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(54) **TROCAR, AND SURGERY ASSISTANCE SYSTEM**

(71) Applicants: **National University Corporation Chiba University**, Chiba-shi (JP); **Advanced Healthcare Co., Ltd.**, Tokyo (JP)

(72) Inventor: **Toshiya NAKAGUCHI**, Funabashi-shi (JP)

(73) Assignees: **National University Corporation Chiba University**, Chiba-shi (JP); **Advanced Healthcare Co., Ltd.**, Tokyo (JP)

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(57) **ABSTRACT**

Problem

To provide a surgery assistance system that performs measurement of shapes within the abdominal cavity at high accuracy in three dimensions, and a trocar for use in such a surgery assistance system.

Means for Solution

A surgery assistance system **101** includes forceps trocars **1***a* and **1***b* having retractable cameras **17***a* and **17***b* and marks **19***a* and **19***b*, a laparoscope trocar **3**, forceps **4***a* and **4***b*, a laparoscope **5** having a mark **19***d*, an image processing device **6** that inputs the images obtained from the retractable cameras **17***a* and **17***b* and the image obtained from the laparoscope **5** and combines these images to create a three dimensional image, a three dimensional monitor **7** that outputs the three dimensional image created by the image processing device **6**, and an optical tracking sensor **9**. The positional relationships of the marks **19** and the corresponding cameras **17** are fixed. The positions of the marks **19** are detected by the optical tracking sensor **9**, and the image processing device **6** estimates the distance between the cameras.

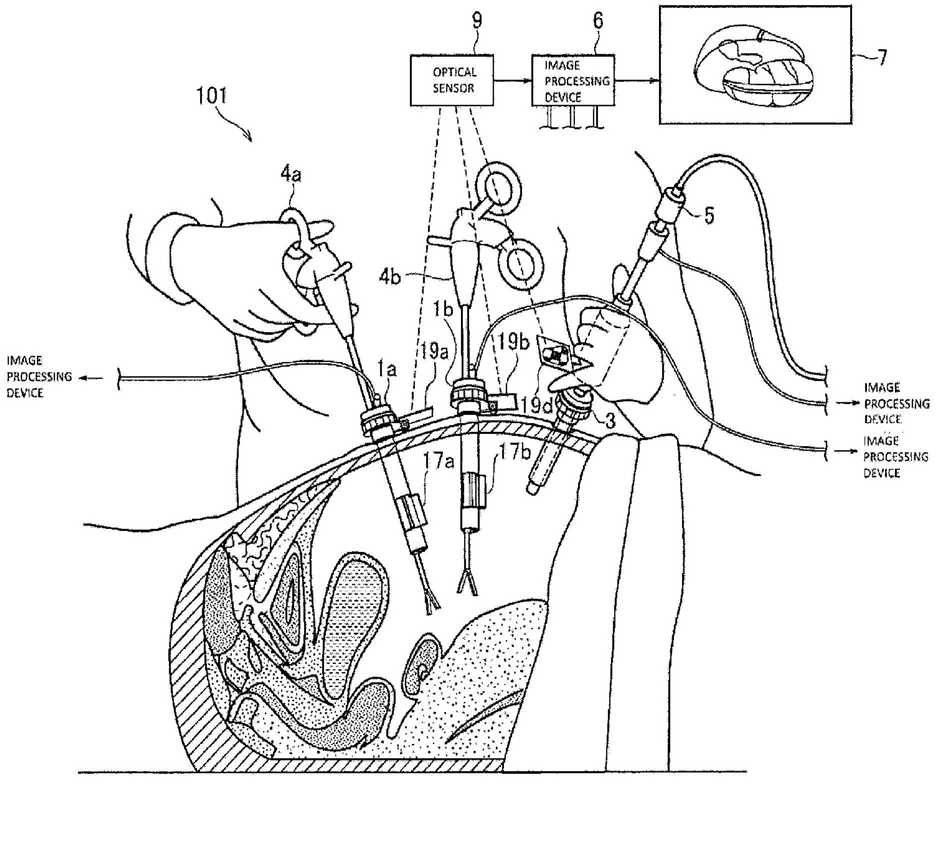
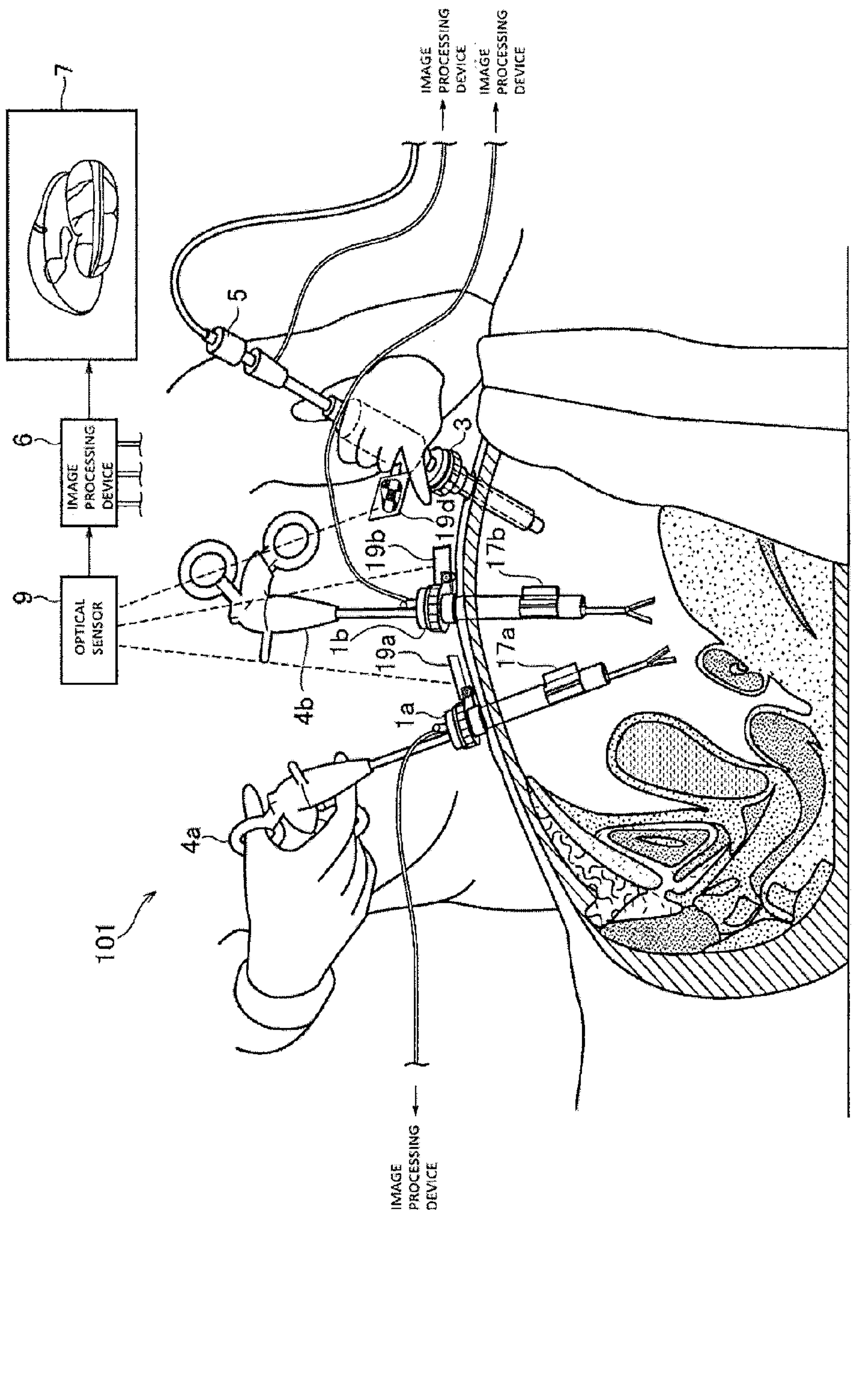


