United States Patent Application Publication	20250264711
Kind Code	A1
Publication Date	August 21, 2025
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CAMERA HEAD AND IMAGING SYSTEM

Abstract

In some cases, it is desirable for a camera head to be small. A camera head has an elongated shape, and is used for imaging an imaging area located in a vicinity of a leading end portion in a longitudinal direction. The camera head includes: a camera module; two or more light source units disposed at positions farther from the leading end portion than the camera module is in the longitudinal direction; and a light guide unit disposed radially outside an outer surface of the camera module and configured to guide light emitted from each of the two or more light source units to the vicinity of the leading end portion so that the imaging area is irradiated with the light, and at least two light source units of the two or more light source units are located at different positions in the longitudinal direction. With such a configuration, the camera head can be made even smaller.

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Family ID:	**1000008616703**
Appl. No.:	**19/105607**
Filed (or PCT Filed):	**October 18, 2024**
PCT No.:	**PCT/JP2024/037275**

Foreign Application Priority Data

JP	2023-183689	Oct. 26, 2023

Publication Classification

Int. Cl.: **G02B23/24** (20060101); **H04N23/50** (20230101); **H04N23/56** (20230101)

U.S. Cl.:

CPC **G02B23/2469** (20130101); **G02B23/2423** (20130101); **G02B23/2484** (20130101); **H04N23/555** (20230101); **H04N23/56** (20230101);

Background/Summary

TECHNICAL FIELD

[0001] The present invention relates to a camera head and an imaging system used to image an imaging area in the vicinity of a leading end portion in a longitudinal direction.

BACKGROUND ART

[0002] Conventionally, various types of camera heads have been used in endoscopes for observing living organisms, industrial endoscopes, and the like. Some camera heads have a structure for emitting illumination light, and a camera module.

[0003] To reduce the diameter of such camera heads, some have a structure in which a light source is disposed behind the imaging module and a light guide guides light from the light source to the leading end (for example, see Patent Documents 1, 2, 3, 4, and 5 below).

[0004] Note that some camera heads have a structure in which a plurality of light guides and light emitters are disposed at equal intervals around the imaging element (for example, see Patent Documents 6, 7, and 8 below).

BACKGROUND ART

Patent Document

[0005] Patent Document 1: JP 6995659B [0006] Patent Document 2: JP 2005-204944A [0007] Patent Document 3: JP 4530128B [0008] Patent Document 4: JP 2012-205849A [0009] Patent Document 5: JP 02-110505A [0010] Patent Document 6: JP 7100171B [0011] Patent Document 7: JP 6020870B [0012] Patent Document 8: JP 6055691B

SUMMARY OF INVENTION

Technical Problem

[0013] If a camera head can be downsized, the camera head and the imaging system using the camera head will become more useful in several applications.

[0014] The present invention aims to provide a smaller camera head and imaging system.

Solution to Problem

[0015] A camera head according to a first aspect of the present invention is a camera head that has an elongated shape and is used for imaging an imaging area located in a vicinity of a leading end portion in a longitudinal direction, including: a camera module; two or more light source units disposed at positions farther from the leading end portion than the camera module is in the longitudinal direction; and a light guide unit disposed radially outside an outer surface of the camera module and configured to guide light emitted from each of the two or more light source units to the vicinity of the leading end portion so that the imaging area is irradiated with the light, wherein at least two light source units of the two or more light source units are disposed at different positions in the longitudinal direction.

[0016] With such a configuration, the camera head that can irradiate the imaging area with light from the two or more light source units can be made smaller.

[0017] A camera head according to a second aspect of the present invention is the camera head according to the first aspect of the invention, wherein at least two light source units of the two or more light source units are configured to emit light of wavelengths different from each other.

[0018] With such a configuration, the camera head capable of irradiating the imaging area with light of multiple wavelengths can be made smaller.

