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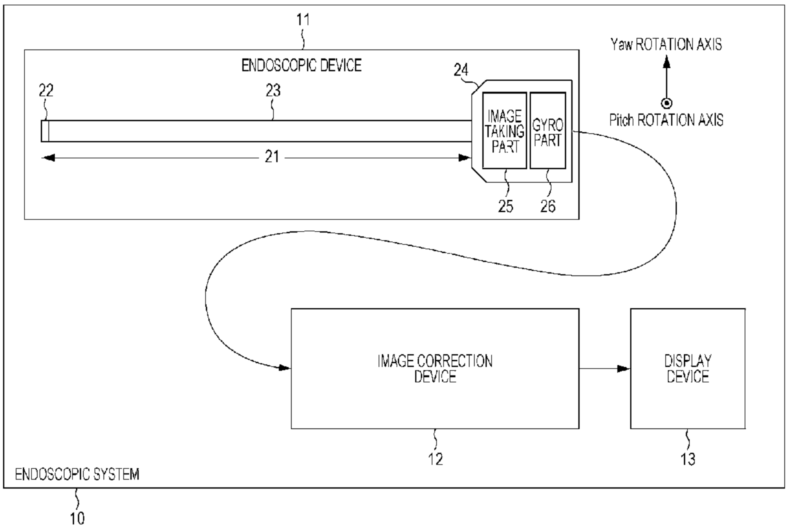
(54) **Title**: ENDOSCOPIC SYSTEM, IMAGE PROCESSING DEVICE, IMAGE PROCESSING METHOD, AND PROGRAM

FIG. 2



(57) **Abstract**: To solve the above problem, a first technology is an image processing device configured to estimate an approximate center of rotation of an endoscopic device based on motion detection in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.

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Description

Title of Invention: ENDOSCOPIC SYSTEM, IMAGE PROCESSING DEVICE, IMAGE PROCESSING METHOD, AND PROGRAM

Technical Field

[0001] The present disclosure relates to an endoscopic system, an image processing device, an image processing method, and a program, and particularly, for example, to an endoscopic system, an image processing device, an image processing method, and a program adapted to correct image shake in an image taken by an endoscopic device which is used in laparoscopic operations and the like.

[0002] <CROSS REFERENCE TO RELATED APPLICATIONS>

This application claims the benefit of Japanese Priority Patent Application JP 2014-015575 filed January 30, 2014, the entire contents of which are incorporated herein by reference.

Background Art

[0003] In recent years, in medical practice, laparoscopic operations may be performed instead of laparotomies in the related art.

[0004] Fig. 1 shows an outline of a laparoscopic operation. In the laparoscopic operation, for example, when an abdominal operation is performed, several opening tools, called trocars 2, are attached to an abdominal wall instead of performing a laparotomy, which has been hitherto performed, by cutting the abdominal wall 1, and a laparoscope (hereinafter, also referred to as an endoscopic device or an endoscope) 3 and a processing tool 4 are inserted into a body from holes provided in the trocars 2. While viewing an image of an affected part (a tumor or the like) 5 taken by the endoscope 3, a process such as excising the affected part 5 using the processing tool 4 is performed.

[0005] Since image shake may occur in the image taken by the endoscope 3, it is necessary to provide a mechanism for correcting the image shake.

[0006] For example, PTL 1 discloses an endoscope capable of adjusting an image taking position by bending a tip end part, and also discloses that a bending direction and a bending angular velocity of the tip end part are detected to correct shake based on the bending direction and the bending angular velocity.

Citation List

Patent Literature

[0007] PTL 1: Japanese Unexamined Patent Application Publication No. 5-49599

Summary of Invention

Technical Problem

[0008] In the endoscope 3 having a linear rod shape as shown in Fig. 1, a head part 6 is held by an operator, an assistant, a scopist, a robot, or the like. However, when a hand or the like holding the head part 6 is shaken, the motion of the shake is transmitted to an objective lens 7 with the trocar 2 acting as a support (rotation center), and thus image shake may occur due to the shake of the hand holding the head part 6. In the related art, a gyro has been built in the head part 6 to detect a moving angular velocity thereof, but this moving angular velocity is used to detect a direction of a camera necessary for realizing, for example, three-dimensional display, and is not used in the correction of the image shake.

[0009] It is desirable to correct an image based on an angular velocity of a head part.

Solution to Problem

[0010] To solve the above problem, a first technology is an image processing device configured to estimate an approximate center of rotation of an endoscopic device based on motion detection in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.

Advantageous Effects of Invention

[0011] According to the first and second embodiments of the present disclosure, it is possible to correct an image taken by the endoscopic device based on the angular velocity of the head part of the endoscopic device.

Brief Description of Drawings

[0012] [fig.1]Fig. 1 is a diagram showing an outline of a laparoscopic operation.

[fig.2]Fig. 2 is a block diagram showing an example of a configuration of an endoscopic system to which the present disclosure is applied.

[fig.3]Fig. 3 is a block diagram showing another example of a configuration of an endoscopic device of Fig. 2.

[fig.4]Fig. 4 is a diagram illustrating an outline of a correction process of an image correction device.

[fig.5]Fig. 5 is a block diagram showing an example of a configuration of the image correction device.

[fig.6]Fig. 6 is a block diagram showing an example of a configuration of a global motion vector calculation part.

[fig.7]Fig. 7 is a diagram showing a positional relationship between an objective lens, a rotation center, and a gyro part in the endoscopic device.

[fig.8]Fig. 8 is a diagram showing a relationship between an angular velocity of the gyro part and a moving amount of the objective lens.

[fig.9]Fig. 9 is a flowchart illustrating the image correction process.

[fig.10]Fig. 10 is a diagram illustrating stitching composition using an image after hand shake correction.
[fig.11]Fig. 11 is a block diagram showing an example of a configuration of a computer.

Description of Embodiment

[0013] Hereinafter, the best modes for carrying out the present disclosure (hereinafter, referred to as embodiments) will be described in detail with reference to the drawings.

[0014] (Example of Configuration of Endoscopic System)
Fig. 2 shows an example of a configuration of an endoscopic system according to an embodiment of the present disclosure. This endoscopic system 10 includes an endoscopic device 11, an image correction device (image processing device) 12, and a display device 13.

[0015] The endoscopic device 11 and the image correction device 12 may be connected to each other through a cable or wirelessly. In addition, the image correction device 12 may be disposed at a position separated from an operating room and be connected through a network such as local LAN or the Internet. The image correction device 12 and the display device 13 are connected to each other in the same manner.

[0016] The endoscopic device 11 includes a tube part 21 having a linear rod shape and a head part 24. The tube part 21 is also referred to as an optical visual tube or a hard tube, and the length thereof is approximately several tens of cm. At one end on the body insertion side thereof, an objective lens 22 is provided, and the other end is connected to the head part 24. An optical lens part 23 of a relay optical system is provided inside the tube part 21. The shape of the tube part 21 is not limited to the linear rod shape.

[0017] The head part 24 has an image taking part 25 and a gyro part 26 built therein. The image taking part 25 has an image taking element such as a CMOS and converts an optical image of an affected part input from the tube part 21 into an image signal at a predetermined frame rate.

[0018] The gyro part 26 detects an angular velocity at the time when the head part 24 is moved (a Yaw angular velocity w_y with respect to a Yaw rotation axis and a Pitch angular velocity w_p with respect to a Pitch rotation axis), and outputs the result of the detection to the downstream image correction device 12.

[0019] In the endoscopic device 11, the optical image of the affected part converged by the objective lens 22 enters the image taking part 25 of the head part 24 through the optical lens part 23, is converted into an image signal of a predetermined frame rate by the image taking part 25, and is output to the downstream image correction device 12. In addition, in the endoscopic device 11, the gyro part 26 detects a moving angular velocity of the head part 24, and outputs the result of the detection to the downstream image correction device 12.

[0020] Fig. 3 shows another example of the configuration of the endoscopic device 11. As shown in Fig. 3, the image taking part 25 may be disposed immediately after the objective lens 22 and the optical lens part 23 inside the tube part 21 may be omitted.

[0021] Next, Fig. 4 shows an outline of a correction process of the image correction device 12. The image correction device 12 outputs, to the downstream display device 13, an image signal which is obtained by cutting, from an entire region (effective pixel area) of an image signal input at a predetermined frame rate from the image taking part 25 of the endoscopic device 11, a cutting area having a smaller size than the effective pixel area. At this time, hand shake can be corrected by moving the position of the cutting area by a shift amount corresponding to the hand shake. In addition, when a shutter mechanism of the image taking part 25 of the endoscopic device 11 is a rolling shutter, a rolling shutter distortion occurring due to this can be removed.

[0022] Fig. 5 shows an example of a configuration of the image correction device 12. The image correction device 12 includes a global motion vector calculation part 31, a rotation center position estimation part 32, a rotation center position leveling part 33, an angular velocity leveling part 34, a shift amount determination part 35, an image cutting part 36, a distortion removing part 37, and an image output part 38.

[0023] The global motion vector calculation part 31 calculates, based on an image signal of a predetermined frame rate input from the image taking part 25 of the endoscopic device 11, a motion vector of the whole image (hereinafter, referred to as a global motion vector) and a reliability thereof, and outputs the result of the calculation to the rotation center position estimation part 32.

[0024] Fig. 6 shows an example of a configuration of the global motion vector calculation part 31. The global motion vector calculation part 31 includes a local motion detection part 41 and a global motion leveling part 42.

[0025] The local motion detection part 41 divides an image of an image signal input from the image taking part 25 into blocks having a predetermined size and performs comparison with an image signal before one frame per block to output a motion vector in a block unit (hereinafter, also referred to as a local motion vector) and a reliability thereof to the global motion leveling part 42.

