may be determined theoretically based upon optical modeling or other physics, empirically through observation, or some combination of these, and may be calibrated to compensate for optical aberrations, lens defects, and any other physical variations or features of a particular physical system.

[0045] While a single image plane 402 is illustrated for purposes of explanation, it will be appreciated that a multi-aperture camera (or other multi-channel system) may have a number of physically offset optical channels that provide a different image plane for each channel, and the differences in feature locations (the x-y displacement) between the images for each optical channel may be represented as the disparity field. In various certain processing steps, the disparity data may be referenced to a single image plane such as a center channel image plane of the camera.

[0046] Fig. 5 illustrates a sequence of images captured from a moving camera. In the sequence 500, a camera 502, which may include, for example, any of the cameras 102 described above, may capture an image of an object 504 from a number of different positions 506a-506e along a camera path 507. While the camera path 507 is depicted as a continuous curvilinear path which represents the physical path of a camera, it will be understood that analytically the camera path 507 may be represented by discrete, straight line transformations along with associated rotations in three-dimensional space. While five camera positions are shown in the camera path 507 of Fig. 5, it will be appreciated that more or fewer camera positions may be used consistent with the principles described herein. In an embodiment, the camera 502 may at each position 506 capture an image set:

$$\mathrm{ISn}\left\{x_i = (x_i, y_i)^T \mid i = 1, \cdots, N_n\right\} \qquad \text{[Eq. 1]}$$

of two-dimensional images from which a point cloud:

$$PC_n\left\{X_i = (X_i, Y_i, Z_i)^T \mid i = 1, \cdots, N_n\right\} \qquad \text{[Eq. 2]}$$

may be reconstructed (or any other suitable three-dimensional measurement for the camera position). In general, these three-dimensional point clouds (or other three-dimensional data) captured from the sequence 500 may be combined into a three-dimensional model such as an aggregate point cloud or other three-dimensional model of the object, such as by minimization of errors in a three-dimensional registration of individual three-dimensional measurements, or any of a variety of other techniques. It should also be understood that, in certain embodiments, the camera may remain fixed while the subject moves. In such cases, motion of the object 504 is determined, rather than motion of the camera 502, although the use of camera motion versus object motion may be a relatively arbitrary matter of convenience, or of the computational efficiency of a camera coordinate system versus an object coordinate system.

[0047] Fig. 6 is a conceptual representation of a three-dimensional data acquisition process 600 that may be used in the systems described above. In general, the camera (which may be any of the cameras described above) obtains two-dimensional measurements of a surface of an object 601 such as a first measurement 602 from a side channel (e.g., a left channel image), a second measurement from another side channel 604 (e.g., a right channel image), and a third measurement from a center channel 603 (e.g., a center channel image). It will be understood that while three channels are depicted, a system may recover three-dimensional data from more or less channels using various techniques that will be apparent to one of ordinary skill, and any such techniques that might be improved with the refinement techniques described herein are intended to fall within the scope of this disclosure. These measurements 602, 603, 604 may be processed, for example, to obtain a disparity field 606 that identifies relative movement of features within the images of each measurement. A camera model 610 for the camera may be used to relate the disparity field 606 to the three-dimensional reconstruction 612 of the surface of the object 610 as measured from a camera pose. While a center channel image may conveniently be used as the reference for the camera pose of the resulting three-dimensional reconstruction 612, this is not required and may not, in certain systems be available as a reference in any event. The three-dimensional reconstruction 612 can be stitched to other such three-dimensional measurements using camera path information or the like to obtain a three-dimensional model 620 of the object 601.

[0048] In a model refinement process as described below, one of the two-dimensional measurements, such as the first measurement 602, may be projected onto the three-dimensional model using available spatial information (e.g., the camera position and orientation). The resulting projection may then be backprojected to the second camera pose using warping or other deformation techniques to obtain an expected measurement at the second camera position. In the case of a side channel two-dimensional image or the like, the expected measurement may be a corresponding image expected in the center channel or another side channel. By adapting the three-dimensional measurement from this image pair to reduce or minimize an error between the actual and expected measurements in an overlapping area of the object, the three-dimensional measurement may be refined for that camera position to more accurately represent a surface of the object 601. In one aspect, the three-dimensional model may be directly refined with the new spatial information. In another aspect, the improved three-dimensional measurement for the camera may be used in a new motion estimation to recover camera path and three-dimensional model data for an entire scan or any portion thereof. By refining the individual three-dimensional measurements and the camera path in this manner, a more accurate three-dimensional model for the object may be obtained. It will be appreciated that, in general, error minimization may be performed on a number of different data sets that encode three-dimensional information, such as the two-dimensional image sets, or upon processed representations of these measurement such as the disparity field.

[0049] Fig. 7 is a flow chart of a process for refining three-dimensional data. In general, the process 700 refines a three-dimensional model by refining individual three-dimensional-measurements taken at different camera positions, which information may be employed to refine the resulting model. This process 700 may be usefully employed, for example, to warp two-dimensional images in a module 362 of a high accuracy processing pipeline 350, such as to improve two-dimensional registration and/or three-dimensional stitching results. While a particular embodiment is described below in detail, it will be appreciated that any similar technique for generating an expected two-dimensional measurement at one camera position using an actual two-dimensional measurement from a different camera position, along with a three-dimensional model of the imaged subject matter (and a camera model as appropriate), may similarly be employed. Thus the techniques described herein may be readily adapted to other systems that obtain a three-dimensional model from a series of individual three-dimensional measurements, such as systems using structured light or systems using a series of two-dimensional images.

[0050] As shown in step 710, the process 700 may begin by acquiring frames of image data along a camera path. This image data may include image pairs that capture an image from two or more offset optical channels of a multi-aperture camera or other multi-channel imaging device. In one embodiment, each image in an image pair contains a two-dimensional image from two coupled poses having a known, fixed relationship to one another. In such an embodiment, a center channel may also be provided that captures a third image as a part of the frame of image data to provide a conventional, undistorted two-dimensional view of the scanned subject matter (where distortions in the side channels encode distance to a surface). The center channel may also serve as a reference pose for a three-dimensional measurement derived from the pair of two-dimensional images. It will be understood, however, that this arrangement is somewhat arbitrary, and other cameras may be employed such as a camera with a center channel and a single side channel, or only two side channels, or any of a number of other arrangements. More generally, any camera that captures two-dimensional images for use in a three-dimensional reconstruction may be used with techniques described herein.

[0051] As shown in step 712, three-dimensional measurements may be obtained from the image data. In general, this may include processing image sets or the like to obtain disparity data across a processing mesh of the camera, and further processing the disparity data to obtain a three-dimensional surface reconstruction. In one embodiment, the disparity data encodes depth information, and may be employed to recover a three-dimensional measurement using a camera model or the like to relate disparity data to depth information for each pixel of the processing mesh. This step 712 may be repeated for each individual measurement (e.g., image set) obtained by the camera. As a result, a three-dimensional measurement or reconstruction may be obtained for each camera pose along a camera path. It will be understood that the disparity data is itself a three-dimensional measurement, and may be employed in place of a three-dimensional reconstruction for many of the processing steps described herein, with suitable adaptations being readily understood by one of ordinary skill in the art. It will further be understood that other three-dimensional imaging techniques are known and may be adapted to obtain three-dimensional measurements from an object surface.

[0052] As shown in step 714, a three-dimensional model may be constructed from the individual three-dimensional measurements obtained in step 712. Where the three-dimensional measurements of the surface of the object overlap, these three-dimensional measurements may be registered to one another using any of a variety of known techniques. As a result, the camera path from pose to pose may be recovered, and the three-dimensional measurements from each pose may be combined into a full three-dimensional model of scanned regions of the surface of the object.

[0053] As shown in step 716, a two-dimensional image or other measurement from one channel of a camera may be spatially projected onto the full three-dimensional model obtained in step 714. In general, the raw camera measurement includes a two-dimensional image of pixel values, which may be projected onto the three-dimensional model using texture mapping or any other suitable techniques to place the two-dimensional data from the image sets into the coordinate system of the three-dimensional model. As a significant advantage, this approach employs a three-dimensional model of the object that may, for example, contain global information that was not available when the data was initially collected. The model may, for example, average errors and/or reduce noise in individual camera measurements, as well as minimizing errors in a global camera path where possible. Using this initial model as a starting spatial reference point, the process 700 may revisit the individual three-dimensional measurements as further described below.

[0054] As shown in step 718, the projected measurement may be backprojected from the three-dimensional model to another channel of the camera, which may be the center channel or another side channel of the camera described above. The projected result from step 716 may be backprojected using any suitable techniques to obtain a synthetic view of the measurement from one camera channel as it should appear from the other camera channel, based upon the spatial relationship between the projected result, the three-dimensional model, and the position and rotation of the other channel. It will be appreciated that if there were no errors in the initial measurement, this synthetic view would exactly correspond to the actual two-dimensional image obtained from the other channel. However, in a high-speed processing pipeline such as that described above, an initial three-dimensional model may fail to accurately capture surface details for any number of reasons (lower resolution processing, absence of global surface data such as the completed three-dimensional model, etc.). Thus it is expected that in a practical system there may be variations between a synthesized view (based on observations from a different position) and an actual view. Backprojection may be accomplished, for example, by warping or otherwise deforming the projected result based upon the three-dimensional model and camera pose information for respective measurements. By processing these synthesized image sets to obtain disparity data, and further backprojecting the synthesized disparity data through the camera model, a backprojected result may be obtained that represents a synthesized or expected version of the three-dimensional measurement from the second camera position.

[0055] As shown in step 720, a three-dimensional measurement by a camera (e.g., the measurement derived from an image set in a frame of data) may be refined by adjusting the three-dimensional reconstruction to minimize an error between the backprojected result obtained in step 718 and an actual corresponding two-dimensional measurement captured in step 710. More generally, where two images contain measurements from an overlapping portion of the surface of the object, the backprojected (e.g., synthesized) measurement and the actual measurement may be directly compared. In one embodiment, camera calibration data and other information descriptive of the camera or the channels of the camera may be incorporated into the projection and/or backprojection in order to improve three-dimensional accuracy of the resulting three-dimensional measurement.

[0056] As shown in step 722, the three-dimensional model may be refined based upon the refined three-dimensional measurements for each frame of image data. A number of techniques may be employed to refine the model. In one aspect, the three-dimensional data for a refined three-dimensional measurement may be used to directly modify the three-dimensional model, e.g., by estimating the contribution of the changes in the refined three-dimensional measurement on the reconstruction process for the three-dimensional model. In another aspect, a new motion-based reconstruction for some or all of the scan data may be performed using the refined three-dimensional measurements in place of the initial three-dimensional measurements to recover a camera path used to relate the individual measurements to a global coordinate system. In another aspect, this process may be repeated to obtain iterative refinements in the three-dimensional model, e.g., for a predetermined number of iterations, or until a predetermined error threshold is reached, or until no further refinement is obtained from a previous iteration, and so forth, as well as various combinations of these. Iterations may be performed locally (e.g., on specific regions where errors are large) or globally (e.g., for every overlapping region between camera positions), or some combinations of these.

[0057] It will also be appreciated that this approach may be usefully employed with other three-dimensional reconstruction techniques, as well as in other ways within the image-pair based processing described above. For example, while the model-based refinement of a specific three-dimensional measurement may improve accuracy, the same approach may be employed to backproject a two-dimensional image from one image set onto a two-dimensional image from another image set in order to achieve frame-to-frame improvements in accuracy. Further, these image sets may be offset by any number of intervening image sets, and complementary, bi-directional refinements may be performed for any and all of the foregoing wherever the two measurements contain some overlap on the surface of the object. More generally, while a technique for testing a specific set of overlapping measurements is described above, this technique may be repeated any number of times, in any order, for some or all of the overlapping regions in measurements used to obtain a three-dimensional model, and all such variations are intended to fall within the scope of this disclosure.

[0058] Fig. 8 is a flow chart of a global path optimization. In one aspect, the refinement of individual three-dimensional measurements may be used in combination with numerical techniques for global path optimization for an entire camera path to yield further iterative improvement to a resulting three-dimensional model. A suitable global path optimization technique is now described in greater detail.

[0059] The process 800 may begin with preprocessing as shown in step 810. It will be understood that preprocessing as described herein presupposes the availability of a number of frames of image data from which a camera path and three-dimensional model can be reconstructed. The information for the three-dimensional reconstruction may be generated in numerous ways including coming from structured light projection, shading based three-dimensional reconstruction, or disparity data. Disparity data may be generated by a conventional image plus one or more other channels or side channels. The preprocessing may include determining the number of available frames, the amount of overlap between neighboring frames, identification and elimination of frames with blurred or badly distorted images, and any other suitable preprocessing steps. An estimate of the number of desired key frames may be initially determined during the preprocessing step.

[0060] As shown in step 812, key frames may be selected from among all of the frames of data acquired from a scanner along a camera path. In general, computational costs can be reduced by storing certain data and performing certain calculations and processing steps exclusively with reference to key frames. These key frames may be related to one another in a manner that permits characterization of a complete camera path, typically through the registration of overlapping three-dimensional data in respective key frames. Various methods are known in the art for selecting a subset of frames of data as key frames, including techniques based on image overlap, camera path distance, the number of intervening non-key frames and so forth. Key frames may also or instead be selected based upon an amount of image overlap from the preceding key frame and/or a candidate for a following key frame (if available). Too little overlap may impair frame-to-frame registration. Too much overlap may produce excess key frames requiring additional processing. Key frames may be selected based on spatial displacement. Key frames may also be selected based on sequential displacement. This type of sequential displacement could mean for example that every tenth frame is selected as a key frame. In one aspect, key frames may be selected as data is acquired based on any number of suitable criteria. In another aspect, key frame pairs may be determined post hoc by examining all possible candidate key frames. All possible key frame pairs may be examined and candidates may be removed, for example, where there is insufficient overlap to form a stitch. Still more generally, any technique suitable for selecting a subset of frames in a data set may be usefully employed to select key frames for processing in order to reduce computational complexity.

[0061] Once key frames have been selected, additional processing may be performed. For example, full image data (e.g., full resolution center and side channel images) may be stored for each key frame, along with image signature data, point cloud centroid calculations, and any other measured or calculated data to support use of the key frames in a three-dimensional reconstruction process as described herein.

[0062] As shown in step 814, candidate stitches may be identified. In general, a stitch is a relationship between two separate three-dimensional measurements from two different camera poses. Once a stitch is established, a rotation and a translation may be determined for the path of a camera between the two poses. In a complementary fashion, the three-dimensional measurements from the poses may be combined into a portion of a three-dimensional model. Candidate stitches may be analyzed around each key frame, such as from the key frame to some or all of the frames of data between the key frame and neighboring key frames. In another aspect, a candidate stitch may be made to every other key frame, or in order to reduce computational complexity, every key frame within a spatial or sequential neighborhood around a key frame. Stitches may be based on the originally imaged frames. It may also be useful to deform or warp two-dimensional images during registration and other steps in a stitching process in order to improve accuracy and/or speed. Stitches may also or instead be based on other observed epipolar relationships in source data.

[0063] As shown in step 816, stitches may be selected for the complete camera path from the universe of candidate stitches. The selection of stitches may be made based upon, e.g., the lowest calculated error in resulting portions of the three-dimensional model. In general, each key frame may be stitched to one or more other key frames and each non-key frame may be stitched to at least one sequentially neighboring key frame.

[0064] As shown in step 818, a graph analysis may be performed using the key frames and the associated stitching to calculate a global path for the camera used to obtain a three-dimensional model. The graph analysis may consider each key frame as a node or vertex and each stitch as an edge between a pair of nodes. A key frame is selected as a starting point. A breadth- or depth-first search may be performed through the graph to identify stitches which may connect the current key frame to another key frame. Each key frame may be marked as the graph is processed. A check may be performed to see if all key frames have been reached within the graph. If all key frames have not been reached through traversing stitches in the graph analysis, the largest sub-graph is identified. This sub-graph may be examined to see if the entire three-dimensional image may be modeled.

