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MEDICAL SUPPORT DEVICE, ENDOSCOPE, MEDICAL SUPPORT METHOD, AND PROGRAM

Abstract

A medical support device includes a processor, in which the processor is configured to acquire intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic of the duodenum; and output the intestinal tract direction-related information.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation application of International Application No. PCT/JP2023/036269, filed Oct. 4, 2023, the disclosure of which is incorporated herein by reference in its entirety. Further, this application claims priority from Japanese Patent Application No. 2022-177613, filed Nov. 4, 2022, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND
1. Technical Field
[0002] The technology of the present disclosure relates to a medical support device, an endoscope, a medical support method, and a program.
2. Description of the Related Art
[0003] JP2020-62218A discloses a learning apparatus comprising an acquisition unit that acquires a plurality of pieces of information in which an image of a duodenal Vater's papilla of a bile duct and information indicating a cannulation method, which is a method of inserting a catheter into the bile duct, are associated with each other; a learning unit that performs machine learning using the information indicating the cannulation method as training data based on the image of the duodenal Vater's papilla of the bile duct; and a storage unit that stores a result of the machine learning performed by the learning unit and the information indicating the cannulation method in association with each other.
SUMMARY
[0004] One embodiment according to the technology of the present disclosure provides a medical support device, an endoscope, a medical support method, and a program that allow a user to easily grasp to what extent a posture of an endoscope scope deviates with respect to an intestinal tract direction of a duodenum.
[0005] A first aspect according to the technology of the present disclosure is a medical support device comprising a processor, in which the processor is configured to acquire intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic of the duodenum; and output the intestinal tract direction-related information.
[0006] A second aspect according to the technology of the present disclosure is the medical support device according to the first aspect, in which the intestinal tract direction-related information includes deviation amount information indicating a deviation amount between a posture of the endoscope scope and the intestinal tract direction.
[0007] A third aspect according to the technology of the present disclosure is the medical support device according to the first aspect or the second aspect, in which the geometrical characteristic information includes an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope, and the processor is configured to acquire the intestinal tract direction-related information by executing first image recognition processing on the intestinal wall image.

[0008] A fourth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to third aspects, in which the outputting of the intestinal tract direction-related information includes displaying the intestinal tract direction-related information on a first screen.
[0009] A fifth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to fourth aspects, in which the intestinal tract direction-related information includes first direction information capable of specifying a first direction intersecting the intestinal tract direction at a predetermined angle.
[0010] A sixth aspect according to the technology of the present disclosure is the medical support device according to the fifth aspect, in which the first direction information is obtained by executing second image recognition processing on an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope.
[0011] A seventh aspect according to the technology of the present disclosure is the medical support device according to the sixth aspect, in which the first direction information is information obtained with a degree of certainty equal to or greater than a threshold value by performing image recognition processing using an AI method as the second image recognition processing.
[0012] An eighth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to seventh aspects, in which the processor is configured to acquire posture information capable of specifying a posture of the endoscope scope in a state in which the endoscope scope is inserted into the duodenum, the intestinal tract direction-related information includes posture adjustment support information for supporting adjustment of the posture, and the posture adjustment support information is information determined based on a deviation amount between the intestinal tract direction and the posture specified from the posture information.
[0013] A ninth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to eighth aspects, in which the intestinal tract direction-related information includes condition information indicating a condition for changing a posture of the endoscope scope to match an optical axis direction of a camera provided in the endoscope scope with a second direction intersecting the intestinal tract direction at a predetermined angle.
[0014] A tenth aspect according to the technology of the present disclosure is the medical support device according to the ninth aspect, in which the condition includes an operation condition related to an operation performed on the endoscope scope to match the optical axis direction with the second direction.
[0015] An eleventh aspect according to the technology of the present disclosure is the medical support device according to any one of the first to tenth aspects, in which, in a case where an optical axis direction of a camera provided in the endoscope scope matches a third direction intersecting the intestinal tract direction at a predetermined angle, the intestinal tract direction-related information includes notification information for notifying that the optical axis direction matches the third direction.
[0016] A twelfth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to eleventh aspects, in which the processor is configured to detect a duodenal papilla region by executing third image recognition processing on an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope; display the duodenal papilla region on a second screen; and display, on the second screen, papilla orientation information indicating an orientation of the duodenal papilla region, the papilla orientation information being obtained based on the intestinal tract direction-related information.
[0017] A thirteenth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to twelfth aspects, in which the processor is configured to detect a duodenal papilla region by executing fourth image recognition processing on

an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope; display the duodenal papilla region on a third screen; and display, on the third screen, running direction information indicating a running direction of a duct leading to an opening of the duodenal papilla region, the running direction information being obtained based on the intestinal tract direction-related information.

[0018] A fourteenth aspect according to the technology of the present disclosure is the medical support device according to the thirteenth aspect, in which the duct is a bile duct or a pancreatic duct.

[0019] A fifteenth aspect according to the technology of the present disclosure is the medical support device according to any one of the first to fourteenth aspects, in which the geometrical characteristic information includes depth information indicating a depth of the duodenum, and the intestinal tract direction-related information is acquired based on the depth information.

[0020] A sixteenth aspect according to the technology of the present disclosure is an endoscope comprising the medical support device according to any one of the first to fifteenth aspects, and the endoscope scope.

[0021] A seventeenth aspect according to the technology of the present disclosure is a medical support method comprising acquiring intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic of the duodenum; and outputting the intestinal tract direction-related information.

[0022] An eighteenth aspect according to the technology of the present disclosure is a program causing a computer to execute processing comprising acquiring intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic of the duodenum; and outputting the intestinal tract direction-related information.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** is a conceptual diagram showing an example of an aspect in which a duodenoscope system is used.

[0024] FIG. **2** is a conceptual diagram showing an example of an overall configuration of the duodenoscope system.

[0025] FIG. **3** is a block diagram showing an example of a hardware configuration of an electrical system of the duodenoscope system.

[0026] FIG. **4** is a conceptual diagram showing an example of an aspect in which a duodenoscope is used.

[0027] FIG. **5** is a block diagram showing an example of a hardware configuration of an electrical system of an image processing device.

[0028] FIG. **6** is a conceptual diagram showing an example of the correlation between an endoscope scope, a duodenoscope body, an image acquisition unit, an image recognition unit, and a derivation unit.

[0029] FIG. **7** is a conceptual diagram showing an example of the correlation between the display device, the image acquisition unit, the image recognition unit, the derivation unit, and a display control unit.

[0030] FIG. **8** is a flowchart showing an example of a flow of medical support processing.

[0031] FIG. **9** is a conceptual diagram showing an example of the correlation between the endoscope scope, the duodenoscope body, the image acquisition unit, the image recognition unit, and the derivation unit.

[0032] FIG. **10** is a conceptual diagram showing an example of the correlation between the endoscope scope, the duodenoscope body, the image acquisition unit, the image recognition unit, and the derivation unit.
[0033] FIG. **11** is a conceptual diagram showing an example of the correlation between the display device, the image recognition unit, the derivation unit, and the display control unit.
[0034] FIG. **12** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0035] FIG. **13** is a conceptual diagram showing an example of the correlation between the display device, the image recognition unit, the derivation unit, and the display control unit.
[0036] FIG. **14** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.
[0037] FIG. **15** is a conceptual diagram showing an example of the correlation between the endoscope scope, the duodenoscope body, the image acquisition unit, the image recognition unit, and the derivation unit.
[0038] FIG. **16** is a conceptual diagram showing an example of the correlation between the display device, the image recognition unit, the derivation unit, and the display control unit.
[0039] FIG. **17** is a conceptual diagram showing an example of an aspect in which the endoscope scope is made to directly face a papilla.
[0040] FIG. **18** is a conceptual diagram showing an example of the correlation between the endoscope scope, the duodenoscope body, the image acquisition unit, the image recognition unit, and the derivation unit.
[0041] FIG. **19** is a conceptual diagram showing an example of the correlation between the endoscope scope, the duodenoscope body, the image acquisition unit, the image recognition unit, and the derivation unit.
[0042] FIG. **20** is a conceptual diagram showing an example of the correlation between the display device, the image recognition unit, the derivation unit, and the display control unit.
[0043] FIG. **21** is a conceptual diagram showing an example of the correlation between the endoscope scope, the duodenoscope body, the image acquisition unit, the image recognition unit, and the derivation unit.
[0044] FIG. **22** is a conceptual diagram showing an example of the correlation between the display device, the image recognition unit, the derivation unit, and the display control unit.
[0045] FIG. **23** is a conceptual diagram showing an example of the correlation between the display device, the image recognition unit, the derivation unit, and the display control unit.
[0046] FIG. **24** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0047] FIG. **25** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.
[0048] FIG. **26** is a flowchart showing an example of a flow of medical support processing.
[0049] FIG. **27** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.
[0050] FIG. **28** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0051] FIG. **29** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.
[0052] FIG. **30** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0053] FIG. **31** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0054] FIG. **32** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.

[0055] FIG. **33** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0056] FIG. **34** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.
[0057] FIG. **35** is a conceptual diagram showing an example of the correlation between the endoscope scope, the image acquisition unit, the image recognition unit, and the derivation unit.
[0058] FIG. **36** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.
[0059] FIG. **37** is a conceptual diagram showing an example of the correlation between the display device, the derivation unit, and the display control unit.

DETAILED DESCRIPTION

[0060] Hereinafter, examples of embodiments of a medical support device, an endoscope, a medical support method, and a program according to the technology of the present disclosure will be described with reference to the accompanying drawings.
[0061] First, terms used in the following description will be described.
[0062] CPU is an abbreviation for “central processing unit”. GPU is an abbreviation for “graphics processing unit”. RAM is an abbreviation for random-access memory”. NVM is an abbreviation for “non-volatile memory”. EEPROM is an abbreviation for “electrically erasable programmable read-only memory”. ASIC is an abbreviation for “application-specific integrated circuit”. PLD is an abbreviation for “programmable logic device”. FPGA is an abbreviation for “field-programmable gate array”. SoC is an abbreviation for “system-on-a-chip”. SSD is an abbreviation for “solid-state drive”. USB is an abbreviation for “Universal Serial Bus”. HDD is an abbreviation for “hard disk drive”. EL is an abbreviation for “electro-luminescence”. CMOS is an abbreviation for “complementary metal-oxide-semiconductor”. CCD is an abbreviation for “charge-coupled device”. AI is an abbreviation for “artificial intelligence”. BLI is an abbreviation for “blue light imaging”. LCI is an abbreviation for “linked color imaging”. I/F is an abbreviation for “interface”. FIFO is an abbreviation for “first in, first out”. ERCP is an abbreviation for “endoscopic retrograde cholangio-pancreatography”. ToF is an abbreviation for “time of flight”.

First Embodiment

[0063] For example, as shown in FIG. **1**, a duodenoscope system **10** comprises a duodenoscope **12** and a display device **13**. The duodenoscope **12** is used by a doctor **14** in endoscopy. The duodenoscope **12** is communicably connected to a communication device (not shown), and information obtained by the duodenoscope **12** is transmitted to the communication device. The communication device receives the information transmitted from the duodenoscope **12** and performs processing using the received information (for example, the processing of recording the information on an electronic medical record or the like).
[0064] The duodenoscope **12** comprises an endoscope scope **18**. The duodenoscope **12** is a device for performing medical care on an observation target **21** (for example, a duodenum) included in a body of a subject **20** (for example, a patient) using the endoscope scope **18**. The observation target **21** is a target observed by the doctor **14**. The endoscope scope **18** is inserted into the body of the subject **20**. The duodenoscope **12** causes the endoscope scope **18** inserted into the body of the subject **20** to image the observation target **21** inside the body of the subject **20**, and performs various medical treatments on the observation target **21** as necessary. The duodenoscope **12** is an example of an “endoscope” according to the technology of the present disclosure.
[0065] The duodenoscope **12** images the inside of the body of the subject **20** to acquire an image showing an aspect of the inside of the body and outputs the image. In the present embodiment, the duodenoscope **12** is an endoscope having an optical imaging function of irradiating the inside of the body with light to image the light reflected by the observation target **21**.
[0066] The duodenoscope **12** comprises a control device **22**, a light source device **24**, and an image processing device **25**. The control device **22** and the light source device **24** are installed in a wagon

34. A plurality of tables are provided in the wagon **34** in a vertical direction, and the image processing device **25**, the control device **22**, and the light source device **24** are installed from a lower table to an upper table. In addition, the display device **13** is installed on the uppermost table in the wagon **34**.

[0067] The control device **22** is a device that controls the entire duodenoscope **12**. In addition, the image processing device **25** is a device that performs image processing on the image captured by the duodenoscope **12** under the control of the control device **22**.

[0068] The display device **13** displays various types of information including an image (for example, an image subjected to image processing by the image processing device **25**). An example of the display device **13** includes a liquid-crystal display or an EL display. In addition, a tablet terminal with a display may be used instead of the display device **13** or together with the display device **13**.

[0069] A plurality of screens are displayed side by side on the display device **13**. In the example shown in FIG. **1**, screens **36**, **37**, and **38** are shown. An endoscopic image **40** obtained by the duodenoscope **12** is displayed on the screen **36**. The observation target **21** is captured in the endoscopic image **40**. The endoscopic image **40** is an image obtained by imaging the observation target **21** with a camera **48** (see FIG. **2**) provided in the endoscope scope **18** inside the body of the subject **20**. An example of the observation target **21** includes an intestinal wall of a duodenum. In the following, for convenience of description, an intestinal wall image **41**, which is an endoscopic image **40** in which the intestinal wall of the duodenum is imaged, is described as an example of the observation target **21**. In addition, the duodenum is merely an example, and any region that can be imaged by the duodenoscope **12** may be used. For example, an esophagus or a stomach is given as an example of the region that can be imaged by the duodenoscope **12**. The intestinal wall image **41** is an example of the “intestinal wall image” and the “geometrical characteristic information” according to the technology of the present disclosure.

[0070] A moving image including a plurality of frames of the intestinal wall images **41** is displayed on the screen **36**. That is, the plurality of frames of intestinal wall images **41** are displayed on the screen **36** at a predetermined frame rate (for example, several tens of frames/sec).

[0071] As shown in FIG. **2** as an example, the duodenoscope **12** comprises an operating part **42** and an insertion part **44**. The insertion part **44** is partially bent by operating the operating part **42**. The insertion part **44** is inserted while being bent according to the shape of the observation target **21** (for example, the shape of the stomach) in response to the operation of the operating part **42** by the doctor **14**.