FIG. 1



7
6
IMAGE PROCESSING DEVICE
9
OPTICAL SENSOR
IMAGE PROCESSING DEVICE
IMAGE PROCESSING DEVICE
5
3
19d
19b
17b
1b
19a
17a
4b
1a
4a
101
IMAGE PROCESSING DEVICE

FIG. 2A

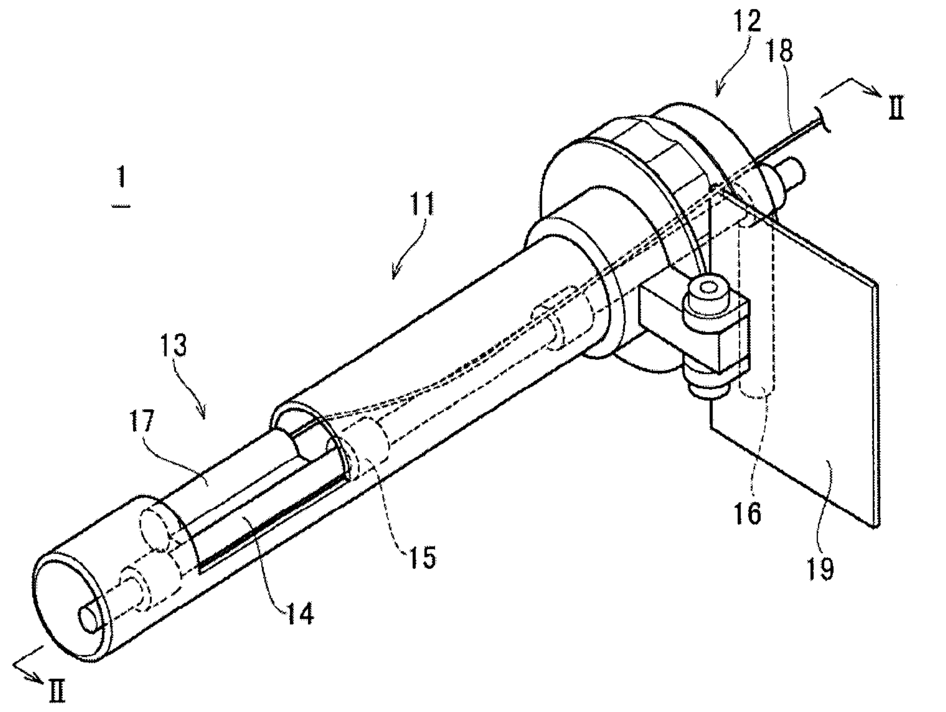


FIG. 2B

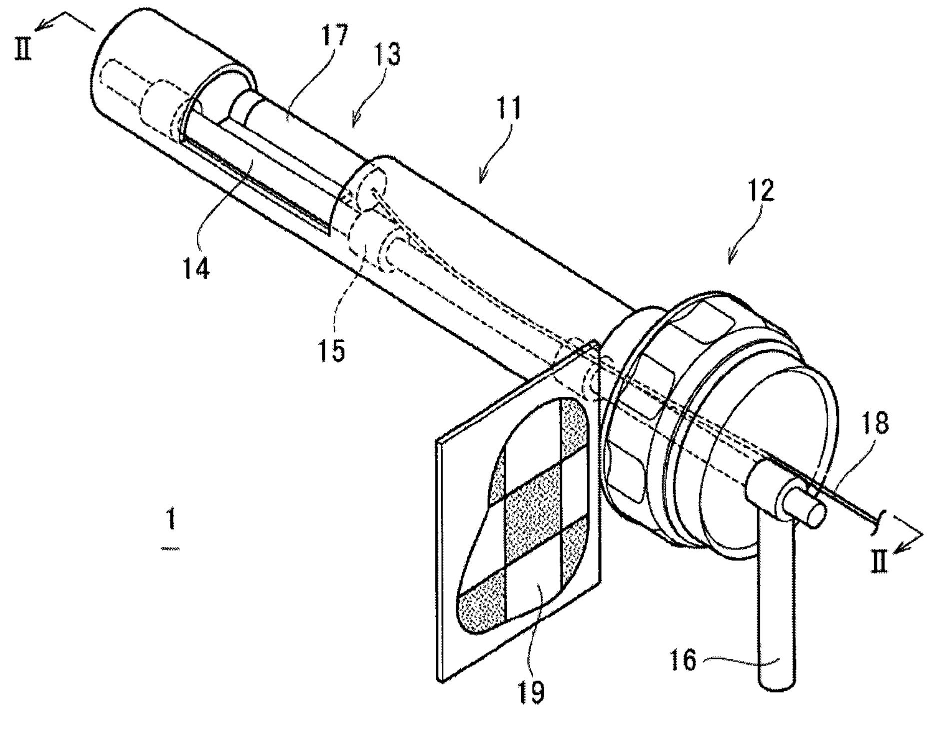


FIG. 3A

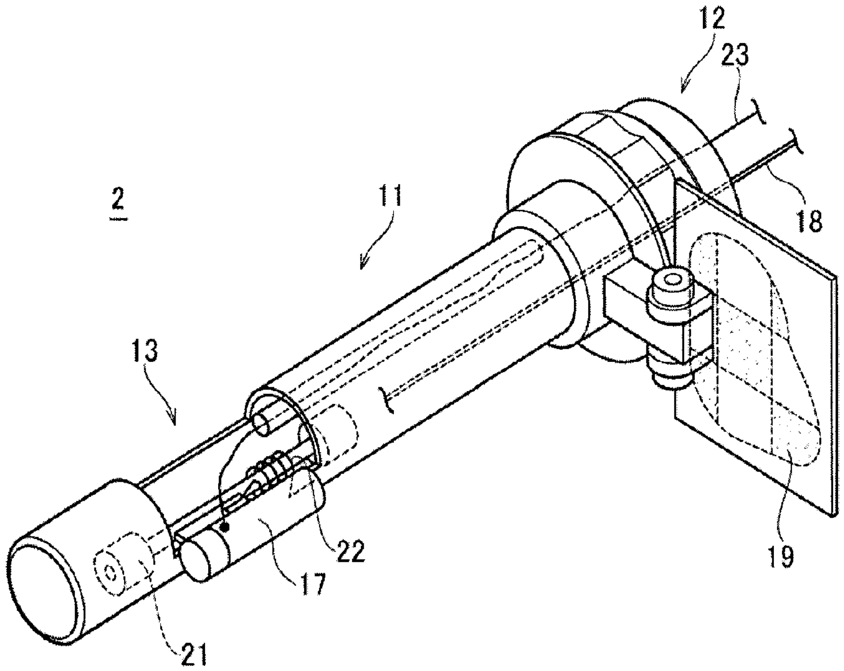


FIG. 3B