[0065] It may be that certain sub-graphs are not required to complete the three-dimensional imaging. If the camera lingered over a particular region of a surface of an object, or if the camera looped on a region multiple times, the associated sub-graph(s) may not be needed. If a separate sub-graph is identified, which is needed to complete the three-dimensional imaging, an optional branch back to step 812 may be performed. For example, a set of key frames may have been selected which did not have sufficient stitching from one key frame to the next key frame. By choosing a different set of key frames, sufficient stitching may be obtained in order to obtain a complete graph of all needed aspects of the three-dimensional imaging. A key frame which is too sparse, meaning it has insufficient stitches to aid in building a graph, may indicate that a different set of key frames should be selected. Based on the graph analysis, a global path may be selected, and the graph may then be analyzed to optimize the path calculation.

[0066] As shown in step 820, a numerical optimization may be performed to reduce errors in the calculated camera path based upon available data for the complete camera path such as, for example, cross links that interrelate temporally distant measurements. In general, the objective of numerical optimization is to minimize a calculated error based upon an error function for the camera path and/or reconstructed three-dimensional model. A useful formulation of the error minimization problem for a global camera path is presented below.

[0067] There may be a set of candidate camera poses, each including a rotation and a translation (or position) referenced to a world coordinate system. There may also be a set of measured frame-to-frame camera motions, each including a rotation and a translation between poses. A measured camera motion may be referenced in the coordinate system of one camera pose. An example set of three key frames may be considered with an origin "O" and three other points "A", "B", and "C", each of the points having a position in a three-dimensional space. In addition to the position of these points, a camera at each of these points may have a different orientation. Therefore, between each of these points is a translation, meaning a change in position, and a rotation, meaning a change in orientation. The translation and rotation values comprise the motion parameters. The relationship between a point, X, expressed in the world coordinate system as X_O and the same point expressed in the A coordinate system, X_A may be expressed as:

$$X_A = R_{OA} X_O + T_{OA} \qquad \text{[Eq. 3]}$$

R_{OA} is the rotation taking points from the world to the A coordinate system. T_{OA} is the translation of the world coordinate system to the A coordinate system. It should be understood that symbols X and T may represent a vector, rather than a scalar, e.g. where X includes x, y, and z coordinate values. Further, it should be understood that symbol R may represent a matrix. The following equations may similarly represent the transformation between the world and the B and C coordinate systems respectively:

$$X_B = R_{OB} X_O + T_{OB} \qquad \text{[Eq. 4]}$$

$$X_C = R_{OC} X_O + T_{OC} \qquad \text{[Eq. 5]}$$

[0068] By rearranging, equations 4 and 5 may be represented as follows:

$$X_O = R_{OA}^{-1}\left(X_A - T_{OA}\right) = R_{OB}^{-1}\left(X_B - T_{OB}\right) \qquad \text{[Eq. 6]}$$

[0069] The representation of a point in one camera's coordinate system may be related to the same point in another coordinate system. For example, as in equations 3-5, coordinates of a point, X, may be transformed from the A coordinate system to the B coordinate system as follows:

$$X_B = R_{AB} X_A + T_{AB} \qquad \text{[Eq. 7]}$$

[0070] The rotation R_{AB} rotates points from the A to the B coordinate system and T_{AB} translates the origin of the A coordinate system to the B coordinate system.

[0071] In optimization, the pose of every camera may be optimized based on measured transformations between poses. That is, a number of camera-to-world rotations and camera-to-world translations, R_{On} and T_{On} may be performed. In general, one of these may be defined as the identity rotation and zero translation, with the remaining values may be optimized as described below.

[0072] The rotations and translations may be measured for many pairs of cameras. For the ith such measured frame-to-frame motion, let one of the cameras of the pair be camera A and the other be camera B. This may also be considered the ith stitch. Let R^i_{AB} be the measured rotation taking points in the A system to the B system and T^i_{AB} be the coordinates of the A position expressed in the B system, as in equation 7.

[0073] The rotations and translations for all cameras, R_{On} and T_{On} may be optimized. $R^i_{C,OA}$ and $R^i_{C,OB}$ may be defined to be the candidate rotations; $T^i_{C,OA}$ and $T^i_{C,OB}$ may be defined to be the candidate translations corresponding to the A and B camera of the ith stitch. Further, $R^i_{C,AB} = R^i_{C,OB}(R^i_{C,OA})^{-1}$ may be defined as the candidate rotation from A to B, and $T^i_{C,AB} = T^i_{C,OB} - R^i_{C,AB}T^i_{C,OA}$, the candidate translation for the transformation from A to B.

[0074] Note that with sufficient stitches, the motion constraints may form an overdetermined system of motion constraint equations. Using these equations as a starting point, numerical optimization may be performed on the rotational and translational components of each camera based on the measured stitches.

[0075] In a decoupled optimization, the rotational and translational components may be independently optimized. Given a candidate set of camera rotations, R^i_C the corresponding candidate camera-to-camera rotations, $R^i_{C,AB}$, may be computed that correspond to each of the measured camera-to-camera rotations, R^i_{AB}. Thus the corresponding residual rotations are given by $R^i_{residual,AB} = R^i_{C,AB}(R^i_{AB})^{-1}$. A scalar-valued rotational cost function, e_r, may be computed that depends on the candidate camera rotations

$$e_r(R_{C,On}) = \sum_{i=1}^{\#stitches} r_r^{i^T} r_r^i, \quad where\ r_r^i = \log_{SO(3)} R_{residual,AB}^i, \qquad \text{[Eq. 8]}$$

[0076] In equation 8, $\log_{SO(3)}(R)$ returns the axis-angle vector, v, that corresponds to the rotation R. In other words, $\log_{SO(3)}(R)$ returns the vector, v, that has a cross-product matrix, $[v]_\times$, that is the matrix logarithm of R.

[0077] Next, a similar scalar-valued cost function may be computed for translation that depends on the candidate rotations and translations.

$$e_t(R_{C,On}, T_{C,On}) = \sum_{i=1}^{\#stitches} r_t^{i^T} r_t^i, \quad where\ r_t^i = T_{C,AB}^i - T_{AB}^i \qquad \text{[Eq. 9]}$$

[0078] Equation 8 may be minimized as a nonlinear optimization; equation 9 may be minimized as a linear optimization.

[0079] In one conventional, decoupled approach to solving these simultaneous systems of equations, the rotational error function may be converted into a quaternion expression in order to translate the numerical problem into a linear system of equations for solution. While this approach may increase computational efficiency, it offers an incomplete optimization solution.

[0080] The decoupled approach described above does not provide a truly optimal one, in a maximum-likelihood sense, as it cannot use information from the translation portion of the stitches in determining rotation. In order to achieve a coupled optimization a weighting may be used to balance the contributions of rotational and translational components to a combined cost function:

$$e_c(R_{C,On}, T_{C,On}) = \sum_{i=1}^{\#stitches} \left(\begin{bmatrix} r_t^i \\ r_r^i \end{bmatrix}^T W_c^i \begin{bmatrix} r_t^i \\ r_r^i \end{bmatrix} \right) \qquad \text{[Eq. 10]}$$

Multiple approaches may be used to optimize this cost function, but in one embodiment the weights may be expressed as matrices. Different stitches may receive different weightings based upon a number of factors including the number of points in the stitch (e.g., the shared content), the quality of a particular three-dimensional measurement, and/or any other factors impacting the known reliability of a stitch. In one approach, the weight matrices may also account for anisotropic error in the individual points collected, such as due to acquisition of depth information from disparity measurements, which results in measurement precision that varies with distance from the camera.

[0081] In some cases, equation 10 may be reformulated so that the rotation and translation weights are decoupled for each stitch (i.e., W_c^i is a block diagonal). In particular, this may occur in the case where the motion stitches are recovered from three-dimensional point correspondences with isotropic point error. In that case, for a given stitch i, between camera A and camera B, the optimal solution may bring the point cloud as seen from camera A into correspondence with that seen from camera B. If $\overline{X}_A^i$ and $\overline{X}_B^i$ are the positions of the center of the point cloud in the A and B systems respectively, then r_t^i may be replaced in equation 10 with the residual displacement between the point-cloud centers based on the candidate camera pose as follows:

$$r_{t,ctr}^i = \overline{X}_B^i - (R_{C,AB}^i \overline{X}_A^i + T_{C,AB}^i) \qquad \text{[Eq. 11]}$$

Equation 10 may then be reformulated as:

$$e_c(R_{C,On}, T_{C,On}) = \sum_{i=1}^{\#stitches} \left(r_{t,ctr}^{i\ T} W_r^i r_{t,ctr}^i + r_r^{iT} W_r^i r_r^i \right) \qquad \text{[Eq. 12]}$$

This coupled optimization problem may still be considered as being non-linear. It should be understood that other optimizations are also possible that would fall within the scope of this disclosure.

[0082] In general, by minimizing equation 10, both rotational errors and translational errors may be minimized simultaneously. The weight matrices can be chosen, for example, according to "First Order Error Propagation of the Procrustes Method for 3D Attitude Estimation" by Leo Dorst, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 27, No. 2, Feb. 2005, pp. 221-9 which is incorporated in its entirety by reference. Once a more consistent set of motion parameters has been generated the three-dimensional model may be updated.

[0083] In one aspect, the residual error may be employed as a calibration metric. When total error or some portion of error has been minimized, the residual error may be evaluated. If a minimized error falls beyond a certain threshold then calibration for the scanner and associated hardware may be recommended, based upon an inference that the inability to produce better quality results is due to a miscalibration or other malfunction of the camera system. The threshold value may be empirically determined based on the specific scanner hardware equipment or it may be learned experientially over time for a given system. When a system is new or has been freshly aligned, expected minimized error values may be obtained. When minimized error values deviate from these expected values, a calibration state evaluation flag may be set, or other alert or message generated, indicating that the tool should be calibrated.

[0084] As shown in step 822, upsampling may be performed to augment a three-dimensional model with data from non-key frames. For example, non-key frames may be registered to nearby key frames to create small, local reconstruction patches including the full image detail available from non-key frames. In this manner, path optimization may be performed on a key-frame-based data set, thus reducing the data requiring processing, while retaining additional data points from non-key frames for use in the final three-dimensional model.

[0085] It will be appreciated that any of the above system and/or methods may be realized in hardware, software, or any combination of these suitable for the data acquisition and modeling technologies described herein. This includes realization in one or more microprocessors, microcontrollers, embedded microcontrollers, programmable digital signal processors or other programmable devices, along with internal and/or external memory. The may also, or instead, include one or more application specific integrated circuits, programmable gate arrays, programmable array logic components, or any other device or devices that may be configured to process electronic signals. It will further be appreciated that a realization may include computer executable code created using a structured programming language such as C, an object oriented programming language such as C++, or any other high-level or low-level programming language (including assembly languages, hardware description languages, and database programming languages and technologies) that may be stored, compiled or interpreted to run on one of the above devices, as well as heterogeneous combinations of processors, processor architectures, or combinations of different hardware and software. Thus in one aspect there is disclosed herein a computer program product comprising computer executable code that, when executing on one or more computing devices, performs any and/or all of the steps described above. At the same time, processing may be distributed across devices such as a camera and/or computer and/or fabrication facility and/or dental laboratory and/or server in a number of ways or all of the functionality may be integrated into a dedicated, standalone device. All such permutations and combinations are intended to fall within the scope of the present disclosure.

[0086] While the invention has been disclosed in connection with the preferred embodiments shown and described in detail, various modifications and improvements thereon will become readily apparent to those skilled in the art. Accordingly, the spirit and scope of the present invention is not to be limited by the foregoing examples, but is to be understood in the broadest sense allowable by law.

CLAIMS

What is claimed is:

1. A method of refining a three-dimensional model comprising the steps of:

providing a three-dimensional model of an object;

obtaining a first two-dimensional image of the object from a first camera pose;

obtaining a second two-dimensional image of the object from a second camera pose, wherein the second two-dimensional image includes a common portion of a surface of the object with the first two-dimensional image;

deforming the first two-dimensional image based upon a spatial relationship of the first camera pose, the second camera pose, and the three-dimensional model to obtain an expected image from the second camera pose based upon the first camera pose;

comparing the second two-dimensional image to the expected image to identify one or more discrepancies; and

correcting the three-dimensional model based upon the one or more discrepancies.

2. The method of claim 1 wherein the first camera pose and the second camera pose include a position and an orientation of a single camera in two dependent positions.

3. The method of claim 2 wherein the first camera pose and the second camera pose include a position and an orientation of two offset channels of a multi-aperture camera.

4. The method of claim 1 wherein the first camera pose and the second camera pose include a position and an orientation of a single camera in two independent positions.

5. The method of claim 4 wherein a relationship between the first camera pose and the second camera pose is calculated based upon a three-dimensional measurement of the surface of the object from each of the first camera pose and the second camera pose.

6. The method of claim 1 further comprising deriving the three-dimensional model from a plurality of three-dimensional measurements of the surface of the object from a plurality of camera poses including the first camera pose and the second camera pose.

7. The method of claim 1 further comprising applying the one or more discrepancies to directly refine the three-dimensional model.

8. The method of claim 1 further comprising applying the one or more discrepancies to refine a three-dimensional measurement from one or more of the first camera pose and the second camera pose to provide a refined measurement.

9. The method of claim 8 further comprising refining a camera path calculation for a camera path used to create the three-dimensional model using the refined measurement to provide a refined camera path.

10. The method of claim 9 further comprising using the refined camera path and the refined measurement to refine the three-dimensional model.

11. The method of claim 1 wherein the three-dimensional model includes a point cloud or a polygonal mesh.

12. The method of claim 1 wherein the object includes human dentition.

13. The method of claim 1 wherein the second camera pose corresponds to a center channel of a multi-aperture camera system, the center channel providing a conventional two-dimensional image of the object.

14. The method of claim 14 further comprising obtaining a third two-dimensional image of the object from a third camera pose corresponding to a second side channel of the multi-aperture system and deforming the third two-dimensional image to an expected

image for the center channel for use in further refining the three-dimensional measurement from the multi-aperture camera system.

15. A computer program product for refining a three-dimensional model of an object comprising computer executable code embodied on a computer readable medium that, when executing on one or more computing devices, performs the steps of:

providing a three-dimensional model of an object;

obtaining a first two-dimensional image of the object from a first camera pose;

obtaining a second two-dimensional image of the object from a second camera pose, wherein the second two-dimensional image includes a common portion of a surface of the object with the first two-dimensional image;

deforming the first two-dimensional image based upon a spatial relationship of the first camera pose, the second camera pose, and the three-dimensional model to obtain an expected image from the second camera pose based upon the first camera pose;

comparing the second two-dimensional image to the expected image to identify one or more discrepancies; and

correcting the three-dimensional model based upon the one or more discrepancies.

16. The computer program product of claim 15 wherein the first camera pose and the second camera pose include a position and an orientation of a single camera in two dependent positions.

17. The computer program product of claim 16 wherein the first camera pose and the second camera pose include a position and an orientation of two offset channels of a multi-aperture camera.

18. The computer program product of claim 15 wherein the first camera pose and the second camera pose include a position and an orientation of a single camera in two independent positions.

19. The computer program product of claim 18 wherein a relationship between the first camera pose and the second camera pose is calculated based upon a three-dimensional measurement of the surface of the object from each of the first camera pose and the second camera pose.

20. The computer program product of claim 15 further comprising code for performing the step of deriving the three-dimensional model from a plurality of three-dimensional measurements of the surface of the object from a plurality of camera poses including the first camera pose and the second camera pose.

21. The computer program product of claim 15 further comprising code for performing the step of applying the one or more discrepancies to directly refine the three-dimensional model.

22. The computer program product of claim 15 further comprising code for performing the step of applying the one or more discrepancies to refine a three-dimensional measurement from one or more of the first camera pose and the second camera pose to provide a refined measurement.

23. The computer program product of claim 22 further comprising code for performing the step of refining a camera path calculation for a camera path used to create the three-dimensional model using the refined measurement to provide a refined camera path.