[0072] The camera **48**, an illumination device **50**, a treatment opening **51**, and an elevating mechanism **52** are provided at a distal end part **46** of the insertion part **44**. The camera **48** and the illumination device **50** are provided on a side surface of the distal end part **46**. That is, the duodenoscope **12** serves as a side-viewing scope. Accordingly, the intestinal wall of the duodenum is easily observed.

[0073] The camera **48** is a device that acquires the intestinal wall image **41** as a medical image by imaging the inside of the body of the subject **20**. An example of the camera **48** includes a CMOS camera. However, this is merely an example, and the camera **48** may be other types of cameras such as CCD cameras. The camera **48** is an example of the “camera” according to the technology of the present disclosure.

[0074] The illumination device **50** has an illumination window **50**A. The illumination device **50** emits light through the illumination window **50**A. Examples of the type of the light emitted from the illumination device **50** include visible light (for example, white light) and invisible light (for example, near-infrared light). In addition, the illumination device **50** emits special light through the illumination window **50**A. Examples of the special light include light for BLI and/or light for LCI. The camera **48** images the inside of the body of the subject **20** using an optical method in a state in which the inside of the body of the subject **20** is irradiated with light by the illumination device **50**.

[0075] The treatment opening **51** is used as a treatment tool protruding port through which a treatment tool **54** is made to protrude from the distal end part **46**, a suction port for suctioning, for example, blood and body waste, and a delivery port for sending out a fluid.
[0076] The treatment tool **54** protrudes from the treatment opening **51** in response to the operation of the doctor **14**. The treatment tool **54** is inserted into the insertion part **44** from a treatment tool insertion port **58**. The treatment tool **54** passes through the inside of the insertion part **44** through the treatment tool insertion port **58** and protrudes from the treatment opening **51** into the body of the subject **20**. In the example shown in FIG. **2**, a cannula protrudes from the treatment opening **51** as the treatment tool **54**. The cannula is merely an example of the treatment tool **54**, and other examples of the treatment tool **54** include a papillotomy knife and a snare.
[0077] The elevating mechanism **52** changes a protruding direction of the treatment tool **54** protruding from the treatment opening **51**. The elevating mechanism **52** comprises a guide **52**A, and the guide **52**A rises with respect to the protruding direction of the treatment tool **54**, so that the protruding direction of the treatment tool **54** is changed along the guide **52**A. Accordingly, it is easy to protrude the treatment tool **54** toward the intestinal wall. In the example shown in FIG. **2**, the protruding direction of the treatment tool **54** is changed to a direction perpendicular to a traveling direction of the distal end part **46** by the elevating mechanism **52**. The elevating mechanism **52** is operated by the doctor **14** using the operating part **42**. Accordingly, the degree of change in the protruding direction of the treatment tool **54** is adjusted.
[0078] The endoscope scope **18** is connected to the control device **22** and the light source device **24** through a universal cord **60**. The display device **13** and a receiving device **62** are connected to the control device **22**. The receiving device **62** receives an instruction from a user (for example, the doctor **14**) and outputs the received instruction as an electric signal. In the example shown in FIG. **2**, a keyboard is given as an example of the receiving device **62**. However, this is merely an example, and the receiving device **62** may be, for example, a mouse, a touch panel, a foot switch, and/or a microphone.
[0079] The control device **22** controls the entire duodenoscope **12**. For example, the control device **22** controls the light source device **24** or transmits and receives various signals to and from the camera **48**. The light source device **24** emits light under the control of the control device **22** and supplies the light to the illumination device **50**. A light guide is provided in the illumination device **50**, and the light supplied from the light source device **24** is emitted from the illumination windows **50**A and **50**B through the light guide. The control device **22** causes the camera **48** to execute the imaging, acquires the intestinal wall image **41** (see FIG. **1**) from the camera **48**, and outputs the intestinal wall image **41** to a predetermined output destination (for example, the image processing device **25**).
[0080] The image processing device **25** is communicably connected to the control device **22**, and the image processing device **25** performs image processing on the intestinal wall image **41** output from the control device **22**. Details of the image processing in the image processing device **25** will be described below. The image processing device **25** outputs the intestinal wall image **41** subjected to the image processing to a predetermined output destination (for example, the display device **13**). In addition, here, the form example in which the intestinal wall image **41** output from the control device **22** is output to the display device **13** through the image processing device **25** has been described. However, this is merely an example. The control device **22** and the display device **13** may be connected to each other, and the intestinal wall image **41** subjected to the image processing by the image processing device **25** may be displayed on the display device **13** through the control device **22**.
[0081] As shown in FIG. **3** as an example, the control device **22** comprises a computer **64**, a bus **66**, and an external I/F **68**. The computer **64** comprises a processor **70**, a RAM **72**, and an NVM **74**. The processor **70**, the RAM **72**, the NVM **74**, and the external I/F **68** are connected to the bus **66**.
[0082] For example, the processor **70** includes a CPU and a GPU and controls the entire control

device **22**. The GPU operates under the control of the CPU and is in charge of, for example, executing various processing operations of a graphics system and performing calculation using a neural network. In addition, the processor **70** may be one or more CPUs with which the functions of the GPU have been integrated or may be one or more CPUs with which the functions of the GPU have not been integrated.

[0083] The RAM **72** is a memory that temporarily stores information and is used as a work memory by the processor **70**. The NVM **74** is a non-volatile storage device that stores, for example, various programs and various parameters. An example of the NVM **74** includes a flash memory (for example, an EEPROM and/or an SSD). In addition, the flash memory is merely an example and may be other non-volatile storage devices, such as HDDs, or a combination of two or more types of non-volatile storage devices.

[0084] The external I/F **68** transmits and receives various types of information between a device (hereinafter, also referred to as an "external device") outside the control device **22** and the processor **70**. An example of the external I/F **68** is a USB interface.

[0085] The camera **48** is connected to the external I/F **68** as one of the external devices, and the external I/F **68** controls the exchange of various types of information between the camera **48** provided in the endoscope scope **18** and the processor **70**. The processor **70** controls the camera **48** through the external I/F **68**. In addition, the processor **70** acquires the intestinal wall image **41** (see FIG. **1**) obtained by imaging the inside of the body of the subject **20** with the camera **48** provided in the endoscope scope **18** through the external I/F **68**.

[0086] As one of the external devices, the light source device **24** is connected to the external I/F **68**, and the external I/F **68** transmits and receives various types of information between the light source device **24** and the processor **70**. The light source device **24** supplies light to the illumination device **50** under the control of the processor **70**. The illumination device **50** performs irradiation with the light supplied from the light source device **24**.

[0087] As one of the external devices, the receiving device **62** is connected to the external I/F **68**. The processor **70** acquires the instruction received by the receiving device **62** through the external I/F **68** and executes the processing corresponding to the acquired instruction.

[0088] The image processing device **25** is connected to the external I/F **68** as one of the external devices, and the processor **70** outputs the intestinal wall image **41** to the image processing device **25** through the external I/F **68**.

[0089] During the treatment on the duodenum using the endoscope, a treatment called endoscopic retrograde cholangio-pancreatography (ERCP) examination may be performed. As shown in FIG. **4** as an example, in the ERCP examination, for example, first, the duodenoscope **12** is inserted into a duodenum J through the esophagus and the stomach. In this case, the insertion state of the duodenoscope **12** may be checked by X-ray imaging. Then, the distal end part **46** of the duodenoscope **12** reaches the vicinity of a duodenal papilla N (hereinafter, also simply referred to as a "papilla N") present in the intestinal wall of the duodenum J.

[0090] In the ERCP examination, for example, a cannula **54**A is inserted from the papilla N. Here, the papilla N is a part that protrudes from the intestinal wall of the duodenum J, and an opening of an end part of a bile duct T (for example, a common bile duct, an intrahepatic bile duct, or a cystic duct) and a pancreatic duct S are present in a papillary protuberance NA of the papilla N. X-ray imaging is performed in a state in which a contrast agent is injected into the bile duct T, the pancreatic duct S, and the like through the cannula **54**A from the opening of the papilla N. In this way, the ERCP examination includes various procedures such as the insertion of the duodenoscope **12** into the duodenum J, the checking of the position, orientation, and type of the papilla N, and the insertion of a treatment tool (for example, a cannula) into the papilla N. Therefore, the doctor **14** needs to operate the duodenoscope **12** and observe the state of the target part according to each procedure.

[0091] For example, in a case where the duodenoscope **12** is inserted into the duodenum J, in a state where the endoscope scope **18** of the duodenoscope **12** is inclined with respect to an intestinal tract direction, the papilla N is visually recognized in an inclined state. Therefore, there is a possibility that running directions of the bile duct T and the pancreatic duct S are erroneously recognized from the papilla N. Therefore, it is necessary to grasp to what extent the posture of the endoscope scope **18** is inclined with respect to the intestinal tract direction in the duodenum J.

[0092] Thus, in consideration of such circumstances, the medical support processing is performed by a processor **82** of the image processing device **25** in order to support the implementation of the medical care for the duodenum including the ERCP examination.

[0093] As shown in FIG. **5** as an example, the image processing device **25** comprises a computer **76**, an external I/F **78**, and a bus **80**. The computer **76** comprises the processor **82**, an NVM **84**, and a RAM **81**. The processor **82**, the NVM **84**, the RAM **81**, and the external I/F **78** are connected to the bus **80**. The computer **76** is an example of the "medical support device" and the "computer" according to the technology of the present disclosure. The processor **82** is an example of the "processor" according to the technology of the present disclosure.

[0094] In addition, a hardware configuration (that is, the processor **82**, the NVM **84**, and the RAM **81**) of the computer **76** is essentially the same as a hardware configuration of the computer **64** shown in FIG. **3**. Thus, the description of the hardware configuration of the computer **76** will be omitted here. In addition, since the role of the external I/F **78** in the image processing device **25** to transmit and receive information to and from the outside is essentially the same as the role performed by the external I/F **68** in the control device **22** shown in FIG. **3**, the description thereof will be omitted here.

[0095] A medical support processing program **84**A is stored in the NVM **84**. The medical support processing program **84**A is an example of the "program" according to the technology of the present disclosure. The processor **82** reads the medical support processing program **84**A from the NVM **84** and executes the read medical support processing program **84**A on the RAM **81**. The medical support processing according to the present embodiment is realized by the processor **82** operating as an image acquisition unit **82**A, an image recognition unit **82**B, a derivation unit **82**C, and a display control unit **82**D in response to the medical support processing program **84**A executed on the RAM **81**.

[0096] A trained model **84**B is stored in the NVM **84**. In the present embodiment, the image recognition unit **82**B performs image recognition processing using an AI method as the image recognition processing for object detection. The trained model **84**B is optimized by performing machine learning on the neural network in advance.

[0097] As shown in FIG. **6** as an example, the image acquisition unit **82**A acquires the intestinal wall images **41**, which have been generated by the camera **48** capturing the images at an imaging frame rate (for example, several tens of frames/sec), from the camera **48** in units of one frame.

[0098] The image acquisition unit **82**A holds a time-series image group **89**. The time-series image group **89** is a plurality of time-series intestinal wall images **41** in which the observation target **21** is captured. The time-series image group **89** includes, for example, a predetermined number of frames (for example, a predetermined number of frames within a range of several tens to several hundreds of frames) of intestinal wall images **41**. The image acquisition unit **82**A updates a time-series image group **89** using a FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0099] Here, the form example in which the time-series image group **89** is held and updated by the image acquisition unit **82**A has been described, but this is merely an example. For example, the time-series image group **89** may be held and updated in a memory, such as the RAM **81**, which is connected to the processor **82**.

[0100] The image recognition unit **82**B performs image recognition processing using the trained model **84**B on the time-series image group **89**. By performing the image recognition processing, an intestinal tract direction CD included in the observation target **21** is detected. Here, the intestinal tract direction CD refers to a luminal direction of the duodenum. Here, the detection of the intestinal tract direction refers to the processing of storing intestinal tract direction information **90** (for example, position coordinates indicating the direction in which the duodenum extends) that is information capable of specifying the intestinal tract direction CD and the intestinal wall image **41** in the memory in an associated state. The intestinal tract direction information **90** is an example of the "intestinal tract direction-related information" according to the technology of the present disclosure.

[0101] The trained model **84**B is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data is an annotation capable of specifying the intestinal tract direction CD.

[0102] Here, an example of the annotation in the correct answer data includes an annotation (for example, an annotation in which a line segment connecting centers of arc shapes of the fold shapes is set as the intestinal tract direction CD) of the intestinal tract direction CD based on the fold shape of the intestinal tract shown in the intestinal wall image **41**. In addition, in a case where the intestinal wall image **41** is a depth image, examples of the annotation (for example, an annotation in which a direction in which depth in a depth direction indicated by depth information increases is set as the intestinal tract direction CD) in the other correct answer data include an annotation based on the depth information.

[0103] In addition, here, a form in which only one trained model **84**B is used by the image recognition unit **82**B is given as an example, but this is merely an example. For example, the trained model **84**B selected from a plurality of the trained models **84**B may be used by the image recognition unit **82**B. In this case, each trained model **84**B is created by performing machine learning specialized for each procedure (for example, the position of the duodenoscope **12** with respect to the papilla N, or the like) of the ERCP examination, and the trained model **84**B corresponding to the procedure of the ERCP examination currently being performed may be selected and used by the image recognition unit **82**B.

[0104] The image recognition unit **82**B inputs the intestinal wall image **41** acquired from the image acquisition unit **82**A to the trained model **84**B. Accordingly, the trained model **84**B outputs the intestinal tract direction information **90** corresponding to the input intestinal wall image **41**. The image recognition unit **82**B acquires the intestinal tract direction information **90** output from the trained model **84**B.

[0105] The derivation unit **82**C derives the amount of deviation (hereinafter, simply referred to as a "deviation amount") of the endoscope scope **18** with respect to the intestinal tract direction CD. Here, the deviation amount refers to the degree of deviation between the posture of the endoscope scope **18** and the intestinal tract direction CD. Specifically, the deviation amount refers to the deviation amount between a direction along an imaging surface of an imaging element of the camera **48** provided in the endoscope scope **18** (for example, an up-down direction in the angle of view) and the intestinal tract direction CD. In addition, since the camera **48** is provided at the distal end part **46**, the deviation amount can also be said to be an angle between a longitudinal direction SD (for example, a central axis direction in a case where the distal end part **46** has a cylindrical shape) of the distal end part **46** and the intestinal tract direction CD.