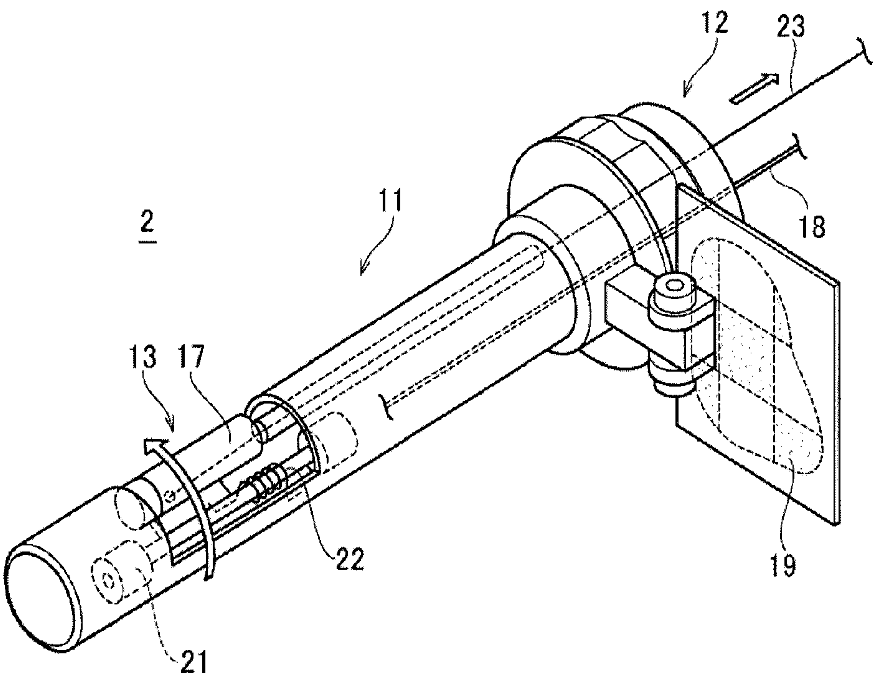


FIG. 4

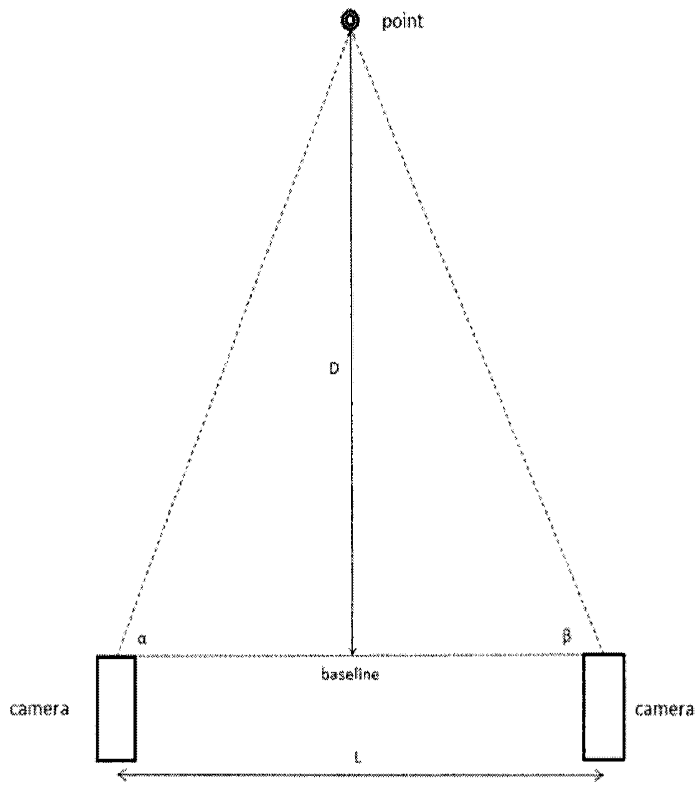


FIG. 5

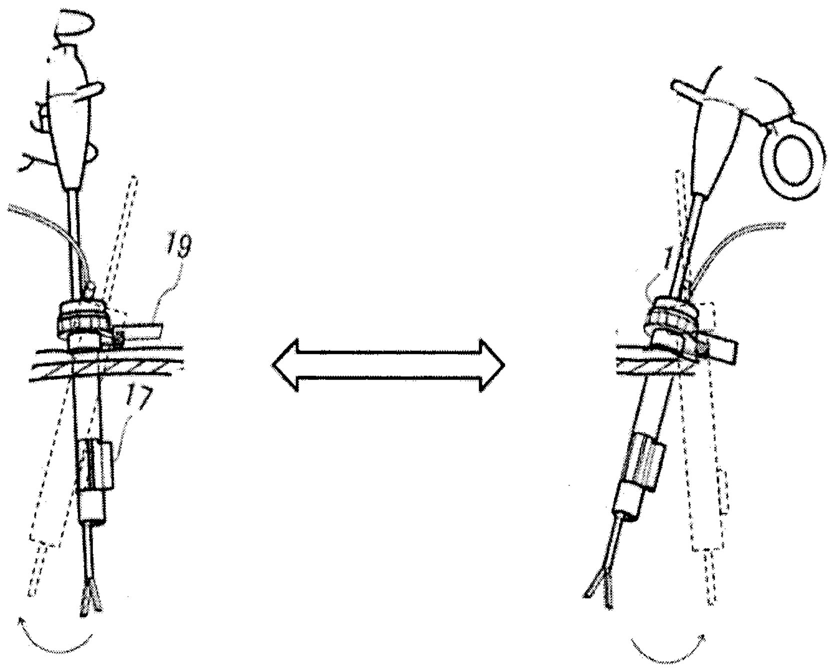


FIG. 6A

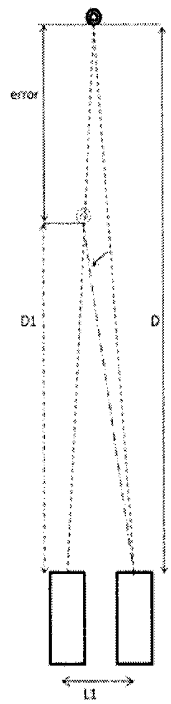


FIG. 6B

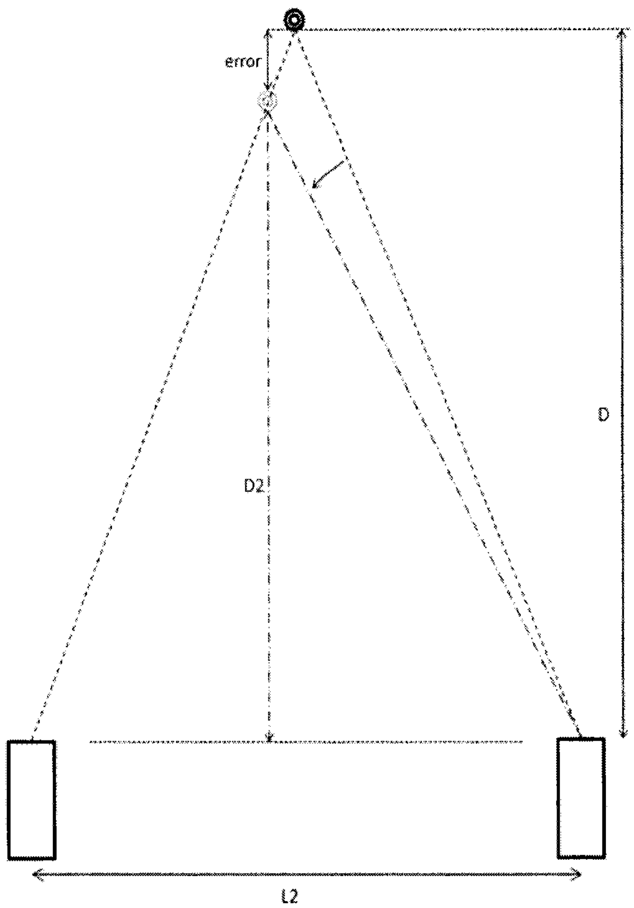


FIG. 7

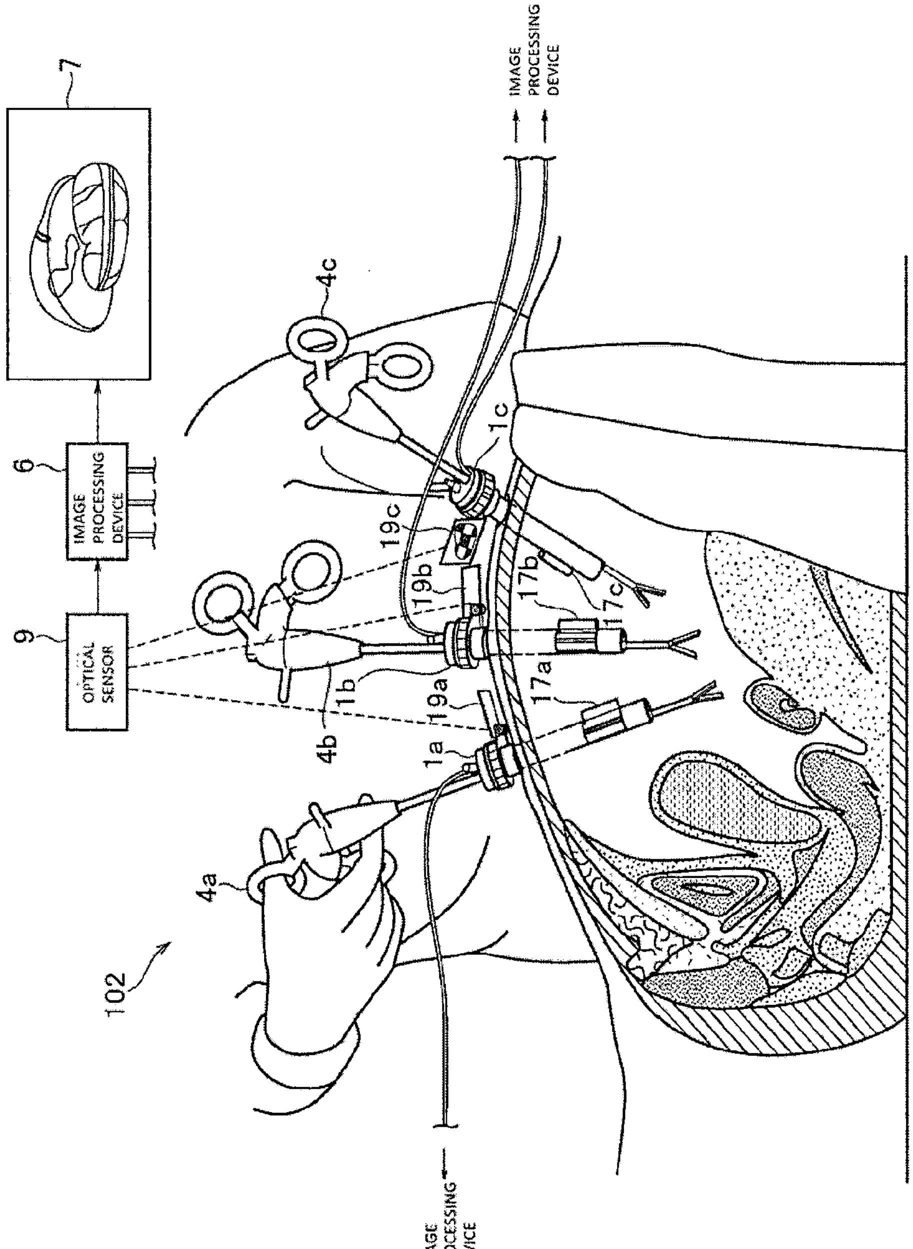
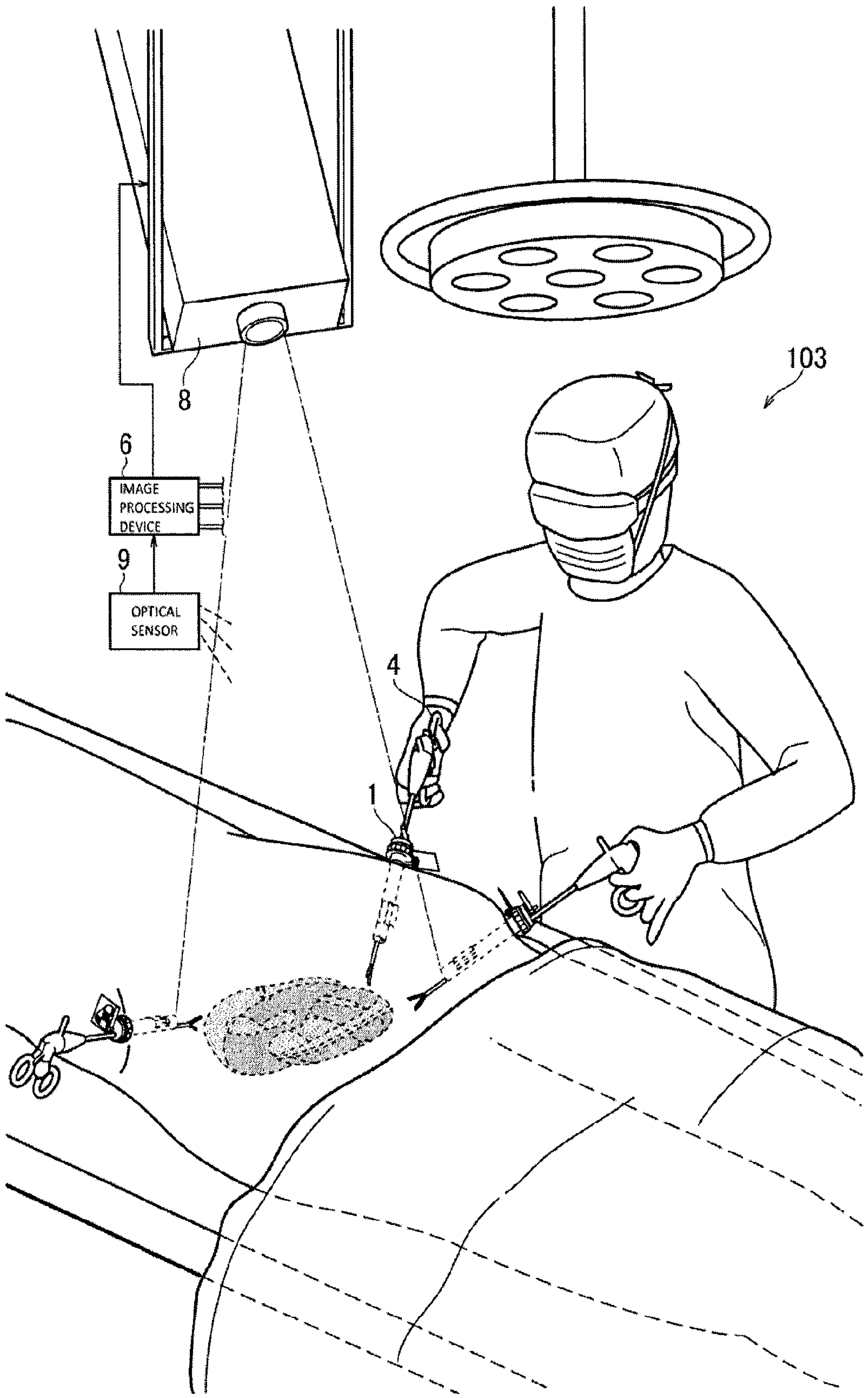

7
6
IMAGE PROCESSING DEVICE
9
OPTICAL SENSOR
4c
1c
19c
19b
17b
7c
1b
4b
19a
17a
1a
4a
102
IMAGE PROCESSING DEVICE
IMAGE PROCESSING DEVICE

FIG. 8



TROCAR, AND SURGERY ASSISTANCE SYSTEM

TECHNICAL FIELD

[0001] The present invention relates to a trocar and to a surgery assistance system that includes a trocar, and in particular relates to measurement of shapes in three dimensions.