24. The computer program product of claim 23 further comprising code for performing the step of using the refined camera path and the refined measurement to refine the three-dimensional model.

25. The computer program product of claim 15 wherein the three-dimensional model includes a point cloud or a polygonal mesh.

26. The computer program product of claim 15 wherein the object includes human dentition.

27. The computer program product of claim 15 wherein the second camera pose corresponds to a center channel of a multi-aperture camera system, the center channel providing a conventional two-dimensional image of the object.

28. The computer program product of claim 15 further comprising code for performing the steps of obtaining a third two-dimensional image of the object from a third camera pose corresponding to a second side channel of the multi-aperture system and deforming the third two-dimensional image to an expected image for the center channel for use in further refining the three-dimensional measurement from the multi-aperture camera system.

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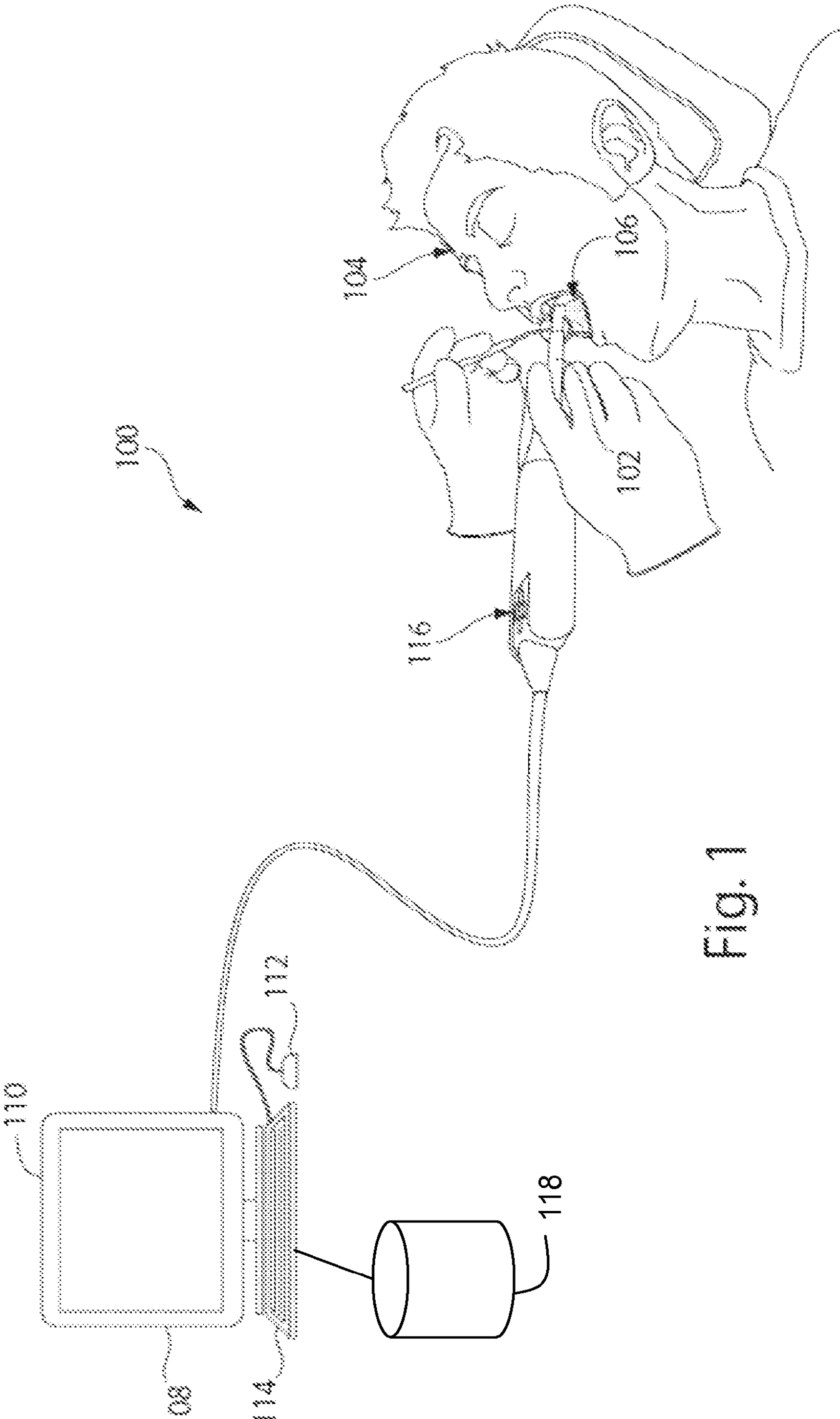
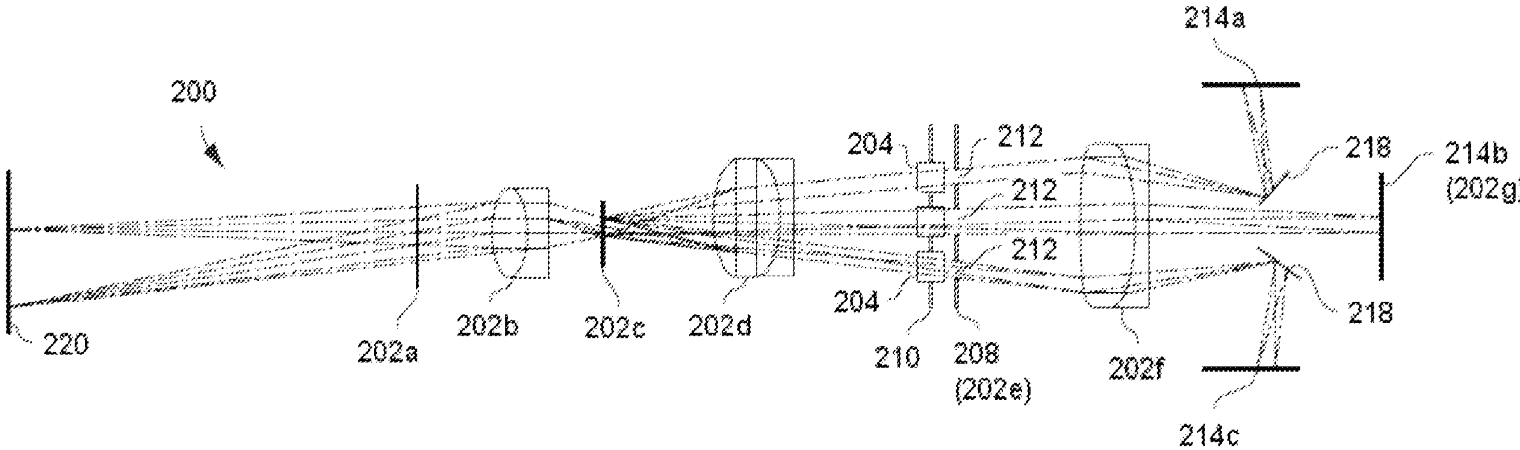


Fig. 1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202f

Fig. 2

WO 2009/089126 PCT/US2009/030065

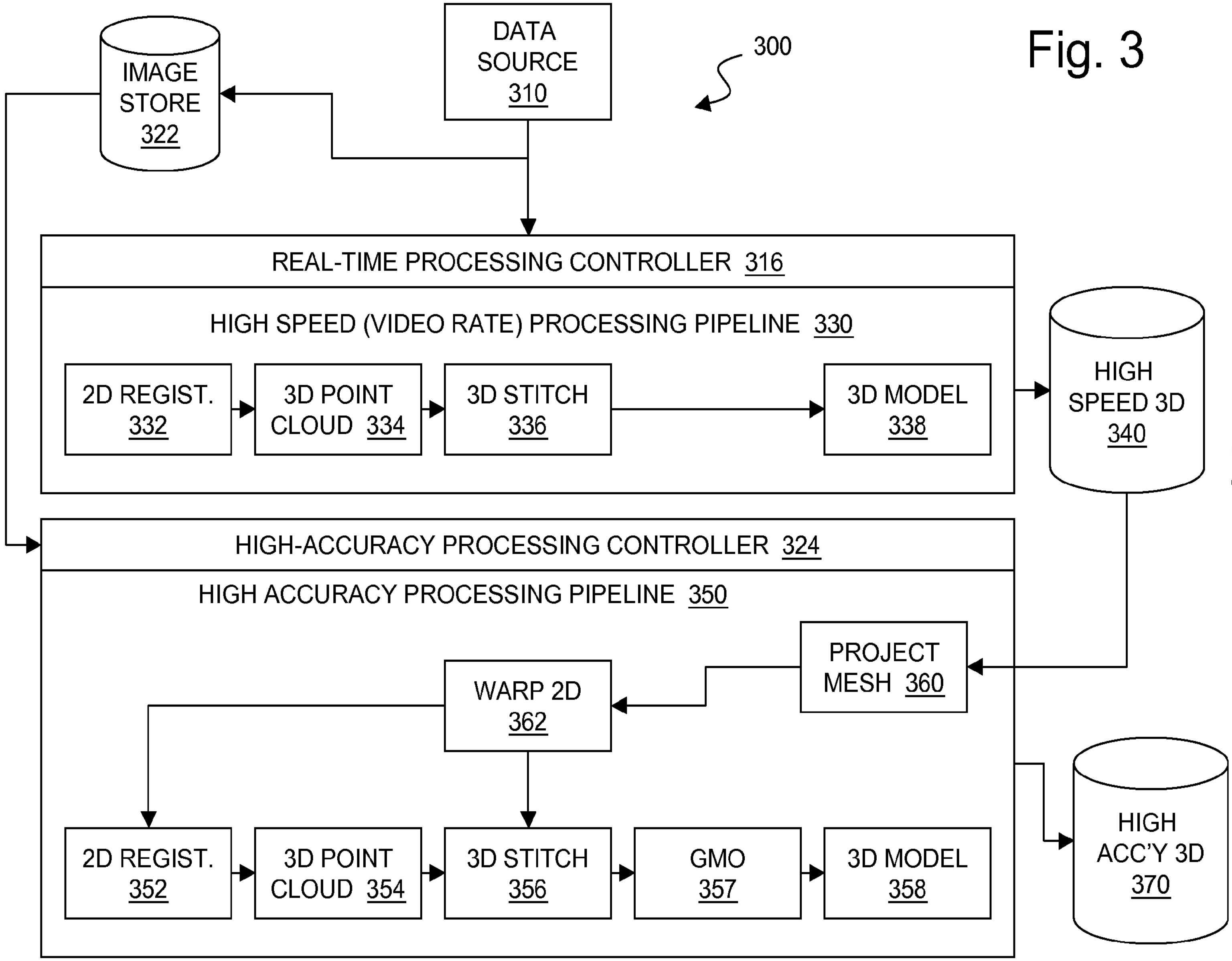

Fig. 3

0371

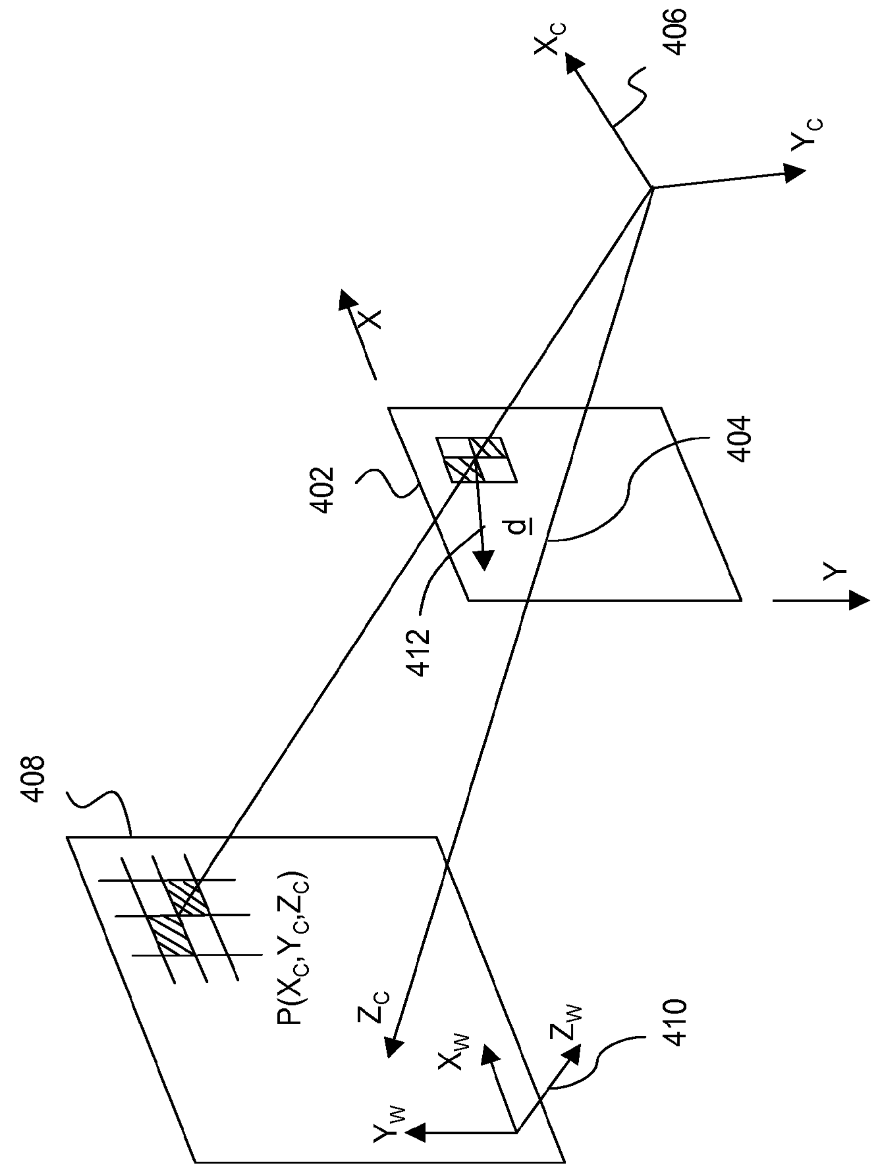

Fig. 4

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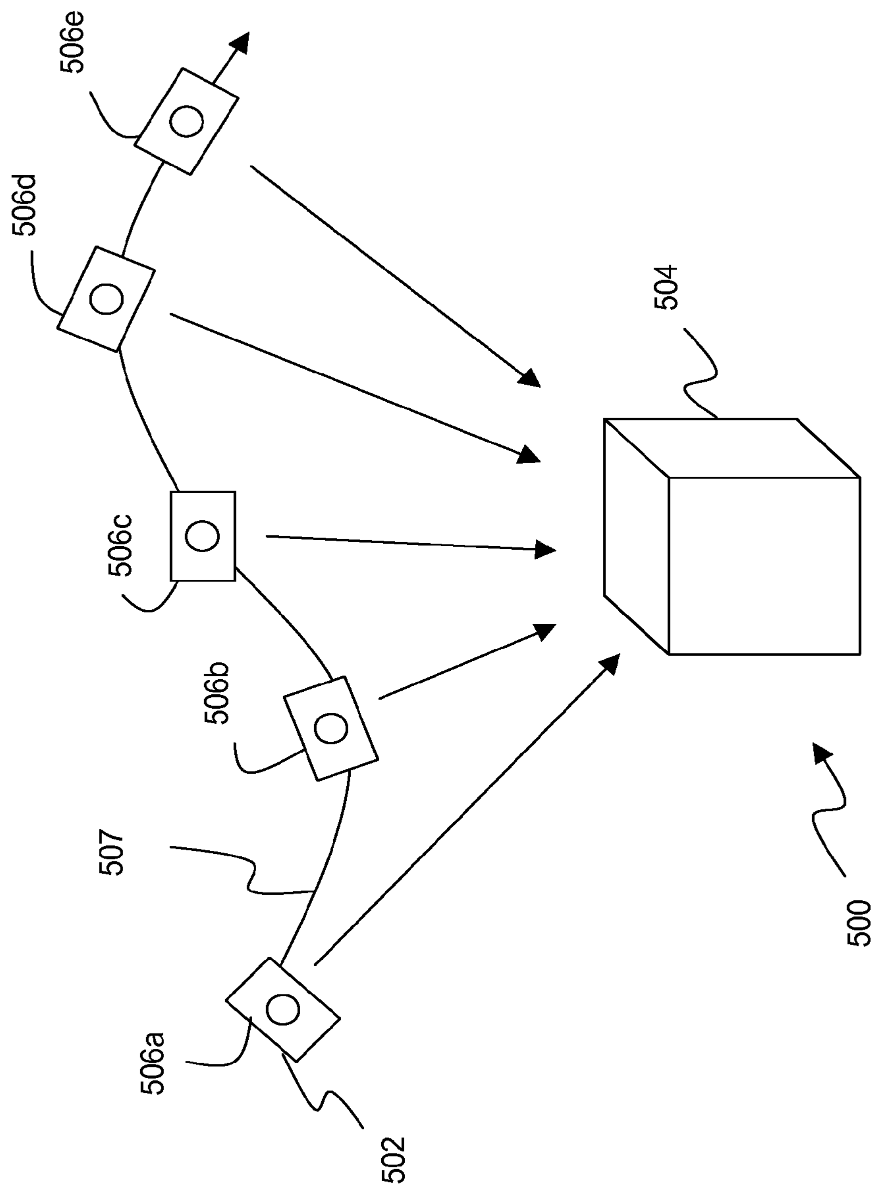