[0026] The global motion leveling part 42 integrates a high-reliability local motion vector among the local motion vectors of the blocks of the respective frames to determine a global motion vector of the corresponding frame. Furthermore, the global motion leveling part 42 removes an instantaneous error by leveling global motion vectors of several frames before the corresponding frame. When a frequency of estimation of a rotation center position in the downstream rotation center position estimation part 32 is lower than the frame rate of the image signal, the leveling may be performed using the global motion vectors of several frames after the corresponding frame together.

[0027] Returning to Fig. 5, the rotation center position estimation part 32 estimates, based on the angular velocity of the head part 24 detected by the gyro part 26 of the endoscopic device 11, the global motion vector, and the reliability thereof, the position of the rotation center (support) at the time when the objective lens 22 is moved by moving the head part 24 of the endoscopic device 11, and outputs the result of the estimation with a reliability thereof to the rotation center position leveling part 33. The rotation center position is continuously estimated at predetermined time intervals.

[0028] The rotation center position leveling part 33 performs leveling by integrating the estimated rotation center position in a time direction, and outputs, to the shift amount determination part 35, the rotation center position from which the instantaneous error has been removed.

[0029] The angular velocity leveling part 34 performs leveling by integrating the angular velocity of the head part 24 detected by the gyro part 26 of the endoscopic device 11 in the time direction, and outputs, to the shift amount determination part 35 and the distortion removing part 37, the angular velocity from which the instantaneous error has been removed.

[0030] The shift amount determination part 35 calculates a moving amount of the objective lens 22 based on the leveled rotation center position and the leveled angular velocity, determines a shift amount of the image cutting area from the calculated moving amount of the objective lens 22, and notifies the image cutting part 36 of the result of the determination. The shift amount of the image cutting area corresponding to the moving amount of the objective lens 22 varies with the magnification of the objective lens 22. Therefore, in the shift amount determination part 35, a function for calculating the shift amount from the magnification and the moving amount of the objective lens 22 is held, or a table indicating the correspondence between these elements is previously held.

[0031] The image cutting part 36 cuts the pixels of the cutting area, of which the position is adjusted according to the shift amount from the shift amount determination part 35, from an image signal of a predetermined frame rate sequentially input from the image taking part 25 of the endoscopic device 11, and outputs, to the distortion removing part 37, a hand shake correction image signal obtained as a result.

[0032] When a rolling shutter distortion (which may occur when the shutter mechanism of the image taking part 25 is a rolling shutter) occurs in the hand shake correction image signal from the image cutting part 36, the distortion removing part 37 removes the distortion to output the resulting signal to the image output part 38. An existing arbitrary method may be applied to remove the rolling shutter distortion.

[0033] The image output part 38 outputs, to the downstream (in this case, the display device

13), the hand shake correction image signal input through the distortion removing part 37.

[0034] Next, the estimation of the rotation center position and the shift amount of the position of the cutting area will be described in detail with reference to Figs. 7 and 8.

[0035] Fig. 7 shows a relationship between the objective lens 22 of the endoscopic device 11, the gyro part 26, and the rotation center position. Fig. 8 shows a relationship between the moving amount of the objective lens 22 and the angular velocity of the gyro part 26.

[0036] As shown in Fig. 7, a distance between the objective lens 22 and the gyro part 26 is represented by d, a distance between the objective lens 22 and the rotation center is represented by a, and a distance between the rotation center and the gyro part 26 is represented by b. When the endoscopic device 11 is used in a laparoscopic operation in the state shown in Fig. 1, the trocar 2 becomes a rotation center.

[0037] The relationship between the moving amount (Dx, Dy, Dz) of the objective lens 22 and the angular velocity (Yaw angular velocity w_y, Pitch angular velocity w_p) of the gyro part 26 is as the following expression (1) (approximate expression).

$Dx=a$ degree $\sin(w_y t)$

$Dy=a$ degree $\sin(w_p t)$

$Dz=a(1-\cos(w_y t))(1-\cos(w_p t))$ (1)

t represents a one-frame time.

[0038] In addition, the relationship between the detected global motion vector (Vx, Vy) and the angular velocity (Yaw angular velocity w_y, Pitch angular velocity w_p) of the gyro part 26 is as the following expression (2) (approximate expression).

$Vx=a$ degree $\sin(w_y t)$

$Vy=a$ degree $\sin(w_p t)$ (2)

t represents a one-frame time.

[0039] In the rotation center position estimation part 32, the sequentially input angular velocity and the leveled global motion vector are applied to the expression (2) to calculate a value of the position a of the rotation center.

[0040] In the shift amount determination part 35, the leveled rotation center position a and the leveled angular velocity are applied to the expression (1) to calculate the moving amounts Dx, Dy, and Dz of the objective lens 22 and to determine a shift amount of the cutting area based on these moving amounts.

[0041] (Description of Operation)

Next, Fig. 9 is a flowchart illustrating the image correction process of the image correction device 12.

[0042] In Step S1, the input of an image signal of a predetermined frame rate and the input of an angular velocity signal indicating the motion of the head part 24 are started from the endoscopic device 11 to the image correction device 12. The image signal is input to the global motion vector calculation part 31 and the image cutting part 36, and the angular velocity signal is input to the rotation center position estimation part 32 and the angular velocity leveling part 34.

[0043] In Step S2, in the global motion vector calculation part 31, the local motion detection part 41 divides an image of an image signal input from the upstream into blocks having a predetermined size and performs comparison with an image signal before one frame per block to calculate a local motion vector in a block unit and a reliability thereof. In Step S3, the global motion leveling part 42 of the global motion vector calculation part 31 integrates a high-reliability local motion vector among the local motion vectors of the blocks of the respective frames to determine a global motion vector of the corresponding frame, and levels global motion vectors of several frames before the corresponding frame to output the result of the leveling to the rotation center position estimation part 32.

[0044] In Step S4, in the rotation center position estimation part 32, the sequentially input angular velocity and the leveled global motion vector are applied to the expression (2) to calculate a value of the position a of the rotation center. In Step S5, the rotation center position leveling part 33 performs leveling by integrating the estimated rotation center position in the time direction, and outputs the result of the leveling to the shift amount determination part 35.

[0045] In the angular velocity leveling part 34, in Step S6, the leveling is performed by integrating the angular velocity of the head part 24 detected by the gyro part 26 of the endoscopic device 11 in the time direction, and the result of the leveling is output to the shift amount determination part 35 and the distortion removing part 37. In Step S7, the shift amount determination part 35 calculates the moving amount of the objective lens 22 based on the leveled rotation center position and the leveled angular velocity, and determines a shift amount of the image cutting area from the calculated moving amount of the objective lens 22 to notify the image cutting part 36 of the result of the determination.

[0046] In Step S8, the image cutting part 36 cuts the pixels of the cutting area, of which the position is adjusted according to the shift amount from the shift amount determination part 35, from the image signal of a predetermined frame rate sequentially input from the endoscopic device 11, and outputs, to the distortion removing part 37, a hand shake correction image signal obtained as a result.

[0047] In Step S9, when a rolling shutter distortion occurs in the hand shake correction image signal from the image cutting part 36, the distortion removing part 37 removes the distortion to output the resulting signal to the image output part 38. The image output part 38 outputs, to the display device 13, the hand shake correction image signal input through the distortion removing part 37. The description of the image correction process is finished.

[0048] As described above, the endoscopic system 10 according to this embodiment can correct hand shake which may occur in a video image taken by the endoscopic device 11.

[0049] In addition, the endoscopic system 10 according to this embodiment can notify a user such as a doctor of, for example, the value of the the estimated position a of the rotation center (trocar). Accordingly, the user can grasp the length of the part which is inserted into the abdominal cavity.

[0050] In addition, for example, when a 3D measurement functions is applied to the endoscopic device 11, the positional relationship between the affected part which is a subject and the rotation center (trocar) can be easily calculated.

[0051] Furthermore, for example, when a plurality of images obtained as a result of taking the images by moving the endoscopic device 11 with the trocar acting as a rotation center are subjected to stitching composition based on the rotation center position and the angular velocity as shown in Fig. 10, a wide-viewing angle image with high accuracy can be obtained with a relatively small processing amount.

[0052] The above-described series of processes of the image correction device 12 can be executed by hardware or software. When executing the series of processes by software, a program constituting the software is installed in a computer. Here, the computer includes a computer incorporated in dedicated hardware, and a computer such as a general-purpose personal computer which can execute various functions through installation of various programs.

[0053] Fig. 11 is a block diagram showing an example of a configuration of hardware of the computer which executes the above-described series of processes using a program.

[0054] In a computer 100, a central processing unit (CPU) 101, a read only memory (ROM) 102, and a random access memory (RAM) 103 are connected to each other through a bus 104.

[0055] Furthermore, an input/output interface 105 is connected to the bus 104. An input part 106, an output part 107, a storage part 108, a communication part 109, and a drive 110 are connected to the input/output interface 105.

[0056] The input part 106 is composed of a keyboard, a mouse, a microphone, or the like. The output part 107 is composed of a display, a speaker, or the like. The storage part 108 is composed of a hard disk, a nonvolatile memory, or the like. The communication part 109 is composed of a network interface or the like. The drive 110 drives a removable medium 111 such as a magnetic disk, an optical disk, a magneto-optical disk, or a semiconductor memory.

[0057] In the computer 100 configured as described above, the CPU 101 executes, for example, a program stored in the storage part 108 by loading the program to the RAM 103 through the input/output interface 105 and the bus 104, and thus the above-described series of processes are performed.

[0058] The program which is executed by the computer 100 (CPU 101) can be provided by being recorded on, for example, the removable medium 111 as a package medium or the like. In addition, the program can be provided through a wired or wireless transmission medium such as local area network, the Internet, or digital satellite broadcasting.

[0059] The program which is executed by the computer 100 may be a program for performing the processes chronologically along the order described in the present description, or a program for performing the processes in parallel or at necessary timings such as when there is a call.