BACKGROUND ART

[0002] In recent years, in order to maintain and enhance the QOL (quality of life) of patients, surgical operations of low invasiveness are being performed using laparoscopic surgery and so on. In abdominal laparoscopic surgery, carbonic acid gas is injected into the abdominal cavity so that the abdominal wall is distended, and thereby space and a good field of view for manipulation are ensured. A small hole is formed in the abdominal wall, and an instrument called a trocar is inserted. Then, usually, a laparoscope (i.e. a CCD camera) and a forceps (which is a surgical instrument) are inserted into the interior of the body of the patient, and the required surgical operation is performed while observing an image displayed upon a monitor by the laparoscope.

[0003] Now this operation is typically performed while relying only upon the image obtained from the laparoscope. Ascertaining the position of the forceps within the abdominal cavity demands high experience from the surgeon. In particular, it is impossible to derive information related to depth from the image displayed upon the monitor, and so accordingly reliance upon the experience and the intuition of the surgeon for depth estimation is unavoidable. And there is a fear that erroneous contact with internal organs or the like may occur, if an inexperienced surgeon inserts the forceps too far.

[0004] In order to cope with this type of problem, a proximity-aware operation navigation system has been proposed (refer to Non Patent Document #1) which emits a warning when the forceps has been inserted too far inward on the basis of a position sensor that is provided to the forceps. Due to this, even if image information relating to depth is not derived, it is still possible to prevent erroneous contact due to the forceps being inserted too far.

CITATION LIST

Non-Patent Literature

[0005] Non-Patent Document #1: Yume Honda, Ikuma Sato, and Ryoichi Nakamura, "Evaluation of the Effectiveness of Surgical Navigation with Distance Sensation Indicator for Laparoscopic Surgery", 20th Japan Computer Surgery Conference, Yokohama, 22 24 November 2011, Journal of Japan Society of Computer Aided Surgery, 13(3): 280 281, 2011.

SUMMARY OF THE INVENTION

Technical Problem

[0006] While the navigation system described above is capable of alleviating the burden upon the surgeon, it is not related to measurement of shapes in three dimensions.

[0007] In order to improve the field of view during laparoscopic surgery in an innovative manner, it is necessary to estimate depths within the abdominal cavity, to measure shapes in three dimensions, and to recreate this information upon a monitor display or the like.

[0008] Now, three dimensional endoscopes are currently manufactured and marketed, and it is possible to measure shapes within the abdominal cavity in three dimensions by using such a three dimensional endoscope. A three dimensional endoscope incorporates two cameras, and depth is estimated on the basis of the triangle defined by the two cameras and the subject point. However, with a three dimensional endoscope, the distance between the cameras is extremely small, and as a result the accuracy of depth estimation is not good.

[0009] The present invention has been conceived in order to solve the problem described above, and its object is to provide a surgery assistance system with which measurement of shapes in three dimensions within the abdominal cavity of a patient can be performed at high accuracy, and to provide a trocar that is used in such a surgery assistance system.

Means for Solution

[0010] In order to solve the problem described above, the present invention proposes a trocar for being passed through an abdominal wall of a patient, comprising: a pipe portion that inserts a surgical instrument into the interior of the body of the patient; a head portion that is connected to an upper portion of said pipe portion; an opening portion that is provided at a position of said pipe portion that, during surgery, is within the body of the patient; a camera that is disposed so that it can be changed between a stored position in which it is stored within the pipe portion and a deployed position in which it is deployed via said opening portion to the exterior of the pipe portion and is capale of photography; and a position mark provided upon said head portion.

[0011] More desirably, said position mark is an optical mark.

[0012] According to the basic theory of three dimensional shape measurement, the depth estimation accuracy is enhanced if the accuracy of estimation of the distance between the cameras is improved. A retractable camera and a position mark are provided to the trocar of the present invention, and, even if the trocar wobbles, the positional relationship between the camera and the mark does not change. Accordingly, if the position mark is detected at high accuracy, then the position of the retractable camera can be estimated at high accuracy, and as a result it is also possible to estimate the depth at high accuracy.

[0013] And, in order to solve the problem described above, the present invention proposes a surgery assistance system including: a laparoscope including a camera and a position mark; a forceps trocar having a retractable camera that can be changed between a stored position and a deployed position, and a position mark; a position detection sensor that detects the positions of the position mark of said laparoscope and of the position mark of said forceps trocar; and an image processing device that estimates the positions of said cameras on the basis of the positions of said position marks, and that combines the images obtained from said cameras on the basis of the positions of said cameras to create a three dimensional image.

[0014] Generally, a plurality of forceps are used in laparoscopic surgery. As a result, apart from the laparoscope, a plurality of cameras are inserted into the abdominal cavity of the patient. Due to this, it is possible to estimate depths at high accuracy, and it is possible to perform measurement of shapes within the abdominal cavity in three dimensions at high accuracy.

[0015] Generally, with laparoscopic surgery, a plurality of trocars for the use of forceps are implanted in the abdominal wall as being spaced apart almost equally. To put it in another manner, the possibility that the trocars will be grouped closely together is almost nil. Due to this, it is possible to ensure sufficiently great distances between the cameras, and it is possible to estimate the depths at high accuracy, so that it is possible to perform measurement of the shapes within the abdominal cavity in three dimensions at high accuracy.

[0016] Moreover, in order to solve the problem described above, the present invention proposes a surgery assistance system including: a plurality of forceps trocars, each having a retractable camera that can be changed between a stored position and a deployed position, and a position mark; a position detection sensor that detects the positions of the position marks of said forceps trocars; and an image processing device that estimates the positions of said cameras on the basis of the positions of said position marks, and combines the images obtained from said cameras on the basis of the positions of said cameras to create a three dimensional image.

[0017] Due to this, it is possible to perform measurement of shapes within the abdominal cavity in three dimensions with good accuracy. Moreover the invasiveness is reduced, since no hole for laparoscope is required.

[0018] More desirably, this surgery assistance system further includes a three dimensional projector that is provided above the operating table, and that projects said three dimensional image upon the abdomen of the patient.

[0019] With this arrangement, the line of sight of the surgeon and the direction of his field of operation coincide with one another, so that he can really experience the same feeling as that during an open-abdomen operation.

[0020] In order to solve the problem described above, the present invention proposes a port for being passed through a chest wall of a patient, comprising: a pipe portion that inserts a surgical instrument into the interior of the chest of the patient; a head portion that is connected to an upper portion of said pipe portion; an opening portion that is provided at a position of said pipe portion that, during surgery, is within the body of the patient; a camera that is disposed so that it can be changed between a stored position in which it is stored within the pipe portion and a deployed position in which it is deployed via said opening portion to the exterior of the pipe portion and is capale of photography; and a position mark provided upon said head portion.

Advantageous Effect of the Invention

[0021] According to the present invention, it is possible to perform measurement of shapes within the abdominal cavity of a patient at high accuracy in three dimensions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** shows a first embodiment of the surgery assistance system;

[0023] FIG. **2**A shows a trocar having a retractable camera and a mark;

[0024] FIG. **2**B shows a trocar having a retractable camera and a mark (another point of view);

[0025] FIG. **3**A shows a variant embodiment of the trocar (deployed position);

[0026] FIG. **3**B shows a variant embodiment of the trocar (stored position);

[0027] FIG. **4** shows the fundamental theory of three dimensional shape measurement;

[0028] FIG. **5** illustrates the difficulty of camera position estimation;

[0029] FIG. **6**A shows a relationship between camera distance (extremely small) and depth estimation accuracy;

[0030] FIG. **6**B shows a relationship between camera distance (quite large) and depth estimation accuracy;

[0031] FIG. **7** is a second embodiment of the surgery assistance system; and

[0032] FIG. **8** is a third embodiment of the surgery assistance system.