[0106] The derivation unit **82**C acquires the intestinal tract direction information **90** from the image recognition unit **82**B. In addition, the derivation unit **82**C acquires posture information **91** from an optical fiber sensor **18**A provided in the endoscope scope **18**. The posture information **91** is information indicating the posture of the endoscope scope **18**. The optical fiber sensor **18**A is a sensor disposed inside the endoscope scope **18** (for example, the insertion part **44** and the distal end part **46**) in the longitudinal direction. By using the optical fiber sensor **18**A, the posture (for example, the inclination of the distal end part **46** from a reference position (for example, a straight state of the endoscope scope **18**)) of the endoscope scope **18** can be detected. In this case, for example, a known endoscope posture detection technology of JP6797834B or the like can be appropriately used. The posture information **91** is an example of the “posture information” according to the technology of the present disclosure.

[0107] In addition, here, the posture detection technology using the optical fiber sensor **18**A has been described, but this is merely an example. For example, the inclination of the distal end part **46** of the endoscope scope **18** may be detected by using a so-called electromagnetic navigation method. In this case, for example, a known endoscope posture detection technology of JP6534193B or the like can be appropriately used.

[0108] The derivation unit **82**C derives deviation amount information **93** that is information indicating the deviation amount, by using the intestinal tract direction information **90** and the posture information **91**. In the example shown in FIG. **6**, an angle A is shown as the deviation amount information **93**. The derivation unit **82**C derives the deviation amount using, for example, a deviation amount calculation expression (not shown). The deviation amount calculation expression is a calculation expression in which the position coordinates of the intestinal tract direction CD indicated by the intestinal tract direction information **90** and the position coordinates of the distal end part **46** in the longitudinal direction SD indicated by the posture information **91** are set as independent variables, and the angle between the intestinal tract direction CD and the longitudinal direction SD of the distal end part **46** is set as a dependent variable. The deviation amount information **93** is an example of the “deviation amount information” according to the technology of the present disclosure.

[0109] As shown in FIG. **7** as an example, the display control unit **82**D acquires the intestinal wall image **41** from the image acquisition unit **82**A. In addition, the display control unit **82**D acquires the intestinal tract direction information **90** from the image recognition unit **82**B. Moreover, the display control unit **82**D acquires the deviation amount information **93** from the derivation unit **82**C. The display control unit **82**D generates an operation instruction image **93**A for matching the longitudinal direction SD of the distal end part **46** with the intestinal tract direction CD, according to the deviation amount indicated by the deviation amount information **93**. The operation instruction image **93**A is, for example, an arrow indicating an operation direction of the distal end part **46** in which the deviation amount is reduced. The display control unit **82**D generates a display image **94** including the intestinal wall image **41**, the intestinal tract direction CD indicated by the intestinal tract direction information **90**, and the operation instruction image **93**A, and outputs the display image **94** to the display device **13**. Specifically, the display control unit **82**D performs graphical user interface (GUI) control for displaying the display image **94** to cause the screen **36** to be displayed on the display device **13**. The screen **36** is an example of the “first screen” according to the technology of the present disclosure. The operation instruction image **93**A is an example of “posture adjustment support information” according to the technology of the present disclosure.

[0110] In addition, here, the form example in which the operation instruction image **93**A is displayed on the screen **36** to allow a user to grasp the deviation amount has been described, but the technology of the present disclosure is not limited to this. For example, a message (not shown) indicating the operation content for reducing the deviation amount may be displayed on the screen **36**. An example of the message is “Please incline the distal end part of the duodenoscope toward the back side by 10 degrees.” A voice output device such as a speaker may notify the user.

[0111] The user can grasp the intestinal tract direction CD by visually recognizing the screen **36** of the display device **13**. In addition, by visually recognizing the operation instruction image **93**A displayed on the screen **36**, it is possible to grasp the operation for reducing the deviation between the distal end part **46** of the endoscope scope **18** and the intestinal tract direction CD.

[0112] Next, the operation of a portion of the duodenoscope system **10** according to the technology of the present disclosure will be described with reference to FIG. **8**.

[0113] FIG. **8** shows an example of a flow of the medical support processing performed by the processor **82**. The flow of the medical support processing shown in FIG. **8** is an example of the "medical support method" according to the technology of the present disclosure.

[0114] In the medical support processing shown in FIG. **8**, first, in step ST**10**, the image acquisition unit **82**A determines whether or not imaging for one frame has been performed by the camera **48** provided in the endoscope scope **18**. In a case where the imaging for one frame has not been performed by the camera **48** in step ST**10**, the determination result is "No", and the determination in step ST**10** is performed again. In a case where the imaging for one frame has been performed by the camera **48** in step ST**10**, the determination result is "Yes", and the medical support processing proceeds to step ST**12**.

[0115] In step ST**12**, the image acquisition unit **82**A acquires one frame of the intestinal wall image **41** from the camera **48** provided in the endoscope scope **18**. After the processing in step ST**12** is executed, the medical support processing proceeds to step ST**14**.

[0116] In step ST**14**, the image recognition unit **82**B performs image recognition processing (that is, image recognition processing using the trained model **84**B) using the AI method on the intestinal wall image **41** acquired in step ST**12** to detect the intestinal tract direction CD. After the processing in step ST**14** is executed, the medical support processing proceeds to step ST**16**.

[0117] In step ST**16**, the derivation unit **82**C acquires the posture information **91** from the optical fiber sensor **18**A of the endoscope scope **18**. After the processing in step ST**16** is executed, the medical support processing proceeds to step ST**18**.

[0118] In step ST**18**, the derivation unit **82**C derives the deviation amount based on the intestinal tract direction CD obtained by the image recognition unit **82**B in step ST**14** and the posture information **91** acquired in step ST**16**. Specifically, the derivation unit **82**C derives an angle between the intestinal tract direction CD and the longitudinal direction SD of the distal end part **46** indicated by the posture information **91**. After the processing in step ST**18** is executed, the medical support processing proceeds to step ST**20**.

[0119] In step ST**20**, the display control unit **82**D generates the display image **94** on which the operation instruction image **93**A and the intestinal tract direction CD according to the deviation amount derived in step ST**18** are superimposed and displayed on the intestinal wall image **41**. After the processing in step ST**20** is executed, the medical support processing proceeds to step ST**22**.

[0120] In step ST**22**, the display control unit **82**D outputs the display image **94** generated in step ST**20** to the display device **13**. After the processing in step ST**22** is executed, the medical support processing proceeds to step ST**24**.

[0121] In step ST**24**, the display control unit **82**D determines whether or not a condition for ending the medical support processing is satisfied. An example of the medical support processing end condition is a condition (for example, a condition in which an instruction to end the medical support processing is received by the receiving device **62**) in which an instruction to end the medical support processing is issued to the duodenoscope system **10**.

[0122] In a case where a condition to end the medical support processing is not satisfied in step ST**24**, the determination result is "No", and the medical support processing proceeds to step ST**10**. In a case where the condition to end the medical support processing is satisfied in step ST**24**, the determination result is "Yes", and the medical support processing ends.

[0123] As described above, in the duodenoscope system **10** according to the present first embodiment, the image recognition processing is performed on the intestinal wall image **41** in the image recognition unit **82**B of the processor **82**, and the intestinal tract direction CD in the intestinal wall image **41** is detected as a result of the image recognition processing. Then, the intestinal tract direction information **90** indicating the intestinal tract direction CD is output to the display control unit **82**D, and the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the intestinal tract direction CD superimposed and displayed on the intestinal wall image **41**. Accordingly, the user can recognize the intestinal tract direction CD. According to the present configuration, it is possible to easily allow the user to grasp to what extent the posture of the endoscope scope **18** deviates with respect to the intestinal tract direction CD.

[0124] In addition, in the duodenoscope system **10** according to the present first embodiment, the deviation amount information **93** is derived in the derivation unit **82**C. The deviation amount information **93** indicates a deviation amount between the posture of the endoscope scope **18** and the intestinal tract direction CD. The deviation amount information **93** is output to the display control unit **82**D, and the display image **94** generated by the display control unit **82**D is output to the display device **13**. The display image **94** includes a display based on the deviation amount information **93**. Accordingly, the user can recognize the deviation amount between the posture of the endoscope scope **18** and the intestinal tract direction CD. According to the present configuration, it is possible to easily allow the user to grasp to what extent the posture of the endoscope scope **18** deviates with respect to the intestinal tract direction CD.

[0125] In addition, in the duodenoscope system **10** according to the present first embodiment, the image recognition processing is performed on the intestinal wall image **41** in the image recognition unit **82**B, so that the intestinal tract direction information **90** indicating the intestinal tract direction CD is obtained. Accordingly, the intestinal tract direction information **90** with higher accuracy is obtained compared to a case where the user designates the intestinal tract direction CD with respect to the intestinal wall image **41** by visual observation.

[0126] In addition, in the duodenoscope system **10** according to the present first embodiment, the intestinal tract direction information **90** is output to the display device **13** by the display control unit **82**D, and the intestinal tract direction CD is displayed on the screen **36** of the display device **13**. Accordingly, it is possible to allow the user to easily visually grasp to what extent the posture of the endoscope scope **18** deviates with respect to the intestinal tract direction CD.

[0127] In addition, in the duodenoscope system **10** according to the present first embodiment, the derivation unit **82**C acquires the posture information **91**, which is information capable of specifying the posture of the endoscope scope **18**, from the optical fiber sensor **18**A. In addition, in the derivation unit **82**C, the deviation amount information **93** is generated based on the posture information **91** and the intestinal tract direction information **90**. Moreover, in the display control unit **82**D, the operation instruction image **93**A indicating the operation direction in which the deviation amount is reduced is generated based on the deviation amount information **93**. The display control unit **82**D outputs the operation instruction image **93**A to the display device **13**, and the operation instruction image **93**A is superimposed and displayed on the intestinal wall image **41** on the display device **13**. Accordingly, in a state in which the endoscope scope **18** is inserted into the duodenum, it is easy for the user to set the posture of the endoscope scope **18** with respect to the intestinal tract direction CD to an intended posture. For example, the user can bring the intestinal tract direction CD and the posture of the endoscope scope **18** closer to each other by performing the operation of changing the posture of the endoscope scope **18** in the direction indicated by the operation instruction image **93**A.

[0128] In the above first embodiment, the form example in which the intestinal tract direction CD is detected by the image recognition processing using the AI method has been described, but the technology of the present disclosure is not limited to this. For example, the intestinal tract direction CD may be detected by image recognition processing using a pattern matching method. In this case, for example, a form may be adopted in which a region (that is, a fold region) indicating a fold of the intestinal tract included in the intestinal wall image **41** is detected, and the intestinal tract direction is estimated from the arc shape of the fold region (for example, a line connecting the centers of the arcs is estimated as the intestinal tract direction).

First Modification Example

[0129] In the above first embodiment, the form example in which the detection of the intestinal tract direction CD is performed using the intestinal wall image **41** that does not include the depth information has been described, but the technology of the present disclosure is not limited to this. In the present first modification example, the image recognition unit **82**B derives the intestinal tract direction using the intestinal wall image **41** which is the depth image. As shown in FIG. **9** as an example, the intestinal wall image **41** is a depth image having depth information **41**A that is information indicating the depth (that is, the distance to the intestinal wall) of the duodenum, which is a subject, as a pixel value. The depth of the duodenum is obtained by, for example, distance measurement using a so-called ToF method by a distance-measuring sensor mounted on the distal end part **46**. The image recognition unit **82**B acquires the intestinal wall image **41** from the image acquisition unit **82**A. The depth information **41**A is an example of the "depth information" according to the technology of the present disclosure.
[0130] The image recognition unit **82**B derives the intestinal tract direction information **90** based on the depth information **41**A indicated by the intestinal wall image **41**. The image recognition unit **82**B derives the intestinal tract direction information **90**, for example, by using an intestinal tract direction calculation expression **82**B**1**. The intestinal tract direction calculation expression **82**B**1** is, for example, a calculation expression in which the depth indicated by the depth information **41**A is set as an independent variable and a position coordinate group of an axis line indicating the intestinal tract direction CD is set as a dependent variable. In this way, the intestinal tract direction information **90** is obtained based on the depth information **41**A of the intestinal wall image **41**.
[0131] As described above, in the duodenoscope system **10** according to the present first modification example, the intestinal wall image **41** has the depth information **41**A indicating the depth of the duodenum, and the intestinal tract direction information **90** is acquired based on the depth information **41**A. The intestinal tract direction CD is a direction along a depth direction in a lumen of the duodenum. The depth information **41**A reflects the depth of the lumen of the duodenum. Therefore, since the intestinal tract direction CD is derived based on the depth information **41**A, the intestinal tract direction information **90** indicating the intestinal tract direction CD with higher accuracy is obtained compared to a case where the depth information **41**A is not considered.
Second Modification Example
[0132] In the above first embodiment, the form example in which the intestinal tract direction CD is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present second modification example, a direction (hereinafter, also simply referred to as a "predetermined direction") intersecting the intestinal tract direction CD at a predetermined angle is obtained.
[0133] As shown in FIG. **10** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.
[0134] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to the trained model **84**C. Accordingly, the trained model **84**C outputs vertical direction information **97** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the vertical direction information **97** output from the trained model **84**C. Here, the vertical direction information **97** is information (for example, a position coordinate group indicating an axis line perpendicular to the intestinal tract direction CD) capable of specifying a direction VD (hereinafter, also simply referred to as a "vertical direction VD") perpendicular to the intestinal tract direction CD.
[0135] In the image recognition processing using the trained model **84**C, the degree of certainty of the identification result is calculated according to the result of specifying the direction perpendicular to the intestinal tract direction CD. Here, the degree of certainty is a statistical measure indicating the certainty of the identification result. The degree of certainty is, for example,

a score input to an activation function (for example, a softmax function or the like) of an output layer of the trained model **84**C. The vertical direction information **97** output from the trained model **84**C has a score equal to or greater than a threshold value (for example, equal to or greater than 0.9).

[0136] In addition, in the present embodiment, “vertical” indicates vertical in a meaning including an error that is generally allowed in the technical field to which the technology of the present disclosure belongs, and an error to such an extent not contrary to the gist of the technology of the present disclosure, in addition to completely vertical. In addition, here, the vertical direction with respect to the intestinal tract direction CD is exemplified as the predetermined angle with respect to the intestinal tract direction CD, but the technology of the present disclosure is not limited to this. For example, the predetermined angle may be 45 degrees, 60 degrees, or 80 degrees.

[0137] The trained model **84**C is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data is an annotation capable of specifying the vertical direction VD.

[0138] The derivation unit **82**C derives the rate of match between the predetermined direction and the direction of an optical axis of the camera **48**. The fact that the predetermined direction and the direction of the optical axis match means that a direction in which the camera **48** is directed matches a direction predetermined by the user. That is, this means that the distal end part **46** provided with the camera **48** is not in a direction (for example, a direction inclined with respect to the intestinal tract direction CD) that is not intended by the user.