[0060] The embodiments of the present disclosure are not limited to the above-described embodiments, and various modifications can be made without departing from the gist of the present disclosure.

[0061] Further, the present technology may employ the following configurations.

(1) An image processing device that processes images obtained by an endoscopic device including: circuitry configured to estimate an approximate center of rotation of the endoscopic device based on motion detection in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.

(2) The image processing device of (1), wherein the motion detection includes determining an angular velocity.

(3) The image processing device of any of (1) to (2), wherein determining the motion detection includes analysis of relative motion of multiple images obtained by the endoscopic device.

(4) The image processing device of (3), wherein the analysis of relative motion of multiple images includes determining a motion vector of whole images obtained by the objective lens.

(5) The image processing device of any of (1) to (4), wherein the motion detection includes obtaining an angular velocity of the proximal portion of the endoscopic device.

(6) The image processing device of (5), wherein the angular velocity of the proximal portion of the endoscopic device is detected by a motion sensor at the proximal portion of the endoscopic device.

(7) The image processing device of any of (1) to (6), wherein the circuitry removes instantaneous error values in the estimated approximate center of rotation based on an integration of estimated approximate center of rotation values over time.

(8) The image processing device of (2), wherein the circuitry removes instantaneous error values in the angular velocity based on an integration of detected angular velocity values over time.
(9) The image processing device of any of (1) to (8), wherein the circuitry removes rolling shutter distortion in images obtained by the endoscopic device.
(10) The image processing device of any of (1) to (9), wherein the circuitry corrects hand shake in images obtained by the endoscopic device based on the approximate center of rotation of the endoscopic device.
(11) The image processing device of any of (1) to (10), wherein the circuitry combines a plurality of images obtained by moving the endoscopic device based on the approximate center of rotation of the endoscopic device.
(12) The image processing device of any of (1) to (11), wherein the circuitry determines a length of insertion of the treatment device based on the approximate center of rotation of the endoscopic device.
(13) The image processing device of any of (1) to (12), wherein the circuitry determines a positional relationship between a target treatment site and the treatment device based on the approximate center of rotation of the endoscopic device.
(14) An endoscopic system, including: an endoscopic device that includes an objective lens at a distal portion thereof; and an image processing device that includes circuitry configured to estimate an approximate center of rotation of the endoscopic device based on motion detection in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.
(15) The endoscopic system of (14), wherein the motion detection includes determining an angular velocity.
(16) The endoscopic system of any of (14) to (15), wherein determining the motion detection includes analysis of relative motion of multiple images obtained by the endoscopic device.
(17) The endoscopic system of any of (14) to (16), wherein the image processing device corrects hand shake in images obtained by the endoscopic device.
(18) The endoscopic system of any of (14) to (17), wherein the image processing device produces a wide-viewing angle image by combining a plurality of images based on the approximate center of rotation of the endoscopic device.
(19) The endoscopic system of (18), wherein the image processing device produces the wide-viewing angle image by combining the plurality of images based on a detected angular velocity of the endoscopic device.
(20) The endoscopic system of any of (14) to (19), wherein the endoscopic device is a rigid endoscope.

(21) A method of processing images obtained by an endoscopic device, comprising: estimating, based on motion detection, an approximate center of rotation of the endoscopic device in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.
(22) An method of performing a laparoscopic procedure, comprising: inserting a treatment device through a trocar positioned in a patient; and obtaining, based on motion detection, information regarding an approximate center of rotation of the treatment device in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.
(23) The method of performing a laparoscopic procedure according to (22), wherein the treatment device is a rigid endoscope.
(24) The method of performing a laparoscopic procedure according to any of (22) to (23), further including determining a length of insertion of the treatment device based on the approximate center of rotation.
(25) The method of performing a laparoscopic procedure according to any of (22) to (24), further comprising determining a positional relationship between a target treatment site and the treatment device based on the approximate center of rotation.
(26) The method of performing a laparoscopic procedure according to (25), wherein the determining the positional relationship between the target treatment site and the treatment device includes measuring the target treatment site in three dimensions.
(27) An endoscopic system includes: an endoscopic device in which an objective lens is provided at a tip end of an insertion part which is inserted into a body cavity, a head part is provided at a base end, and a gyro part which detects a moving angular velocity of the head part is provided in the head part; and an image processing device including a global motion calculation part which calculates, from an image signal which is input from the endoscopic device and corresponds to an optical image converged by the objective lens, a motion of the entire image corresponding to the image signal, and an estimation part which estimates, based on the calculated motion of the entire image and the detected angular velocity, a position of a rotation center when the objective lens is moved according to the motion of the head part.
(28) The endoscopic system according to (27), in which the image processing device is further provided with a correction part which corrects hand shake of the image signal by cutting a cutting area from an effective pixel area of the image signal input from the endoscopic device, and the cutting area is determined based on the estimated position of the rotation center and the detected angular velocity.
(29) The endoscopic system according to (27) or (28), in which the image processing device is further provided with an objective lens moving amount calculation part which calculates a moving amount of the objective lens based on the estimated position of the

rotation center and the detected angular velocity.
(30) The endoscopic system according to (29), in which the objective lens moving amount calculation part further determines a shift amount of the cutting area based on the calculated moving amount of the objective lens, and the correction part corrects the hand shake of the image signal by adjusting a position of the cutting area according to the determined shift amount.
(31) The endoscopic system according to any one of (28) to (30), in which the correction part corrects the hand shake of each image signal input at a predetermined frame rate from the endoscopic device, and the estimation part estimates the position of the rotation center at a frequency which is equal to or lower than the predetermined frame rate.
(32) The endoscopic system according to any one of (27) to (31), in which the image processing device is further provided with a rotation center position leveling part which levels the estimated position of the rotation center in a time direction.
(33) The endoscopic system according to any one of (27) to (32), in which the image processing device is further provided with an angular velocity leveling part which levels the detected angular velocity in a time direction.
(34) The endoscopic system according to any one of (28) to (33), in which the image processing device is further provided with a distortion removing part which removes a rolling shutter distortion of the image signal subjected to the hand shake correction.
(35) An image processing device includes: a global motion calculation part which calculates, from an image signal which is input from an endoscopic device in which an objective lens is provided at a tip end of an insertion part which is inserted into a body cavity, a head part is provided at a base end, and a gyro part which detects a moving angular velocity of the head part is provided in the head part, and corresponds to an optical image converged by the objective lens, a motion of the entire image corresponding to the image signal; and an estimation part which estimates, based on the calculated motion of the entire image and the angular velocity input from the endoscopic device, a position of a rotation center when the objective lens is moved according to the motion of the head part.
(36) An image processing method which is performed by an image processing device which processes an image signal which is input from an endoscopic device in which an objective lens is provided at a tip end of an insertion part which is inserted into a body cavity, a head part is provided at a base end, and a gyro part which detects a moving angular velocity of the head part is provided in the head part, and corresponds to an optical image converged by the objective lens, includes: calculating a motion of the entire image corresponding to the image signal; and estimating, based on the calculated motion of the entire image and the angular velocity input from the endoscopic device,

a position of a rotation center when the objective lens is moved according to the motion of the head part.

(37) A program which causes a computer to function as: a global motion calculation part which calculates, from an image signal which is input from an endoscopic device in which an objective lens is provided at a tip end of an insertion part which is inserted into a body cavity, a head part is provided at a base end, and a gyro part which detects a moving angular velocity of the head part is provided in the head part, and corresponds to an optical image converged by the objective lens, a motion of the entire image corresponding to the image signal; and an estimation part which estimates, based on the calculated motion of the entire image and the angular velocity input from the endoscopic device, a position of a rotation center when the objective lens is moved according to the motion of the head part.

[0062] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

Reference Signs List

[0063] 2 Trocar

10 Endoscopic system

11 Endoscopic device

12 Image correction device

13 Display device

21 Tube part

22 Objective lens

23 Optical lens part

24 Head part

25 Image taking part

26 Gyro part

31 Global motion vector calculation part

32 Rotation center position estimation part

33 Rotation center position leveling part

34 Angular velocity leveling Part

35 Shift amount determination part

36 Image cutting part

37 Distortion removing part

38 Image output part

41 Local motion detection part

42 Global motion leveling part
100 Computer
101 CPU

Claims

[Claim 1] An image processing device that processes images obtained by an endoscopic device, comprising:
circuitry configured to estimate an approximate center of rotation of the endoscopic device based on motion detection in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.

[Claim 2] The image processing device of claim 1, wherein the motion detection includes determining an angular velocity.

[Claim 3] The image processing device of claim 1, wherein determining the motion detection includes analysis of relative motion of multiple images obtained by the endoscopic device.

[Claim 4] The image processing device of claim 3, wherein the analysis of relative motion of multiple images includes determining a motion vector of whole images obtained by the objective lens.

[Claim 5] The image processing device of claim 1, wherein the motion detection includes obtaining an angular velocity of the proximal portion of the endoscopic device.

[Claim 6] The image processing device of claim 5, wherein the angular velocity of the proximal portion of the endoscopic device is detected by a motion sensor at the proximal portion of the endoscopic device.

[Claim 7] The image processing device of claim 1, wherein the circuitry removes instantaneous error values in the estimated approximate center of rotation based on an integration of estimated approximate center of rotation values over time.

[Claim 8] The image processing device of claim 2, wherein the circuitry removes instantaneous error values in the angular velocity based on an integration of detected angular velocity values over time.

[Claim 9] The image processing device of claim 1, wherein the circuitry removes rolling shutter distortion in images obtained by the endoscopic device.

[Claim 10] The image processing device of claim 1, wherein the circuitry corrects hand shake in images obtained by the endoscopic device based on the approximate center of rotation of the endoscopic device.