DESCRIPTION OF THE EMBODIMENTS

The First Embodiment

[0033] (Structure of the Surgery Assistance System)

[0034] A surgery assistance system **101** that employs a three dimensional image will now be explained. FIG. **1** shows the general structure of this surgery assistance system **101**.

[0035] The surgery assistance system **101** comprises forceps trocars **1***a* and **1***b* (to be described in detail hereinafter) that are respectively equipped with retractable cameras **17***a* and **17***b* and respectively carry marks **19***a* and **19***b*, a laparoscope trocar **3**, forceps **4***a* and **4***b*, a laparoscope **5** that carries a mark **19***d*, an image processing device **6** that inputs images obtained from the retractable cameras **17***a* and **17***b* and an image obtained from the laparoscope **5** and performs processing to create a three dimensional image by combining these images, a three dimensional monitor **7** that outputs this three dimensional combined image created by the image processing device **6**, and an optical tracking sensor **9**.

[0036] The forceps **4***a* and **4***b* are surgical instruments of one type, and are used for grasping, holding down, pulling, and cutting blood vessels and organs and so on. Each of them is generally formed as a pair of scissors, and its inner working end portion is operated by outer gripping portions being rotated around a fulcrum. When the gripping portions are closed together, the forceps **4***a*, **4***b* can be inserted through the trocar **1***a*, **1***b*. It should be understood that while, generally, a plurality of forceps are used in abdominal laparoscopic surgery, at least one forceps and one forceps trocar are enough for application of this system.

[0037] The laparoscope **5** is an endoscopic instrument of one type, and comprises a camera and a light source. The laparoscope **5** is inserted into the body of the patient by being passed through the laparoscope trocar **3**. The mark **19***d* is provided at a position on the laparoscope which is exterior to the body of the patient.

[0038] The optical tracking sensor **9** measures the positions of the marks **19***a*, **19***b*, and **19***d* in three dimensions, and outputs the results of these measurements to the image processing device **6**. It should be understood that while, in this embodiment, the optical tracking sensor **9** is a device that recognizes black and white patterns on the marks with visible light radiation, it would also be acceptable to arrange for it to emit infrared radiation, and to receive infrared radiation reflected by the marks. Moreover, the use of an optical tracking sensor is not to be considered as being limitative; it would also be acceptable to employ a magnetic sensor, provided that it can measure the positions of the marks in three dimensions.

[0039] (Structure of the Trocars)

[0040] The structure of these trocars equipped with retractable cameras will now be described. FIG. **2** shows two perspective views of one of these trocars equipped with a retractable camera. FIG. 2A and FIG. 2B show this trocar from different points of view.

[0041] The trocar **1** comprises a pipe portion **11** and a head portion **12**. The greater part of the pipe portion **11** is inserted into a hole in the abdominal wall of the patient. The head portion **12** is provided as connected to the upper portion of the pipe portion **12**. The head portion **12** is hollow, and a forceps can be inserted thereinto from above. Moreover, although the details thereof are not shown, the head portion **12** is provided with a sealing mechanism that prevents air leakage when the forceps is inserted and withdrawn, and with an air blowing mechanism that injects air into the abdominal cavity.

[0042] An opening portion **13** is provided at a position of the pipe portion **11**. The position of the opening portion **13** can be relied upon to be within the body of the patient when the trocar has been inserted. A shaft **14** is disposed along the axial direction of the pipe portion, along an edge of the opening portion **13**. A plurality of bearings **15** are fixed to the inner wall of the pipe portion **11**, and these bearings **15** hold the shaft **14** so that it can be rotated. The end portion of the shaft **14** projects to the exterior of the trocar. A selection lever **16** is fixed to the end portion of the shaft **14**. This selection lever **16** can be rotated between a stored position and a deployed position, and can be retained in each of these positions. A detent mechanism not shown in the figures may be used to retain.

[0043] A camera **17** is rigidly and integrally fixed to the shaft **14** at a position that corresponds to the opening portion **13**. A cable **18** is connected to the camera **17**, and this cable **18** is led out through the trocar **1** and is connected to the external image processing device **6**.

[0044] When the pipe portion **11** is to be inserted into a hole in the abdominal wall of the patient, the selection lever **16** is fixed in the stored position, and this holds the camera **17** in the stored position via the shaft **14**. Due to this, it is possible to insert the pipe portion **11** through the hole in the abdominal wall without the camera **17** causing any hindrance. After the pipe portion **11** has been inserted, the selection lever **16** is moved over to the deployed position and fixed there, so that the camera **17** is moved to the deployed position via the shaft **14**. Photography is performed in this state, and then, when the pipe portion **11** is to be withdrawn after the operation has been completed, the selection lever **16** is moved back to the stored position and is fixed there, so that the camera **17** is moved back to the stored position via the shaft **14**. Due to this, it is possible to withdraw the pipe portion **11** from the hole in the abdominal wall without any hindrance being caused by the camera **17**.

[0045] It should be understood that while, in the shown configuration, the cable **18** is led out along the shaft **18**, it would be even more desirable to make the shaft **14** hollow, and to lead out the cable **18** through the shaft **14**; in this case, there would be no danger of the cable **18** becoming disconnected during insertion of the forceps.

[0046] The mark **19** is provided upon the head portion **12** of the trocar. In this embodiment, a white and black checkered flag pattern is shown as one example of this mark **19**, but this is not to be considered as being limitative; any mark that can be recognized by the optical tracking sensor **9** will be acceptable.

[0047] (A variant Embodiment of the Trocar)

[0048] The structure described above is not limitative; it is only necessary that the trocar should be provided with a camera **17** and a mark **19**. FIG. **3** is a perspective view of a trocar **2** according to a variant embodiment. FIG. **3**A is a figure showing this trocar **2** in the deployed state with the camera **17** in the deployed position, while FIG. **3**B is a figure showing this trocar **2** in the stored state with the camera **17** in the stored position. Elements of the structure that are the same as in the previously described embodiment are denoted by the same reference symbols. This trocar **2** comprises a pipe portion **11** and a head portion **12**. An opening portion **13** is provided at a position of the pipe portion **11**. The position of the opening portion **13** can be relied upon to be within the body of the patient when the trocar has been inserted. A rotatable hinge mechanism **21** is provided along an edge of the opening portion **13** and extends along the axial direction of the pipe portion **11**, and a camera **17** is connected to the pipe portion **11** via this hinge mechanism **21**. A torsion spring **22** is provided to the hinge mechanism **21**, and normally the elastic force of this torsion spring **22** acts to deploy the camera **17**. On the other hand, a tension cable **23** is connected to the camera **17** and extends to the exterior of the trocar, and, when this tension cable **23** is pulled, the camera **17** is stored in the opening portion **13** against the resistance of the elastic force of the torsion spring **22** which is overcome. And a cable **18** is connected to the camera **17**.

[0049] When the pipe portion **11** is to be inserted into a hole in the abdominal wall of the patient, the tension cable **23** is pulled and the camera **17** is held in the stored position, and, after the pipe portion **11** has been inserted, the tension in the tension cable **23** is slackened, and the camera **17** moves over to the deployed position. Photography is performed in this state, and then, when the pipe portion **11** is to be withdrawn after the operation has been completed, the tension cable **23** is again pulled, so that the camera **17** is moved back to the stored position.

[0050] It should be understood that the cable **23** is protected by a guide, so as to reduce the danger of the tension cable **23** being cut when the forceps **4** is inserted into or pulled out from the trocar.

