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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 October 2015 (29.10.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/164402 A1

(51) International Patent Classification:
A61B 19/00 (2006.01)

(21) International Application Number:
PCT/US2015/026916

(22) International Filing Date:
21 April 2015 (21.04.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/982,787 22 April 2014 (22.04.2014) 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, BN, 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, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, 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, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, 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, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

(54) **Title**: INTRA-OPERATIVE MEDICAL IMAGE VIEWING SYSTEM AND METHOD

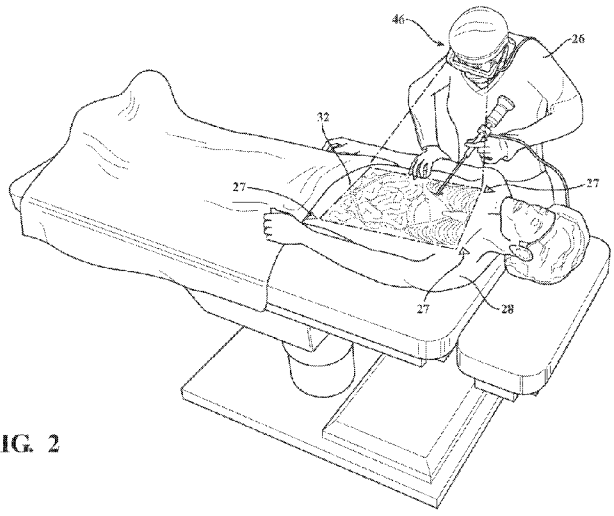

FIG. 2

(57) **Abstract**: An intra-operative medical image viewing system can allow a surgeon to maintain a viewing perspective on the patient while calling-up visual images on-the-fly. A digital image source has at least one image file representative of an anatomical or pathological feature of a patient. A display is worn by the surgeon or positioned between the surgeon and her patient during surgery. The display is selectively transparent, and exhibits to the surgeon an image derived from the image file. An image control unit retrieves the image file from the image source and controls the display so that at least a portion of the image depiction can be exhibited and modified at will by the surgeon. A plurality of peripheral devices are each configured to receive an image control input from the

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INTRA-OPERATIVE MEDICAL IMAGE VIEWING SYSTEM AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to Provisional Patent Application No. 61/982,787 filed April 22, 2014, the entire disclosure of which is hereby incorporated by reference and relied upon.

BACKGROUND OF THE INVENTION

[0002] Field of the Invention. The invention relates generally to generating, processing, transmitting or transiently displaying images in a medical environment, in which the local light variations composing the images may change with time, and more particularly to subject matter in which the image includes portions indicating the three-dimensional nature of the original object.

[0003] Description of Related Art. In a surgical environment, there are often many display screens each displaying different visual information that is of interest to the medical practitioner, such as a surgeon. In particular, the visual information may include images representing an anatomical or pathological feature of a patient, such as an X-ray, MRI, ultrasound, thermal image or the like. The term surgeon is used throughout this patent document in a broad sense to refer to any of the one or more specialized medical practitioners present in a surgical or interventional-procedural environment that provide critical personal treatment to a patient. In addition to practitioners and interventionalists, the term surgeon can also mean a medical student, as well as any other suitable person. The term surgical environment is also used broadly to refer to any surgical, interventional or procedural environment. Similarly, the term surgical procedure is chosen to broadly represent both interventional and non-interventional activities, i.e., including purely exploratory activities. Figure 1 is a simplified illustration of a surgical environment in which numerous display screens 20, 22, 24 compete for the attention of a surgeon 26 while the surgeon provides critical personal treatment to a patient 28. The display screens 20, 22, 24 are typically located in widely distributed locations within the operating room. Some of the displays 22, 24 are suspended from boom-arms, others are mounted to the wall, and still others 20 can be mounted to mobile carts. An operating room that is filled with many display screens all presenting different relevant anatomical or pathological image data to the surgeon causes several problems in the medical community, which problems have proven particularly difficult to eradicate.

[0004] A first problem relates to distraction of the surgeon's attention posed by the need to frequently look away from her patient in order to see the images on one or more display screens dispersed about the operating room. While surgeons are generally gifted with extraordinary eye-hand coordination, the surgical procedures they perform often depend on sub-millimeter-level control of their instruments. The risk of a tiny, unwanted hand movement rises each time a surgeon must consult an image on a screen that is located some distance away from the patient. The accidental nicking of an adjacent organ could perhaps in some cases be attributed to the surgeon's momentary head turn as she looks at an important anatomical or pathological image on a display screen on a nearby medical cart or suspended from a boom arm.

[0005] A second problem that is provoked by the presence of multiple display screens in an operating room relates to compounding a surgeon's cognitive load. Cognitive load refers to the total amount of mental effort being used in the working memory of the surgeon. Surgeons are trained to function at high cognitive loading levels, yet every human has a limit. Biomedical research has confirmed that managing a surgeon's cognitive load level will allow her to perform at peak ability for a longer period of time. In operating room settings, one of the most intense contributors to the cognitive load of a surgeon is the mental act of image registration. Image registration is the process of transforming different sets of data into one coordinate system. For the surgeon in an operating environment, this means the ability to compare or integrate the data obtained from medical images presented on the display screens to the patient in front of them. For example, if the image on the display screen was taken (or is being rendered) from a perspective different than the instantaneous visual perspective of the surgeon, the surgeon automatically aligns the image to the patient by envisioning a rotation, pan, tilt, zoom or other manipulation of the displayed image to that of the live patient in front of them. While image registering a single static image to the patient may not be particularly taxing, the cognitive load quickly compounds when there are many display screens to be consulted, each exhibiting an image taken from yet a different perspective or presented in a different scale. Therefore, the multiplied act of image-registering a large number of images profoundly intensifies the cognitive loading imposed on a surgeon, which in turn produces an accelerated fatiguing effect.