[Claim 11] The image processing device of claim 1, wherein the circuitry combines a plurality of images obtained by moving the endoscopic device based on the approximate center of rotation of the endoscopic device.

[Claim 12] The image processing device of claim 1, wherein the circuitry determines a length of insertion of the treatment device based on the approximate center of rotation of the endoscopic device.

[Claim 13] The image processing device of claim 1, wherein the circuitry determines a positional relationship between a target treatment site and the treatment device based on the approximate center of rotation of the endoscopic device.

[Claim 14] An endoscopic system, comprising:
an endoscopic device that includes an objective lens at a distal portion thereof; and
an image processing device that includes circuitry configured to estimate an approximate center of rotation of the endoscopic device based on motion detection in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.

[Claim 15] The endoscopic system of claim 14, wherein the motion detection includes determining an angular velocity.

[Claim 16] The endoscopic system of claim 14, wherein determining the motion detection includes analysis of relative motion of multiple images obtained by the endoscopic device.

[Claim 17] The endoscopic system of claim 14, wherein the image processing device corrects hand shake in images obtained by the endoscopic device.

[Claim 18] The endoscopic system of claim 14, wherein the image processing device produces a wide-viewing angle image by combining a plurality of images based on the approximate center of rotation of the endoscopic device.

[Claim 19] The endoscopic system of claim 18, wherein the image processing device produces the wide-viewing angle image by combining the plurality of images based on a detected angular velocity of the endoscopic device.

[Claim 20] The endoscopic system of claim 14, wherein the endoscopic device is a rigid endoscope.

[Claim 21] A method of processing images obtained by an endoscopic device, comprising:
estimating, based on motion detection, an approximate center of rotation of the endoscopic device in response to a movement of an objective lens at a distal portion of the endoscopic device by ma-

nipulating a proximal portion of the endoscopic device.

[Claim 22] A method of performing a laparoscopic procedure, comprising: inserting a treatment device through a trocar positioned in a patient; and obtaining, based on motion detection, information regarding an approximate center of rotation of the treatment device in response to a movement of an objective lens at a distal portion of the endoscopic device by manipulating a proximal portion of the endoscopic device.

[Claim 23] The method of performing a laparoscopic procedure according to claim 22, wherein the treatment device is a rigid endoscope.

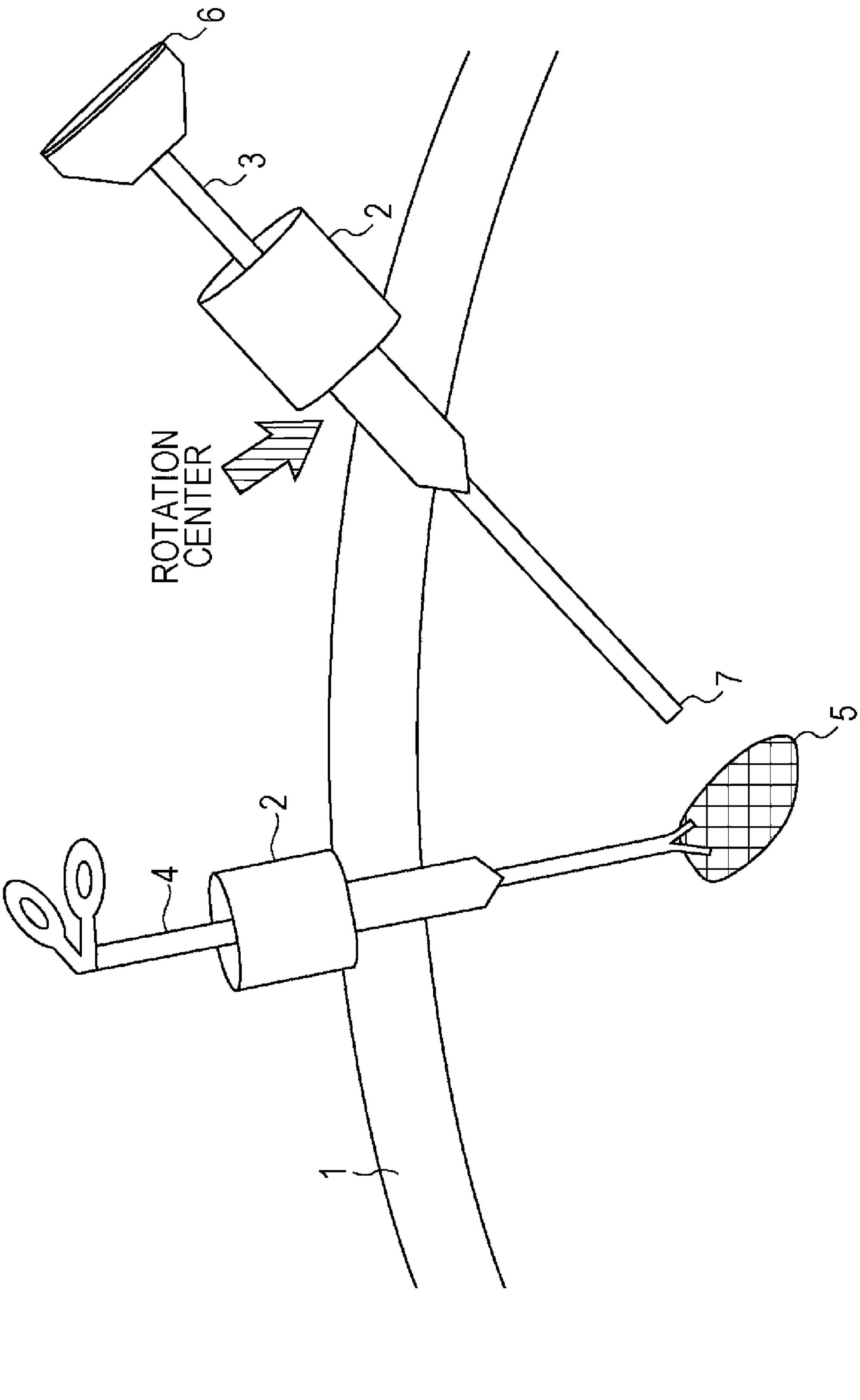
[Claim 24] The method of performing a laparoscopic procedure according to claim 22, further comprising determining a length of insertion of the treatment device based on the approximate center of rotation.

[Claim 25] The method of performing a laparoscopic procedure according to claim 22, further comprising determining a positional relationship between a target treatment site and the treatment device based on the approximate center of rotation.

[Claim 26] The method of performing a laparoscopic procedure according to claim 25, wherein the determining the positional relationship between the target treatment site and the treatment device includes measuring the target treatment site in three dimensions.

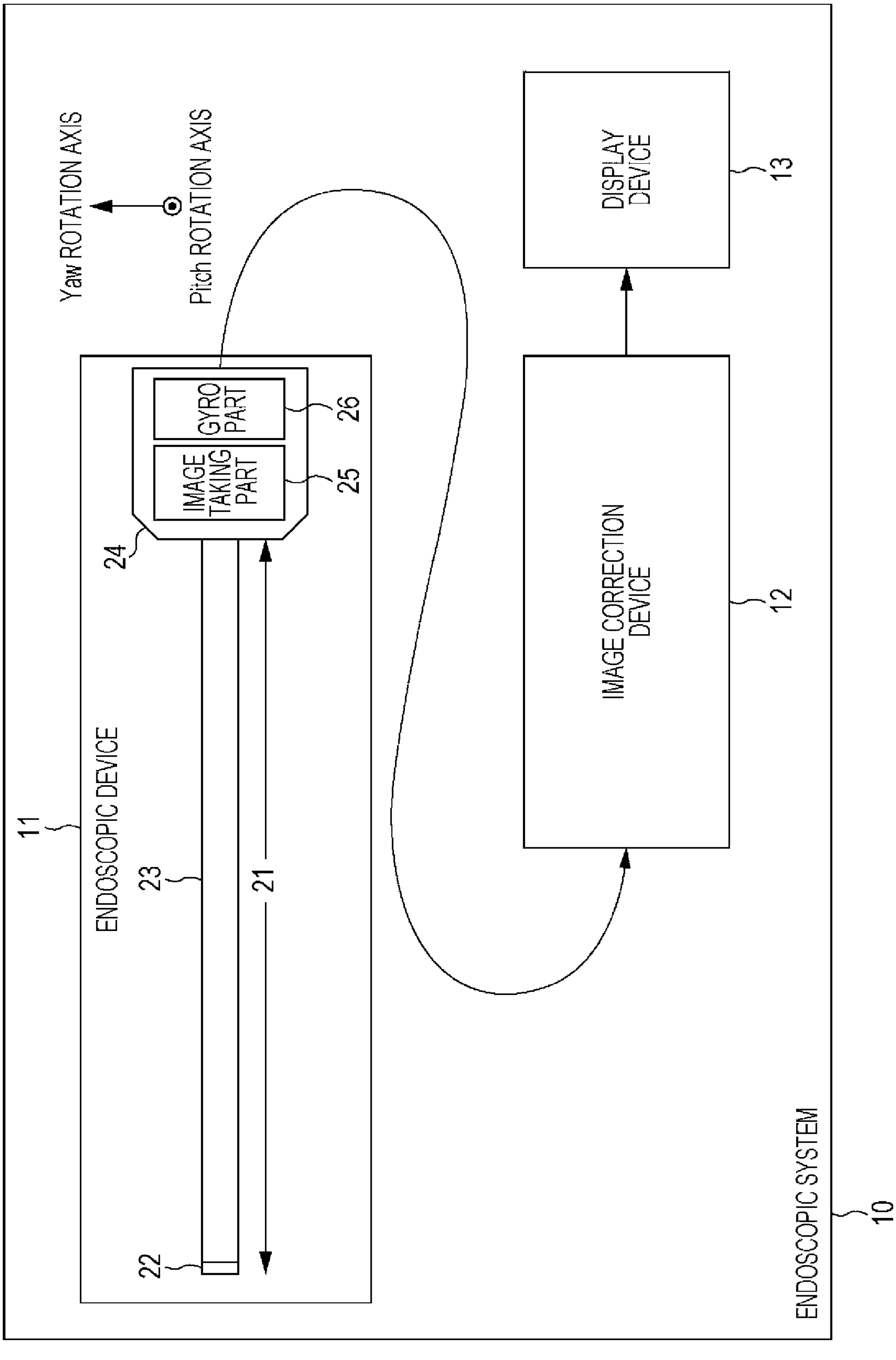
[Fig. 1]