[0019] A camera head according to a third aspect of the present invention is the camera head according to the first or second aspect of the invention, the light guide unit includes two or more

optical fibers respectively corresponding to at least two light source units of the two or more light source units, and the two or more optical fibers are disposed around the camera module so as to be spaced apart from each other in a circumferential direction and lined up in the circumferential direction.
[0020] With such a configuration, the imaging area can be uniformly irradiated with the light from the light source units.
[0021] A camera head according to a fourth aspect of the present invention is the camera head according to the third aspect of the invention, wherein, of the two or more optical fibers, two or more optical fibers provided for guiding light within one wavelength band are disposed around the camera module so as to be spaced apart from each other in the circumferential direction, and the light guide unit is configured to irradiate the imaging area with the light within the one wavelength band from two or more positions that are spaced apart from each other in the circumferential direction.
[0022] With such a configuration, the imaging area can be uniformly irradiated with the light within the one wavelength band.
[0023] A camera head according to a fifth aspect of the present invention is the camera head according to the third or fourth aspect of the invention, wherein the camera module has a columnar portion having a polygonal columnar shape, and the two or more optical fibers are disposed along planar side surfaces of the columnar portion.
[0024] With such a configuration, the camera head can be made even smaller.
[0025] A camera head according to a sixth aspect of the present invention is the camera head according to any one of the first to fifth aspects of the invention, further including a sleeve formed into a tubular shape, wherein the camera module, the light source units, and the light guide unit are housed in the sleeve.
[0026] With such a configuration, a camera head that is small and easy to manufacture can be formed.
[0027] A camera head according to a seventh aspect of the present invention is the camera head according to any one of the first to fifth aspects of the invention, further including a sleeve formed into a tubular shape, wherein the sleeve is a light transmissive member, the light guide unit is a portion or an entirety of the sleeve, and the camera module is housed in the sleeve.
[0028] With such a configuration, the camera head can be made even smaller.
[0029] A camera head according to an eighth aspect of the present invention is the camera head according to any one of the first to seventh aspects of the invention, wherein the camera module and the light guide unit are integrated into one piece.
[0030] With such a configuration, a camera head that is small and easy to manufacture can be formed.
[0031] A camera head according to a ninth aspect of the present invention is the camera head according to any one of the first to eighth aspects of the invention, wherein, of the two or more light source units, at least two light source units located at different positions in the longitudinal direction are disposed so as to partially overlap each other when viewed from a front in the longitudinal direction.
[0032] With such a configuration, a camera head with at least two light source units can be reliably made smaller.
[0033] An imaging system according to a tenth aspect of the present invention is the imaging system according to any one of the first to ninth aspects of the invention, including: a camera head; and an image acquisition device connected to the camera head and configured to acquire an image captured by the camera head.
[0034] With such a configuration, an image can be acquired using a small camera head capable of irradiating the imaging area with the light from the two or more light source units.
Advantageous Effects of Invention

[0035] According to the present invention, it is possible to provide a smaller camera head and imaging system.

Description

BRIEF DESCRIPTION OF DRAWINGS

[0036] FIG. **1** is a diagram illustrating a configuration of an imaging system according to one embodiment of the present invention.

[0037] FIG. **2** is a block diagram of the imaging system according to the same.

[0038] FIG. **3** is a cross-sectional side view of a camera head according to the same.

[0039] FIG. **4** is a cross-sectional view taken along a line A-A in FIG. **3**.

[0040] FIG. **5** is a cross-sectional view taken along a line B-B in FIG. **3**.

[0041] FIG. **6** is a cross-sectional view taken along a line C-C in FIG. **3**.

[0042] FIG. **7** is a cross-sectional view taken along a line D-D in FIG. **3**.

[0043] FIG. **8** is a diagram illustrating a configuration of an illumination filter for the camera head according to the same.

[0044] FIG. **9** is a diagram illustrating an example of a configuration of a camera head according to one comparative example of the present embodiment.

[0045] FIG. **10** is a diagram illustrating a use example of the imaging system according to the present embodiment.

[0046] FIG. **11** is a diagram illustrating an example of a configuration of a camera head according to a first modification of the embodiment of the present invention.

[0047] FIG. **12** is a diagram illustrating an example of a configuration of a camera head according to a second modification of the embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0048] Hereinafter, an embodiment of a camera head, an imaging system using the same, and the like will be described with reference to the drawings. In the embodiment, components with the same reference numerals perform similar operations, and therefore repeated explanations may be omitted.