[0051] The mark **19** is provided upon the head portion. It should be understood that, for convenience, the checkerboard pattern is shown on the rear surface of the mark by dotted lines in the drawing.

[0052] (Measurement of Shapes in Three Dimensions)

[0053] FIG. **4** is a conceptual figure showing the fundamental theory of measurement of shapes in three dimensions. The most important difference between measurement of shapes in two dimensions and in three dimensions is estimation of depth.

[0054] In the triangle defined by two cameras and a subject point, the depth D can be estimated on the basis of the distance L between the two cameras, the angle a subtended by the base line between the cameras and the line of sight of one of the cameras, and the angle **8** subtended by the base line between the cameras and the line of sight of the other camera. It should be understood that it is possible to enhance the accuracy of estimation by increasing the number of cameras, since a greater number of triangles are thereby defined.

[0055] With the trocar **1** of this embodiment, the marks **19** are fixed. Moreover, during surgery, the cameras **17** are fixed in their deployment positions. In other words, the positional relationships between the marks **9** and the corresponding cameras **17** do not change. Due to this, the image processing device **6** is able to estimate the three dimensional positions of the cameras **17***a* and **17***b* on the basis of the three dimensional positions of the marks **19***a* and **19***b* respectively. In a similar manner, the image processing device **6** is able to estimate the three dimensional position of the camera of the laparoscope **5** on the basis of the three dimensional position of the mark **19***d*. In other words, it is capable of estimating the distances between the cameras.

[0056] Furthermore, for each subject point, the angles α and β are measured, and thus it is possible to estimate the positions in depth of the subject points on the basis of the fundamental theory described above. And it is possible to measure the three dimensional shapes within the abdominal cavity by shifting the subject point and repeating the estimation of its depth position.

[0057] (Beneficial Effects of this System)

[0058] (1) Since laparoscopic surgery using this surgery assistance system **101** is based upon conventional laparoscopic surgery, and there is no great change in the method of operation, accordingly a surgeon is able to take advantage of his current fund of knowledge and experience relating to conventional operational technique.

[0059] (2) Moreover, this surgery assistance system **101** has a simple structure that employs an improved trocar (refer to FIG. **2** or FIG. **3**), so that it is possible still to apply a surgery assistance system of an already existing type with a few simple improvements.

[0060] (3) Now, in conventional abdominal laparoscopic surgery according to the prior art, the field of view is narrow, since the surgery is performed while only relying upon the image obtained from the laparoscope. In particular, no image information is obtained related to depth. And, if a new hole is opened in the abdominal wall in order to insert another camera for performing three dimensional shape measurement with good accuracy, then the advantage of low invasiveness is lost.

[0061] However, in this embodiment, it is possible to insert a plurality of cameras into the abdominal cavity of the patient by using the trocars **1***a* and **1***b* that are equipped with the retractable cameras **17***a* and **17***b* respectively. Since trocars for forceps are used at this time, there is no need to make any new holes in the abdominal wall. Due to this, it is possible to measure shapes in three dimensions while maintaining the advantage of low invasiveness.

[0062] Moreover, the image processing device **6** creates a three dimensional image, and this three dimensional image is outputted upon the three dimensional monitor **7**. Thus, by viewing the three dimensional monitor **7**, the surgeon is able to obtain a broad field of view that includes depth information. Due to this, it is possible to alleviate the burden upon the surgeon.

[0063] It should be understood that, since it is possible to perform three dimensional measurement and to generate a three dimensional image, accordingly, naturally, it is also possible to perform two dimensional measurement and to generate a two dimensional image. And it is also possible to change over between a two dimensional image and a three dimensional image.

[0064] (Beneficial Effects Related to Enhancement of Accuracy)

[0065] (1) As explained in connection with the fundamental theory of three dimensional shape measurement, it is necessary to derive the three dimensional positions of the cameras **17***a* and **17***b* for estimating the depth. However, since the cameras **17***a* and **17***b* are located within the abdominal cavity, it is not possible to measure their positions directly. Moreover, the angles of the trocars **1***a* and **1***b* change somewhat along with the movement of the forceps **4***a* and **4***b*, so that, as a result, the cameras **17***a* and **17***b* quiver to a certain extent. Due to this, there is the problem that it is difficult to estimate their three dimensional positions. FIG. **5** is a conceptual figure for explanation of problems related to the difficulty of camera position estimation.

[0066] Accordingly, the present inventors have directed their attention to the fact that the cameras **17***a* and **17***b* undergo a certain degree of quivering along with the shaking of the trocars **1***a* and **1***b*, and, because of this, the marks **19***a* and **19***b* are provided upon the head portions **12** of the trocars **1***a* and **1***b*. In other words, the positional relationships of the cameras **17***a* and **17***b* with the positions at which the marks **19***a* and **19***b* appear do not change. And furthermore, the positions of the marks **19***a* and **19***b* in three dimensions can be detected at high accuracy by the optical tracking sensor **9**. Accordingly, it is possible to estimate the positions in three dimensions of the cameras **17***a* and **17***b* at high accuracy on the basis of the positions in three dimensions of the marks **19***a* and **19***b*.

[0067] It should be understood that the mark **19***d* is provided upon the laparoscope **5** in order for movement of the camera of the laparoscope **5** due to quivering of its trocar **3** not to present any problem. Due to the provision of this mark **19***d*, it is possible to estimate the position in three dimensions of the camera of the laparoscope **5** at high accuracy.

[0068] The result of the facts that it is possible to estimate the three dimensional positions of the cameras at high accuracy, and that it is possible to estimate the distance between the cameras at high accuracy, is that it is possible to estimate depths at high accuracy, and that it is possible to measure the three dimensional shapes within the abdominal cavity at high accuracy.

[0069] (2) As explained in connection with the fundamental theory of three dimensional shape measurement, the accuracy of depth estimation is enhanced by increasing the number of cameras. Generally a plurality of forceps are used in laparoscopic surgery (for example, two through five). As a result, apart from the laparoscope **5**, the plurality of cameras **17** are inserted into the abdominal cavity. Due to this, it is possible to estimate depth at high accuracy, and it is possible to perform measurement of shapes within the abdominal cavity in three dimensions at high accuracy.

[0070] (3) Now, it is also possible to perform measurement of shapes in three dimensions within the abdominal cavity of the patient if a three dimensional endoscope is used. However, with a three dimensional endoscope, the distance between the cameras is extremely small, so that the triangle described above becomes extremely long and thin, and as a result the accuracy of depth estimation is deteriorated.

[0071] FIG. **6** is a conceptual figure showing the relationship between the distance between the cameras and the accuracy of depth estimation. FIG. **6**A shows a case when the distance between the cameras is extremely small, while FIG. **6**B shows a case when the distance between the cameras is quite large.

[0072] In FIG. **6**A, the distance between the cameras is denoted by L1 and is extremely small, while the actual depth is denoted by D. If there is an error in the line of sight of one of the cameras, then the estimated depth becomes D1. And, in FIG. **6**B, the distance between the cameras is denoted by L2 and is quite large, while the actual depth is denoted by D (the same as in FIG. **6**A). If there is an error in the line of sight of one of the cameras (of the same level as in FIG. **6**A), then the estimated depth becomes D2.

[0073] In this case, the error in the estimated depth D2 is small, by contrast with the estimated depth D1 that has a large error.

[0074] Generally, with laparoscopic surgery, a plurality of trocars **1** (for example two through five) for the use of forceps are implanted in the abdominal wall as being spaced apart almost equally. To put it in another manner, the possibility that the trocars **1** will be grouped closely together is almost nil. Due to this, it is possible to ensure sufficiently great distances between the cameras, and it is possible to estimate the depths at high accuracy, so that it is possible to perform measurement of the shapes within the abdominal cavity in three dimensions at high accuracy.