FIG. 1



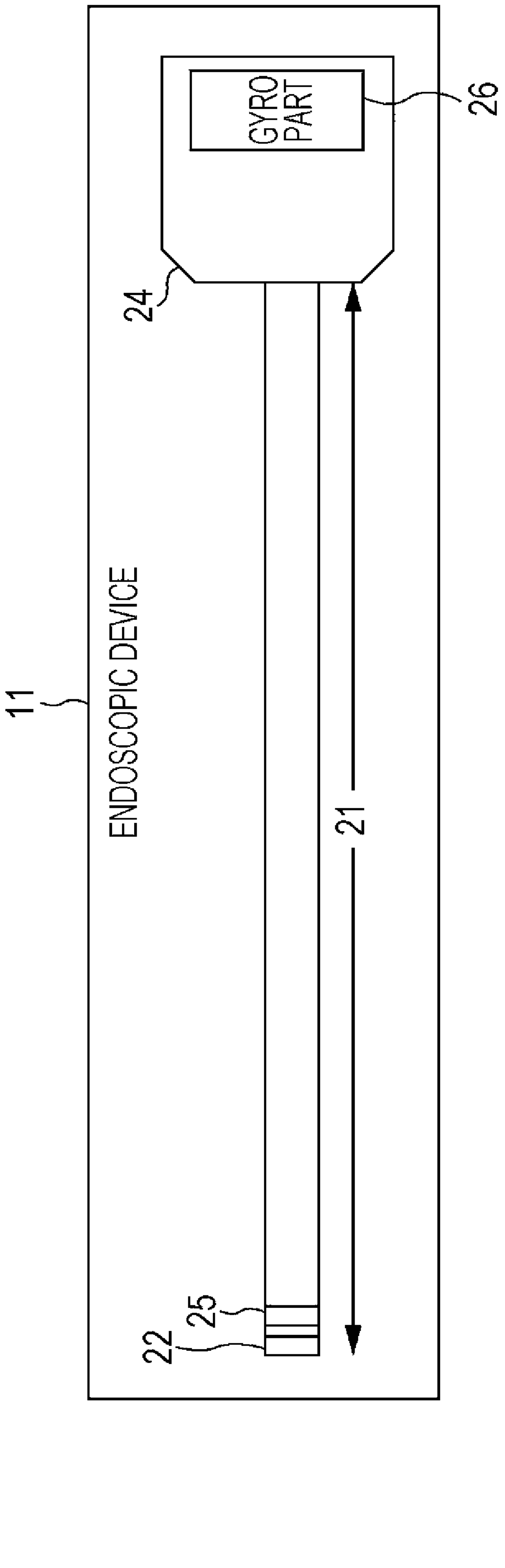
[Fig. 2]

FIG. 2


Yaw ROTATION AXIS
Pitch ROTATION AXIS
DISPLAY DEVICE
13
GYRO PART
26
IMAGE TAKING PART
25
24
IMAGE CORRECTION DEVICE
12
ENDOSCOPIC DEVICE
11
23
21
22
ENDOSCOPIC SYSTEM
10

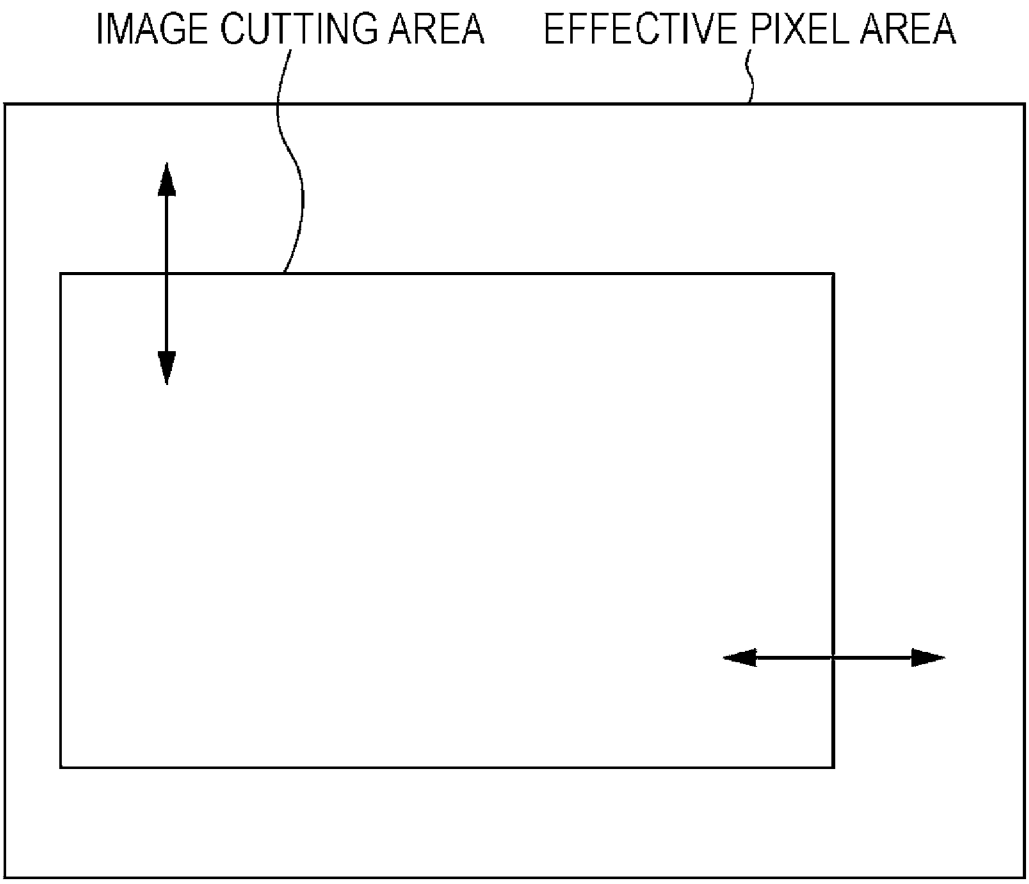
[Fig. 3]

FIG. 3



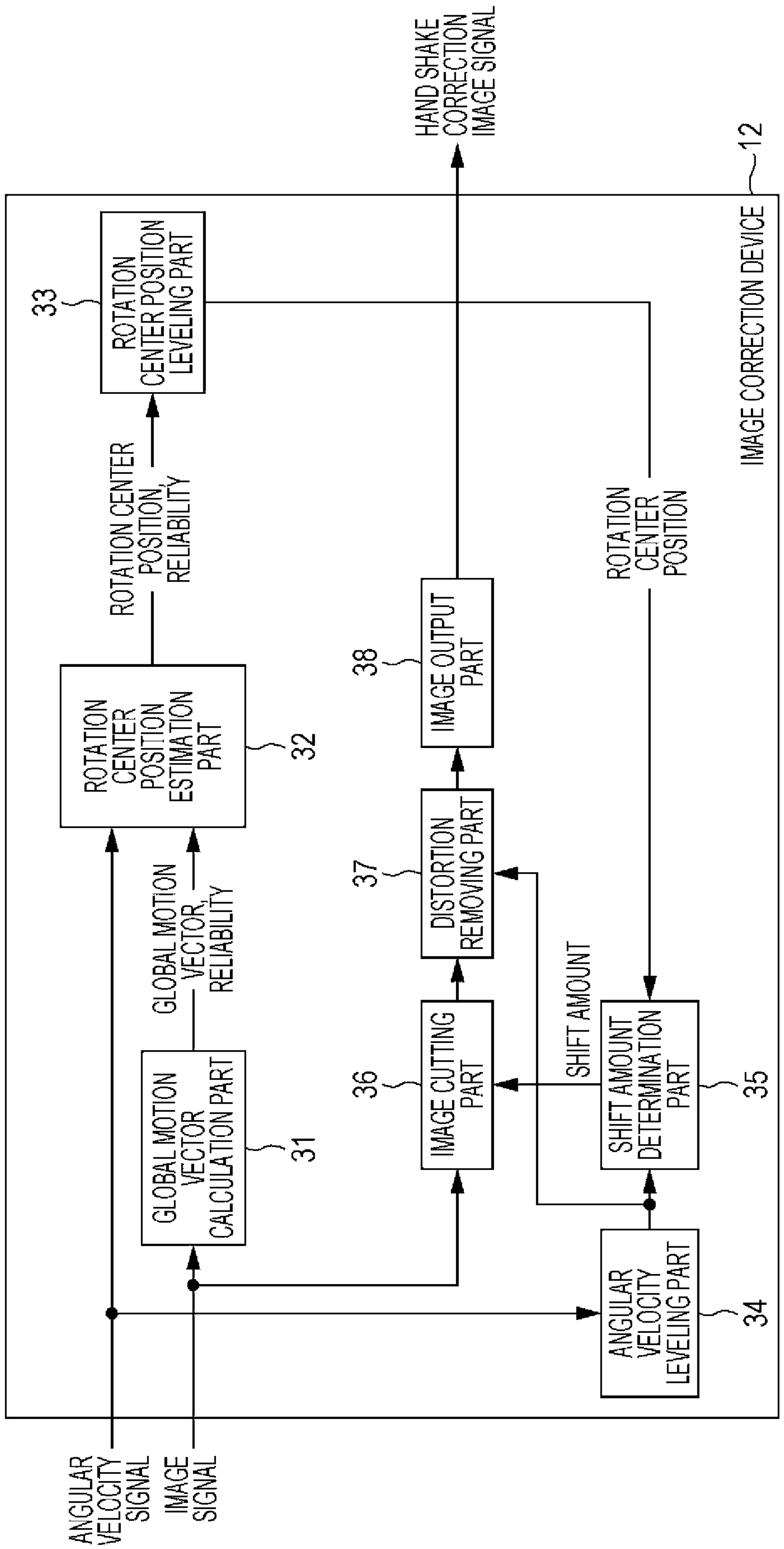
[Fig. 4]