[0049] In the following description, the direction orthogonal to the longitudinal direction of the tubular camera head may also be referred to as a radial direction, and the direction along an arc centered around the central axis of the camera head extending in the longitudinal direction may also be referred to as a circumferential direction. In addition, in the following description, the direction toward the leading end portion in the radial direction may also be referred to as a “front” and the opposite direction may also be referred to as a “rear”. For example, the shape and positional relationships of each unit may be described by indicating a particular direction in this way, but the explicit direction is only for ease of description and does not limit the orientation or posture of each device, etc., according to the present invention when used. In addition, expressions indicating a direction or expressions indicating a state such as horizontal, vertical, orthogonal, etc., only indicate that they can be roughly understood in that way, and do not necessarily have to be interpreted strictly as expressed.

Embodiment

[0050] The summary of the embodiments is as follows. The camera head is for imaging an imaging area in the vicinity of the leading end in the longitudinal direction. The camera head has a structure in which at least two light source units are disposed at different positions in the longitudinal direction farther from the leading end than the camera module is. The at least two light source units are preferably configured to emit light of wavelengths different from each other. Hereinafter, a camera head with such a configuration and the configuration of an imaging system using the camera head will be described.

[0051] FIG. **1** is a diagram illustrating a configuration of an imaging system **1** according to one embodiment of the present invention. FIG. **2** is a block diagram of the imaging system **1** according to the same.

[0052] As shown in the figures, the imaging system **1** includes a camera head **10** and an image acquisition device **100**. The imaging system **1** can be used as an endoscope for observing and inspecting various organs of living organisms, an industrial endoscope, or the like. The imaging system **1** may also be referred to as an imaging device. The use of the imaging system **1** is not limited to the application described above. The imaging system **1** is configured to be capable of acquiring imaging results of an imaging area in the vicinity of the leading end of the camera head **10**. The imaging system **1** is configured to be capable of recording the imaging results as images and outputting them to an internal or external output device.

[0053] Note that the images may be still images or moving images. A moving image may be considered to include a plurality of still images. In addition, there is no limitation on the format of the data recorded or output as images.

[0054] The expression "(to) output to an output device" includes displaying on a display or the like, printing on a medium using a printer or the like, transmitting information to another device via a network, etc.

[0055] The camera head **10** includes a camera module **30** and light source units **40**. In the present embodiment, the light source units **40** include, for example, first light source units **41** and second light source units **42** that emit light of wavelengths different from each other. More types of light sources may be used. Further details of the structure of the camera head **10** will be described later.

[0056] The camera head **10** is connected to the image acquisition device **100** via a cable **19**. The cable **19** includes, for example, a signal line for communicating with the camera module **30**, electrical wires for supplying power for driving the camera module **30** and the light source units **40**, and so on. The cable **19** is configured to be flexible, but is not limited to such a configuration.

[0057] The image acquisition device **100** is, for example, a device including a computer and configured to be capable of driving the camera head **10** to capture images. In the present embodiment, the image acquisition device **100** is configured to be capable of recording the imaging results and outputting the imaging results to an external terminal device **600** or the like and displaying them on a display of the terminal device **600** or the like. The image acquisition device **100** may have its own display and may be configured to be capable of displaying captured images. The image acquisition device **100** may be, for example, a personal computer itself or the like. In the present embodiment, the imaging system **1** may be understood to include the terminal device **600**.

[0058] In the present embodiment, the image acquisition device **100** includes, for example, a storage unit **110**, an acceptance unit **130**, an image acquisition unit **140**, a camera head driving unit **150**, and a communication unit **160**.

[0059] The storage unit **110** is preferably a non-volatile recording medium, but may also be realized as a volatile recording medium. The storage unit **110** stores each piece of information acquired by the image acquisition device **100**. The process in which information or the like is stored is not limited to any specific process. For example, information or the like may be stored via a recording medium, information or the like transmitted via a communication line or the like may be stored, or information or the like input via an input device may be stored.

[0060] The acceptance unit **130** accepts the imaging results from the camera head **10**, information or the like received by the communication unit **160**, etc. as information input to the image acquisition device **100**. The accepted information is accumulated temporarily or for the long term in the storage unit **110**, or is used in the processing by the other units.

[0061] Note that the acceptance unit **130** may be capable of receiving information input from an input means. The input means may be any means, such as a numeric keypad, a keyboard, a mouse, or a menu screen. In this case, the acceptance unit **130** can be realized by a device driver for an input means such as a numeric keypad or a keyboard, or control software or the like for a menu screen.