[0139] Thus, the derivation unit **82**C acquires the vertical direction information **97**. In addition, the derivation unit **82**C acquires optical axis information **48**A from the camera **48** of the endoscope scope **18**. The optical axis information **48**A is information for specifying an optical axis of an optical system of the camera **48**. Then, the derivation unit **82**C generates rate-of-match information **99** by comparing a direction indicated by the vertical direction information **97** with the direction of the optical axis indicated by the optical axis information **48**A. The rate-of-match information **99** is information indicating the rate of match (for example, an angle formed between the direction of the optical axis and the predetermined direction) between the direction of the optical axis and the predetermined direction. In addition, in the present embodiment, “match” refers to a match in the sense of including an error generally allowed in the technical field to which the technology of the present disclosure belongs, that is, an error to the extent that it does not contradict the gist of the technology of the present disclosure, in addition to an exact match. The vertical direction information **97** is an example of the “first direction information” and the “intestinal tract direction-related information” according to the technology of the present disclosure.

[0140] Moreover, the derivation unit **82**C determines whether or not the direction of the optical axis matches the predetermined direction. In a case where the direction of the optical axis matches the predetermined direction, the derivation unit **82**C generates notification information **100**. The notification information **100** is information for notifying the user that the direction of the optical axis matches the predetermined direction (for example, text indicating that the direction of the optical axis matches the predetermined direction).

[0141] As shown in FIG. **11** as an example, the display control unit **82**D acquires the vertical direction information **97** from the image recognition unit **82**B. In addition, the display control unit **82**D acquires the rate-of-match information **99** from the derivation unit **82**C. The display control unit **82**D generates an operation instruction image **93**B (for example, an arrow indicating an operation direction) for matching the direction of the optical axis with the predetermined direction according to the rate of match between the direction of the optical axis indicated by the rate-of-match information **99** and the predetermined direction. Then, the display control unit **82**D generates a display image **94** including the vertical direction VD indicated by the vertical direction information **97**, the operation instruction image **93**B, and the intestinal wall image **41**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **11**, the display device **13** shows the intestinal wall image **41** on which the vertical direction VD and the operation instruction image **93**B are superimposed and displayed on the screen **36**. The vertical direction VD is an example of the “first direction”, the “second direction”, and the “third direction” according to the technology of the present disclosure. The operation instruction image **93**B is an example of the “condition information” according to the technology of the present disclosure.

[0142] In addition, in a case where the direction of the optical axis matches the predetermined direction, the derivation unit **82**C outputs the notification information **100** to the display control unit **82**D instead of the rate-of-match information **99**. In this case, the display control unit **82**D generates the display image **94** including the content for notifying the user that the direction of the optical axis indicated by the notification information **100** matches the predetermined direction, instead of the operation instruction image **93**B. The example shown in FIG. **11** shows that, on the display device **13**, an example in which a message “the optical axis matches the vertical direction” is displayed on the screen **37**. The notification information **100** is an example of the “notification information” according to the technology of the present disclosure.

[0143] In addition, here, the form example in which a message based on the notification information **100** is displayed on the display device **13** has been described, but this is merely an example. For example, a symbol such as a circle mark based on the notification information **100** may be displayed. In addition, the notification information **100** may be output to a voice output device such as a speaker instead of the display device **13** or together with the display device **13**.

[0144] As described above, in the duodenoscope system **10** according to the present second modification example, the derivation unit **82**C derives the vertical direction information **97** that is information capable of specifying the direction perpendicular to the intestinal tract direction CD. The vertical direction information **97** is output to the display control unit **82**D, and the display image **94** generated by the display control unit **82**D is output to the display device **13**. The display image **94** includes the vertical direction VD indicated by the vertical direction information **97**. Accordingly, the user can recognize the direction intersecting the intestinal tract direction CD at the predetermined angle.

[0145] In addition, in the duodenoscope system **10** according to the present second modification example, the image recognition processing is performed on the intestinal wall image **41** in the image recognition unit **82**B, so that the vertical direction information **97** indicating the vertical direction VD is obtained. Accordingly, the vertical direction information **97** with high accuracy is obtained compared to a case where the user designates the vertical direction VD with respect to the intestinal wall image **41** by visual observation.

[0146] In addition, in the duodenoscope system **10** according to the present second modification example, in the image recognition processing using the trained model **84**C in the image recognition unit **82**B, the vertical direction information **97** is obtained with a degree of certainty equal to or greater than a threshold value. Accordingly, in the image recognition processing using the trained model **84**C in the image recognition unit **82**B, the vertical direction information **97** with higher accuracy is obtained compared to a case where the threshold value is not set for the degree of certainty.

[0147] In addition, in the duodenoscope system **10** according to the present second modification example, the derivation unit **82**C acquires the optical axis information **48**A from the camera **48**. In addition, in the derivation unit **82**C, the rate-of-match information **99** is generated based on the optical axis information **48**A and the vertical direction information **97**. Moreover, in the display control unit **82**D, the display image **94** is generated based on the rate-of-match information **99** and is output to the display device **13**. The display image **94** includes a display related to the rate of match between the direction of the optical axis indicated by the rate-of-match information **99** and the predetermined direction. Accordingly, the user can grasp to what extent the optical axis of the camera **48** deviates from the vertical direction VD. For example, in a case where the optical axis matches the vertical direction VD, there is a high probability that the camera **48** faces the intestinal wall of the duodenum. By maintaining the posture of the endoscope scope **18** in this state, it is easy to find the papilla N present in the intestinal wall of the duodenum, and it is also easy to cause the camera **48** to directly face the papilla N.

[0148] In addition, in the duodenoscope system **10** according to the present second modification example, the display control unit **82**D generates the operation instruction image **93**B for matching the direction of the optical axis with the predetermined direction based on the rate-of-match information **99**. The display control unit **82**D outputs the operation instruction image **93**B to the display device **13**, and the operation instruction image **93**B is superimposed and displayed on the intestinal wall image **41** on the display device **13**. Accordingly, the user can grasp the operation required to match the optical axis direction of the camera **48** with the vertical direction VD.

[0149] In addition, in the duodenoscope system **10** according to the present second modification example, the derivation unit **82**C determines whether or not the direction of the optical axis matches the predetermined direction. In a case where the direction of the optical axis matches the predetermined direction, the derivation unit **82**C generates the notification information **100**. In the display control unit **82**D, the display image **94** is generated based on the notification information **100** and is output to the display device **13**. The display image **94** includes a display indicating that the direction of the optical axis indicated by the notification information **100** matches the predetermined direction. Accordingly, the user can be made to perceive that the direction of the optical axis matches the predetermined direction.

Third Modification Example

[0150] In the above first embodiment, the form example in which the intestinal tract direction CD is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present third modification example, a running direction TD of the bile duct is obtained based on the intestinal tract direction CD.

[0151] As shown in FIG. **12** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0152] The image recognition unit **82**B performs papilla detection processing using a trained model **84**D on the time-series image group **89**. The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to the trained model **84**D. Accordingly, the trained model **84**D outputs papilla region information **95** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the papilla region information **95** output from the trained model **84**D. Here, the papilla region information **95** includes information (for example, coordinates and a range in the image) for specifying a papilla region N**1** in the intestinal wall image **41** in which the papilla N is captured.

[0153] The trained model **84**D is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The training data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the papilla region N**1**.

[0154] The derivation unit **82**C derives running direction information **96** that is information indicating the running direction TD of the bile duct. The running direction information **96** includes information (for example, position coordinates indicating the direction in which the bile duct extends) capable of specifying the direction in which the bile duct extends. The derivation unit **82**C acquires the papilla region information **95** from the image recognition unit **82**B. In addition, the derivation unit **82**C acquires the intestinal tract direction information **90** obtained by the image recognition processing using the trained model **84**B (see FIG. **6**) from the image recognition unit **82**B. Then, the derivation unit **82**C derives the running direction information **96** based on the intestinal tract direction information **90** and the papilla region information **95**. The derivation unit **82**C derives the running direction TD from, for example, a predetermined orientation relationship between the intestinal tract direction CD and the running direction TD. Specifically, the derivation unit **82**C derives the running direction TD as a direction of 11 o'clock to 12 o'clock in a case where the intestinal tract direction CD is a direction of 6 o'clock. Moreover, the derivation unit **82**C uses the papilla region N**1** indicated by the papilla region information **95** as a starting point in the running direction TD.
[0155] As shown in FIG. **13** as an example, the display control unit **82**D acquires the running direction information **96** from the derivation unit **82**C. In addition, the display control unit **82**D acquires the papilla region information **95** from the image recognition unit **82**B. The display control unit **82**D generates the display image **94** on which the running direction TD indicated by the running direction information **96** and the papilla region N**1** indicated by the papilla region information **95** are superimposed and displayed on the intestinal wall image **41** acquired from the image acquisition unit **82**A (see FIG. **6**), and outputs the display image **94** to the display device **13**. On the display device **13**, the intestinal wall image **41** on which the running direction TD is superimposed and displayed is displayed on the screen **36**.
[0156] As described above, in the duodenoscope system **10** according to the present third modification example, the image recognition unit **82**B performs the papilla detection processing using the trained model **84**D. The papilla region information **95** is obtained by the papilla detection processing. In addition, the image recognition unit **82**B performs the image recognition processing using the trained model **84**A to obtain the intestinal tract direction information **90**. The derivation unit **82**C derives the running direction information **96** based on the intestinal tract direction information **90** and the papilla region information **95**. Then, the display image **94** is output to the display device **13** by the display control unit **82**D. The display image **94** includes the papilla region N**1** indicated by the papilla region information **95** and the running direction TD of the bile duct indicated by the running direction information **96**. On the display device **13**, the papilla region N**1** and the running direction TD of the bile duct are displayed on the screen **36**. Accordingly, it is possible to make it easier for the user who observes the papilla N through the screen **36** to visually grasp the running direction TD of the bile duct.
[0157] For example, in the ERCP examination, the camera **48** may be made to directly face the papilla N. In this case, by using the running direction of the bile duct or the pancreatic duct, it is easy to grasp the posture of the endoscope scope **18**. In addition, in a case where a treatment tool is inserted into the papilla N, the running direction of the bile duct or the pancreatic duct is grasped, so that it is easy to perform the operation of inserting a tube into the bile duct or the pancreatic duct in the papilla N.
Fourth Modification Example
[0158] In the above first embodiment, the form example in which the intestinal tract direction CD is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present fourth modification example, the orientation of the papillary protuberance NA in the papilla N (hereinafter, also simply referred to as a “papilla orientation ND”) is obtained based on the intestinal tract direction CD.
[0159] The image recognition unit **82**B performs the image recognition processing on the intestinal

wall image **41** to obtain the intestinal tract direction information **90** and the papilla region information **95** (see FIG. **12**). As an example, as shown in FIG. **14**, the derivation unit **82**C generates papilla orientation information **102** based on the intestinal tract direction information **90** and the papilla region information **95**. The papilla orientation information **102** is information capable of specifying the papilla orientation ND (for example, an orientation in which the papillary protuberance NA faces the treatment tool). The papilla orientation ND is obtained, for example, as a tangent line at the papillary protuberance NA in the running direction TD of the bile duct. Thus, the derivation unit **82**C derives the running direction TD of the bile duct from the intestinal tract direction CD indicated by the intestinal tract direction information **90**, and further derives the direction of the tangent line at the papillary protuberance NA from the running direction TD as the papilla orientation ND.

[0160] The display control unit **82**D acquires the papilla orientation information **102** from the derivation unit **82**C. The display control unit **82**D generates the display image **94** on which the papilla orientation ND indicated by the papilla orientation information **102** and the papilla region N**1** indicated by the papilla region information **95** are superimposed and displayed on the intestinal wall image **41** acquired from the image acquisition unit **82**A (see FIG. **6**), and outputs the display image **94** to the display device **13**. On the display device **13**, the intestinal wall image **41** on which the papilla orientation ND is superimposed and displayed is displayed on the screen **36**.

[0161] Here, the form example in which the papilla orientation ND is displayed as an arrow has been described, but this is merely an example. The papilla orientation ND may be an aspect in which a direction is indicated by text.

[0162] As described above, in the duodenoscope system **10** according to the present fourth modification example, the papilla detection processing is performed in the image recognition unit **82**B (see FIG. **12**), and the papilla region information **95** is obtained. In addition, the image recognition unit **82**B performs the image recognition processing using the trained model **84**B (see FIG. **6**) to obtain the intestinal tract direction information **90**. The derivation unit **82**C derives the papilla orientation information **102** based on the intestinal tract direction information **90**. Then, the display image **94** is output to the display device **13** by the display control unit **82**D. The display image **94** includes the papilla region N**1** indicated by the papilla region information **95** and the papilla orientation ND indicated by the papilla orientation information **102**. On the display device **13**, the papilla region N**1** and the papilla orientation ND are displayed on the screen **36**. Accordingly, it is possible to make it easier for the user who observes the papilla N through the screen **36** to visually grasp the papilla orientation ND.

[0163] For example, in the ERCP examination, the camera **48** may be made to directly face the papilla N. In this case, by using the papilla orientation ND, it is easy to grasp the posture of the endoscope scope **18**. In addition, in a case where a treatment tool is inserted into the papilla N, the papilla orientation ND is grasped, so that the treatment tool can be made to directly face the papilla N, and the treatment tool can be easily inserted into the papilla N.

Second Embodiment

[0164] In the above first embodiment, the form example in which the intestinal tract direction CD is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present second embodiment, the intestinal wall image **41** is an image obtained by imaging the intestinal wall including the papilla N, and a rising direction RD of the papilla N is obtained by the image recognition processing on the intestinal wall image **41**.

[0165] For example, in the ERCP examination, the camera **48** may made to directly face the papilla N in the rising direction RD. Accordingly, it is easy to estimate the running direction of the bile duct T and the pancreatic duct S extending from the papilla N, or it is easy to insert a treatment tool (for example, the cannula) into the papilla N. Thus, in the present second embodiment, the rising direction RD of the papilla N is acquired by the image recognition processing on the intestinal wall image **41**.

[0166] As shown in FIG. **15** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0167] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**E. Accordingly, the trained model **84**E outputs rising direction information **104** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the rising direction information **104** output from the trained model **84**E. Here, the rising direction information **104** is information (for example, a position coordinate group of an axis line indicating the rising direction RD) capable of specifying the direction in which the papilla N protrudes.

[0168] The trained model **84**E is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The training data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the rising direction RD of the papilla N.