FIG. 4



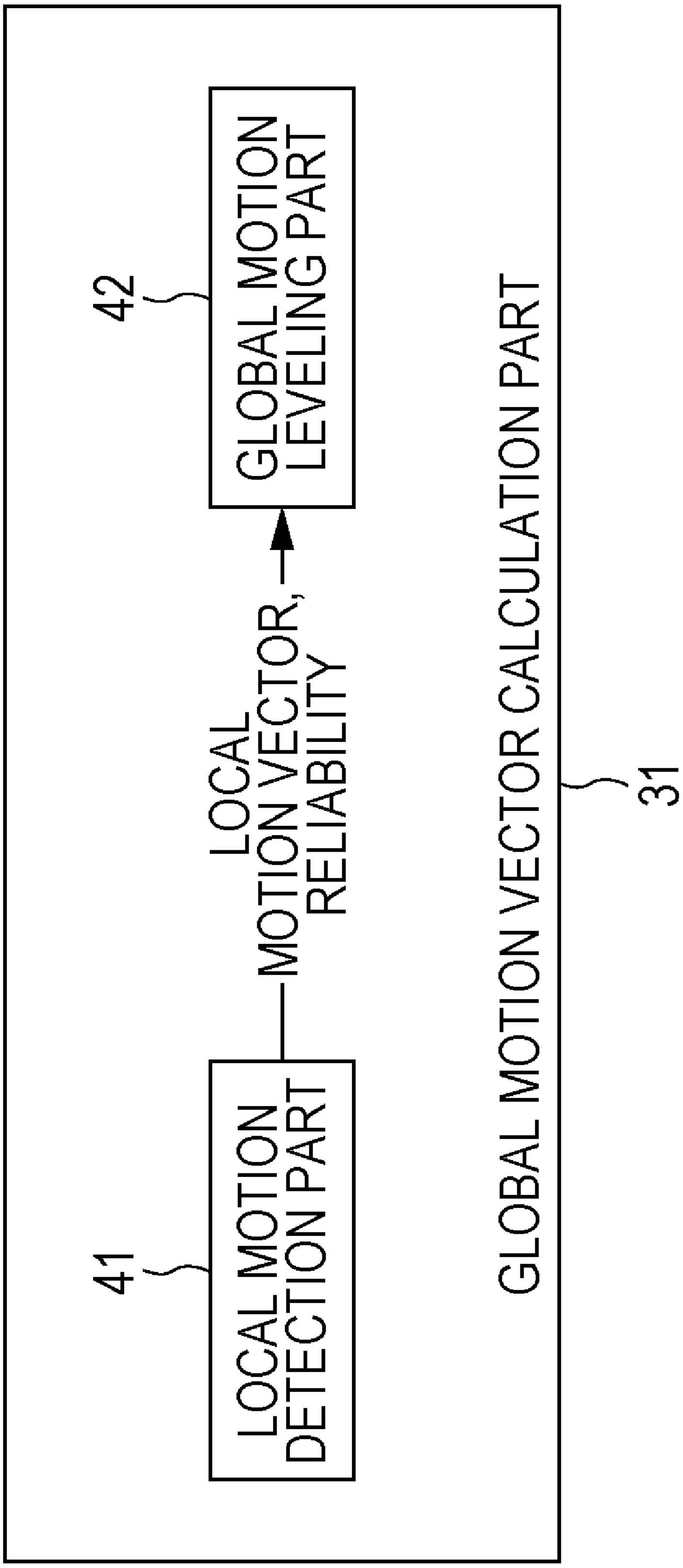
[Fig. 5]

FIG. 5


HAND SHAKE CORRECTION IMAGE SIGNAL
12
IMAGE CORRECTION DEVICE
33
ROTATION CENTER POSITION LEVELING PART
ROTATION CENTER POSITION, RELIABILITY
ROTATION CENTER POSITION
32
ROTATION CENTER POSITION ESTIMATION PART
38
IMAGE OUTPUT PART
37
DISTORTION REMOVING PART
GLOBAL MOTION VECTOR, RELIABILITY
SHIFT AMOUNT
31
GLOBAL MOTION VECTOR CALCULATION PART
36
IMAGE CUTTING PART
35
SHIFT AMOUNT DETERMINATION PART
34
ANGULAR VELOCITY LEVELING PART
ANGULAR VELOCITY SIGNAL
IMAGE SIGNAL

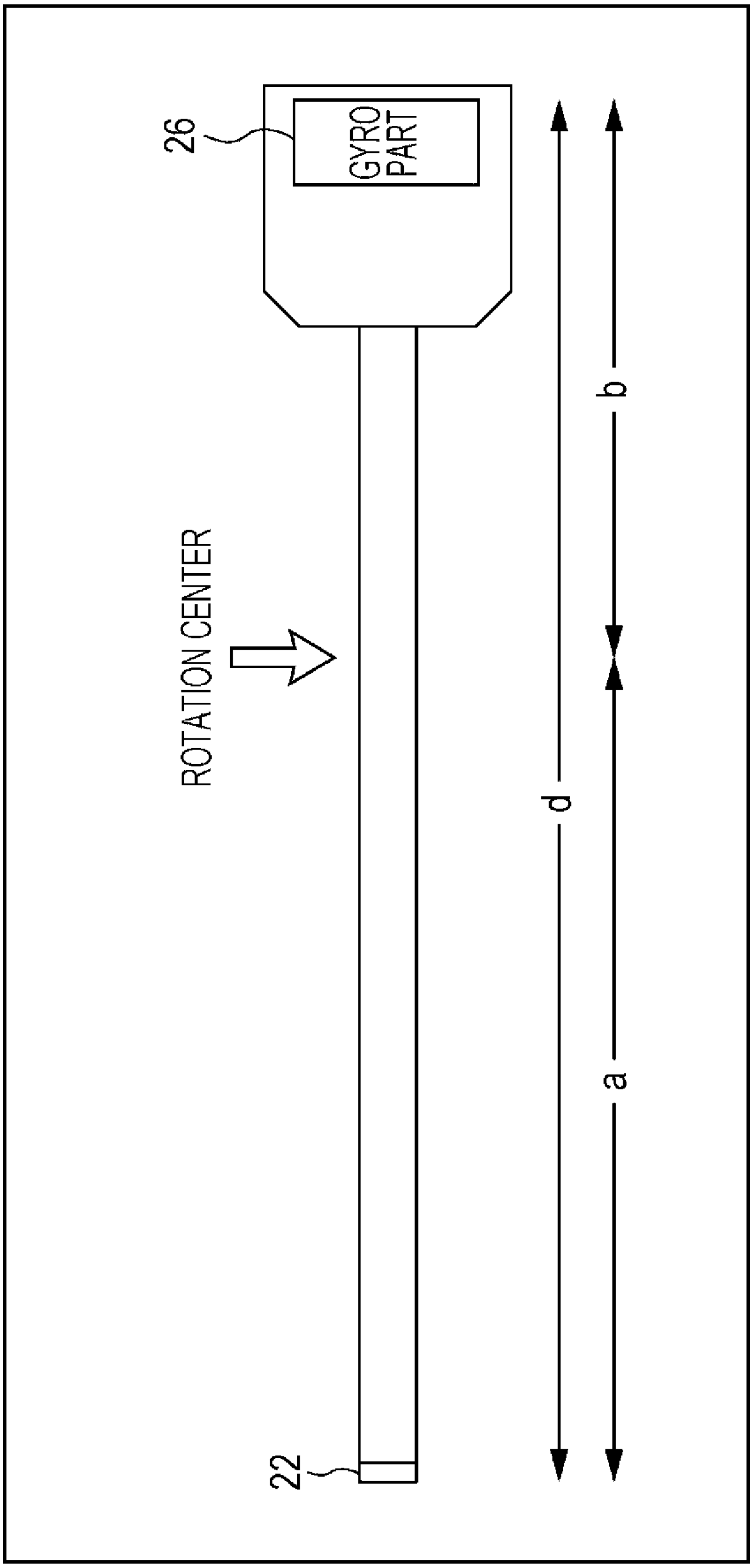
[Fig. 6]

FIG. 6


GLOBAL MOTION LEVELING PART
42
LOCAL MOTION VECTOR, RELIABILITY
LOCAL MOTION DETECTION PART
41
GLOBAL MOTION VECTOR CALCULATION PART
31

[Fig. 7]

FIG. 7



[Fig. 8]