Fig. 5

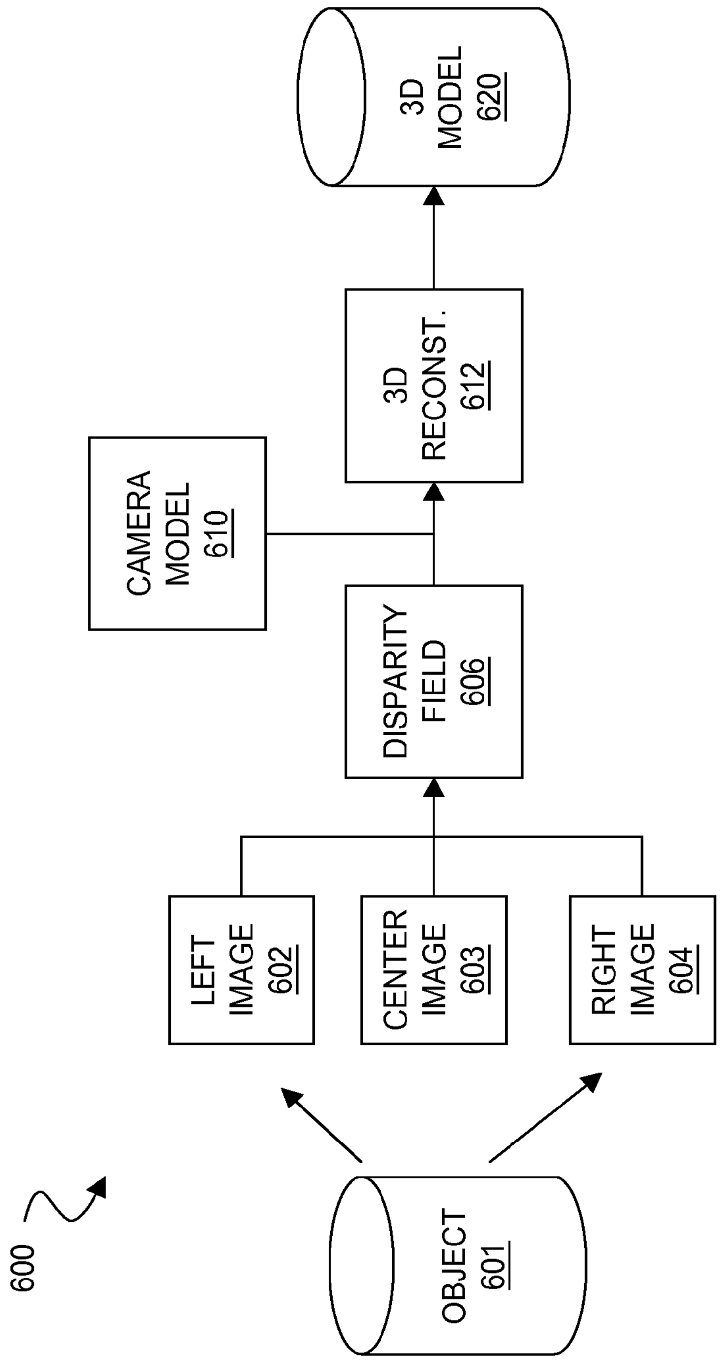
600
OBJECT 601
LEFT IMAGE 602
CENTER IMAGE 603
RIGHT IMAGE 604
DISPARITY FIELD 606
CAMERA MODEL 610
3D RECONST. 612
3D MODEL 620

Fig. 6

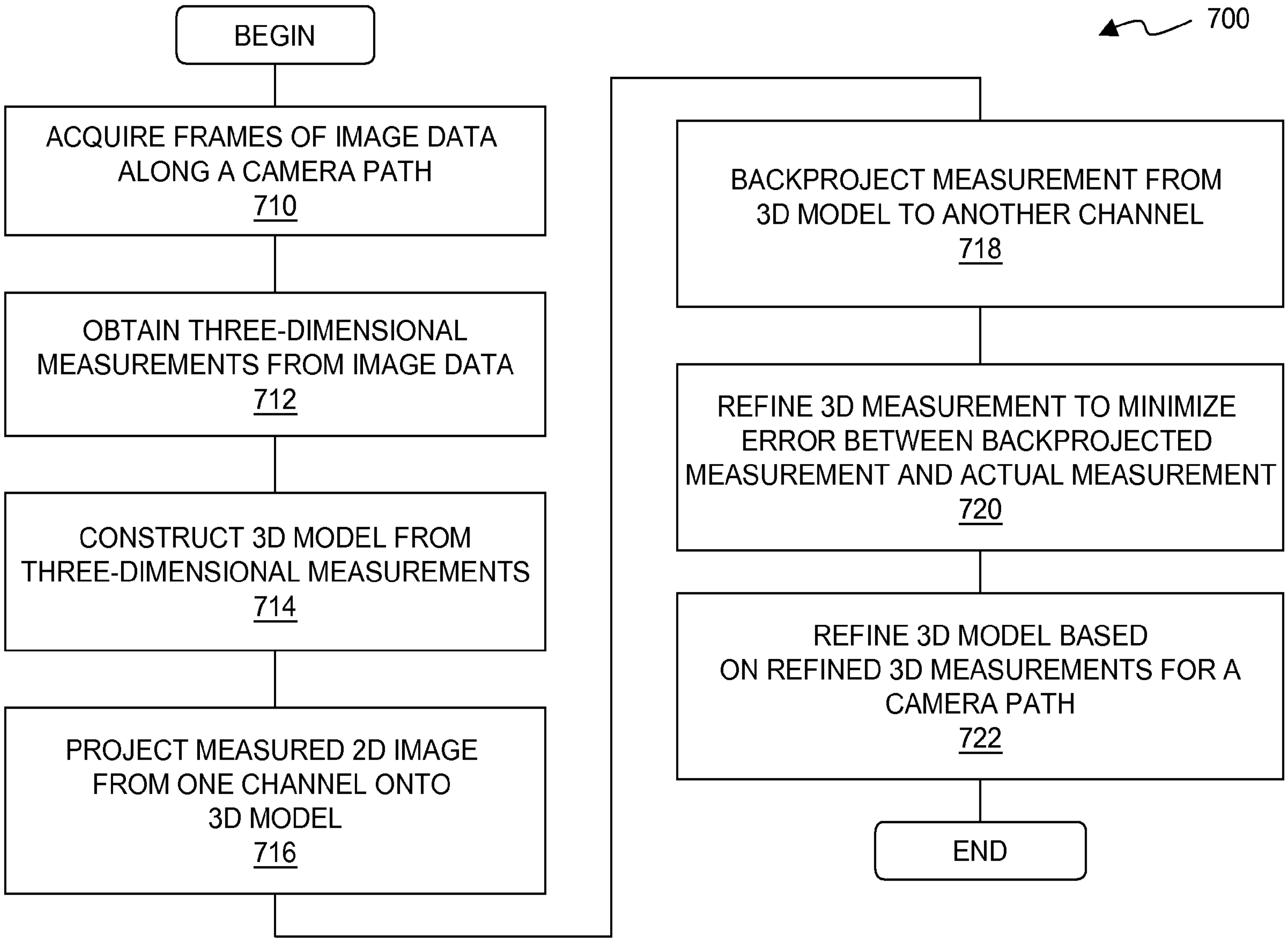
700
BEGIN
ACQUIRE FRAMES OF IMAGE DATA ALONG A CAMERA PATH
710
OBTAIN THREE-DIMENSIONAL MEASUREMENTS FROM IMAGE DATA
712
CONSTRUCT 3D MODEL FROM THREE-DIMENSIONAL MEASUREMENTS
714
PROJECT MEASURED 2D IMAGE FROM ONE CHANNEL ONTO 3D MODEL
716
BACKPROJECT MEASUREMENT FROM 3D MODEL TO ANOTHER CHANNEL
718
REFINE 3D MEASUREMENT TO MINIMIZE ERROR BETWEEN BACKPROJECTED MEASUREMENT AND ACTUAL MEASUREMENT
720
REFINE 3D MODEL BASED ON REFINED 3D MEASUREMENTS FOR A CAMERA PATH
722
END

Fig. 7

8/8

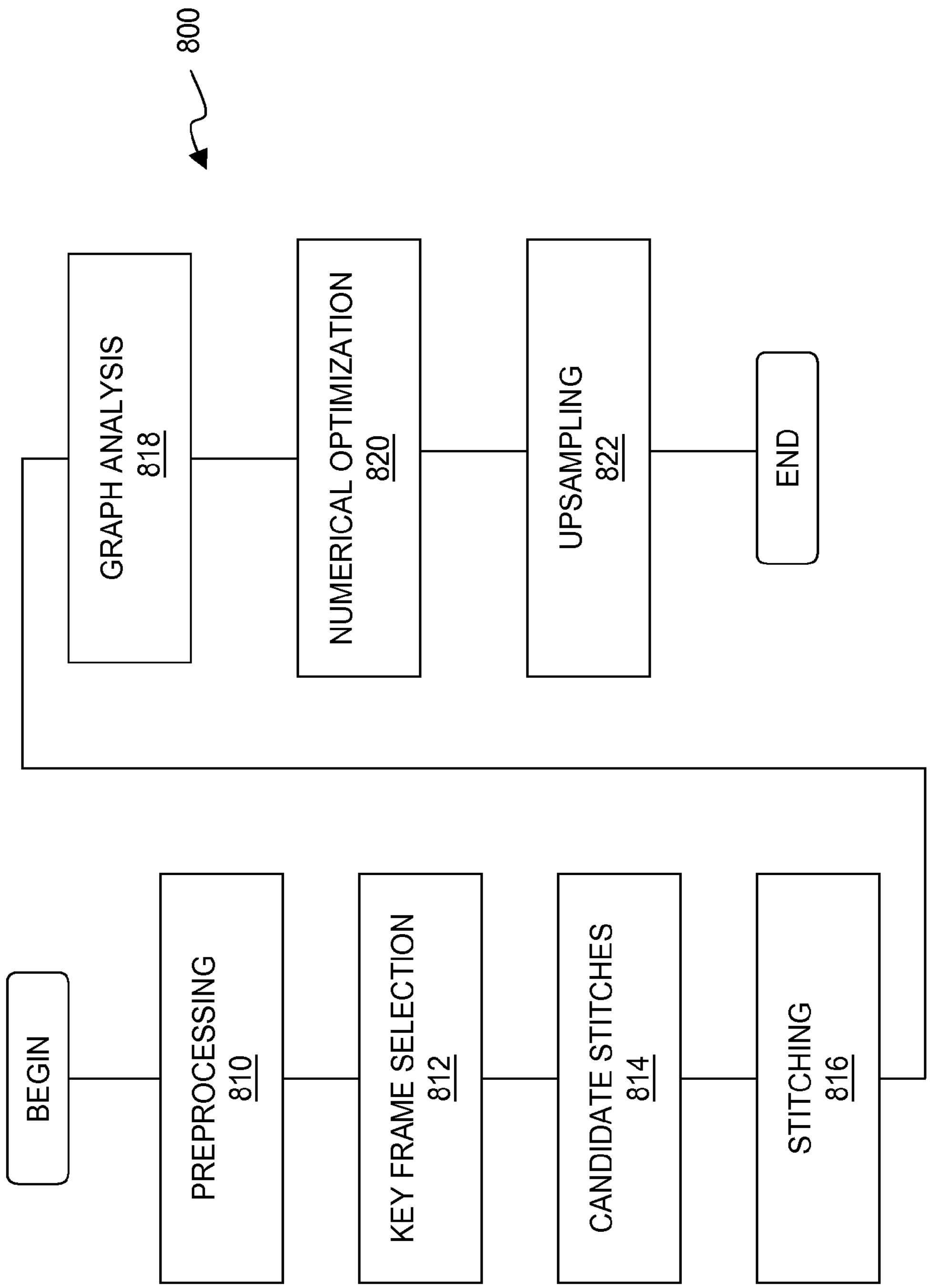
800
BEGIN
PREPROCESSING 810
KEY FRAME SELECTION 812
CANDIDATE STITCHES 814
STITCHING 816
GRAPH ANALYSIS 818
NUMERICAL OPTIMIZATION 820
UPSAMPLING 822
END

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2009/030065

A. CLASSIFICATION OF SUBJECT MATTER

H04N 13/00(2006.01)i, H04N 13/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility Models : IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKIPASS(KIPO Internal) : "3D", "MODEL", "CAMERA", "DISCREPANCY"

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2006-0204076 A1 (GOPAL B. AVINASH et al.) 14 September 2006 See abstract; claims 1-25; figures 1-9.	1, 4,11-12,15,18,25-26 2-3,5-10,13-14, 16-17, 19-24, 27-28
Y A	US 2007-0103460 A1 (TONG ZHANG et al.) 10 May 2007 See abstract; claims 1-53; figures 1-5.	1, 4,11-12,15,18,25-26 2-3,5-10,13-14, 16-17, 19-24, 27-28
A	KR 10-2007-0039641 A (PANTECH CO., LTD.) 13 April 2007 See abstract; claims 1-13; figures 1-7.	1-28

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 MAY 2009 (27.05.2009)	**28 MAY 2009 (28.05.2009)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	JUNG, Yun Seok Telephone No. 82-42-481-8123

Form PCT/ISA/210 (second sheet) (July 2008)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2009/030065

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2006-0204076 A1	14.09.2006	DE 102006009570 A1 JP 2006-239420 A	07.09.2006 14.09.2006
US 2007-0103460 A1	10.05.2007	EP 1952354 A2 WO 2007-056768 A2	06.08.2008 18.05.2007
KR 10-2007-0039641 A	13.04.2007	None	

Form PCT/ISA/210 (patent family annex) (July 2008)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
27 January 2011 (27.01.2011)

PCT

(10) International Publication Number
WO 2011/011193 A1

(51) International Patent Classification:
A61C 3/00 (2006.01)

(21) International Application Number:
PCT/US2010/041045

(22) International Filing Date:
6 July 2010 (06.07.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/227,255 21 July 2009 (21.07.2009) US

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(74) Agent: GUERIN, William G.; Guerin & Rodriguez, LLP, 5 Mount Royal Avenue, Mount Royal Office Park, Marlborough, MA 01752 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

WO 2011/011193 A1

(54) Title: INTEGRATED DISPLAY IN A HAND-HELD THREE-DIMENSIONAL METROLOGY SYSTEM

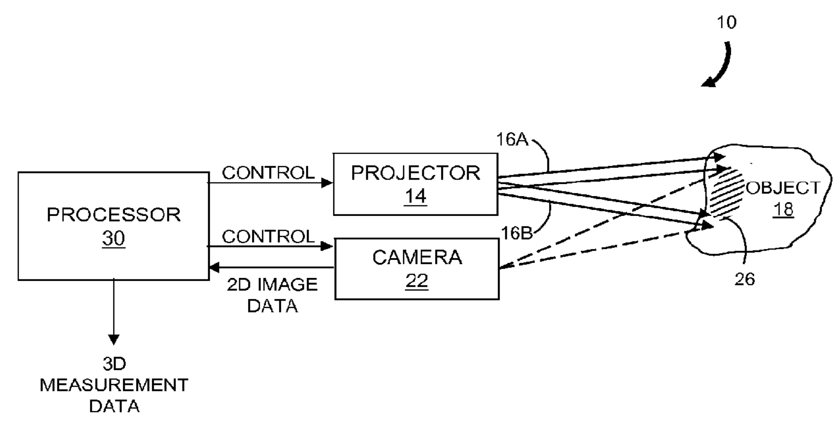

FIG. 1

(57) Abstract: Described is a user-manipulated imaging device for measuring a three-dimensional surface of an object. The device includes an imager configured for acquiring two-dimensional images of the surface and a device housing coupled to the imager and configured for manual positioning of the imager. The device also includes a processor in communication with the imager and configured to generate three-dimensional surface data based on the two-dimensional images. The device further includes a display coupled to the device housing and in communication with at least one of the imager and the processor. The display shows images of the surface and is observable within a field of view of the user while the device housing is manually positioned within the field of view and relative to the surface. In various embodiments, the display shows the two-dimensional images and representations of the three-dimensional surface data.