The Second Embodiment

[0075] FIG. **7** is a figure showing the general structure of another surgery assistance system **102**. This surgery assistance system **102** comprises forceps trocars **1***a,* **1***b,* and **1***c* that are respectively equipped with retractable cameras **17***a,* **17***b,* and **17***c* and marks **19***a,* **19***b,* and **19***c,* forceps **4***a,* **4***b,* and **4***c,* an image processing device **6** that estimates the three dimensional positions of the cameras **17***a,* **17***b,* and **17***c* on the basis of the three dimensional positions of the marks **19***a,* **19***b,* and **19***c,* combines the images obtained from the cameras, and creates a three dimensional image, and a three dimensional monitor **7** that outputs the three dimensional image created by the image processing device **6**.

[0076] In other words, the laparoscope trocar **3**, the laparoscope **5**, and the mark **19***d* in the surgery assistance system **101** of the first embodiment are omitted, and another forceps trocar **1***c* including a retractable camera **17***c,* another forceps **4***c,* and a corresponding mark **19***c* are added instead.

[0077] It should be understood that while, generally, a plurality of forceps are used in abdominal laparoscopic surgery, at least two forceps and two forceps trocars are enough for the application of this system according to the second embodiment. Moreover it should be understood that, although no laparoscope is actually used in this embodiment, for convenience it is referred to as laparoscopic surgery.

[0078] By contrast to the situation when a laparoscope **5** is used as in the first embodiment, in which the surgeon needs actively to orient the laparoscope **5** in order to take a photograph of the spot where cutting or the like is being performed, since, in this embodiment, the retractable camera **17** reliably photographs the end portion of the forceps **4***a,* accordingly it is possible reliably to obtain an image of the actual spot where cutting or the like is being performed, which is a very important image. Thus, on the supposition that that the performance of the retractable camera **17** is high, it is possible to obtain an image of higher quality than that obtained with a laparoscope.

[0079] On the other hand, by dispensing with the laparoscope trocar **3** and the laparoscope **5**, it becomes unnecessary to make any hole in the abdominal wall for passing laparoscope **5**, so that the invasiveness becomes yet lower.

[0080] However, instead of the light source provided to the laparoscope **5**, it is necessary to provide light sources to the trocars **1** (or to the cameras **17**).

The Third Embodiment

[0081] The third embodiment is a variant of the first and second embodiments. While in the first and second embodiments the surgeon performs an operation by manipulating the forceps **4** and the laparoscope **5** while looking at the monitor **7**, there is a discrepancy between the line of sight of the surgeon and the direction towards the actual field of operation, so that the surgeon experiences a sense of discomfort, and this constitutes a burden. In particular, a surgeon who has performed a lot of open—abdomen operations sometimes finds it difficult to get used to abdominal laparoscopic surgery.

[0082] FIG. **8** is a figure showing the general structure of a surgery assistance system **103** according to this third embodiment. Elements that are common to the first and second embodiments are omitted as appropriate. This surgery assistance system **103** comprises a three dimensional projector **8**, instead of the three dimensional monitor **7**. The three dimensional projector **8** is provided over the operating table, and projects the combined image created by the image processing device **6** directly upon the abdominal portion of the patient.

[0083] Due to this, the line of sight of the surgeon and the direction of his field of operation coincide, so that he is able to experience the same feeling of reality as in an open-abdomen operation. This means that the burden upon the surgeon is alleviated.

[0084] <Port having Retractable Camera>

[0085] While the above explanation has been expressed in terms of abdominal laparoscopic surgery, the present invention can also be applied to chest laparoscopic surgery. However, the operating instrument that is termed a "trocar" in abdominal laparoscopic surgery is called a "port" in chest laparoscopic surgery. That is to say, a trocar and a port are devices of almost the same type.

EXPLANATION OF THE REFERENCE SYMBOLS

[0086] **1**: trocar
[0087] **2**: trocar (variant embodiment)
[0088] **3**: trocar (for laparoscope)
[0089] **4**: forceps
[0090] **5**: laparoscope
[0091] **6**: image processing device
[0092] **7**: three dimensional monitor
[0093] **8**: three dimensional projector
[0094] **9**: optical tracking sensor
[0095] **11**: pipe portion
[0096] **12**: head portion
[0097] **13**: opening portion
[0098] **14**: shaft
[0099] **15**: bearing
[0100] **16**: selection lever
[0101] **17**: camera
[0102] **18**: cable
[0103] **19**: mark
[0104] **21**: hinge mechanism
[0105] **22**: torsion spring
[0106] **23**: tension cable
[0107] **101103**: surgery assistance systems

1. A trocar, comprising:

a pipe portion that inserts a surgical instrument into an interior of a body of a patient;

a head portion that is connected to an upper portion of the pipe portion;

an opening portion that is at a position of the pipe portion that, during surgery, is within the body of the patient;

a camera that is disposed so that it can be changed between a stored position in which it is stored within the pipe portion and a deployed position in which it is deployed via the opening portion to an exterior of the pipe portion and is capable of photography; and

a position mark on the head portion.

2. The trocar according to claim **1**, wherein the position mark is an optical mark.

3. A surgery assistance system, comprising:

the trocar according to claim **1**, which is a forceps trocar;

a laparoscope having a camera and a position mark;

a position detection sensor that detects positions of a position mark of the laparoscope and a position mark of the forceps trocar; and

an image processing device that estimates the positions of the cameras on a basis of the positions of the position marks, and combines images obtained from the cameras on a basis of the positions of the cameras to create a three dimensional image.

4. A surgery assistance system, comprising:

a plurality of trocars according to claim **1**, wherein the trocars are forceps trocars;

a position detection sensor that detects the positions of the position marks of the forceps trocars; and

an image processing device that estimates the positions of the cameras on a basis of the positions of the position marks, and combines images obtained from the cameras on a basis of the positions of the cameras to create a three dimensional image.

5. The surgery assistance system according to claim **3**, further comprising a three dimensional projector that is above an operating table, and projects the three dimensional image upon an abdomen of the patient.

6. A port, comprising:

a pipe portion that inserts a surgical instrument into an interior of a chest of a patient;

a head portion that is connected to an upper portion of the pipe portion;

an opening portion that is at a position of the pipe portion that, during surgery, is within a body of the patient;

a camera that is disposed so that it can be changed between a stored position in which it is stored within the pipe portion and a deployed position in which it is deployed via the opening portion to an exterior of the pipe portion and is capable of photography; and

a position mark on the head portion.

* * * * *

专利名称(译)	Trocar和手术辅助系统		
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申请(专利权)人(译)	国立大学法人千叶大学 高级HEALTHCARE CO.，LTD.		
当前申请(专利权)人(译)	高级HEALTHCARE CO.，LTD. 国立大学法人千叶大学		
[标]发明人	NAKAGUCHI TOSHIYA		
发明人	NAKAGUCHI, TOSHIYA		
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摘要(译)

问题 提供一种手术辅助系统，其以三维高精度执行腹腔内形状的测量，以及用于这种手术辅助系统的套管针。 解决方案 手术辅助系统101包括具有可伸缩摄像机17a和17b以及标记19a和19b的钳子套管针1a和1b，腹腔镜套管针3，钳子4a和4b，具有标记19d的腹腔镜5，输入图像的图像处理装置6从可伸缩照相机17a和17b获得的图像和从腹腔镜5获得的图像并组合这些图像以产生三维图像，输出由图像处理装置6产生的三维图像的三维监视器7和光学跟踪传感器9.标记19和相应的摄像机17的位置关系是固定的。标记19的位置由光学跟踪传感器9检测，并且图像处理装置6估计相机之间的距离。