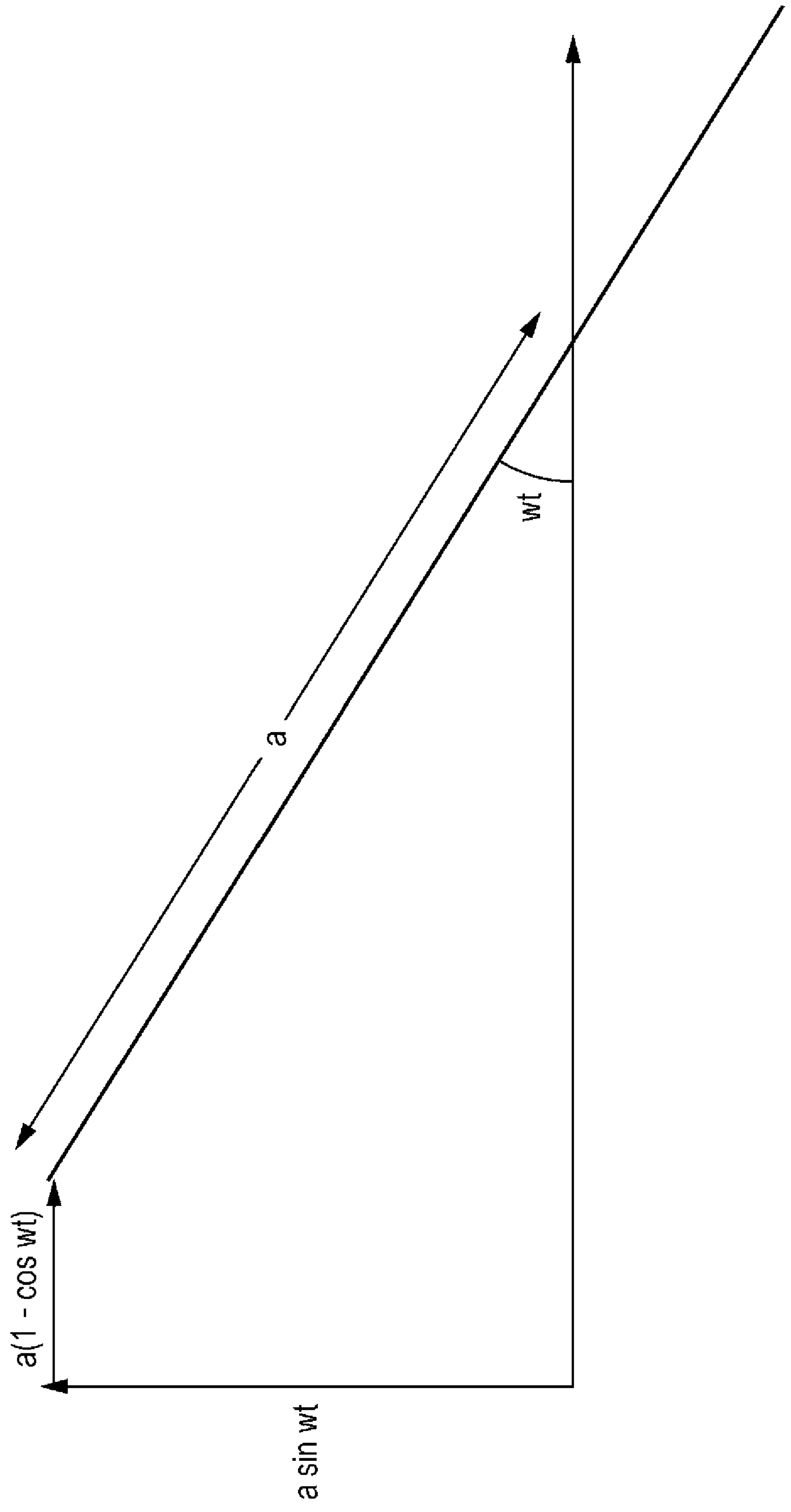
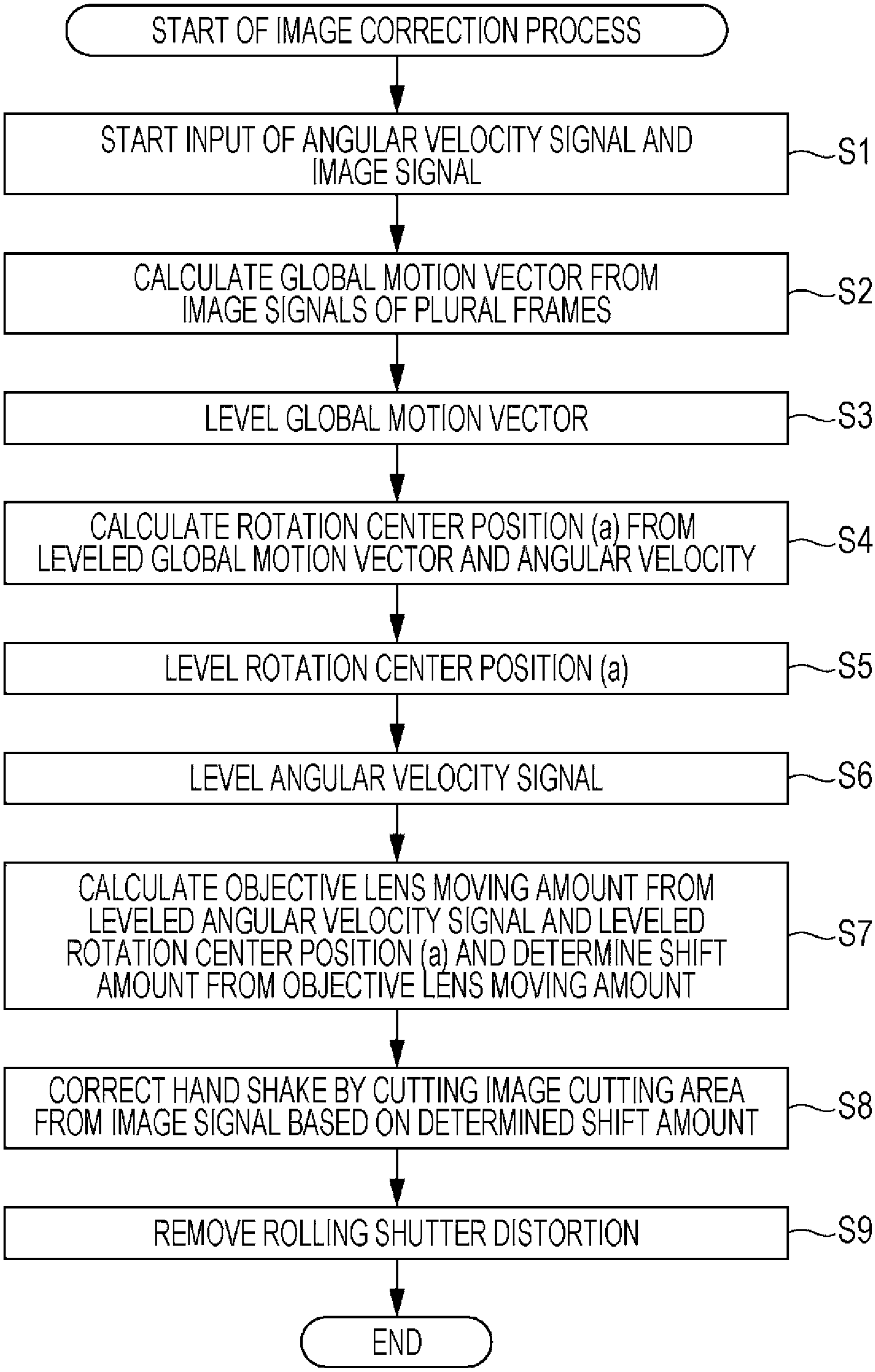


FIG. 8

[Fig. 9]

FIG. 9


START OF IMAGE CORRECTION PROCESS
START INPUT OF ANGULAR VELOCITY SIGNAL AND IMAGE SIGNAL
S1
CALCULATE GLOBAL MOTION VECTOR FROM IMAGE SIGNALS OF PLURAL FRAMES
S2
LEVEL GLOBAL MOTION VECTOR
S3
CALCULATE ROTATION CENTER POSITION (a) FROM LEVELED GLOBAL MOTION VECTOR AND ANGULAR VELOCITY
S4
LEVEL ROTATION CENTER POSITION (a)
S5
LEVEL ANGULAR VELOCITY SIGNAL
S6
CALCULATE OBJECTIVE LENS MOVING AMOUNT FROM LEVELED ANGULAR VELOCITY SIGNAL AND LEVELED ROTATION CENTER POSITION (a) AND DETERMINE SHIFT AMOUNT FROM OBJECTIVE LENS MOVING AMOUNT
S7
CORRECT HAND SHAKE BY CUTTING IMAGE CUTTING AREA FROM IMAGE SIGNAL BASED ON DETERMINED SHIFT AMOUNT
S8
REMOVE ROLLING SHUTTER DISTORTION
S9
END

[Fig. 10]

