As already mentioned, two operators may collaborate and work on a shared magnified operand. This is particularly common among surgeons, where tasks such as suturing are easier with more than two hands. Figure 4 is a schematic illustration of a single-user flatscope according to the prior art, which may be used by a plurality of collaborating operators. Figure 4 shows a single display screen 401 located between the physical work site 403 and the eyes 405 of a plurality of operators. In Figure 4, two operators are shown, but any number of operators may collaborate. Figure 5 is a schematic illustration of a two-user flatscope according to the prior art. Figure 5 shows two display screens 501 located between the physical work site 503 and the eyes 505 of two operators. Analogous placements for three or four operators will be evident to persons skilled in the art.

Hand/eye co-location involves not only a sense of the direction in which the operand lies, but a sense of the distance from the eyes of each object within the work site; this is referred to as "depth". Some sensory cues of depth are relative, such as which object obscures another and is therefore closer to the eyes. Accurate manipulation requires awareness of the absolute position in all directions. The main visual cues for absolute depth are stereo (reconstruction of distance from the differences between the views of the two eyes), and parallax (reconstruction of distance from the changes in view as the head, and thus each eye, moves). The system shown in Figure 3 relies on an arrangement of a pair of cameras (or one camera with a split view) and optics, so that the views captured geometrically correspond to the views that would appear to eyes in the expected locations. This approach is a great improvement over previous systems but does have limitations. In particular, unless the optics move as the eyes move (which is not impossible, but creates substantial difficulty, and requires mechanical motion of parts), the approach presents two fixed views, making parallax impossible.

It is an object of the invention to provide an imaging system and method which avoids or mitigates the problems of known systems described above.

Summary of the Invention

According to a first aspect of the invention, there is provided an imaging system comprising: an image capture apparatus for capturing an image of an operator work site, the image including depth information; and a display apparatus in communication with the

image capture apparatus, the display apparatus comprising at least one display screen and being arranged to receive the image captured by the image capture apparatus, including the depth information, and display to the operator the image captured by the image capture apparatus, including the depth information, on the display screen;wherein the display screen is located between the operator's eyes and the position of the work site. The imaging system further comprises means configured to obtain real-time information of a position relating to one or both of the operator's eyes, and means configured to provide the depth information in the image by adjusting the image displayed on the at least one display screen to show a change in view corresponding to a change in said position relating to one or both of the operator's eyes such that the depth information is conveyed to the operator by parallax.

The combination of the image of the work site which includes depth information together with the location of the display screen between the work site position, which is preferably below the display screen, and the operator's eyes, which are preferably above the display screen allows the return of a parallax depth cue. This cue is obtained without the need for mechanical motion of parts, because the computation of depth information may be handled in software. Such a depth cue has been absent from any enlargement system more powerful and complex than a single large lens. Provision of such a parallax depth cue allows an operator to accurately position tools in the depth direction of the work site, even without strong stereo depth perception.This enlarges the range of operators for whom the system is natural and usable with minimal training. Such advantages over eyepiece microscopes as the reduction of strain, since the operator is not compelled to keep head and shoulders in a fixed position throughout any procedure, become even stronger in the presence of parallax, since the apparent position of the work site is more stable than with stereo alone.

The imaging system may be referred to as a flatscope in this specification. The position of the work site may be the actual physical location of the work site if the operator is working directly on the work site. Alternatively, if the operator is working on a remote work site via remotely controlled tools, the position of the work site may be the hand-sensed position of the work site as sensed by the operator as the operator controls the tools.

The at least one display screen may comprise a single display screen between the eyes of each of a plurality of operators and a shared work site. Alternatively, the at least one display screen may comprise a plurality of display screens, each display screen between the eyes of a respective operator of a plurality of operators and a shared work site. In a preferred embodiment, the plurality of display screens comprises two display screens.

need to move his hands substantially in order to control the imaging system, as well as to work on the subject in the work site.

The detected positions of the tools may be used to select modes of input. Alternatively or additionally, the detected positions of the tools may be used to select points or substructures in the displayed object. Alternatively or additionally, the detected positions of the tools may be used to mark annotations on the displayed object. Alternatively or additionally, the detected positions of the tools may be used to define spatial forms in the space of the displayed object. Alternatively or additionally, the open or closed state of the tool tip may provide input for the grasping or release of a virtual object. Alternatively or additionally, the motion of the tool tip or the state of the tool tip or both the motion and the state of the tool tip may be used to manipulate the shape of a virtual object.