[0062] The image acquisition unit **140** acquires images captured by the camera head **10**. That is, the imaging results acquired by the camera module **30** of the camera head **10** and transmitted to the image acquisition device **100** via the cable **19** are acquired as images. The image acquisition unit **140** is configured to be capable of recording the acquired images in the storage unit **110**.

[0063] The camera head driving unit **150** is configured to supply power to the camera module **30** and the light source units **40** of the camera head **10**, to drive each unit, and to control the operation of each unit.

[0064] The image acquisition unit **140** and the camera head driving unit **150** are configured to be capable of operating, for example, by a computer executing a predetermined control program, but are not limited to to such a configuration.

[0065] The communication unit **160** connects the image acquisition device **100** to an external device so as to be able to communicate with each other. The communication unit **160** is realized, for example, by a wireless or wired communication means, but may also be realized by a means for receiving broadcast or a broadcasting means. In the present embodiment, the communication unit **160** is configured to be capable of communicating with, for example, an external terminal device **600** or the like, and transmitting images, which are imaging results of the camera head **10**, to the terminal device **600**. That is to say, the image acquisition device **100** is capable of outputting images captured using the camera head **10**.

[0066] Next, the structure of the camera head **10** according to the present embodiment will be described.

[0067] FIG. **3** is a cross-sectional side view of the camera head **10** according to the same. FIG. **4** is a cross-sectional view taken along the line A-A in FIG. **3**. FIG. **5** is a cross-sectional view taken along the line B-B in FIG. **3**. FIG. **6** is a cross-sectional view taken along the line C-C in FIG. **3**. FIG. **7** is a cross-sectional view taken along the line D-D in FIG. **3**.

[0068] In these figures and in similar cross-sectional views below, hatching indicates cross-sections of members, but for ease of illustration, cross-sections of not all members are necessarily hatched.

[0069] As shown in the figures, the camera head **10** has an overall elongated shape. In the present embodiment, the camera head **10** as a whole has a substantially cylindrical shape. Note that the leading end portion and the rear end portion of the camera head **10** may be rounded, or may have partial projections and recesses. FIG. **3** can be said to show a cross-section taken along a plane passing through the central axis of the camera head **10**.

[0070] The camera head **10** includes, for example, a sleeve **20**, the camera module **30**, the light source units **40**, a light guide unit **60**, and filters **70** and **80**. An illumination filter **70** and an imaging filter **80** are provided as the filters **70** and **80** in the present embodiment.

[0071] The sleeve **20** is formed into a cylindrical shape. It may be said that the sleeve **20** is formed into a tubular shape. There is no restriction on the material of the sleeve **20**. Any material such as metal, ceramic, or resin may be used. In the present embodiment, each unit of the camera head **10** is housed in the sleeve **20**. It may be said that each unit of the camera head **10** is located inside the sleeve **20**. It may also be said that each unit of the camera head **10** is located inside the inner circumferential surface of the sleeve **20** in the radial direction (the direction toward or away from the central axis of the camera head **10**). In the present embodiment, the inner circumferential surface of the sleeve **20** has a cylindrical shape.

[0072] The camera module **30** is a module in which an imaging element and an optical system such as a lens are packaged. For example, a module having a known structure can be used as the camera module **30**. The camera module **30** has a structure in which a light receiving unit **32**, which is located on the leading end side and into which light to be captured enters, an optical system including the lens, etc., and the imaging element are lined up in the longitudinal direction of the camera head **10** (the left-right direction in FIG. **3**). Wires **91** connected to the imaging element are connected to a rear end portion **34** of the camera module **30**, i.e., the rear end portion **34** of the imaging element. The wires **91** can be bundled into a cable **19** and connected to the image acquisition device **100** or the like.

[0073] In the present embodiment, the camera module **30** as a whole has a rectangular prism shape formed such that the longitudinal direction of the camera head **10** corresponds to the height direction. That is to say, the outer surface (the circumference-side surface) of the camera module **30** is constituted roughly by four flat portions **35** that are substantially flat. The cross-section of the camera module **30** is substantially square, but may have another rectangular or quadrangular shape. Note that the camera module **30** is not limited to such a shape and may have any shape as long as it includes a columnar portion having a polygonal columnar shape. The flat portions **35** may be said to be planar side surfaces of the columnar portion.