DPI-019PC

INTEGRATED DISPLAY IN A HAND-HELD THREE-DIMENSIONAL METROLOGY SYSTEM

RELATED APPLICATION

This application claims the benefit of the earlier filing date of U.S. Provisional Patent Application Serial No. 61/227,255, filed July 21, 2009, titled "Integrated Display in a Hand-Held Three-Dimensional Metrology System," the entirety of which is incorporated herein by reference.

FIELD OF THE INVENTION

The invention relates to the field of three-dimensional imaging and more specifically to the field of displaying non-contact surface measurement data for dental and medical applications.

BACKGROUND OF THE INVENTION

A variety of precision non-contact three-dimensional (3D) metrology systems have been developed for dental and medical applications. Conventional systems typically include a handheld camera or scanner connected to a processing unit that communicates with a display monitor. The display monitor presents a variety of information to the user. The information can include control options, acquired images, and operator assistance information such as an indication of an optimal focus condition. This configuration requires the user to look in two directions, that is, to look at the position of the handheld device with respect to the patient and to look at the display monitor to determine that proper images are being acquired. Thus the time and effort to obtain the desired measurement data is adversely affected by the requirement for the user to alternately view the position of the device and view the acquired images.

SUMMARY

In one aspect, the invention features a method of displaying information for a user-manipulated 3D imaging device. The method includes acquiring a plurality of two-dimensional (2D) images of a surface of an object with an imaging device manipulated by a user in position relative to the surface of the object and within a field of view of the user. The 2D images are processed to generate three-dimensional surface data for the surface of the object. Measurement data are displayed to the user within the field of view of the user during continued manipulation of the imaging device. In one embodiment, the displayed measurement information includes the two-dimensional images acquired by the imaging device and, in another embodiment, the displayed information includes a representation of the 3D surface data.

In another aspect, the invention features a user-manipulated imaging device for measuring a 3D surface of an object. The imaging device includes an imager, a device housing, a processor and a display. The imager is configured for acquiring 2D images of a surface of the object. The device housing is coupled to the imager and configured for manipulation by a user to position the imager relative to the surface of the object. The processor communicates with the imager and is configured to generate 3D surface data for the surface based on the 2D images. The display is coupled to the device housing and communicates with at least one of the imager and the processor. The display shows images of the surface observable within a field of view of the user while the device housing is manually positioned within the field of view of the user relative to the surface. In one embodiment, the display shows the 2D images of the surface acquired by the imager and, in another embodiment, the display shows a representation of the 3D surface data generated by the processor.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and further advantages of this invention may be better understood by referring to the following description in conjunction with the accompanying drawings, in which like numerals indicate like structural elements and features in the various figures. The drawings are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention.

FIG. 1 illustrates a 3D imaging device that projects a structured light pattern onto an object.

FIG. 2 is a flowchart representation of an embodiment of a measurement procedure using a hand-held 3D imaging device according to the invention.

FIG. 3 illustrates an embodiment of a user-manipulated imaging device according to the invention.

FIG. 4A illustrates an embodiment of a user-manipulated imaging device according to the invention and showing a display panel in an open position.

FIG. 4B illustrates the user-manipulated imaging device of FIG. 4A showing the display panel in a closed position.

DETAILED DESCRIPTION

In brief overview, the invention relates to a user-manipulated 3D metrology device such as a hand-held camera or scanning device. The device includes an integrated display monitor that provides the user with convenient access to control options, acquired images, and operator assistance indications within a field of view of the user. Advantageously, the location of the operating tip of the device relative to the object being measured can be viewed without the need to redirect the view of the user to a display monitor. For medical and dental 3D metrology devices, the user positions and aligns the device to a patient while simultaneously viewing a display of the acquired images or data. As a result, measurement data are obtained with less time and operator effort than is required for conventional user-manipulated 3D metrology devices.

The present teaching will now be described in more detail with reference to exemplary embodiments thereof as shown in the accompanying drawings. While the present teaching is described in conjunction with various embodiments and examples, it is not intended that the present teaching be limited to such embodiments. On the contrary, the present teaching encompasses various alternatives, modifications and equivalents, as will be appreciated by those of skill in the art. Those of ordinary skill in the art having access to the teaching herein will recognize additional implementations, modifications and embodiments, as well as other fields of use, which are within the scope of the present disclosure as described herein.

In a typical dental or medical 3D camera or scanner imaging system, a series of 2D intensity images of an object surface is acquired where the illumination for each image can vary. In some systems, structured light patterns are projected onto the surface and detected in each 2D intensity image. FIG. 1 shows an example of a 3D imaging system 10 in which the structured light pattern is generated by a projector 14 as a pair of overlapping coherent optical beams 16A and 16B that illuminate the object 18. The 3D imaging system 10 may be constructed to operate in accordance with the principles described in U.S. Patent No. 5,870,191, titled "Apparatus and Methods for Surface Contour Measurement," incorporated herein by reference in its entirety. A CCD camera 22 is used to acquire images of the illuminated object 18. The fringe pattern 26 resulting from the interference of the two beams 16 is varied between successive 2D images acquired by the camera 22. For example, the fringes in the fringe pattern 26 can be shifted by changing the phase difference between the two beams 16.

A processor 30 calculates the distance from the camera 22 to the object surface for each image pixel based on the intensity values for the pixel in the 2D images. Thus the process creates a set of 3D coordinates, that is, a "point cloud," for the object surface.

In a dynamic 3D imaging system, a series of point clouds is acquired while the camera or scanner is in motion relative to the object surface. For example, the imaging system can be a handheld device that a user manually positions relative to the object surface. In some applications, multiple objects surfaces are measured by moving the device relative to the objects so that surfaces obscured from view of the device in one position are observable by the device in another position. A processor registers the overlapped region of adjacent point clouds, using a 3D correlation technique or other registration technique, to transform each successive point cloud into an initial coordinate space. The successive point clouds are thus "stitched" into a common reference space.

Referring to FIG. 2, at the start of an embodiment of a measurement procedure 100 according to the invention, the user aligns and positions (step 110) the hand-held imaging device relative to the patient while acquiring 2D images of a patient area of interest. The 2D images are processed (step 120) to generate 3D surface data of the area of interest. The user simultaneously observes measurement images in a display while controlling (step 130) the positioning and motion of the handheld imaging device with respect to the patient. The images in the display can be the acquired 2D images. Alternatively, the displayed images can be 3D surface representations generated by processing the acquired 2D images. By way of examples, the 3D surface representations can be 3D wire-mesh representations of point clouds or artificial surface displays that comprise simple geometrical shapes (e.g., triangles) between neighboring points in point clouds.

Providing a display that is in communication with the processor and mounted to or otherwise integrated with the 3D imaging device according to the principles of the invention permits the user to see the acquired 2D images, 3D surface representation, other display information or combinations of such images and information simultaneous with the observation and continued manipulation of the 3D imaging device relative to the patient. Thus the user can more easily and rapidly complete the measurement procedure than would be possible using a conventional handheld dental or medical imaging device. Other displayed information can include operator assistance information such as a slide bar shown along the edge of the display to indicate measured position within a usable imaging range, the distance to a surface of the object being measured, and a color box to indicate the current mode of the device, such as idle, preview and scan modes.

In one embodiment, the display includes a touchscreen that permits the user to input selection data while maintaining the handheld device in proper position relative to the patient. Control options shown on the touchscreen display can include, by way of example, preview, scan and stop function activation "buttons;" save and redo buttons presented at the completion of a scan, and input data buttons. For example, in dental applications, the input data buttons can be used to indicate the jaw to be imaged (upper or lower) or particular teeth to be imaged for a partial jaw scan.

In another embodiment illustrated in FIG. 3, the imaging device 34 includes a miniature display 38 similar to the displays typically used in mass-produced cell phones for consumers. The miniature display 38 can be embedded in a side of the device housing 42 and optionally has a viewing surface that is flush with the housing 42. By way of a specific example, the miniature display 38 may have a 1.8 inch diagonal viewing area. In one embodiment, the display is a compact liquid crystal display (LCD).

In an alternative embodiment, a display 46 is integral to a panel 50 that is pivotally attached to a side of a device housing 54 for the 3D imaging device 58 shown in FIG. 4A and FIG. 4B. The panel 50 is small enough to be compatible with the overall dimensions of the device 58 and yet include a display 46 that is large enough to present detailed images to the user. By way of a specific example, the display 46 can have a four inch diagonal viewing area. FIG. 4A shows the panel 50 in an open position in which the user views the displayed images, 3D representations and information. FIG. 4B shows the panel 50 in a closed position such that the panel 50 is substantially parallel and adjacent to the side of the device housing 54. The closed position is intended for when the device 58 is stored or otherwise not in use for extended periods of time.

In the embodiments described above, the device according to the invention is generally described as a handheld device; however, the invention also contemplates that the device can be manually adjusted or manipulated by a user without being directly held by hand.

While the invention has been shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

CLAIMS

1. A method of displaying information for a user-manipulated three-dimensional imaging device, the method comprising:

acquiring a plurality of two-dimensional images of a surface of an object with an imaging device manipulated by a user in position relative to the surface of the object and within a field of view of the user;

processing the two-dimensional images to generate three-dimensional surface data for the surface of the object; and

displaying measurement information to the user within the field of view of the user during continued manual manipulation of the imaging device.

2. The method of claim 1 wherein the displayed measurement information comprises the two-dimensional images acquired by the imaging device.

3. The method of claim 1 wherein the displayed measurement information comprises a representation of the three-dimensional surface data.

4. The method of claim 1 wherein the displayed measurement information comprises operator assistance information.

5. The method of claim 4 wherein the operator assistance information comprises a distance to the surface of the object.

6. A user-manipulated imaging device for measuring a three-dimensional surface of an object, comprising:

an imager configured for acquiring two-dimensional images of a surface of an object;

a device housing coupled to the imager and configured for manipulation by a user to position the imager relative to the surface of the object;

a processor in communication with the imager and configured to generate three-dimensional surface data for the surface based on the two-dimensional images; and

a display coupled to the device housing and in communication with at least one of the imager and the processor, the display showing images of the surface observable within a field of view of the user while the device housing is manually positioned within the field of view of the user relative to the surface.

7. The user-manipulated device of claim 6 wherein the images shown in the display are the two-dimensional images of the surface acquired by the imager.

8. The user-manipulated device of claim 6 wherein the images shown in the display are representations of the three-dimensional surface data generated by the processor.

9. The user-manipulated device of claim 6 wherein the display shows operator assistance information.

10. The user-manipulated device of claim 9 wherein the operator assistance information includes a distance to the surface of the object.

11. The user-manipulated device of claim 6 wherein the display is a touchscreen display configured to receive data input from the user.

12. The user-manipulated device of claim 6 wherein the display comprises a liquid crystal display (LCD).

13. The user-manipulated device of claim 6 wherein the display comprises a display panel pivotably secured to a side of the device housing, the display panel extending away from a surface of the device housing while in an open position and extending substantially parallel to the surface of the device housing while in a closed position, and wherein images of the surface are observable to the user while the display panel is in the open position.

14. The user-manipulated device of claim 6 wherein the display comprises a viewing surface that is substantially flush with a side of the device housing.

15. The user-manipulated device of claim 6 further comprising a projector in communication with the processor and configured for projecting a structured light pattern onto the surface of the object.

16. The user-manipulated device of claim 15 wherein the projector comprises a source of coherent optical beams for illuminating the surface of the object with a fringe pattern.

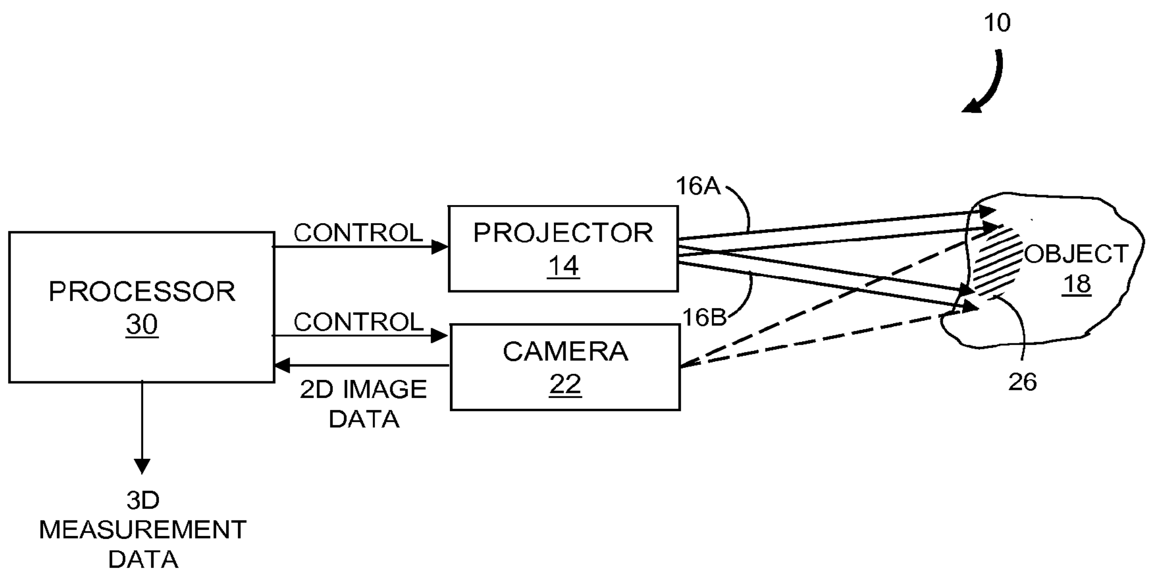
10
16A
PROCESSOR
30
CONTROL
PROJECTOR
14
CONTROL
CAMERA
22
2D IMAGE
DATA
16B
OBJECT
18
26
3D
MEASUREMENT
DATA