According to a second aspect of the invention, there is provided a method for capturing and displaying an image of an operator work site, the method comprising the steps of: capturing the image of the operator work site, the image including depth information; communicating the captured image, including the depth information, to display apparatus comprising a display screen; and displaying to the operator the captured image, including the depth information, on the display screen located between the operator's eyes and the position of the work site. The method further comprises obtaining real-time information of a position relating to one or both of the operator's eyes, and providing the depth information in the image by adjusting the image displayed on the at least one display screen to show a change in view corresponding to a change in said position relating to one or both of the operator's eyes such that the depth information is conveyed to the operator by parallax.

The step of capturing the image preferably comprises obtaining the depth information by a camera capable of obtaining depth information. The depth information included in the image may comprise information allowing the operator to determine depth by a stereo depth cue. The depth information included in the image may comprise information allowing the operator to determine depth by a parallax depth cue.

Features described in relation to the first aspect of the invention may also be applicable to the second aspect of the invention, and features described in relation to the second aspect of the invention may also be applicable to the first aspect of the invention.

According to a third aspect of the invention, there is provided an imaging system comprising: a display screen for displaying an image to an operator; means to obtain real-time information specifying the position of one or both of the operator's eyes; and means to use changes in the position of the operator's eyes to control magnification of all or part of the displayed image.

Claims

1. An imaging system comprising:

image capture apparatus for capturing an image of an operator work site, the image including depth information; and

display apparatus in communication with the image capture apparatus, the display apparatus comprising at least one display screen and being arranged to receive the image captured by the image capture apparatus, including the depth information, and display to the operator the image captured by the image capture apparatus, including the depth information, on the display screen;

wherein the display screen is located between the operator's eyes and the position of the work site; and

wherein the imaging system has real- time information of the position of one or both of the operator's eyes, which real-time information is obtained by a tracking device worn by the operator.

2. An imaging system according to claim 1, wherein the image capture apparatus comprises a camera capable of obtaining depth information.

3. An imaging system according to claim 1, wherein the image capture apparatus comprises a plurality of cameras, and the depth information is obtained by comparing images captured by the plurality of cameras.

4. An imaging system according to any preceding claim, wherein the depth information is conveyed to the operator by management of the views delivered to each of the operator's eyes.

5. An imaging system according to claim 1, wherein the real-time information specifying the position of one or both of the operator's eyes is obtained by one or more cameras mounted on the imaging system together with analysis to locate the positions of the operator's eyes.

6. An imaging system according to any of claim 1 or 5, wherein the real-time information specifying the position of one or both of the operator's eyes is used to control zoom of all or part of the displayed image.

7. An imaging system according to any preceding claim, wherein the depth information is conveyed to the operator by parallax as the operator's head moves.

8. An imaging system according to any preceding claim, wherein the image capture apparatus comprises sensors for obtaining the image by detecting light in or in and around the visible range.

9. An imaging system according to any preceding claim, wherein the image capture apparatus comprises sensors for obtaining the image by detecting radiated or transmitted infrared radiation.

10. An imaging system according to any preceding claim, wherein the image capture apparatus comprises ultrasound emitters and sensors, and the display apparatus is enabled to display the image on the display screen, such that the work site appears to the operator to be at a location substantially corresponding to the position of the work site.

11. An imaging system according to any preceding claim, wherein the image capture apparatus is arranged to obtain the image by magnetic resonance imaging (MRI).

12. An imaging system according to any preceding claim, wherein images obtained by at least two modesare combined to form the image displayed to the operator on the

display screen, the two modes being from a set including but not limited to visible light, magnetic resonance, ultrasound and infrared radiation.

13. An imaging system according to any preceding claim, wherein the display screen is arranged to display supplemental images.

14. An imaging system according to any preceding claim, wherein detected positions of a tool or tools controlled by the operator or operators provide input to the imaging system.

15. A method for capturing and displaying an image of an operator work site, the method comprising the steps of:

capturing the image of the operator work site, the image including depth information;

communicating the captured image, including the depth information, to display apparatus comprising a display screen; and

displaying to the operator the captured image, including the depth information, on the display screen located between the operator's eyes and the position of the work site.

16. A method according to claim 5, wherein the step of capturing the image comprises obtaining the depth information by a camera capable of obtaining depth information.

17. An imaging system comprising:

a display screen for displaying an image to an operator;

means to obtain real-time information specifying the position of one or both of the operator's eyes; and

means to use changes in the position of the operator's eyes to control magnification of all or part of the displayed image.

18. An imaging system according to claim 17, wherein the display screen shows images stereographically, by showing different images to each of the operator's eyes.