[0074] For example, the camera module **30** is not limited to having a quadrangular column shape, and may be formed to have a triangular column shape or another polygonal column shape. That is to say, the circumference-side surface of the camera module **30** may be constituted by three or more flat portions **35** that are substantially flat. In addition, the camera module may also have a three-dimensional shape called a torsion column (helical column), in which the bottom surface rotates around a central axis along the height direction. The camera module **30** may be cylindrical or have another shape.

[0075] Each light source unit **40** is a light source that irradiates the imaging area when imaging is performed using the camera head **10**. For example, each light source unit **40** may be, but is not limited to, an LED chip. For example, each light source unit **40** may be another type of light source, such as a laser diode. For example, electrical wires (not shown) passed through the cable **19** are connected to the light source units **40**, and each light source unit **40** is configured to illuminate when power is supplied from the image acquisition device **100** or the like. For example, each light source unit **40** as a whole has a rectangular parallelepiped shape as described below, but is not limited to having such a shape, and may have another shape, such as a cylindrical shape, a coin shape, a flat plate shape, or the like.

[0076] The camera head **10** includes two or more light source units **40**. For example, in the present embodiment, four light source units **40** are provided. Two of the four light source units **40** are the first light source units **41**, and the other two are the second light source units **42**. Each of the first light source units **41** and the second light source units **42** as a whole is, for example, an LED chip having a substantially rectangular parallelepiped shape and is disposed to emit light from the front surface thereof. The first light source units **41** and the second light source units **42** are configured to emit light of wavelengths different from each other. In the present embodiment, the first light source units **41** and the second light source units **42** are provided, so that it is possible to simplify the structure of the light guide unit **60** that guides light from each light source unit forward. In addition, it is easier to adjust the amount of light emitted from the camera head **10** for each wavelength.

[0077] Note that the number of the light source units **40** is not limited to the number mentioned above. It is sufficient that two or more light source units **40** are provided. Of the two or more light source units **40**, at least two are preferably configured to emit light of wavelengths different from each other, as in the present embodiment. For example, the camera head **10** may be provided with one first light source unit **41** and one second light source unit **42**. Note that the present invention is not limited to such a configuration and may have a configuration in which the first light source units **41** and the second light source units **42** emit light of the same wavelength. Alternatively, it is also possible to adopt a configuration in which one light source unit **40** or two or more light source units **40** that emit light of the same wavelength are provided, and the light emitted from the light source unit(s) **40** is passed through filters that transmit light within wavelength bands different from each other so that light of two or more wavelengths can be transmitted from the camera head **10**.

[0078] As shown in the figure, each light source unit **40** is disposed at a position farther from the leading end portion **12** than the camera module **30** is in the longitudinal direction. That is to say, each light source unit **40** is disposed rearward of the camera module **30**. It may be said that each light source unit **40** is located behind the camera module **30** when viewed from the front in the longitudinal direction of the camera head **10** (the leading end portion **12** side). Since each light source unit **40** is located away from the leading end portion **12**, heat generated by each light source unit **40** is less likely to be transmitted to the leading end portion **12**, and is prevented from affecting the subject. In addition, each light source unit **40** is disposed at a position where a portion of the light source unit **40** overlaps the camera module **30** when viewed from the front in the longitudinal direction. As a result, each unit of the camera head **10** can be housed in the sleeve **20** with a smaller diameter, and the camera head **10** can be made smaller in diameter (thinner in diameter).

[0079] In addition, in the camera head **10**, at least two light source units **40** of the light source units **40** are located at different positions in the longitudinal direction. The rear end of at least one light source unit **40** of the at least two light source units **40** is located forward of the front end of the other at least one light source unit **40**. Since at least two light source units **40** are located at different positions in the longitudinal direction in this manner, the light source units **40** can be housed in the sleeve **20** with a smaller diameter. In other words, the diameter of the camera head **10** can be made smaller. In order to make the diameter further smaller, the at least two light source units **40** can be disposed so as to partially overlap each other when viewed from the front in the longitudinal direction.

[0080] In addition, the at least two light source units **40** are located at different positions in the circumferential direction. Since the at least two light source unit **40** are located at different positions in the circumferential direction, the structure for guiding the light from each light source unit **40** to the leading end portion **12** can be simplified as will be described later.

[0081] More specifically, in the present embodiment, in the camera head **10**, the two first light source units **41** are located forward of the two second light source units **42**. In other words, the camera module **30**, the two first light source units **41**, and the two second light source units **42** are disposed in this order in the longitudinal direction from the leading end portion **12** side. It can be said that the two first light source units **41** are sandwiched between the rear end portion **34** of the camera module **30** and the front end portions of the second light source units **42**.

