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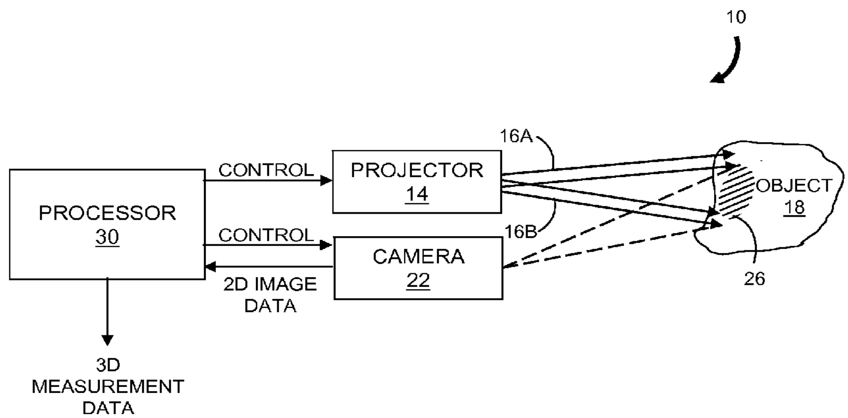

FIG. 1

(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

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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.

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