FIG. 1

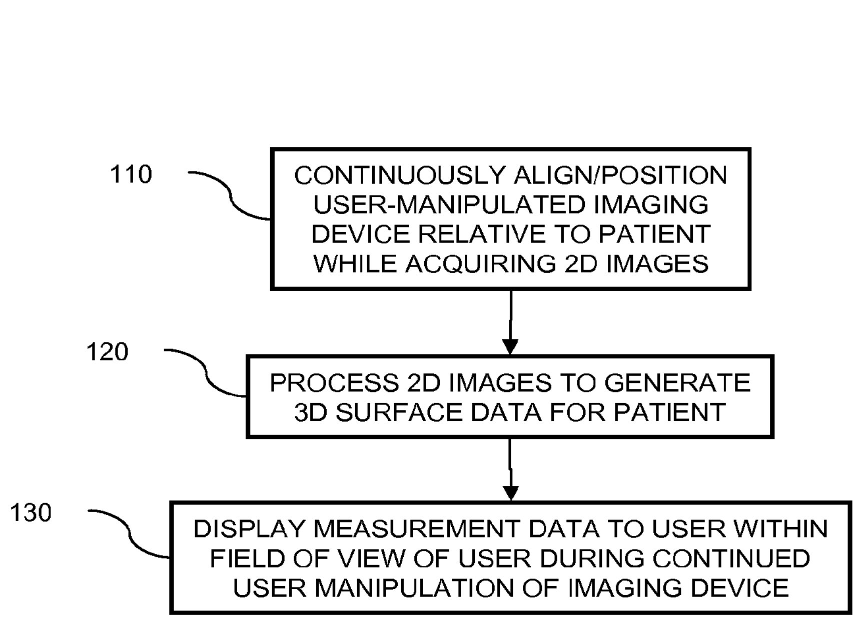
100
110
CONTINUOUSLY ALIGN/POSITION USER-MANIPULATED IMAGING DEVICE RELATIVE TO PATIENT WHILE ACQUIRING 2D IMAGES
120
PROCESS 2D IMAGES TO GENERATE 3D SURFACE DATA FOR PATIENT
130
DISPLAY MEASUREMENT DATA TO USER WITHIN FIELD OF VIEW OF USER DURING CONTINUED USER MANIPULATION OF IMAGING DEVICE

FIG. 2

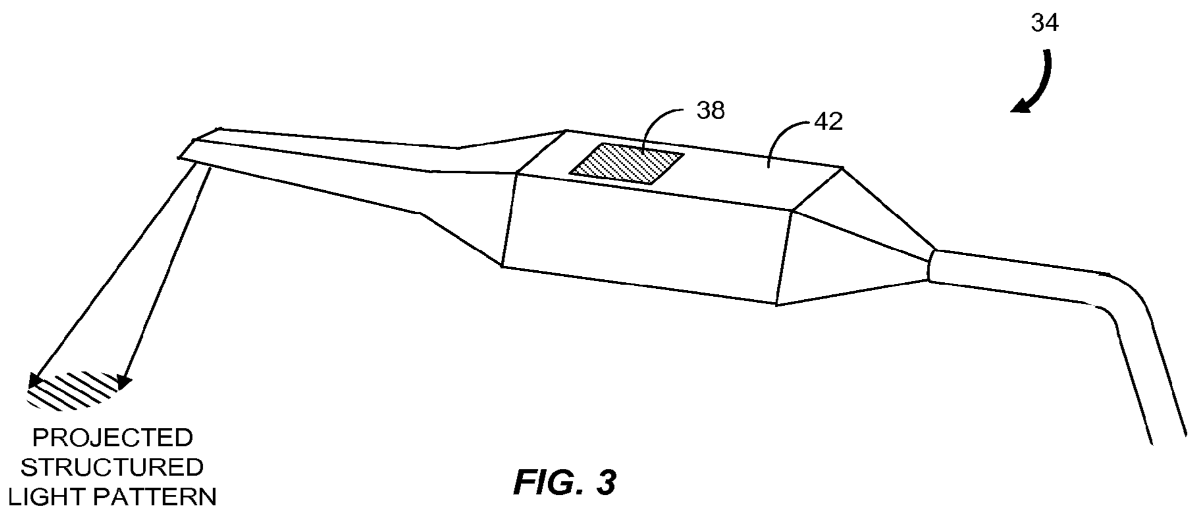

FIG. 3

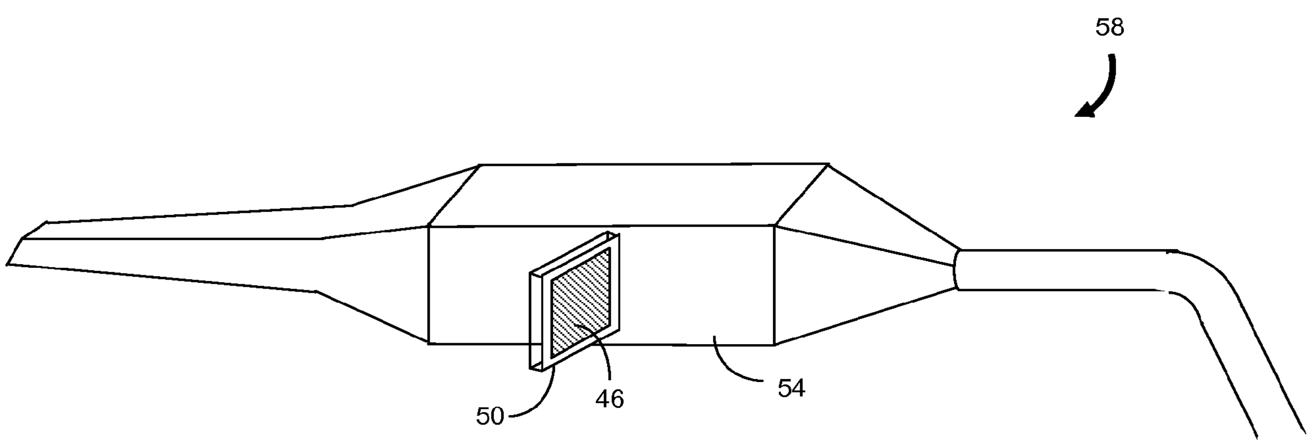

FIG. 4A

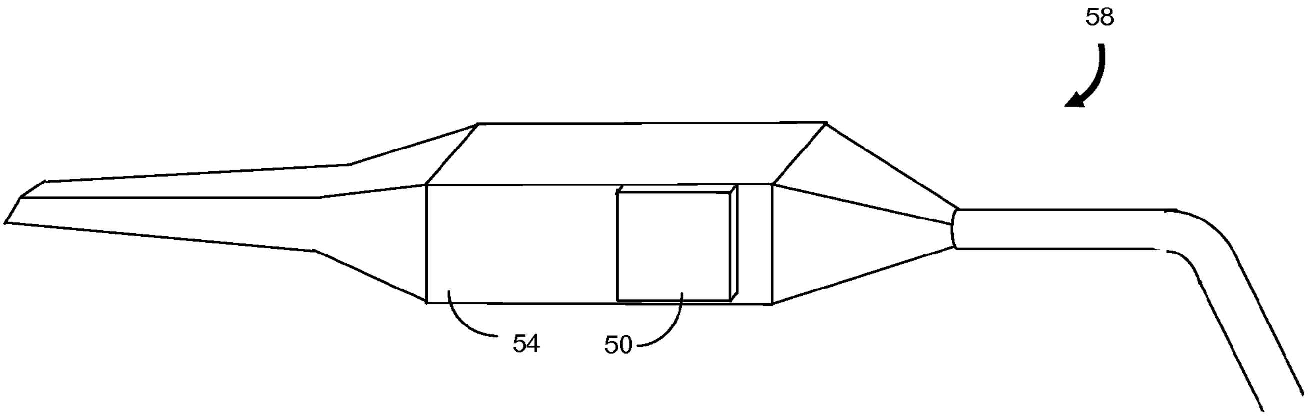

FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 10/41045

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61C 3/00 (2010.01)
USPC - 433/29
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC - A61C 3/00 (2010.01)
USPC - 433/29

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 345/419,420,421,422,423,424,426,427

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PubWEST (PGPB,USPT,USOC,EPAB,JPAB); Google Scholar
Search terms - display, screen, touch screen, fringe patter, two dimension$, three dimension$, pivot$, hinge$, control$, distance, surface, contour

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2005/0237581 A1 (KNIGHTON et al.) 27 October 2005 (27.10.2005) entire document, especially para [0025]-[0035,] [0047]-[0048], [0052]-[0054]; Fig 1, 6	1-12, 14 --- 13, 15-16
Y	US 7,046,286 B1 (KOBAYASHI et al.) 16 May 2006 (16.05.2006) Fig 4-6	13
Y	US 6,438,272 B1 (HUANG et al.) 20 August 2002 (20.08.2002) col 5, ln 4-34	15-16

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 September 2010 (16.09.2010)	27 SEP 2010

Name and mailing address of the ISA/US	Authorized officer:
Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

Form PCT/ISA/210 (second sheet) (July 2009)

Electronic Patent Application Fee Transmittal

Application Number:	13991513
Filing Date:	04-Jun-2013
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Filer:	William C. Rowland/Stacey Pflieger
Attorney Docket Number:	0079124-000070

Filed as Small Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Submission- Information Disclosure Stmt	2806	1	90	90
		Total in USD ($)		**90**

Electronic Acknowledgement Receipt

EFS ID:	23196398
Application Number:	13991513
International Application Number:	
Confirmation Number:	9282
Title of Invention:	SYSTEM WITH 3D USER INTERFACE INTEGRATION
First Named Inventor/Applicant Name:	Henrik Öjelund
Customer Number:	21839
Filer:	William C. Rowland/Stacey Pflieger
Filer Authorized By:	William C. Rowland
Attorney Docket Number:	0079124-000070
Receipt Date:	13-AUG-2015
Filing Date:	04-JUN-2013
Time Stamp:	09:04:42
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$90
RAM confirmation Number	9674
Deposit Account	024800
Authorized User	ROWLAND, WILLIAM C

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		070amd.pdf	33127 a0fbdfb8014582cc1fd0883f921709205ec2545a	yes	7

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Claims	2	5
Applicant Arguments/Remarks Made in an Amendment	6	7

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
2	Information Disclosure Statement (IDS) Form (SB08)	070ids.pdf	65478 8b2dd96452e9d4cb35138519fc255c2d2f61ba7f	no	4

Warnings:

Information:

This is not an USPTO supplied IDS fillable form

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
3	Foreign Reference	070cn350.pdf	2831304 bdd1ee0db72dbfeb521ac07d9ef88c0f161a8f7c	no	18

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
4	Foreign Reference	070wo126.pdf	2199184 57821276c49e8a0928e43508957f854319086cf0	no	48

Warnings:

Information:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
5	Foreign Reference	070wo193.pdf	553799 03e5201bfa6e7ee1225daa1217261cfa6c497887	no	16

Warnings:

Information:

6	Non Patent Literature	070cnoa.pdf	86037 adb8bef514d51b7a2f409e4f280924ca30333fe6	no	13
Warnings:					
Information:					
7	Fee Worksheet (SB06)	fee-info.pdf	31006 1eaa1eb3e9d35adeebf6a1344622af504e506a48	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	5799935	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/991,513	Filing Date 06/04/2013	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	RATE ($)	FEE ($)
☒ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	**140**
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	**140**

APPLICATION AS AMENDED – PART II

AMENDMENT

08/13/2015	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0	x $40 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	x $210 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	**0**

AMENDMENT

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/GWENDOLYN MYERS/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
13/991,513	06/04/2013	Henrik Öjelund	0079124-000070	9282

21839 7590 05/13/2015
BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

EXAMINER
CHOW, VAN NGUYEN

ART UNIT	PAPER NUMBER
2695	

NOTIFICATION DATE	DELIVERY MODE
05/13/2015	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ADIPDOC1@BIPC.com

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 13/991,513	Applicant(s) ÖJELUND ET AL.	
	Examiner VAN CHOW	Art Unit 2695	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE _3_ MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on _09/19/2013_.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) _53-72_ is/are pending in the application.
5a) Of the above claim(s) _____ is/are withdrawn from consideration.
6)☐ Claim(s) _____ is/are allowed.
7)☒ Claim(s) _53-72_ is/are rejected.
8)☐ Claim(s) _____ is/are objected to.
9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.
11)☒ The drawing(s) filed on _06/04/2013_ is/are: a)☒ accepted or b)☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
Certified copies:
a)☒ All b)☐ Some** c)☐ None of the:
1.☒ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.
3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
4) ☐ Other: _____.

Claim Rejections - 35 USC § 112

1. The following is a quotation of 35 U.S.C. 112(b):

(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:

The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

2. Claims 59-61, 70 and 71 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claim 59 recites the limitation "the user interface" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 59 recites the limitation "the used of gestures" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 60 recites the limitation "the gestures" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 60 recites the limitation "the at least one motion sensor" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 61 recites the limitation "the at least one motion sensor" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 61 recites the limitation "the second display" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 70 recites the limitation "the first display and/or the second display" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim 71 recites the limitation "audible information" in line 1. There is insufficient antecedent basis for this limitation in the claim.

Claim Rejections - 35 USC § 103

3. The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. Claims 53-58, 61-69, 72 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Paley et al. (US 7813591) in view of Xia et al. (NPL June, 2001 see attachment).

Regarding claim 53, discloses a system comprising: a handheld device (fig. 1, handheld 116) and at least one display (see fig. 1, display 110), wherein the handheld device is adapted for switching between performing at least one action in a physical 3D environment (see figs. 4, 5, 8, 9), wherein the at least one display is adapted for visually representing the physical 3D environment (see figs. 4, 5, 8, 9).

Moreover, Paley et al. discloses a the scanner 102 is a handheld, freely positionable probe having at least one user input device, such as a button, lever, dial, thumb wheel, switch, or the like, for user control of the image capture system 100 such as starting and stopping scans. Furthermore, the handheld includes the input 116, but the details are not described.

Xia et al. fig. 2, discloses the remotely controlling the view with which the 3D environment is represented on the display.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to provide the remote control in Paley et al. as suggested by Xia et al., the motivation being in order to remotely controlling the view with which the 3D environment is represented on the display.

Regarding claim 54, the combination of Paley et al. and Xia et al., discloses a system according to Claim 53, wherein the handheld device is adapted to record the 3D geometry of the 3D environment (see Paley et al. figs. 4, 5, 8, 9, Xia et al. fig. 2).

Regarding claim 55, the combination of Paley et al. and Xia et al., discloses a system according to Claim 53, wherein means for manually switching between performing the at least one action and remotely controlling the view is provided on the handheld device (see Paley et al. figs. 1, col. 4, lines 42-61, Xia et al. fig. 2).

Regarding claim 56, the combination of Paley et al. and Xia et al., discloses a system according to Claim 53, wherein the at least one action comprises: measuring; recording; scanning; manipulating; and modifying (see Paley et al. abstract, fig. 1, Xia et al. fig. 2).

Regarding claims 57, 58, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device comprises at least one motion sensor; and/or wherein the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor (see Paley et al. col. 18, lines 17-50, Xia et al. fig. 2).

Regarding claim 61, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, herein the handheld device comprises at least one user-interface element other than the at least one motion sensor (see Paley et al. figs. 2, 4, 5, 8, 9, Xia et al. fig. 2).

Regarding claim 62, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, herein the handheld device is adapted to change a viewing angle with which the 3D environment is represented on the at least one display (see Paley et al. figs. 4, 5, 8, 9, Xia et al. fig. 2).

Regarding claim 63, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device is adapted to change a magnification factor with which the 3D environment is represented on the at least one display (see Paley et al. figs. 4, 5, 8, 9, Xia et al. fig. 2).

Regarding claim 64, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner (see Paley et al. abstract, fig. 1, Xia et al. fig. 2).

Regarding claim 65, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device is a surgical instrument (see Paley et al. abstract, fig. 1, Xia et al. fig. 2).

Regarding claim 66, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device is a mechanical tool (see Paley et al. abstract, fig. 1, Xia et al. fig. 2).

Regarding claim 67, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device is an in-ear 3D scanner (see Paley et al.

abstract, figs. 1-9, Xia et al. fig. 2, it is inherently to use the medical device on the other body part).

Regarding claim 68, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the at least one display is defined as a first display, and where the system further comprises a second display (see Paley et al. figs. 4, 5, 8, 9, Xia et al. fig. 2).

Regarding claim 69, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the second display indicates where the handheld device is positioned relative to the 3D environment (see Paley et al. figs. 4, 5, 8, 9, Xia et al. fig. 2).