[0169] Here, the rising direction RD of the papilla N is specified, for example, as a direction extending from the apex of the papillary protuberance NA of the papilla N to the apex of a haustrum H**1**. This is because, according to the medical findings, the rising direction RD of the papilla N is often the same as the direction extending from the apex of the papillary protuberance NA to the apex of the haustrum H**1**. Here, in the papilla N, a plurality of folds (for example, folds H**1** to H**3**) are present around a protruding part. The haustrum H**1** is a fold closest to the papillary protuberance NA. Thus, as an example of the annotation in the correct answer data, an annotation in which a direction passing through the apex of the haustrum H**1** is defined as the rising direction RD is used.

[0170] The derivation unit **82**C derives the rate of match between the rising direction RD and the direction of the optical axis of the camera **48**. The fact that the direction of the rising direction RD matches the direction of the optical axis means that the direction in which the camera **48** is directed directly faces the papilla N. That is, this means a state in which the distal end part **46** provided with the camera **48** is not in a direction (for example, a direction inclined with respect to the rising direction RD of the papilla N) that is not intended by the user.

[0171] Thus, the derivation unit **82**C acquires the rising direction information **104** from the image recognition unit **82**B. In addition, the derivation unit **82**C acquires optical axis information **48**A from the camera **48** of the endoscope scope **18**. Then, the derivation unit **82**C generates rate-of-match information **103** by comparing the direction indicated by the vertical direction information **97** with the direction of the optical axis indicated by the optical axis information **48**A. The rate-of-match information **103** is information indicating the rate of match (for example, an angle formed by the direction of the optical axis and the rising direction RD) between the direction of the optical axis and the rising direction RD.

[0172] As shown in FIG. **16** as an example, the display control unit **82**D acquires the rising direction information **104** from the image recognition unit **82**B. In addition, the display control unit **82**D acquires the rate-of-match information **103** from the derivation unit **82**C. The display control unit **82**D generates an operation instruction image **93**C (for example, an arrow indicating an operation direction) for matching the direction of the optical axis with the rising direction RD according to the rate of match between the direction of the optical axis indicated by the rate-of-match information **103** and the rising direction RD. Then, the display control unit **82**D generates a display image **94** including the rising direction RD indicated by the rising direction information

104, the operation instruction image **93**C, and the intestinal wall image **41**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **16**, the intestinal wall image **41** on which the rising direction RD and the operation instruction image **93**C are superimposed and displayed on the screen **36** is shown on the display device **13**.

[0173] As shown in FIG. **17** as an example, the doctor **14** operates the endoscope scope **18** to bring the optical axis of the camera **48** close to the rising direction RD. Accordingly, since the intestinal wall image **41** in a case where the papilla N and the camera **48** directly face each other is obtained, it is easy to estimate the running direction of the bile duct T and the pancreatic duct S extending from the papilla N, or it is easy to insert a treatment tool (for example, the cannula) into the papilla N.

[0174] As described above, in the duodenoscope system **10** according to the present second embodiment, in the image recognition unit **82**B of the processor **82**, the image recognition processing is performed on the intestinal wall image **41**, and as a result of the image recognition processing, the rising direction RD of the papilla N in the intestinal wall image **41** is detected. Then, the rising direction information **104** indicating the rising direction RD is output to the display control unit **82**D, and the display image **94** generated by the display control unit **82**D is output to the display device **13**. The display image **94** includes the rising direction RD superimposed and displayed on the intestinal wall image **41**. In this way, the display device **13** displays the rising direction RD on the screen **36**. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the rising direction RD of the papilla N.

[0175] In addition, in the duodenoscope system **10** according to the present second embodiment, the image recognition unit **82**B obtains the rising direction information **104** based on the intestinal wall image **41**. The rising direction information **104** is output to the display control unit **82**D, and the display image **94** generated by the display control unit **82**D is output to the display device **13**. The display image **94** includes a display based on the rising direction information **104**. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the rising direction RD of the papilla N.

[0176] In addition, in the duodenoscope system **10** according to the present second embodiment, the display control unit **82**D generates the display image **94**. The display image **94** includes an image of an arrow indicating the rising direction RD. Accordingly, the user who observes the intestinal wall image **41** can be made to visually grasp the rising direction RD of the papilla N by visualizing the rising direction RD.

[0177] In addition, in the duodenoscope system **10** according to the present second embodiment, the derivation unit **82**C acquires the optical axis information **48**A from the camera **48**. In addition, the derivation unit **82**C generates the rate-of-match information **103** based on the optical axis information **48**A and the rising direction information **104**. The display control unit **82**D generates the display image **94** based on the rate-of-match information **103** and outputs the display image **94** to the display device **13**. The display image **94** includes a display related to the rate of match between the direction of the optical axis indicated by the rate-of-match information **103** and the rising direction RD. Accordingly, the user who observes the intestinal wall image **41** can be made to visually grasp the rate of match between the rising direction RD of the papilla N and the optical axis direction. For example, in a case where the optical axis matches the rising direction RD, there is a high probability that the camera **48** directly faces the papilla N. By holding the posture of the endoscope scope **18** in this state, the papilla N is easily observed, and a treatment tool is easily inserted into the papilla N.

[0178] In addition, in the duodenoscope system **10** according to the present second embodiment, in the image recognition processing of the image recognition unit **82**B, the rising direction RD is specified as a direction extending from the apex of the papillary protuberance NA of the papilla N to the haustrum H**1**. Then, the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the rising direction RD. Accordingly, the

user who observes the intestinal wall image **41** can visually grasp the direction extending from the opening of the papillary protuberance NA to the apex of the haustrum H**1**. As a result, it is possible to easily specify the running direction TD of the bile duct leading to the opening of the papilla N.
[0179] In addition, in the duodenoscope system **10** according to the present second embodiment, in the image recognition processing of the image recognition unit **82**B, the rising direction RD is specified as a direction extending from the apex of the papillary protuberance NA of the papilla N to the haustrum H**1**. Then, the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes an image of an arrow indicating the rising direction RD. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the direction extending from the opening of the papillary protuberance NA to the apex of the haustrum H**1**. As a result, it is possible to easily specify the running direction TD of the bile duct leading to the opening of the papilla N.
[0180] In addition, in the duodenoscope system **10** according to the present second embodiment, the image recognition unit **82**B performs the image recognition processing on the intestinal wall image **41** to obtain the rising direction information **104** indicating the rising direction RD. Accordingly, the rising direction information **104** with higher accuracy is obtained compared to a case where the user designates the rising direction RD with respect to the intestinal wall image **41** by visual observation.
Fifth Modification Example
[0181] In the above second embodiment, the form example in which the rising direction RD is specified as a direction extending from the apex of the papillary protuberance NA to the apex of the haustrum H**1** has been described, but the technology of the present disclosure is not limited to this. The rising direction RD is specified based on the aspects of the plurality of folds H**1** to H**3**.
[0182] As shown in FIG. **18** as an example, the image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to the trained model **84**E. Accordingly, the trained model **84**E outputs rising direction information **104** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the rising direction information **104** output from the trained model **84**E.
[0183] Here, the rising direction RD of the papilla N is specified, for example, as the direction passing through the apex of the haustrum H**1**. According to the medical findings, the rising direction RD of the papilla N may match the direction passing through the apex of the haustrum H**1**. Thus, as an example of the annotation in the correct answer data, an annotation in which a direction passing through the apex of the haustrum H**1** is defined as the rising direction RD is used.
[0184] Here, a form example in which the rising direction RD is specified as the direction passing through the apex of the haustrum H**1** has been described, but this is merely an example. The rising direction RD may be specified as a direction passing through at least one of the apexes of the plurality of folds H**1** to H**3**.
[0185] As described above, in the duodenoscope system **10** according to the present fifth modification example, in the image recognition processing in the image recognition unit **82**B, the rising direction RD is specified based on the aspects of the plurality of folds H**1** to H**3**. Then, the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the rising direction RD. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the direction passing through the apex of the haustrum H**1** of the papillary protuberance NA as the rising direction RD.
Sixth Modification Example
[0186] In the above second embodiment, the form example in which the rising direction RD is specified as a direction extending from the apex of the papillary protuberance NA to the apex of the haustrum H**1** has been described, but the technology of the present disclosure is not limited to this. In the present sixth modification example, the rising direction RD is specified based on the papillary protuberance NA and the plurality of folds H**1** to H**3**.

[0187] As shown in FIG. **19** as an example, the image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to the trained model **84**E. Accordingly, the trained model **84**E outputs rising direction information **104** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the rising direction information **104** output from the trained model **84**E.
[0188] Here, the rising direction RD of the papilla N is specified, for example, as the direction passing through the respective apexes of the haustrum H**1**, the folds H**2**, and H**3** from the apex of the papillary protuberance NA. According to the medical findings, the rising direction RD of the papilla N may match the direction passing through the apexes of the haustrum H**1**, the folds H**2**, and H**3** from the apex of the papillary protuberance NA. Thus, as an example of the annotation in the correct answer data, an annotation in which the direction passing through the apexes of the haustrum H**1**, the folds H**2**, and H**3** from the apex of the papillary protuberance NA is defined as the rising direction RD is used.
[0189] As described above, in the duodenoscope system **10** according to the present sixth modification example, in the image recognition processing of the image recognition unit **82**B, the rising direction RD is specified based on the papillary protuberance NA and the plurality of folds H**1** to H**3**. Then, the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the rising direction RD. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the direction passing through the apex of the papillary protuberance NA and the apexes of the plurality of folds H**1** to H**3** as the rising direction RD.
Seventh Modification Example
[0190] In the above second embodiment, the form example in which the rising direction RD is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present seventh modification example, the running direction TD of the bile duct is obtained based on the rising direction RD.
[0191] The image recognition unit **82**B performs the image recognition processing on the intestinal wall image **41** to obtain the rising direction information **104** and the papilla region information **95** (see FIGS. **12** and **15**). As shown in FIG. **20** as an example, the derivation unit **82**C derives the running direction information **96** based on the rising direction information **104**. The running direction TD of the bile duct has a predetermined orientation relationship with the rising direction RD of the papilla N. Specifically, the derivation unit **82**C derives the running direction TD as a direction of 11 o'clock in a case where the rising direction RD is a direction of 12 o'clock.
[0192] The display control unit **82**D acquires the running direction information **96** from the derivation unit **82**C. The display control unit **82**D generates the display image **94** on which the running direction TD indicated by the running direction information **96** is superimposed and displayed on the intestinal wall image **41** acquired from the image acquisition unit **82**A (see FIG. **6**), and outputs the display image **94** to the display device **13**. On the display device **13**, the intestinal wall image **41** on which the running direction TD is superimposed and displayed is displayed on the screen **36**.
[0193] As described above, in the duodenoscope system **10** according to the present seventh modification example, the running direction information **96** is obtained based on the rising direction information **104** in the derivation unit **82**C. In this way, since the running direction information **96** is obtained by the rising direction information **104**, it is easy to specify the running direction TD compared to a case where the running direction information **96** is obtained by the image recognition processing.
[0194] In addition, in the duodenoscope system **10** according to the present seventh modification example, the display control unit **82**D generates the display image **94**. The display image **94** includes an image showing the running direction TD. Accordingly, the user who observes the

intestinal wall image **41** can visually grasp the running direction TD of the bile duct.

Eighth Modification Example

[0195] In the above second embodiment, the form example in which the rising direction RD of the papilla N is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present eighth modification example, a direction MD (hereinafter, also simply referred to as a "plane direction MD") of a plane in which an opening is present at the papilla N is obtained by the image recognition processing on the intestinal wall image **41**.

[0196] As shown in FIG. **21** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0197] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**F. Accordingly, the trained model **84**F outputs plane direction information **106** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the plane direction information **106** output from the trained model **84**F. Here, the plane direction information **106** is information (for example, a position coordinate group of an axis line indicating the plane direction MD) capable of specifying the plane direction MD.

[0198] The trained model **84**F is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the plane direction MD.

[0199] The derivation unit **82**C derives a relative angle between a plane P on which an opening K of the papilla N is provided and the posture of the endoscope scope **18**. The fact that the relative angle between the plane P provided with the opening K of the papilla N and the posture of the endoscope scope **18** approaches 0 means that the camera **48** approaches a state in which the camera **48** directly faces the papilla N. Thus, the derivation unit **82**C acquires the plane direction information **106** from the image recognition unit **82**B. In addition, the derivation unit **82**C acquires the posture information **91** from the optical fiber sensor **18**A of the endoscope scope **18**. Then, the derivation unit **82**C generates relative angle information **108** by comparing the plane P having the opening K from the orientation of the plane indicated by the plane direction information **106** with the posture of the endoscope scope **18** indicated by the posture information **91**. The relative angle information **108** is information indicating an angle A formed by the plane P and the posture (for example, the imaging surface of the camera **48**) of the endoscope scope **18**.

[0200] As shown in FIG. **22** as an example, the display control unit **82**D acquires the plane direction information **106** from the image recognition unit **82**B. In addition, the display control unit **82**D acquires the relative angle information **108** from the derivation unit **82**C. The display control unit **82**D generates an operation instruction image **93**D (for example, an arrow indicating an operation direction) for causing the camera **48** to directly face the papilla N according to the angle indicated by the relative angle information **108**. Then, the display control unit **82**D generates a display image **94** including the plane direction MD indicated by the plane direction information **106**, the operation instruction image **93**D, and the intestinal wall image **41**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **22**, the intestinal wall image **41** on which the plane direction MD and the operation instruction image **93**D are superimposed and displayed on the screen **36** is shown on the display device **13**.

[0201] As described above, in the duodenoscope system **10** according to the present eighth modification example, the image recognition unit **82**B of the processor **82** performs the image recognition processing on the intestinal wall image **41** and detects the plane direction MD of the papilla N in the intestinal wall image **41** as a result of the image recognition processing. Then, the plane direction information **106** indicating the plane direction MD is output to the display control unit **82**D, and the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the plane direction MD superimposed and displayed on the intestinal wall image **41**. In this way, the plane direction MD is displayed on the screen **36** of the display device **13**. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the plane direction MD of the papilla N.

[0202] In addition, in the duodenoscope system **10** according to the present eighth modification example, the derivation unit **82**C acquires the posture information **91**, which is information capable of specifying the posture of the endoscope scope **18**, from the optical fiber sensor **18**A. In addition, the derivation unit **82**C generates the relative angle information **108** based on the posture information **91** and the plane direction information **106**. Moreover, in the display control unit **82**D, the operation instruction image **93**D for causing the camera **48** to directly face the papilla N is generated based on the relative angle information **108**. The display control unit **82**D outputs the operation instruction image **93**D to the display device **13**, and the operation instruction image **93**D is superimposed and displayed on the intestinal wall image **41** on the display device **13**. Accordingly, in a state in which the endoscope scope **18** is inserted into the duodenum, it is easy for the user to set the posture of the endoscope scope **18** with respect to the plane direction MD of the papilla N to an intended posture.