FIG. 10

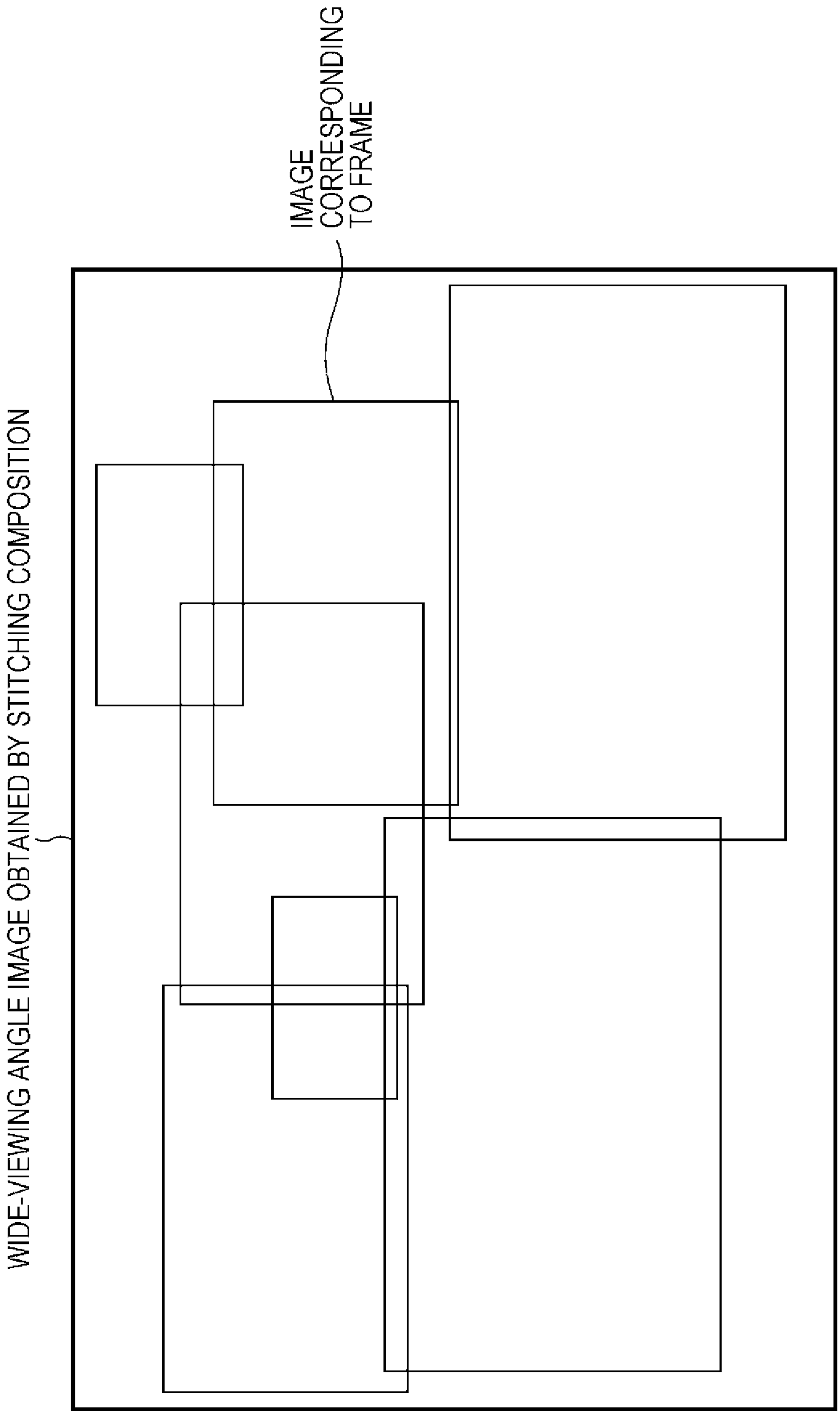
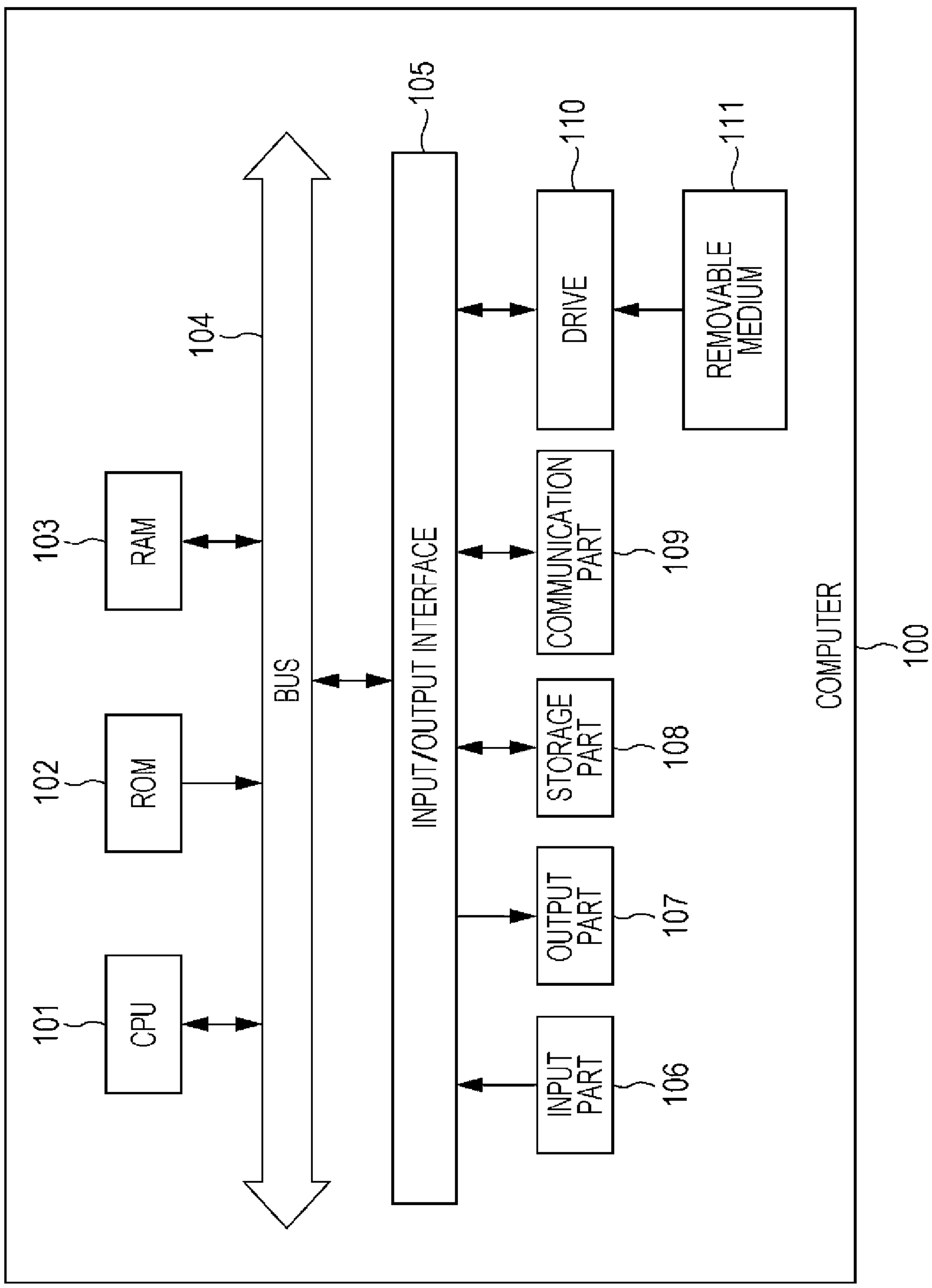


IMAGE
CORRESPONDING
TO FRAME
WIDE-VIEWING ANGLE IMAGE OBTAINED BY STITCHING COMPOSITION

[Fig. 11]

FIG. 11


101
CPU
102
ROM
103
RAM
104
BUS
105
INPUT/OUTPUT INTERFACE
106
INPUT PART
107
OUTPUT PART
108
STORAGE PART
109
COMMUNICATION PART
110
DRIVE
111
REMOVABLE MEDIUM
COMPUTER
100

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2015/000297

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B1/00
ADD.

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)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012/130168 A1 (KONOMURA YUTAKA [JP]) 24 May 2012 (2012-05-24)	1,3,5,9, 11-16, 18,20,21
Y	paragraph [0024] - paragraph [0056]	4
X	WO 2012/141193 A1 (FUJI FILM CORP) 18 October 2012 (2012-10-18) the whole document	1,2,6-8, 10,14, 16,17, 19,21
Y	EP 2 130 479 A1 (OLYMPUS MEDICAL SYSTEMS CORP [JP]) 9 December 2009 (2009-12-09) paragraph [0019]	4

☐ 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 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
15 April 2015	23/04/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Alvazzi Delfrate, S

2

International application No.
PCT/JP2015/000297

INTERNATIONAL SEARCH REPORT

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. [X] Claims Nos.: 22-26
because they relate to subject matter not required to be searched by this Authority, namely:
see FURTHER INFORMATION sheet PCT/ISA/210

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.1

Claims Nos.: 22-26

Claims 22-26 relate to subject-matter mentioned in Rule 39.1(iv) PCT, in particular to a method of surgical treatment of the human body (the "method of performing a laparoscopic procedure" comprises the step of inserting a treatment device in patient, and therefore it is clearly a surgical method). Under terms of Art.17(2)(a)(i) an International Searching Authority is not required to carry out a search of such claims.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/JP2015/000297

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012130168 A1	24-05-2012	NONE	
WO 2012141193 A1	18-10-2012	CN 103477277 A	25-12-2013
		EP 2698668 A1	19-02-2014
		JP 5519077 B2	11-06-2014
		US 2014036101 A1	06-02-2014
		WO 2012141193 A1	18-10-2012
EP 2130479 A1	09-12-2009	CN 101610712 A	23-12-2009
		EP 2130479 A1	09-12-2009
		JP 5030639 B2	19-09-2012
		JP 2008245839 A	16-10-2008
		US 2010016666 A1	21-01-2010
		WO 2008120508 A1	09-10-2008

专利名称(译)	内窥镜系统，图像处理设备，图像处理方法和程序		
公开(公告)号	EP3099213A1	公开(公告)日	2016-12-07
申请号	EP2015704390	申请日	2015-01-23
[标]申请(专利权)人(译)	索尼公司		
申请(专利权)人(译)	索尼公司		
当前申请(专利权)人(译)	索尼公司		
[标]发明人	HAYASHI TSUNEO		
发明人	HAYASHI, TSUNEO		
IPC分类号	A61B1/00		
CPC分类号	A61B1/00009 A61B1/00147 A61B1/00078 A61B1/00154 A61B1/00174 A61B1/3132 A61B17/00234 A61B17/3423 A61B34/75 A61B2034/2055 A61B2034/2065		
代理机构(译)	ðYOUNG＆CO LLP		
优先权	2014015575 2014-01-30 JP		
外部链接	Espacenet		

摘要(译)

为了解决上述问题，第一技术是一种图像处理装置，其被配置为通过操纵a来响应于内窥镜装置的远端部分处的物镜的移动，基于运动检测来估计内窥镜装置的近似旋转中心。内窥镜装置的近端部分。