19. An imaging system according to claim 17, wherein the display screen shows images with parallax, by adjusting the image according to the position of the operator's eyes.

20. An imaging system comprising:

motion capture apparatusfor capturing motion of manipulated tools; and

display apparatus in communication with the motion capture apparatus, the display apparatus comprising at least one display screen and being arranged to receive the motion data captured by the motion capture apparatus, and display to an operator the motion captured by the motion capture apparatus, in the form of images on the display screen;

wherein the display apparatus is further arranged to display additional images on the display screen; and

wherein the display screen is located between the operator's eyes and the position of an operator work site.

21. An imaging system according to claim 20, wherein the additional images comprise images of a recorded procedure performed on real or virtual objects by another operator.

22. An imaging system comprising:

a hand-held device comprising

a camera on a first side for capturing an image of an operator work site, the image including depth information; and

a display screen on a second side opposite the first side, for displaying to the operator the image captured by the camera, including the depth information; and

support means for positioning the hand-held device between the operator's eyes and the position of the work site.

23. An imaging system according to claim 22, wherein the camera of the hand-held device comprises a camera capable of obtaining depth information.

24. An imaging system comprising:

image capture apparatus for capturing an image of a subject, for detecting light in or in and around the visible range, and classifying the captured light into more than three frequency bands; and

computing means for determining from the captured image, the spectral reflectivities of the subject and the lighting conditions when the image was captured, and for producing a further image, in the more than three frequency bands, of the subject in user-specified lighting conditions.

Claims

1. An imaging system comprising an

image capture apparatus for capturing an image of an operator work site, the image including depth information; and a

display apparatus in communication with the image capture apparatus, the display apparatus comprising at least one display screen and being arranged to receive the image captured by the image capture apparatus, including the depth information, and display to the operator the image captured by the image capture apparatus, including the depth information, on the display screen;

wherein the display screen is located between the operator's eyes and the position of the work site, characterized in that:

the imaging system further comprises means configured to obtain real-time information of a position relating to one or both of the operator's eyes, and means configured to provide the depth information in the image by adjusting the image displayed on the at least one display screen to show a change in view corresponding to a change in said position relating to one or both of the operator's eyes such that the depth information is conveyed to the operator by parallax.

2. An imaging system according to claim 1, wherein the image capture apparatus comprises:

a camera capable of obtaining depth information, or

a plurality of cameras, and the depth information is obtained by comparing images captured by the plurality of cameras.

3. An imaging system according to claim 2, comprising a hand-held device, wherein the camera and display screen are provided in the hand-held device.

4. An imaging system according to claim 2 or 3, wherein the camera is a video camera.

5. An imaging system according to any preceding claim, wherein the depth information is conveyed to the operator by management of the views delivered to each of the operator's eyes.

6. An imaging system according to any preceding claim, wherein the real-time information specifying the position relating to one or both of the operator's eyes is obtained by a tracking device worn by the operator and/or one or more cameras mounted on the imaging system operable to locate the positions relating to the operator's eyes, and

wherein the imaging system is operable to use the real-time information to control zoom of all or part of the displayed image.

7. An imaging system according to any preceding claim, wherein the depth information is conveyed to the operator by parallax as the operator's head moves.

8. An imaging system according to any preceding claim, wherein the image capture apparatus comprises sensors for obtaining the image by detecting light in or in and around the visible range, radiated or transmitted infrared radiation, magnetic resonance, and/or ultrasound.

9. An imaging system according to any preceding claim, wherein the image capture apparatus comprises ultrasound emitters and sensors, and the display apparatus is enabled to display the image on the display screen, such that the work site appears to the operator to be at a location substantially corresponding to the position of the work site.

10. An imaging system according to any preceding claim, wherein images obtained by at least two modes are combined to form the image displayed to the operator on the display screen, the two modes being from a set including visible light, magnetic resonance, ultrasound and infrared radiation.

11. An imaging system according to any preceding claim, wherein detected positions of a tool or tools controlled by the operator or operators provide input to the imaging system.

12. A method for capturing and displaying an image of an operator work site, the method comprising the steps of:

capturing the image of the operator work site, the image including depth information;

communicating the captured image, including the depth information, to display apparatus comprising a display screen; and

displaying to the operator the captured image, including the depth information, on the display screen located between the operator's eyes and the position of the work site, characterized in that:

the method further comprises obtaining real-time information of a position relating to one or both of the operator's eyes, and providing the depth information in the image by adjusting the image displayed on the at least one display screen to show a change in view corresponding to a change in said position relating to one or both of the operator's eyes such that the depth information is conveyed to the operator by parallax.