Ninth Modification Example

[0203] In the above second embodiment, the form example in which the rising direction RD obtained by the image recognition processing on the intestinal wall image **41** is displayed has been described, but the technology of the present disclosure is not limited to this. In the present ninth modification example, a papilla plane image **93**E is displayed.

[0204] As shown in FIG. **23** as an example, the display control unit **82**D acquires the rising direction information **104** from the image recognition unit **82**B. The display control unit **82**D generates the papilla plane image **93**E based on the rising direction RD indicated by the rising direction information **104**. The papilla plane image **93**E is an image capable of specifying a plane intersecting the rising direction RD at a predetermined angle (for example, 90 degrees). Moreover, the display control unit **82**D adjusts the papilla plane image **93**E to a size and a shape corresponding to the papilla region N**1** based on the papilla region information **95** obtained in the image recognition unit **82**B. In addition, the display control unit **82**D generates the operation instruction image **93**C.

[0205] Then, the display control unit **82**D generates a display image **94** including the papilla plane image **93**E, the operation instruction image **93**C, and the intestinal wall image **41**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **23**, the intestinal wall image **41** on which the papilla plane image **93**E and the operation instruction image **93**C are superimposed and displayed on the screen **36** is shown on the display device **13**.

[0206] As described above, in the duodenoscope system **10** according to the present ninth modification example, the papilla plane image **93**E is generated in the display control unit **82**D based on the rising direction information **104**. The display control unit **82**D outputs the papilla plane image **93**E to the display device **13**, and the papilla plane image **93**E is superimposed and displayed on the intestinal wall image **41** on the display device **13**. Accordingly, it is easy for the user who observes the intestinal wall image **41** to visually predict the position of an opening included in the papilla N.

Third Embodiment

[0207] The form example in which, in the above first embodiment, the intestinal tract direction CD is obtained by the image recognition processing on the intestinal wall image **41**, and in the above second embodiment, the rising direction RD is obtained by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present third embodiment, the running direction TD of the bile duct T is obtained by the image recognition processing on the intestinal wall image **41**.

[0208] For example, in the ERCP examination, a treatment tool (for example, the cannula) may be inserted into the papilla N, and the treatment tool may be intubated into the bile duct T or the pancreatic duct S in the papilla N. In this case, in the intestinal wall image **41**, it is difficult to grasp the running direction of the bile duct T or the pancreatic duct S present inside the papilla N. Thus, in the present third embodiment, the running direction of the bile duct T or the pancreatic duct S is acquired by the image recognition processing on the intestinal wall image **41**. In addition, in the following, for convenience of description, the case of the bile duct T will be described as an example.

[0209] As shown in FIG. **24** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0210] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**G. Accordingly, the trained model **84**G outputs the running direction information **96** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the running direction information **96** output from the trained model **84**G.

[0211] The trained model **84**G is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data is an annotation capable of specifying the running direction TD.

[0212] Here, the running direction TD of the bile duct T is specified as, for example, the direction passing through the apexes of the plurality of folds of the papilla N. This is because, according to the medical findings, the running direction of the bile duct T may match a line connecting the apex of a fold. Thus, as an example of the annotation in the correct answer data, an annotation in which a direction passing through an apex of a fold of the papilla N is set as the running direction TD of the bile duct T is used.

[0213] In addition, the acquired time-series image group **89** is input to a trained model **84**H. Accordingly, the trained model **84**H outputs diverticulum region information **110** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the diverticulum region information **110** output from the trained model **84**H. The diverticulum region information **110** is information (coordinates indicating the size and position of the diverticulum) capable of specifying a region indicating a diverticulum present in the papilla N. Here, the diverticulum is a region in which a part of the papilla N protrudes in a pouch-like shape to the outside of the duodenum.

[0214] The trained model **84**H is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying a region indicating a diverticulum.

[0215] The derivation unit **82**C derives an aspect for displaying the running direction TD. For example, the running direction TD is specified in an aspect in which the diverticulum is avoided. This is because, according to the medical findings, the running direction TD may be formed to avoid the diverticulum. Thus, the derivation unit **82**C changes the display aspect of the running direction TD based on the diverticulum region information **110**. Specifically, the derivation unit **82**C changes a portion intersecting the diverticulum, which is indicated by the diverticulum region information **110**, in the running direction TD indicated by the running direction information **96** to an aspect in which the diverticulum is avoided. In this way, the derivation unit **82**C generates display aspect information **112** indicating the display aspect of the changed running direction TD.
[0216] As shown in FIG. **25** as an example, the display control unit **82**D acquires the display aspect information **112** from the derivation unit **82**C. The display control unit **82**D generates a display image **94** including the changed running direction TD and the intestinal wall image **41** indicated by the display aspect information **112**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **25**, the intestinal wall image **41** on which the changed running direction TD is superimposed and displayed on the screen **36** is shown on the display device **13**.
[0217] Next, the operation of a portion of the duodenoscope system **10** according to the technology of the present disclosure will be described with reference to FIG. **26**.
[0218] FIG. **26** shows an example of a flow of the medical support processing performed by the processor **82**.
[0219] In the medical support processing shown in FIG. **26**, first, in step ST**110**, the image acquisition unit **82**A determines whether or not imaging for one frame has been performed by the camera **48** provided in the endoscope scope **18**. In a case where the imaging for one frame has not been performed by the camera **48** in step ST**110**, the determination result is “No”, and the determination in step ST**110** is performed again. In a case where the imaging for one frame has been performed by the camera **48** in step ST**110**, the determination result is “Yes”, and the medical support processing proceeds to step ST**112**.
[0220] In step ST**112**, the image acquisition unit **82**A acquires one frame of the intestinal wall image **41** from the camera **48** provided in the endoscope scope **18**. After the processing in step ST**112** is executed, the medical support processing proceeds to step ST**114**.
[0221] In step ST**114**, the image recognition unit **82**B performs image recognition processing (that is, image recognition processing using the trained model **84**G) using the AI method on the intestinal wall image **41** acquired in step ST**112** to detect the running direction TD. After the processing in step ST**114** is executed, the medical support processing proceeds to step ST**116**.
[0222] In step ST**116**, the image recognition unit **82**B detects the diverticulum region by performing the image recognition processing (that is, the image recognition processing using the trained model **84**H) using the AI method on the intestinal wall image **41** acquired in step ST**112**. After the processing in step ST**116** is executed, the medical support processing proceeds to step ST**118**.
[0223] In step ST**118**, the derivation unit **82**C changes the display aspect of the running direction TD based on the running direction TD obtained by the image recognition unit **82**B in step ST**114** and the diverticulum region obtained by the image recognition unit **82**B in step ST**116**. Specifically, the derivation unit **82**C changes the display aspect of the running direction TD to an aspect in which the diverticulum region is avoided. After the processing in step ST**118** is executed, the medical support processing proceeds to step ST**120**.
[0224] In step ST**120**, the display control unit **82**D generates the display image **94** on which the running direction TD of which the display aspect is changed by the derivation unit **82**C in step ST**118** is superimposed and displayed on the intestinal wall image **41**. After the processing in step ST**120** is executed, the medical support processing proceeds to step ST**122**.
[0225] In step ST**122**, the display control unit **82**D outputs the display image **94** generated in step ST**120** to the display device **13**. After the processing in step ST**122** is executed, the medical support

processing proceeds to step ST**124**.

[0226] In step ST**124**, the display control unit **82**D determines whether or not a condition for ending the medical support processing is satisfied. An example of the medical support processing end condition is a condition (for example, a condition in which an instruction to end the medical support processing is received by the receiving device **62**) in which an instruction to end the medical support processing is issued to the duodenoscope system **10**.

[0227] In a case where the medical support processing end condition is not satisfied in step ST**124**, the determination result is "No", and the medical support processing proceeds to step ST**110**. In a case where the medical support processing end condition is satisfied in step ST**124**, the determination result is "Yes", and the medical support processing ends.

[0228] As described above, in the duodenoscope system **10** according to the present third embodiment, the image recognition processing is performed on the intestinal wall image **41** in the image recognition unit **82**B of the processor **82**, and the running direction TD of the bile duct in the intestinal wall image **41** is detected as a result of the image recognition processing. Then, the running direction information **96** indicating the running direction TD is output to the display control unit **82**D, and the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the running direction TD superimposed and displayed on the intestinal wall image **41**. In this way, the running direction TD is displayed on the screen **36** of the display device **13**. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the running direction TD of the bile duct.

[0229] In addition, in the duodenoscope system **10** according to the present third embodiment, the image recognition unit **82**B performs the image recognition processing on the intestinal wall image **41** to obtain the diverticulum region information **110**. The derivation unit **82**C generates the display aspect information **112** based on the running direction information **96** and the diverticulum region information **110**. Then, the display aspect information **112** indicating the changed running direction TD is output to the display control unit **82**D, and the display image **94** generated in the display control unit **82**D is output to the display device **13**. The display image **94** includes the changed running direction TD superimposed and displayed on the intestinal wall image **41**. In this way, the changed running direction TD is displayed on the screen **36** of the display device **13**. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the running direction TD of the bile duct changed according to the presence of the diverticulum. For example, it is possible to suppress the occurrence of a situation in which the user who observes the intestinal wall image **41** is made to visually erroneously grasp the running direction TD of the bile duct leading to the opening of the papilla N due to the presence of the diverticulum.

[0230] In addition, in the duodenoscope system **10** according to the present third embodiment, in the derivation unit **82**C, the display aspect information **112** indicates the changed running direction TD in an aspect in which the diverticulum is avoided in the running direction TD indicated by the running direction information **96**. Then, the changed running direction TD is displayed on the screen **36** of the display device **13**. Accordingly, the user who observes the intestinal wall image **41** can visually grasp the running direction TD of the bile duct changed in the aspect in which the diverticulum is avoided.

[0231] In addition, in the above third embodiment, the aspect in which the diverticulum is avoided is exemplified as the form example in which the display aspect of the running direction TD of the bile duct is changed, but the technology of the present disclosure is not limited to this. For example, in the running direction TD of the bile duct, a region intersecting the diverticulum may be hidden, or a region intersecting the diverticulum may be represented by a broken line or may be semi-translucent.

[0232] In addition, in the above third embodiment, the form example in which the diverticulum is detected by the image recognition processing on the intestinal wall image **41** and the display aspect of the running direction TD is changed according to the diverticulum has been described, but the technology of the present disclosure is not limited to this. For example, an aspect in which the detection of the diverticulum is not performed may be adopted.

Tenth Modification Example

[0233] In the above third embodiment, the form example in which the running direction TD of the bile duct is displayed by avoiding the diverticulum has been described, but the technology of the present disclosure is not limited to this. In the present tenth modification example, in a case where the running direction TD of the bile duct intersects the diverticulum, the user is notified of the fact.

[0234] As shown in FIG. **27** as an example, the derivation unit **82**C acquires the running direction information **96** and the diverticulum region information **110** from the image recognition unit **82**B. The derivation unit **82**C specifies a positional relationship between the diverticulum and the running direction TD based on the diverticulum region information **110** and the running direction information **96**. Specifically, the derivation unit **82**C specifies whether or not the diverticulum and the running direction TD intersect each other by comparing the running direction TD indicated by the running direction information **96** with the position and the size of the diverticulum indicated by the diverticulum region information **110**. Then, in a case where the derivation unit **82**C specifies that the running direction TD and the diverticulum have a positional relationship in which the running direction TD intersects the diverticulum, the derivation unit **82**C generates notification information **114**.

[0235] The derivation unit **82**C outputs the notification information **114** to the display control unit **82**D. In this case, the display control unit **82**D generates the display image **94** including the content of notifying the user that the diverticulum indicated by the notification information **114** intersects the running direction TD. In the example shown in FIG. **27**, on the display device **13**, an example in which a message “the diverticulum intersects the running direction” is displayed on the screen **37** is shown.

[0236] As described above, in the duodenoscope system **10** according to the present tenth modification example, the derivation unit **82**C specifies the positional relationship between the diverticulum and the running direction TD based on the diverticulum region information **110** and the running direction information **96**, and generates the notification information **114** based on the identification result. In the display control unit **82**D, the display image **94** is generated based on the notification information **114** and is output to the display device **13**. The display image **94** includes a display indicating that the diverticulum indicated by the notification information **114** intersects the running direction. Accordingly, the user can be made to perceive that the diverticulum intersects the running direction. For example, it is possible to suppress the occurrence of a situation in which the user who observes the intestinal wall image **41** is made to visually erroneously grasp the running direction TD of the bile duct leading to the opening of the papilla N due to the presence of the diverticulum.

Fourth Embodiment

[0237] In the above first embodiment to third embodiment, the form example in which the information related to biological tissue, such as the intestinal tract direction CD, the papilla N, and the running direction TD of the bile duct, is specified by the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present fourth embodiment, a relationship between a treatment tool and the biological tissue is specified by performing the image recognition processing on the intestinal wall image **41**.

[0238] For example, in the ERCP examination, various treatments (for example, the cannula is inserted into the papilla N) using a treatment tool may be performed on the papilla N. In this case, the positional relationship between the papilla N and the treatment tool affects the success or failure of the procedure. For example, in a case where the traveling direction of the treatment tool does not match the papilla orientation ND, the treatment tool cannot appropriately approach the papilla N, and it is difficult to succeed in the procedure. Thus, in the present fourth embodiment, the positional relationship between the treatment tool and the papilla N is specified by the image recognition processing on the intestinal wall image **41**.

[0239] As shown in FIG. **28** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0240] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**I. Accordingly, the trained model **84**I outputs positional relationship information **116** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the positional relationship information **116** output from the trained model **84**I. Here, the positional relationship information **116** is information (for example, a distance and an angle between the position of the papilla N and the position of the tip of the treatment tool) capable of specifying the position of the papilla N and the position of the treatment tool.

[0241] The trained model **84**I is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data is an annotation capable of specifying the position of the papilla N and the position of the treatment tool.

[0242] The derivation unit **82**C acquires the positional relationship information **116** from the image recognition unit **82**B. The derivation unit **82**C generates notification information **118** that is information for notifying the user of the positional relationship between the papilla N and the treatment tool, based on the positional relationship information **116**. The derivation unit **82**C compares the position of the treatment tool indicated by the positional relationship information **116** with the position of the papilla N. Then, in a case where the position of the treatment tool matches the position of the papilla N, the derivation unit **82**C generates the notification information **118** indicating that the position of the treatment tool matches the position of the papilla N. In addition, in a case where the position of the treatment tool does not match the position of the papilla N, the derivation unit **82**C generates the notification information **118** indicating that the position of the treatment tool does not match the position of the papilla N.