Regarding claim 72, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner and the at least one action performed in the physical 3D environment is scanning and that the view is remotely controlled by at least one motion sensor arranged in the handheld device, and wherein an actuator provided on the handheld device switches between performing the at least one action and remotely controlling the view (see rejection above of claim 53).

5. Claims 59, 60 are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Paley et al. (US 7813591), Xia et al. (NPL June, 2001 see attachment) in view of Boilot (US 20080111710).

Regarding claims 59, 60, the combination of Paley et al. and Xia et al., discloses the system according to Claim 53.

Boilot discloses a sensor device (100) and method (300) for touchless finger signing and recognition is provided. The method can include detecting (304) a first pause of a finger in a touchless sensory space (101), tracking (306) a movement (140) of the finger, detecting (308) a second pause of the finger, creating (310) a trace (145) of the finger movement from the tracking, and recognizing (312) a pattern (146) from the trace. The pattern can be an alphanumeric character or a finger gesture. A user can accept or reject the recognized pattern via touchless finger control.

It would have been obvious to a person of ordinary skill in the art at the time the invention was made to provide the finger gesture in Paley et al., Xia et al. as suggested by Boilot, the motivation being in order to touchless finger control.

Therefore, the combination of Paley et al, Xia et al. and Boilot, discloses the user interface functionality comprises the use of gestures; and/or the gestures are detected by the at least one motion sensor (see Paley et al. figs. 4, 5, 8, 9, Xia et al. fig. 2, and Boilot abstract, figs. 1, 2) .

Regarding claim 70 and 71, the combination of Paley et al, Xia et al. and Boilot, discloses the system according to Claim 53, wherein the first display and/or the second display provides instructions for the operator (see Boilot figs. 23, 31, pars. 85, 87, 90-92); and/or audible information to the operator is provided to the operator (see Boilot figs. 4, 6, pars. 45, 46, 65, 69).

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to VAN CHOW whose telephone number is (571)272-7590. The examiner can normally be reached on Tuesday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Joseph Feild can be reached on 571-272-4090. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/VAN CHOW/
Primary Examiner, Art Unit 2695

Notice of References Cited	Application/Control No. 13/991,513	Applicant(s)/Patent Under Reexamination ÖJELUND ET AL.	
	Examiner VAN CHOW	Art Unit 2695	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2004/0204787 A1	10-2004	Kopelman et al.	700/182
*	B	US-6,967,644 B1	11-2005	Kobayashi, Kiwamu	345/158
*	C	US-2006/0092133 A1	05-2006	Touma et al.	345/158
*	D	US-7,813,591 B2	10-2010	Paley et al.	382/285
*	E	US-7,831,292 B2	11-2010	Quaid et al.	600/424
*	F	US-8,035,637 B2	10-2011	Kriveshko, Ilya A.	345/419
*	G	US-8,384,665 B1	02-2013	Powers et al.	345/156
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	Three-Dimensional Virtual Reality Xia et al. JUNE, 2001
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Substitute for PTO/SB/08a&b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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Substitute for form 1449/PTO	Complete if Known	
INFORMATION DISCLOSURE STATEMENT BY APPLICANT	*Application Number*	Unassigned
	Filing Date	June 4, 2013
	First Named Inventor	Henrik ÖJELUND et al.
(Use as many sheets as necessary)	*Art Unit*	Unassigned
	Examiner Name	Unassigned
Sheet 1 of 1	*Attorney Docket Number*	0079124-000070

U.S. PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Document Number Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-2009/0217207 A1	08-27-2009	KAGERMEIER ET AL.	
		US-2003/0158482 A1	08-21-2003	POLAND ET AL.	
		US-7,141,020 B2	11-28-2006	POLAND ET AL.	
		US-2009/0061381 A1	03-05-2009	DURBIN ET AL.	
		US-2006/0146009 A1	07-06-2006	SYRBE ET AL. (corr. to WO 2004/066615 cited below)	
		US-			
		US-			
		US-			

FOREIGN PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Foreign Patent Document Country Code[3] Number[4] Kind Code [5]*(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]
		WO 2004/066615 A1	08-05-2004	NOKIA CORPORATION		

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		International Search Report (PCT/ISA/210) issued on February 22, 2012, by the Danish Patent Office as the International Searching Authority for International Application No. PCT/DK/2011/050461.	

Examiner Signature	/Van Chow/	Date Considered	05/07/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6]Applicant is to place a check mark here if English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.P./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	13991513	ÖJELUND ET AL.
	Examiner	**Art Unit**
	VAN CHOW	2695

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	05/07/2015								
	53	✓								
	54	✓								
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	57	✓								
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	67	✓								
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	70	✓								
	71	✓								
	72	✓								

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	15	("8766786" | "7088342" | "6944472" | "20090295743" | "20060038796" | "8711110" | "5543588" | "20080111710" | "5543588" | "6944472" | "8698761" | "20030184528" | "5729219" | "6909424" | "8514171" | "20060034042" | "20020149561").PN.	US-PGPUB; USPAT	OR	OFF	2015/05/07 21:05
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L13	14	L12 and L11 and scanning	US-PGPUB; USPAT	OR	OFF	2015/05/07 21:55
L14	11	13 AND ((H04N13/0409 OR H04N13/0438 OR H04N13/0452 OR H04N13/0454 OR H04N13/0488 OR H04N13/0048 OR H04N13/0055 OR H04N13/0066 OR H04N13/007 OR H04N13/0404 OR H04N13/0425 OR H04N13/0477 OR H04N13/0497 OR H04N17/04 OR H04N19/597 OR H04N2013/0461 OR H04N21/234327 OR H04N21/2365 OR H04N21/42202 OR H04N21/42646 OR H04N21/4325 OR H04N21/4347 OR H04N21/44 OR H04N21/44218 OR H04N21/4532 OR H04N21/4884 OR H04N21/816 OR H04N2213/001 OR H04N2213/008 OR H04N5/85 OR H04N9/8042 OR H04N9/8227 OR H04N9/8233 OR G06F1/1601 OR G06F1/1613 OR G06F1/1643 OR G06F1/1652 OR G06F1/1656 OR G06F1/1684 OR G06F1/1694 OR G06F2203/04808 OR	US-PGPUB; USPAT	OR	OFF	2015/05/07 21:55

		G06F3/017 OR G06F3/0325 OR G06F3/041 OR G06F3/0412 OR G06F3/0425 OR G06F3/0482 OR G06F3/0485 OR G06F3/04883 OR G06F3/01).CPC.)				
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S8	1	"20130257718"	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:12
S9	0	"2006146009"	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:20
S10	1	"20060146009"	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:28
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S13	30153	HANDHELD AND S11	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:44
S14	179086	"345"/$.ccls.	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:44
S15	4802	S13 and S14	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:46
S16	4175	(physical near4 (3D three$dimensonal "3"$dimensional))	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:48
S17	240	S16 and S13 and S14	US-PGPUB;	OR	OFF	2015/05/06 13:48

			USPAT			
S18	238	S16 and S13 and S14 and display$4	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:48
S19	214	S16 and S13 and S14 and display$4 and visual$4	US-PGPUB; USPAT	OR	OFF	2015/05/06 13:52
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S23	30213	HANDHELD AND S22	US-PGPUB; USPAT	OR	OFF	2015/05/07 00:55
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S25	9942	(physical near4 (3D three$dimensonal "3"$dimensional (three adj2 dimensional)))	US-PGPUB; USPAT	OR	OFF	2015/05/07 00:55
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S28	67	S26 and (remot$4 near3 controll$4)	US-PGPUB; USPAT	OR	OFF	2015/05/07 00:55
S29	92	S26 and (remot$4 near3 control$4)	US-PGPUB; USPAT	OR	OFF	2015/05/07 00:55
S30	82	("20020055800" | "20020102009" | "20020180760" | "20040029078" | "20040155975" | "20040179728" | "20040204787" | "20040220691" | "20050007082" | "20050070782" | "20050153255" | "20050153257" | "20050170309" | "20060003292" | "20060093988" | "20060154198" | "20070172101" | "20070172112" | "20080199829" | "4270901" | "4837732" | "4846684" | "5372502" | "5417572" | "5644386" | "5740222" | "5740802" | "5771310" | "5999840" | "6044232" | "6099314" | "6141105" | "6201541" | "6201880" | "6201889" | "6334853" | "6342917" | "6364660" | "6409504" | "6447453" | "6512838" | "6516213" | "6542249" | "6545637" | "6621491" | "6648640" | "6687393" | "6701006" | "6738063" | "6738727" | "6754370" | "6775404" | "6819318" | "6834119" | "6856321" | "6920242" | "6947038" |	US-PGPUB; USPAT; USOCR	OR	OFF	2015/05/07 13:10

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S34	9942	(physical near4 (3D three$dimensonal "3"$dimensional (three adj2 dimensional)))	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:01
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S36	92	S35 and (remot$4 near3 control$4)	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:01
S38	6	(remot$4 near3 control$4) near8 (physical near4 (3D three$dimensonal "3"$dimensional (three adj2 dimensional)))	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:35
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S40	1651	(remot$4 near3 control$4) near8 (3D three$dimensonal (three adj2 dimensional))	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:36
S41	0	(remot$4 near3 control$4) near8 (3D three$dimensonal (three adj2 dimensional)) same (on near3 (display screen))	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:36
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S43	957	(remot$4 near3 control$4) same (3D three$dimensonal (three adj2 dimensional)) near3 (display screen)	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:38
S44	1628	(remot$4 near3 control$4) same (3D three$dimensonal (three adj2 dimensional)) near9 (display screen)	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:38
S45	25	(remot$4 near3 control$4) same (3D three$dimensonal (three adj2 dimensional)) near3 (display screen) same handheld	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:39
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S47	177	S46 and S33	US-PGPUB; USPAT	OR	OFF	2015/05/07 14:55

S50	15	("8766786" | "7088342" | "6944472" | "20090295743" | "20060038796" | "8711110" | "5543588" | "20080111710" | "5543588" | "6944472" | "8698761" | "20030184528" | "5729219" | "6909424" | "8514171" | "20060034042" | "20020149561").PN.	US-PGPUB; USPAT	OR	OFF	2015/05/07 15:18
S51	2	S50 and (remot$4 near3 controll$4)	US-PGPUB; USPAT	OR	OFF	2015/05/07 15:18

EAST Search History (Interference)

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5/7/2015 9:58:10 PM
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BIB DATA SHEET

CONFIRMATION NO. 9282

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
13/991,513	06/04/2013 **RULE**	345	2695	0079124-000070

APPLICANTS

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Henrik Öjelund, Lyngby, DENMARK;
David Fischer, Stenlose, DENMARK;
Karl-Josef Hollenbeck, Kobenhavn O, DENMARK;

** **CONTINUING DATA** *************************
This application is a 371 of PCT/DK2011/050461 12/05/2011
which claims benefit of 61/420,138 12/06/2010

** **FOREIGN APPLICATIONS** *************************
DENMARK PA 2010 01104 12/06/2010

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** ** ** SMALL ENTITY **
06/25/2013

		STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /VAN NGUYEN CHOW/ Examiner's Signature	☐ Met after Allowance Initials	DENMARK	5	20	1

ADDRESS

BUCHANAN, INGERSOLL & ROONEY PC
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TITLE

SYSTEM WITH 3D USER INTERFACE INTEGRATION

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BIB (Rev. 05/07).

Search Notes	Application/Control No. 13991513	Applicant(s)/Patent Under Reexamination ÖJELUND ET AL.
	Examiner VAN CHOW	**Art Unit** 2695

CPC- SEARCHED

Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED

Symbol	Date	Examiner
G06F1/1601 OR G06F1/1613	05/07/2015	VC

US CLASSIFICATION SEARCHED

Class	Subclass	Date	Examiner

SEARCH NOTES

Search Notes	Date	Examiner
east and text search	05/07/2015	VC

INTERFERENCE SEARCH

US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Substitute for PTO/SB/08a&b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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Substitute for form 1449/PTO **SECOND INFORMATION DISCLOSURE STATEMENT BY APPLICANT** *(Use as many sheets as necessary)*	*Complete if Known*	
	Application Number	13/991,513
	Filing Date	June 4, 2013
	First Named Inventor	Henrik ÖJELUND et al.
	Art Unit	Unassigned
	Examiner Name	Unassigned
Sheet 1 of 1	*Attorney Docket Number*	0079124-000070

U.S. PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Document Number: Number-Kind Code[2] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			
		US-			

FOREIGN PATENT DOCUMENTS

Examiner Initials'	Cite No.[1]	Foreign Patent Document: Country Code[3] Number[4] Kind Code[5] *(if known)*	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T[6]

NON PATENT LITERATURE DOCUMENTS

Examiner Initials*	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
		C. GRAETZEL et al., "A NON-CONTACT MOUSE FOR SURGEON-COMPUTER INTERACTION", Technology and Health Care, 12(3), 2004, pages 1-19.	
		SEBASTIAN VOGT et al., "AN AR SYSTEM WITH INTUITIVE USER INTERFACE FOR MANIPULATION AND VISUALIZATION OF 3D MEDICAL DATA", Stud. Health Technol. Inform., Medicine Meets Virtual Reality 12, 2004; vol. 98, pages 397-403.	

Examiner Signature	/Van Chow/	Date Considered	05/07/2015

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with M.P.E.P. § 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to Applicant.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /V.P./

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
13/991,513	Henrik Öjelund	0079124-000070

21839
BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

INTERNATIONAL APPLICATION NO.	
PCT/DK2011/050461	
I.A. FILING DATE	PRIORITY DATE
12/05/2011	12/06/2010

CONFIRMATION NO. 9282
371 ACCEPTANCE LETTER

OC000000064379628

Date Mailed: 10/17/2013

NOTICE OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C 371 AND 37 CFR 1.495

The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as a Designated / Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is ACCEPTED for national patentability examination in the United States Patent and Trademark Office.

The United States Application Number assigned to the application is shown above and the relevant dates are:

06/04/2013	09/19/2013
DATE OF RECEIPT OF 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) REQUIREMENTS	DATE OF COMPLETION OF ALL 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE " FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371 (c)(1), (c)(2) and (c)(4) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

The following items have been received:

- Indication of Small Entity Status
- Copy of the International Application filed on 06/04/2013
- Copy of the International Search Report filed on 06/04/2013
- Preliminary Amendments filed on 09/19/2013
- Information Disclosure Statements filed on 06/04/2013
- Oath or Declaration filed on 06/04/2013
- Request for Immediate Examination filed on 09/19/2013
- U.S. Basic National Fees filed on 06/04/2013
- Assignee Statement for PGPUB filed on 06/04/2013
- Priority Documents filed on 06/04/2013

FORM PCT/DO/EO/903 (371 Acceptance Notice)

Applicant is reminded that any communications to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above (37 CFR 1.5)

MARILYN J YOUNGER

Telephone: (571) 272-8183

FORM PCT/DO/EO/903 (371 Acceptance Notice)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
13/991,513	06/04/2013	2691	810	0079124-000070	20	1

CONFIRMATION NO. 9282

UPDATED FILING RECEIPT

OC000000064379627

21839
BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

Date Mailed: 10/17/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Henrik Öjelund, Lyngby, DENMARK;
David Fischer, Stenlose, DENMARK;
Karl-Josef Hollenbeck, Kobenhavn O, DENMARK;

Applicant(s)

Henrik Öjelund, Lyngby, DENMARK;
David Fischer, Stenlose, DENMARK;
Karl-Josef Hollenbeck, Kobenhavn O, DENMARK;

Assignment For Published Patent Application

3Shape A/S, Copenhagen K, DENMARK

Power of Attorney: The patent practitioners associated with Customer Number 21839

Domestic Priority data as claimed by applicant

This application is a 371 of PCT/DK2011/050461 12/05/2011
which claims benefit of 61/420,138 12/06/2010

Foreign Applications (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.)
DENMARK PA 2010 01104 12/06/2010 No Access Code Provided

If Required, Foreign Filing License Granted: 06/25/2013
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 13/991,513**
Projected Publication Date: Not Applicable
Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****
Title

SYSTEM WITH 3D USER INTERFACE INTEGRATION

Preliminary Class

345

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 13/991,513

APPLICATION AS FILED - PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	140		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	240		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 40 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*	x 210 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	740		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	RATE($)	ADDITIONAL FEE($)		RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
13/991,513	06/04/2013	Henrik Ojelund	0079124-000070

CONFIRMATION NO. 9282

PUBLICATION NOTICE

OC000000064177789

21839
BUCHANAN, INGERSOLL & ROONEY PC
POST OFFICE BOX 1404
ALEXANDRIA, VA 22313-1404

Title: SYSTEM WITH 3D USER INTERFACE INTEGRATION

Publication No. US-2013-0257718-A1
Publication Date: 10/03/2013

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A SUBMISSION UNDER 35 U.S.C. 371		ATTORNEY'S DOCKET NO. 0079124-000070 U.S. APPLICATION NO. (If known) 13/991,513
INTERNATIONAL APPLICATION NO. PCT/DK2011/050461	INTERNATIONAL FILING DATE December 5, 2011	PRIORITY DATE CLAIMED December 6, 2010
TITLE OF INVENTION SYSTEM WITH 3D USER INTERFACE INTEGRATION		
APPLICANT(S) FOR DO/EO/US ÖJELUND, Henrik FISCHER, David HOLLENBECK, Karl-Josef		

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information.

1. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). NOTE: The express request under 35 U.S.C. 371(f) will not be effective unless the requirements under 35 U.S.C. 371(c)(1), (2), and (4) for payment of the basic national fee, copy of the International Application and English translation thereof (if required), and the oath or declaration of the inventor(s) have been received.

2. ☐ A copy of the International Application (35 U.S.C. 371(c)(2)) is attached hereto (not required if the International Application was previously communicated by the International Bureau or was filed in the United States Receiving Office (RO/US)).

3. An English language translation of the International Application (35 U.S.C. 371(c)(2))

   a. ☐ is attached hereto.

   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

4. An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4))

   a. ☒ is attached.

   b. ☐ was previously filed in the international phase under PCT Rule 4.17(iv).

Items 5 to 8 below concern amendments made in the international phase.

PCT Article 19 and 34 amendments

5. ☐ Amendments to the claims under PCT Article 19 are attached (not required if communicated by the International Bureau) (35 U.S.C. 371(c)(3)).

6. ☐ English translation of the PCT Article 19 amendment is attached (35 U.S.C. 371(c)(3)).

7. ☐ English translation of annexes (Article 19 and/or 34 amendments only) of the International Preliminary Examination Report is attached (35 U.S.C. 371(c)(5)).

Cancellation of amendments made in the international phase

8a. ☐ Do not enter the amendment made in the international phase under PCT Article 19.

8b. ☐ Do not enter the amendment made in the international phase under PCT Article 34.

NOTE: A proper amendment made in English under Article 19 or 34 will be entered in the U.S. national phase application absent a clear instruction from applicant not to enter the amendment(s).

The following items 9 to 17 concern a document(s) or information included.

9. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

10. ☒ A preliminary amendment

11. ☐ An Application Data Sheet under 37 CFR 1.76.

12. ☐ A substitute specification. NOTE: A substitute specification cannot include claims. See 37 CFR 1.125(b).

13. ☐ A power of attorney and/or change of address letter.

14. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13*ter*.3 and 37 CFR 1.821-1.825.

15. ☐ Assignment papers *(cover sheet and document(s))*. Name of Assignee : **3Shape A/S**.

16. ☐ 37 CFR 3.73(c) Statement *(when there is an Assignee)*.

U.S. APPLICATION NO. (If known)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NO.
13/991,513	PCT/DK2011/050461	0079124-000070

17. ☒ Other items or information:

General Authorization for Petitions for Extensions of Time and Payment of Fees
Petition for Extension of Time

The following fees have been submitted.	**CALCULATIONS**	**PTO USE ONLY**
18. ☐ Basic national fee (37 CFR 1.492(a)) **$280**	$	
19. ☒ Examination fee (37 CFR 1.492(c)) If the written opinion prepared by ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... **$0** All other situations.... .... **$720**	$ **720**	
20. ☒ Search fee (37 CFR 1.492(b)) If the written opinion prepared by ISA/US or the International preliminary examination report prepared by IPEA/US indicates all claims satisfy provisions of PCT Article 33(1)-(4) .... **$0** Search fee (37 CFR 1.445(a)(2)) has been paid on the international application to the USPTO as an International Searching Authority............ **$120** International Search Report prepared by an ISA other than the US and provided to the Office or previously communicated to the US by the IB............ **$480** All other situations............ **$600**	$ **480**	
TOTAL OF 18, 19 and 20 =	**$ 1,200**	
☐ Additional fee for specification and drawings filed in paper over 100 sheets (excluding sequence listing in compliance with 37 CFR 1.821(c) or (e) in an electronic medium or computer program listing in an electronic medium) (37 CFR 1.492(j)). Fee for each additional 50 sheets of paper or fraction thereof **$400**		

Total Sheets	Extra sheets	Number of each additional 50 or fraction thereof (round **up** to a whole number)	RATE		
- 100 =	/50 =		x $400	$	

Surcharge of **$140.00** for furnishing any of the search fee, examination fee, or the oath or declaration after the date of commencement of the national stage (37 CFR 1.492(h)).	$ **140**	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	**<<20>>** - 20 =	**<<0>>**	x **$80**	**$ 0**	
Independent Claims	**<<1>>** - 3 =	**<<0>>**	x **$420**	**$ 0**	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			**+ $780**	**$**	

TOTAL OF ABOVE CALCULATIONS =	**$ 1,340**	
☒ Applicant claims small entity status. See 37 CFR 1.27. Fees above are reduced by ½.	**670**	
SUBTOTAL =	**$ 670**	
Processing fee of **$140.00** for furnishing the English translation later than 30 months from the earliest claimed priority date (37 CFR 1.492(i)). +	**$**	
TOTAL NATIONAL FEE =	**$ 670**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	**$**	
TOTAL FEES ENCLOSED =	**$**	
	Amount to be refunded:	**$**
	Amount to be charged:	**$670**

a. ☐ A check in the amount of $_______ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 02-4800 in the amount of $_______ to cover the above fees.

c. ☒ The Director is hereby authorized to charge additional fees which may be required, or credit any overpayment, to Deposit Account No. 02-4800 as follows:

i. ☒ any required fee

ii. ☐ any required fee except for excess claims fees required under 37 CFR 1.492(d) and (e) and multiple dependent claim fee required under 37 CFR 1.492(f).

d. ☒ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038. The PTO-2038 should only be mailed or faxed to the USPTO. However, when paying the basic national fee, the PTO-2038 may NOT be faxed to the USPTO.

ADVISORY: If filing by EFS-Web, do **NOT** attach the PTO-2038 form as a PDF along with your EFS-Web submission. Please be advised that this is **not** recommended and by doing so your **credit card information may be displayed via PAIR**. To protect your information, it is recommended to pay fees online by using the electronic payment method.

NOTE: Where an appropriate time limit under 37 CFR 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the International Application to pending status.

Correspondence Address

☒ The address associated with Customer Number 21839 **OR** ☐ Correspondence address below

Name	**Buchanan Ingersoll & Rooney PC**				
Address	**P.O. Box 1404**				
City	**Alexandria**	State	**VA**	Zip Code	**22313-1404**
Country	**USA**			Telephone	**(703) 836-6620**
Email					

Signature	[signature]	Date	**September 19, 2013**
Name (Print/Type)	William C. Rowland, David R. Kemeny	Registration No. (Attorney/Agent)	30888, 57241

Attorney Docket No. 0079124-000070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	
Henrik ÖJELUND et al.	Group Art Unit: Unassigned
Application No.: 13/991,513	Confirmation No.: 9282
Filed: June 4, 2013	
For: SYSTEM WITH 3D USER INTERFACE INTEGRATION	

GENERAL AUTHORIZATION FOR PETITIONS FOR EXTENSIONS OF TIME AND PAYMENT OF FEES

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

In accordance with 37 C.F.R. § 1.136(a)(3), the U.S. Patent and Trademark Office is hereby provided with a general authorization to treat any concurrent or future reply requiring a petition for an extension of time for its timely submission as containing a request therefor for the appropriate length of time.

The Commissioner is hereby authorized to charge any appropriate fees that may be required by this paper, or any other submissions in this application, and to credit any overpayment, to Deposit Account No. 02-4800.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: September 19, 2013

By: [signature]
William C. Rowland
Registration No. 30888

David R. Kemeny
Reg. # 57241

Customer Number 21839
703.836.6620

Patent
Attorney Docket No. 0079124-000070

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	)	**MAIL STOP MISSING PARTS**
Henrik ÖJELUND et al.	)	Group Art Unit: Unassigned
Application No.: 13/991,513	)	Confirmation No.: 9282
Filed: June 4, 2013	)	
For: SYSTEM WITH 3D USER INTERFACE INTEGRATION	)	

PETITION FOR EXTENSION OF TIME

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

The following extension of time is requested to: Notification of Missing Requirements Application mailed August 28, 2013 for

one Month to September 28, 2013 ☒ $ 100

☒ Charge $100.00 to credit card. Filing fee is being paid electronically concurrent with filing of Notification of Missing Requirements.

The Director is hereby authorized to charge any appropriate fees under 37 C.F.R. §§1.16, 1.17 and 1.21 that may be required by this paper, and to credit any overpayment, to Deposit Account No. 02-4800.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: September 19, 2013

By:
William C. Rowland
Registration No. 30888

David R. Kemeny
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Patent
Attorney's Docket No. 0079124-000070

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In re Patent Application of	
Henrik ÖJELUND et al.	Group Art Unit: Unassigned
Application No.: 13/991,513	Confirmation No.: 9282
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For: SYSTEM WITH 3D USER INTERFACE INTEGRATION	

PRELIMINARY AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

Prior to examination of the above-captioned patent application, kindly amend the application as follows.

AMENDMENTS TO THE ABSTRACT:

Please replace the original Abstract with the following amended Abstract of the Disclosure. This new Abstract of the Disclosure is also set forth on a separate sheet attached to the end of this Preliminary Amendment:

ABSTRACT OF THE DISCLOSURE

~~**System with 3D user interface integration**~~

~~**Abstract**~~

Disclosed is a system comprising a handheld device and at least one display~~,~~ ~~where the~~. The handheld device is adapted for performing at least one action in a physical 3D environment[[,]]; ~~where~~ wherein the at least one display is adapted for visually representing the physical 3D environment[[,]]; and where the handheld device is adapted for remotely controlling the view with which the 3D environment is represented on the display.

~~(fig. 2a) should be published)~~

AMENDMENTS TO THE CLAIMS:

The following listing of claims will replace all prior versions and listings of claims in this application.

LISTING OF CLAIMS:

Claims 1-52 Cancelled.

53. (New) A system comprising:

a handheld device and at least one display, wherein

the handheld device is adapted for switching between performing at least one action in a physical 3D environment, wherein the at least one display is adapted for visually representing the physical 3D environment; and

remotely controlling the view with which the 3D environment is represented on the display.

54. (New) A system according to Claim 53, wherein the handheld device is adapted to record the 3D geometry of the 3D environment.

55. (New) A system according to Claim 53, wherein means for manually switching between performing the at least one action and remotely controlling the view is provided on the handheld device.

56. (New) The system according to Claim 53, wherein the at least one action comprises:

measuring;

recording;

scanning;

manipulating; and

modifying.

57. (New) The system according to Claim 53, wherein the handheld device comprises at least one motion sensor.

58. (New) The system according to Claim 53, wherein the view of the 3D environment represented in the at least one display is at least partly determined by the at least one motion sensor.

59. (New) The system according to Claim 53, wherein the user interface functionality comprises the use of gestures.

60. (New) The system according to Claim 53, wherein the gestures are detected by the at least one motion sensor.

61. (New) The system according to Claim 53, herein the handheld device comprises at least one user-interface element other than the at least one motion sensor.

62. (New) The system according to Claim 53, herein the handheld device is adapted to change a viewing angle with which the 3D environment is represented on the at least one display.

63. (New) The system according to Claim 53, wherein the handheld device is adapted to change a magnification factor with which the 3D environment is represented on the at least one display.

64. (New) The system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner.

65. (New) The system according to Claim 53, wherein the handheld device is a surgical instrument.

66. (New) The system according to Claim 53, wherein the handheld device is a mechanical tool.

67. (New) The system according to Claim 53, wherein the handheld device is an in-ear 3D scanner.

68. (New) The system according to Claim 53, wherein the at least one display is defined as a first display, and where the system further comprises a second display.

69. (New) The system according to Claim 53, wherein the second display indicates where the handheld device is positioned relative to the 3D environment.

70. (New) The system according to Claim 53, wherein the first display and/or the second display provides instructions for the operator.

71. (New) The system according to Claim 53, wherein audible information to the operator is provided to the operator.

72. (New) The system according to Claim 53, wherein the handheld device is an intra-oral 3D scanner and the at least one action performed in the physical 3D environment is scanning and that the view is remotely controlled by at least one motion sensor arranged in the handheld device, and wherein an actuator provided on the handheld device switches between performing the at least one action and remotely controlling the view.

REMARKS

By way of the foregoing amendment, original claims 1-52 have been cancelled and new claims 53-72 have been added. No new matter has been introduced by these changes. It is to be understood that applicants reserve the right to submit additional claims within the scope of the original claims or supported by the specification.

It is requested that the application be examined on the basis of the Abstract of the Disclosure and claims presented herein. Early and favorable consideration of this application is respectfully requested.

Should any questions arise in connection with this application, it is respectfully requested that the undersigned be contacted at the number indicated below.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date: September 19, 2013

By: ______________________
William C. Rowland
Registration No. 30888

David R. Kemeny
Reg. # 57241

Customer No. 21839
(703) 836-6620

ABSTRACT OF THE DISCLOSURE

Disclosed is a system comprising a handheld device and at least one display. The handheld device is adapted for performing at least one action in a physical 3D environment; wherein the at least one display is adapted for visually representing the physical 3D environment; and where the handheld device is adapted for remotely controlling the view with which the 3D environment is represented on the display.

COMBINED DECLARATION AND POWER OF ATTORNEY FOR UTILITY OR DESIGN PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SYSTEM WITH 3D USER INTERFACE INTEGRATION

the application of which **(check only one item below)**:

☐ is attached hereto.

☐ was filed as United States Patent application Number ______________ on ______________ and was amended on ______________ (if applicable).

☒ was filed as PCT International application Number PCT/DK2011/050461 on December 5, 2011 and was amended on ___________ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified application, including the claims, and drawings (if any), as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §§ 119 (a)-(d), 172 or 365(a) of any foreign application(s) for patent or inventor's certificate or of any international (PCT) application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international (PCT) application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. §§119(a)-(d), 172 or 365(a):				
COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (MM/DD/YYYY)	PRIORITY CLAIMED UNDER 35 U.S.C. §§119, 172 OR 365(a)	
			Yes	No
Denmark	PA 2010 01104	12/06/2010	Yes	

I hereby appoint the attorneys and agents associated with the following PTO Customer Number of Buchanan Ingersoll & Rooney PC to prosecute said application and to transact all business in the Patent and Trademark Office connected therewith and to file, prosecute and transact all business in connection with international applications directed to said invention:

Customer Number **21839**

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF SOLE OR FIRST INVENTOR	Henrik ÖJELUND
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Attorney Docket No. 0079124-000070

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SECOND INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Commissioner:

In accordance with the duty of disclosure as set forth in 37 C.F.R. § 1.56, the accompanying information is being submitted in accordance with 37 C.F.R. §§ 1.97 and 1.98.

To assist the Examiner, the documents are listed on the attached citation form. It is respectfully requested that an Examiner initialed copy of this form be returned to the undersigned.

Respectfully submitted,

BUCHANAN INGERSOLL & ROONEY PC

Date September 19, 2013

By: [signature]
William C. Rowland
Registration No. 30888

David R. Kemeny
Reg. # 57241

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703 836 6620