[0006] Yet another problem that is provoked by the presence of multiple display screens in an operating room relates to ergonomics. Namely, the occupational safety and health of a surgeon is directly compromised by the required use of many widely-dispersed images during a surgical procedure. During a surgical procedure, which can sometimes last for many hours, the surgeon 26 must often look up from the patient 28 in order to obtain information from the various display screens 20, 22, 24. In the exemplary illustration of Figure 1, if the surgeon 26

is required to gaze intently at the display screen 20 for a long period of time, her head must be held steadily in an uncomfortable sideways-looking direction. Some surgical procedures, such as a laparoscopic procedure for example, require the surgeon to watch the real-time image feed from a remote camera. The surgeon's gaze may be intently directed to the real-time image on a display screen for an extended period of time. Surgery does not afford the practitioner with the ability to rest or change positions at will in order to combat muscle cramps or nerve aggravations. On a daily basis, this physical fatigue limits a surgeon's ability to perform at optimum ability during long shifts. Over time, the stresses placed on the surgeon accumulate to the point where the injuries accumulate/compound and become chronic and must either be remediated through medical intervention or the surgeon prematurely limits (or truncates) her service career.

[0007] Furthermore, these problems can be inter-related. Issues associated with cognitive load and ergonomics compound each other to diminish a surgeon's working efficiency, which affect the patient by increasing the length of time they must undergo a surgical procedure. Naturally, increased procedure time impacts the surgeon's health but also the surgeon's productivity. That is, with more time in each surgery the surgeon can do fewer operations over the course of a year, which also then limits the surgeon's ability to gain experience. Increased procedure time impacts the patient in a number of ways also, including increased risks associated with prolonged time under anesthesia and its after-affects, increased risk for infections attributed to longer open incision times, longer hospital stays, increased medical costs, and the like.

[0008] Finding a solution to these persistent image-related problems in the operating room has been elusive. One reason is that any proposed solution must itself have a practical chance of being adopted in the surgical community. That is to say, a solution that works only in the lab or only for a small sub-set of practitioners will not be genuinely viable as a marketable product. A real solution needs to be practical for the medical community as a whole. Therefore, understanding and accommodating the medical community, as a whole, is a critical step in assessing whether or not a particular solution will have authentic merit. As a group, surgeons tend to be somewhat unique in temperament. They are generally recognized as excessively driven toward achievement, decisive, well organized, hardworking, assertive, and aim to reduce uncertainty in their operations to reduce risk for their patient's outcomes. Any touted ergonomical or cognitive load benefit (and resultant benefit to patient outcomes) weighs against the heavy judgment of centuries of historic medical science and knowledge. Medical students, and the physicians they become, learn from their mentors the tried and true methods and techniques of their predecessors to ensure no patient harm. Thus, the point of mentioning this assessment is that surgeons by and large will tend not to accept into their

practice a new technique or new technology unless that new technology is regarded as practical. But not all surgeons are alike, and what may be regarded by one surgeon as practical will be deemed unacceptably impractical by another. Therefore, any attempt to introduce a solution to the above-mentioned image issues must be instantly perceived as being practicable to all (or at least a substantial majority of) surgeons. It is predictable that a majority of surgeons will not adopt a solution if the solution is perceived to be overly complicated or as requiring a high degree of training to master.

[0009] The reason why multiple display screens litter the typical operation room today is that display screens are universally intuitive. The mere act of looking at an image displayed on a screen requires no training for use. Therefore, if the surgeon needs to see more patient images during a surgical procedure, there is a tendency to add another display screen in the operating room. Adding more display screens, in turn, compounds the distraction, cognitive loading and ergonomic issues. A degenerative spiral results, because the current state of the art has no simpler, more intuitive option than adding more display screens to exhibit patient medical images in an operating room.

[0010] There is therefore a need for an improved system in which the customary multitude of medical images needed to be viewed by a surgeon during an operation are better managed so that a surgeon is not required to look away from the patient, so that the surgeon does not have to sustain heavy cognitive loading in order to mentally register all of exhibited images, and so that the surgeon does not suffer unnecessary additional physical stresses. However, any an improved system to overcome these issues must be easily and intuitively implemented without the need for extensive training or practice.

BRIEF SUMMARY OF THE INVENTION

[0011] In summary, the invention is an intra-operative medical image viewing system that can allow the surgeon to maintain a viewing perspective on the patient while concurrently obtaining relevant information about the patient. The intra-operative medical image viewing system can include an image source having at least one image file representative of an anatomical or pathological feature of a patient. The intra-operative medical image viewing system can also include a display positionable between a surgeon and the patient during surgery. The display can be configured to exhibit and position at least one image to the surgeon overlaid on or above the patient. The intra-operative medical image viewing system can also include an image control unit configured to retrieve the image file from the image source and control the display so as to exhibit and modify at least a portion of the image. The intra-operative medical image viewing system can also include a plurality of peripheral devices. Each peripheral device may be configured to receive an image control input from

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