[0243] Here, a case whether the position of the treatment tool matches the position of the papilla N has been described as an example, but this is merely an example. For example, whether or not the position of the treatment tool and the position of the papilla N are within a predetermined range (for example, within a predetermined distance and angle range) may be determined.

[0244] As shown in FIG. **29** as an example, the display control unit **82**D acquires the notification information **118** from the derivation unit **82**C. The derivation unit **82**C outputs the notification information **118** to the display control unit **82**D. In this case, the display control unit **82**D generates the display image **94** including the content of notifying the user of the positional relationship between the treatment tool and the papilla N indicated by the notification information **118**. In the example shown in FIG. **29**, on the display device **13**, an example in which a message "the position of the treatment tool and the position of the papilla match" is displayed on the screen **37** is shown.

[0245] As described above, in the duodenoscope system **10** according to the present fourth embodiment, the image recognition unit **82**B of the processor **82** performs the image recognition processing on the intestinal wall image **41** and specifies the positional relationship between the treatment tool and the papilla. The derivation unit **82**C performs the determination related to the positional relationship between the treatment tool and the papilla N based on the positional relationship information **116** indicating the positional relationship between the treatment tool and the papilla and generates the notification information **118** generated based on the determination result. In the display control unit **82**D, the display image **94** is generated based on the notification information **118** and is output to the display device **13**. The display image **94** includes a display related to the positional relationship between the treatment tool indicated by the notification information **118** and the papilla N. Accordingly, the user who observes the intestinal wall image **41** can be made to perceive the relationship between the position of the treatment tool and the position of the papilla N.

Eleventh Modification Example

[0246] In the above fourth embodiment, the form example in which the relationship between the position of the papilla N and the position of the treatment tool is specified as the positional relationship between the treatment tool and the papilla N has been described, but the technology of the present disclosure is not limited to this. In the present eleventh modification example, the relationship between the traveling direction of the treatment tool and the papilla orientation ND is specified.

[0247] As shown in FIG. **30** as an example, the image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**J. Accordingly, the trained model **84**J outputs positional relationship information **116**A corresponding to the input time-series image group **89**. Here, the positional relationship information **116**A is information (for example, an angle formed by the papilla orientation ND and the traveling direction of the treatment tool) capable of specifying the papilla orientation ND and the traveling direction of the treatment tool.

[0248] The trained model **84**J is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the relationship between the papilla orientation ND and the traveling direction of the treatment tool.

[0249] The derivation unit **82**C acquires the positional relationship information **116**A from the image recognition unit **82**B. The derivation unit **82**C generates notification information **118** that is information for notifying the user of the positional relationship between the papilla N and the treatment tool, based on the positional relationship information **116**A. In a case where the angle between the papilla orientation direction ND and the traveling direction of the treatment tool is within a predetermined range, the derivation unit **82**C generates the notification information **118** indicating that the papilla orientation direction ND matches the traveling direction of the treatment tool. In addition, in a case where the angle between the papilla orientation direction ND and the traveling direction of the treatment tool exceeds a predetermined range, the derivation unit **82**C generates the notification information **118** indicating that the papilla orientation direction ND does not match the traveling direction of the treatment tool.

[0250] As described above, in the duodenoscope system **10** according to the present eleventh modification example, the image recognition unit **82**B specifies the relationship between the traveling direction of the treatment tool and the papilla orientation ND. The derivation unit **82**C generates the notification information **118** based on the positional relationship information **116**A indicating the relationship between the traveling direction of the treatment tool and the papilla orientation ND. Accordingly, the user who observes the intestinal wall image **41** can be made to perceive the relationship between the traveling direction of the treatment tool and the papilla orientation ND.

[0251] In addition, in the above eleventh modification example, the form example in which the relationship between the traveling direction of the treatment tool and the papilla orientation ND is specified in the image recognition unit **82**B has been described, but the technology of the present disclosure is not limited to this. For example, in the image recognition unit **82**B, the relationship between the position of the papilla N and the position of the treatment tool may be specified together with the relationship between the traveling direction of the treatment tool and the papilla orientation ND. In this case, the positional relationship information **116**A is information indicating the relationship between the traveling direction of the treatment tool and the papilla orientation ND and the relationship between the position of the papilla N and the position of the treatment tool, and the derivation unit **82**C performs the determination related to the relationship between the traveling direction of the treatment tool and the papilla orientation ND and the determination related to the relationship between the position of the papilla N and the position of the treatment tool, based on the positional relationship information **116**A. Moreover, the derivation unit **82**C generates the notification information **118** according to these determination results.

Twelfth Modification Example

[0252] In the above fourth embodiment, the form example in which the relationship between the position of the papilla N and the position of the treatment tool is specified as the positional relationship between the treatment tool and the papilla N has been described, but the technology of the present disclosure is not limited to this. In the present eleventh modification example, the relationship between the traveling direction of the treatment tool and the running direction TD of the bile duct is specified.

[0253] As shown in FIG. **31** as an example, the image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**K. Accordingly, the trained model **84**K outputs positional relationship information **116**B corresponding to the input time-series image group **89**. Here, the positional relationship information **116**B is information (for example, an angle formed by the direction (hereinafter, simply referred to as a “bile duct tangential direction”) of a tangent line of an opening end part in the running direction TD of the bile duct and the traveling direction of the treatment tool) capable of specifying the relationship between the running direction TD of the bile duct and the traveling direction of the treatment tool.

[0254] The trained model **84**K is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the relationship between the running direction TD of the bile duct and the traveling direction of the treatment tool.

[0255] The derivation unit **82**C acquires the positional relationship information **116**B from the image recognition unit **82**B. The derivation unit **82**C generates the notification information **118** that is information for notifying the user of the relationship between the running direction TD of the bile duct and the traveling direction of the treatment tool, based on the positional relationship information **116**B. In a case where the angle between the bile duct tangential direction and the traveling direction of the treatment tool is within a predetermined range, the derivation unit **82**C generates the notification information **118** indicating that the bile duct tangential direction matches the traveling direction of the treatment tool. In addition, in a case where the angle between the bile duct tangential direction and the traveling direction of the treatment tool exceeds a predetermined range, the derivation unit **82**C generates the notification information **118** indicating that the bile duct tangential direction does not match the traveling direction of the treatment tool.

[0256] As described above, in the duodenoscope system **10** according to the present twelfth modification example, the image recognition unit **82**B specifies the relationship between the traveling direction of the treatment tool and the running direction TD of the bile duct. The derivation unit **82**C generates the notification information **118** based on the positional relationship information **116**B indicating the relationship between the traveling direction of the treatment tool and the running direction TD of the bile duct. Accordingly, the user who observes the intestinal wall image **41** can be made to perceive the relationship between the traveling direction of the treatment tool and the running direction TD of the bile duct.

Thirteenth Modification Example

[0257] In the above fourth embodiment, the form example in which the relationship between the position of the papilla N and the position of the treatment tool is specified as the positional relationship between the treatment tool and the papilla N has been described, but the technology of the present disclosure is not limited to this. In the present thirteenth modification example, a relationship between the traveling direction of the treatment tool and the orientation of a plane vertical to the rising direction RD of the papillary protuberance NA (hereinafter, also simply referred to as a "vertical plane orientation") is specified.

[0258] As shown in FIG. **32** as an example, the image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**L. Accordingly, the trained model **84**L outputs positional relationship information **116**C corresponding to the input time-series image group **89**. Here, the positional relationship information **116**C is information (for example, an angle formed by the vertical plane orientation and the traveling direction of the treatment tool) capable of specifying the relationship between the vertical plane orientation and the traveling direction of the treatment tool.

[0259] The trained model **84**L is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the relationship between the vertical plane orientation and the traveling direction of the treatment tool.

[0260] The derivation unit **82**C acquires the positional relationship information **116**C from the image recognition unit **82**B. The derivation unit **82**C generates the notification information **118** that is information for notifying the user of the relationship between the vertical plane orientation and the traveling direction of the treatment tool, based on the positional relationship information **116**C. In a case where the angle between the vertical plane orientation and the traveling direction of the treatment tool is within a predetermined range, the derivation unit **82**C generates the notification information **118** indicating that the vertical plane orientation matches the traveling direction of the treatment tool. In addition, in a case where the angle between the vertical plane orientation and the traveling direction of the treatment tool exceeds a predetermined range, the derivation unit **82**C generates the notification information **118** indicating that the vertical plane orientation does not match the traveling direction of the treatment tool.

[0261] As described above, in the duodenoscope system **10** according to the present thirteenth modification example, the image recognition unit **82**B specifies the relationship between the vertical plane orientation and the traveling direction of the treatment tool. The derivation unit **82**C generates the notification information **118** based on the positional relationship information **116**C indicating the relationship between the vertical plane orientation and the traveling direction of the treatment tool. Accordingly, the user who observes the intestinal wall image **41** can be made to perceive the relationship between the vertical plane orientation and the traveling direction of the treatment tool.

Fourteenth Modification Example

[0262] In the above fourth embodiment, the form example in which the positional relationship between the treatment tool and the papilla N is specified by performing the image recognition processing on the intestinal wall image **41** example has been described, but the technology of the present disclosure is not limited to this. In the present fourteenth modification example, an evaluation value related to the positional relationship between the treatment tool and the papilla N is acquired by performing the image recognition processing on the intestinal wall image **41**.
[0263] As shown in FIG. **33** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.
[0264] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**M. Accordingly, the trained model **84**M outputs evaluation value information **120** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the evaluation value information **120** output from the trained model **84**M. Here, the evaluation value information **120** is information (for example, the degree of success of a procedure determined according to the placement of the papilla N and the treatment tool) capable of specifying an evaluation value related to an appropriate placement of the papilla N and the treatment tool. The evaluation value information **120** is, for example, a plurality of scores (scores for each success or failure of the procedure) input to an activation function (for example, a softmax function or the like) of the output layer of the trained model **84**M.
[0265] The trained model **84**M is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data is an annotation (for example, an annotation indicating the success or failure of the procedure) capable of specifying an evaluation value related to an appropriate placement of the papilla N and the treatment tool.
[0266] In addition, the image recognition unit **82**B inputs the time-series image group **89** to a trained model **84**N. Accordingly, the trained model **84**N outputs contact presence/absence information **122** corresponding to the input time-series image group **89**. The image recognition unit **82**B acquires the contact presence/absence information **122** output from the trained model **84**N. Here, the contact presence/absence information **122** is information capable of specifying the presence or absence of contact between the papilla N and the treatment tool.
[0267] The trained model **84**N is obtained by performing machine learning using training data on the neural network to optimize the neural network. The training data is a plurality of pieces of data (that is, a plurality of frames of data) in which example data and correct answer data are associated with each other. The example data is, for example, an image (for example, an image corresponding to the intestinal wall image **41**) obtained by imaging a part (for example, an inner wall of the duodenum) that can be a target for the ERCP examination. The correct answer data is an annotation corresponding to the example data. An example of the correct answer data includes an annotation capable of specifying the presence or absence of contact between the papilla N and the treatment tool.
[0268] The derivation unit **82**C acquires the contact presence/absence information **122** from the image recognition unit **82**B. The derivation unit **82**C determines whether or not the contact between the treatment tool and the papilla N is detected based on the contact presence/absence information **122**. In a case where the contact between the treatment tool and the papilla N is detected, the derivation unit **82**C generates notification information **124** based on the evaluation value information **120**. The notification information **124** is information (for example, text

indicating the success probability of the procedure) for notifying the user of the success probability of the procedure.

[0269] As shown in FIG. **34** as an example, the display control unit **82**D acquires the notification information **124** from the derivation unit **82**C. The derivation unit **82**C outputs the notification information **124** to the display control unit **82**D. In this case, the display control unit **82**D generates the display image **94** including the content of notifying the user of the success probability of the procedure indicated by the notification information **124**. In the example shown in FIG. **34**, on the display device **13**, a message "cannula insertion success probability: 90%" is displayed on the screen **37**.

[0270] As described above, in the duodenoscope system **10** according to the present fourteenth modification example, the image recognition unit **82**B of the processor **82** performs the image recognition processing on the intestinal wall image **41** and calculates the evaluation value related to the placement of the treatment tool and the papilla N. The derivation unit **82**C generates the notification information **124** based on the evaluation value information **120** indicating the evaluation value. In the display control unit **82**D, the display image **94** is generated based on the notification information **124** and is output to the display device **13**. The display image **94** includes a display related to the success probability of the procedure indicated by the notification information **124**. Accordingly, the user who observes the intestinal wall image **41** can be notified of the success probability of the procedure using the treatment tool. Since the user can consider the continuation or the change of the operation after grasping the success probability of the procedure, it is possible to support the success of the procedure using the treatment tool.

[0271] In addition, in the duodenoscope system **10** according to the present fourteenth modification example, the image recognition unit **82**B performs the image recognition processing on the intestinal wall image **41** and specifies the presence or absence of contact between the treatment tool and the papilla N. Then, in a case where the treatment tool and the papilla N are in contact with each other based on the contact presence/absence information **122**, the derivation unit **82**C generates the notification information **124** based on the evaluation value information **120**. Accordingly, the user who observes the intestinal wall image **41** can be notified of the success probability of the procedure using the treatment tool only in a necessary situation. In other words, it is possible to support the procedure for the papilla N using the treatment tool at an appropriate timing.

Fifth Embodiment

[0272] In the above fourth embodiment, the form example in which the positional relationship between the treatment tool and the papilla N is specified by performing the image recognition processing on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. In the present fifth embodiment, in a case where the treatment tool is an incision tool, an incision direction is obtained based on the result of the image recognition processing on the intestinal wall image **41**.

[0273] For example, in the ERCP examination, an incision tool (for example, a papillotomy knife) as the treatment tool may be used. This is because the papilla N is incised using the incision tool, so that the insertion of the treatment tool into the papilla N is facilitated or foreign matter in the bile duct T or the pancreatic duct S is easily removed. In this case, in a case where the direction (that is, the incision direction) in which the papilla N is incised by the incision tool is erroneously selected, it may be difficult to perform the procedure successfully due to inadvertent bleeding or the like. Thus, in the present fifth embodiment, a direction (that is, an incision-recommended direction) recommended as the incision direction is specified by performing the image recognition processing on the intestinal wall image **41**.

[0274] As shown in FIG. **35** as an example, the image acquisition unit **82**A updates the time-series image group **89** using the FIFO method each time the intestinal wall image **41** is acquired from the camera **48**.

[0275] The image recognition unit **82**B acquires the time-series image group **89** from the image acquisition unit **82**A and inputs the acquired time-series image group **89** to a trained model **84**E. Accordingly, the trained model **84**E outputs rising direction information **104** corresponding to the input time-series image group **89**.
[0276] The derivation unit **82**C acquires the rising direction information **104** from the image recognition unit **82**B. Then, the derivation unit **82**C derives incision-recommended direction information **126** based on the rising direction information **104**. The incision-recommended direction information **126** is information (for example, a position coordinate group of a start point and an end point of the incision-recommended direction) capable of specifying the incision-recommended direction. The derivation unit **82**C derives the incision-recommended direction from, for example, a predetermined orientation relationship between the rising direction RD and the incision-recommended direction. Specifically, the derivation unit **82**C derives the incision-recommended direction as a direction of 11 o'clock in a case where the rising direction RD is a direction of 12 o'clock.
[0277] As shown in FIG. **36** as an example, the display control unit **82**D acquires the incision-recommended direction information **126** from the derivation unit **82**C. The display control unit **82**D generates an incision direction image **93**F, which is an image showing the incision direction, based on the incision-recommended direction indicated by the incision-recommended direction information **126**. Then, the display control unit **82**D generates the display image **94** including the incision direction image **93**F and the intestinal wall image **41**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **36**, the intestinal wall image **41** on which the incision direction image **93**F is superimposed and displayed on the screen **36** is shown on the display device **13**.
[0278] As described above, in the duodenoscope system **10** according to the present fifth embodiment, the incision-recommended direction information **126** is generated in the derivation unit **82**C. The display control unit **82**D generates the display image **94** based on the incision-recommended direction information **126** and outputs the display image **94** to the display device **13**. The display image **94** includes the incision direction image **93**F indicating the incision-recommended direction indicated by the incision-recommended direction information **126**. Accordingly, the user who observes the intestinal wall image **41** can be made to grasp the incision-recommended direction. As a result, it is possible to support the success of the incision for the papilla N.
Fifteenth Modification Example
[0279] In addition, in the above fifth embodiment, the form example in which the incision-recommended direction is specified has been described, but the technology of the present disclosure is not limited to this. In the present fifteenth modification example, a direction (that is, an incision non-recommended direction) that is not recommended as the incision direction may be specified.
[0280] As shown in FIG. **37** as an example, the derivation unit **82**C derives incision non-recommended direction information **127**. The incision non-recommended direction information **127** is information (for example, an angle indicating a direction other than the incision-recommended direction) capable of specifying the incision non-recommended direction. The derivation unit **82**C derives the incision-recommended direction from, for example, a predetermined orientation relationship between the rising direction RD and the incision-recommended direction. Specifically, the derivation unit **82**C derives the incision-recommended direction as a direction of 11 o'clock in a case where the rising direction RD is a direction of 12 o'clock. Then, the derivation unit **82**C specifies a range excluding a predetermined angle range (for example, a range of ±5 degrees centered on the incision-recommended direction) including the incision-recommended direction as the incision non-recommended direction.
[0281] The display control unit **82**D acquires the incision non-recommended direction information

127 from the derivation unit **82**C. The display control unit **82**D generates an incision non-recommended direction image **93**G, which is an image showing the incision non-recommended direction, based on the incision non-recommended direction indicated by the incision non-recommended direction information **127**. Then, the display control unit **82**D generates a display image **94** including the incision non-recommended direction image **93**G and the intestinal wall image **41**, and outputs the display image **94** to the display device **13**. In the example shown in FIG. **37**, the intestinal wall image **41** on which the incision non-recommended direction image **93**G is superimposed and displayed on the screen **36** is shown on the display device **13**.
[0282] As described above, in the duodenoscope system **10** according to the present fifteenth modification example, the derivation unit **82**C generates the incision non-recommended direction information **127**. The display control unit **82**D generates the display image **94** based on the incision non-recommended direction information **127**, and outputs the display image **94** to the display device **13**. The display image **94** includes the incision non-recommended direction image **93**G indicating the incision non-recommended direction indicated by the incision non-recommended direction information **127**. Accordingly, the user who observes the intestinal wall image **41** can be made to grasp the incision non-recommended direction. As a result, it is possible to support the success of the incision for the papilla N.
[0283] In each of the above embodiments, as an aspect of indicating the operation direction to the user, the form example in which an image of an arrow indicating the operation direction is displayed on the screen **36** has been described, but the technology of the present disclosure is not limited to this. For example, the image indicating the operation direction may be an image of a triangle indicating the operation direction. In addition, an aspect in which a message indicating the operation direction is displayed instead of the image indicating the operation direction or together with the image may be adopted. Moreover, the image indicating the operation direction may be displayed on another window or another display device instead of being displayed on the screen **36**.
[0284] In addition, in each of the above embodiments, the form example in which the bile duct direction TD is indicated has been described, but the technology of the present disclosure is not limited to this. An aspect in which the running direction of the pancreatic duct S is indicated instead of the bile duct direction TD or together with the bile duct direction TD may be adopted.
[0285] In addition, in each of the above embodiments, the form example in which the various types of information are output to the display device **13** has been described, but the technology of the present disclosure is not limited to this. For example, the various types of information may be output to a voice output device such as a speaker (not shown) instead of the display device **13** or together with the display device **13**, or may be output to a printing device such as a printer (not shown).
[0286] In each of the above embodiments, the form example in which the various types of information are output to the display device **13** and the information is displayed on the screen **36** of the display device **13** has been described, but the technology of the present disclosure is not limited to this. The various types of information may be output to an electronic medical record server. The electronic medical record server is a server that stores electronic medical record information indicating a medical care result for a patient. The electronic medical record information includes the various types of information.
[0287] The electronic medical record server is connected to the duodenoscope system **10** through a network. The electronic medical record server acquires the intestinal wall image **41** and the various types of information from the duodenoscope system **10**. The electronic medical record server stores the intestinal wall image **41** and the various types of information as a part of the medical care result indicated by the electronic medical record information.
[0288] The electronic medical record server is also connected to a terminal (for example, a personal computer installed in a medical care facility) other than the duodenoscope system **10** through a network. The user, such as the doctor **14**, can obtain the intestinal wall image **41** and the various

types of information stored in the electronic medical record server through the terminal. In this way, since the intestinal wall image **41** and the various types of information are stored in the electronic medical record server, the user can obtain the intestinal wall image **41** and the various types of information.

[0289] In addition, in each of the above embodiments, the form example in which the image recognition processing using the AI method is executed on the intestinal wall image **41** has been described, but the technology of the present disclosure is not limited to this. For example, the image recognition processing using the pattern matching method may be executed.

[0290] In the above embodiment, the form example in which the medical support processing is performed by the processor **82** of the computer **76** included in the image processing device **25** has been described, but the technology of the present disclosure is not limited to this. For example, the medical support processing may be performed by the processor **70** of the computer **64** included in the control device **22**. In addition, a device that performs the medical support processing may be provided outside the duodenoscope **12**. An example of the device provided outside the duodenoscope **12** is at least one server and/or at least one personal computer that is communicably connected to the duodenoscope **12**. In addition, the medical support processing may be performed in a distributed manner by a plurality of devices.

[0291] In the above embodiment, the form example in which the medical support processing program **84**A is stored in the NVM **84** has been described, but the technology of the present disclosure is not limited to this. For example, the medical support processing program **84**A may be stored in a portable non-transitory storage medium such as an SSD or a USB memory. The medical support processing program **84**A stored in the non-transitory storage medium is installed in the computer **76** of the duodenoscope **12**. The processor **82** performs the medical support processing according to the medical support processing program **84**A.

[0292] In addition, the medical support processing program **84**A may be stored in a storage device of, for example, another computer or a server that is connected to the duodenoscope **12** through a network. Then, the medical support processing program **84**A may be downloaded and installed in the computer **76** in response to a request from the duodenoscope **12**.

[0293] It is not necessary to store all of the medical support processing program **84**A in the NVM **84** or the storage device of another computer or server device connected to the duodenoscope **12**, and a part of the medical support processing program **84**A may be stored.

[0294] Various processors described below can be used as the hardware resource for executing the medical support processing. An example of the processor is a CPU which is a general-purpose processor that executes software, that is, a program, to function as the hardware resource performing the medical support processing. In addition, an example of the processor is a dedicated electronic circuit which is a processor having a dedicated circuit configuration designed to perform a specific process, such as an FPGA, a PLD, or an ASIC. Any processor has a memory built in or connected to it, and any processor executes the medical support processing by using the memory.

[0295] The hardware resource for performing the medical support processing may be configured by one of the various processors or by a combination of two or more processors of the same type or different types (for example, a combination of a plurality of FPGAs or a combination of a CPU and an FPGA). The hardware resource for executing the medical support processing may also be one processor.

[0296] A first example of the configuration using one processor is a form in which one processor is configured by combining one or more CPUs and software, and the processor functions as the hardware resource for executing the medical support processing. A second example of the configuration is an aspect in which a processor that implements the functions of the entire system including a plurality of hardware resources for performing the medical support processing using one IC chip is used. A representative example of this aspect is an SoC. In this way, the medical support processing is implemented by using one or more of the various processors as the hardware

resource.
[0297] More specifically, an electric circuit in which circuit elements such as semiconductor elements are combined can be used as a hardware structure of the various processors. In addition, the above medical support processing is merely an example. Therefore, it goes without saying that unnecessary steps may be deleted, new steps may be added, and the processing order may be changed within a range that does not deviate from the scope.
[0298] The above-described contents and the above-shown contents are detailed descriptions of portions relating to the technology of the present disclosure and are merely examples of the technology of the present disclosure. For example, the description of the configuration, the function, the operation, and the effect above are the description of examples of the configuration, the function, the operation, and the effect of the parts according to the technology of the present disclosure. As a result, it goes without saying that unnecessary parts may be deleted, new elements may be added, or replacements may be made with respect to the above-described contents and the above-shown contents within a range that does not deviate from the gist of the technology of the present disclosure. In addition, the description of, for example, common technical knowledge that does not need to be particularly described to enable the implementation of the technology of the present disclosure is omitted in the above-described contents and the above-shown contents in order to avoid confusion and to facilitate understanding of the portions relating to the technology of the present disclosure.
[0299] In the present specification, “A and/or B” is synonymous with “at least one of A or B”. That is, “A and/or B” may mean only A, only B, or a combination of A and B. In the present specification, the same concept as “A and/or B” also applies to a case in which three or more matters are expressed by association with “and/or”.
[0300] All documents, patent applications, and technical standards described in the present specification are incorporated in the present specification by reference in their entireties to the same extent as in a case where the individual documents, patent applications, and technical standards are specifically and individually written to be incorporated by reference.
[0301] The disclosure of JP2022-177613 filed on Nov. 4, 2022 is incorporated in the present specification by reference.

Claims

1. A medical support device comprising: a processor, wherein the processor is configured to: acquire intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic of the duodenum; and output the intestinal tract direction-related information.
2. The medical support device according to claim 1, wherein the intestinal tract direction-related information includes deviation amount information indicating a deviation amount between a posture of the endoscope scope and the intestinal tract direction.
3. The medical support device according to claim 1, wherein the geometrical characteristic information includes an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope, and the processor is configured to acquire the intestinal tract direction-related information by executing first image recognition processing on the intestinal wall image.
4. The medical support device according to claim 1, wherein the outputting of the intestinal tract direction-related information includes displaying the intestinal tract direction-related information on a first screen.
5. The medical support device according to claim 1, wherein the intestinal tract direction-related information includes first direction information capable of specifying a first direction intersecting

the intestinal tract direction at a predetermined angle.
6. The medical support device according to claim 5, wherein the first direction information is obtained by executing second image recognition processing on an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope.
7. The medical support device according to claim 6, wherein the first direction information is information obtained with a degree of certainty equal to or greater than a threshold value by performing image recognition processing using an AI method as the second image recognition processing.
8. The medical support device according to claim 1, wherein the processor is configured to acquire posture information capable of specifying a posture of the endoscope scope in a state in which the endoscope scope is inserted into the duodenum, the intestinal tract direction-related information includes posture adjustment support information for supporting adjustment of the posture, and the posture adjustment support information is information determined based on a deviation amount between the intestinal tract direction and the posture specified from the posture information.
9. The medical support device according to claim 1, wherein the intestinal tract direction-related information includes condition information indicating a condition for changing a posture of the endoscope scope to match an optical axis direction of a camera provided in the endoscope scope with a second direction intersecting the intestinal tract direction at a predetermined angle.
10. The medical support device according to claim 9, wherein the condition includes an operation condition related to an operation performed on the endoscope scope to match the optical axis direction with the second direction.
11. The medical support device according to claim 1, wherein, in a case where an optical axis direction of a camera provided in the endoscope scope matches a third direction intersecting the intestinal tract direction at a predetermined angle, the intestinal tract direction-related information includes notification information for notifying that the optical axis direction matches the third direction.
12. The medical support device according to claim 1, wherein the processor is configured to: detect a duodenal papilla region by executing third image recognition processing on an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope; display the duodenal papilla region on a second screen; and display, on the second screen, papilla orientation information indicating an orientation of the duodenal papilla region, the papilla orientation information being obtained based on the intestinal tract direction-related information.
13. The medical support device according to claim 1, wherein the processor is configured to: detect a duodenal papilla region by executing fourth image recognition processing on an intestinal wall image obtained by imaging an intestinal wall of the duodenum with a camera provided in the endoscope scope; display the duodenal papilla region on a third screen; and display, on the third screen, running direction information indicating a running direction of a duct leading to an opening of the duodenal papilla region, the running direction information being obtained based on the intestinal tract direction-related information.
14. The medical support device according to claim 13, wherein the duct is a bile duct or a pancreatic duct.
15. The medical support device according to claim 1, wherein the geometrical characteristic information includes depth information indicating a depth of the duodenum, and the intestinal tract direction-related information is acquired based on the depth information.
16. An endoscope comprising: the medical support device according to claim 1; and the endoscope scope.
17. A medical support method comprising: acquiring intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic

of the duodenum; and outputting the intestinal tract direction-related information.

18. A non-transitory computer-readable storage medium storing a program causing a computer to execute processing comprising: acquiring intestinal tract direction-related information related to an intestinal tract direction of a duodenum into which an endoscope scope is inserted, based on geometrical characteristic information capable of specifying a geometrical characteristic of the duodenum; and outputting the intestinal tract direction-related information.