[0082] As shown in FIG. **4**, in the present embodiment, the two first light source units **41** are disposed radially outside the cable **19** so that the cable **19** is sandwiched between the two first light source units **41**. The two first light source units **41** are disposed such that the long sides thereof are substantially parallel to each other when viewed from the front in the longitudinal direction. As shown in FIG. **5**, the two second light source units **42** are also disposed radially outside the cable **19** so that the cable **19** is sandwiched between the two second light source units **42**. The two second light source units **42** are disposed such that the long sides thereof are substantially parallel to each other when viewed from the front in the longitudinal direction.

[0083] In the present embodiment, the first light source units **41** and the second light source units **42** are disposed so that the long sides of the first light source units **41** and the long sides of the second light source units **42** are orthogonal to each other when viewed from the front in the longitudinal direction. That is to say, the first light source units **41** and the second light source units **42** are located at different positions in the circumferential direction. In addition, the first light source units **41** and the second light source units **42** are disposed so as to partially overlap each other when viewed from the front in the longitudinal direction. Here, the expressions “parallel” and “orthogonal” do not necessarily mean that the units strictly have such a relationship. The units need only be substantially parallel or substantially orthogonal to each other. Note that the positional relationship between the first light source units **41** and the second light source units **42** when viewed from the front in the longitudinal direction is not limited to the relationship mentioned above. When viewed from the front in the longitudinal direction, a straight line overlapping the long sides of the first light source units **41** and a straight line overlapping the long sides of the second light source units **42** may intersect at a predetermined angle. It is preferable that two or more light source units **40** at different positions in the longitudinal direction are disposed so that the positions from which light is emitted are different from each other when viewed from the front in the longitudinal direction. Such an arrangement allows the light guide unit **60** to have a relatively simple configuration. For example, when optical fibers are used as the light guide unit **60** as described below, the optical fibers can be easily routed. When the two or more light source units **40** are disposed at different positions in the longitudinal direction, for example, it is possible to adopt a configuration in which the light source units **40** are located so as to be shifted one after another by a predetermined angle about the center of the camera head **10** when viewed from the front in the longitudinal direction.

[0084] Note that one first light source unit **41** and one second light source unit **42** may be disposed at substantially the same position in the longitudinal direction, and the other first light source unit **41** and the other second light source unit **42** may be disposed rearward thereof. Alternatively, the first light source units **41** may be located on the rear side, and the second light source units **42** may be located on the front side. It is sufficient that either the first light source units **41** or the second light source units **42** are located forward or rearward of the others.

[0085] It is preferable that the rear end portion **34** of the camera module **30** and the first light source unit **41** that is closest to the leading end portion **12** among the light source units **40** are close to each other. In the present embodiment, a portion of the leading end portion **12** side front surface of the light source unit **40** that is located closest to the leading end portion **12** faces the rear end portion **34** of the camera module **30** in the longitudinal direction. With such a structure, i.e., a structure in which portions of the light source units **40** overlap the camera module **30** when viewed from the front in the longitudinal direction as shown in FIG. **4**, the camera head **10** can be made even smaller.

[0086] The light guide unit **60** is disposed radially outside the outer surface of the camera module **30**. In the present embodiment, the light guide unit **60** is disposed between the flat portions **35** of the camera module **30** and the inner circumferential surface of the sleeve **20**. The light guide unit **60** guides the light emitted from each of the light source units **40** to the vicinity of the leading end portion **12** so that the imaging area can be irradiated with the light. It can be said that the light guide unit **60** guides the light to the vicinity of the leading end portion **12**. It can also be said that the light guide unit **60** serves to guide for guiding the light to the vicinity of the leading end portion **12**. The vicinity of the leading end portion **12** may include the leading end portion **12**. In the present embodiment, an illumination filter **80** through which the guided light passes is provided in the leading end portion **12**, and the light guide unit **60** is configured to guide the light to the vicinity of a light entrance portion where light enters the illumination filter **80**. That is to say, the light entrance portion where light enters the illumination filter **80** is included in the vicinity of the leading end portion **12**.

[0087] Note that when the light guide unit **60** guides the light emitted from the light source units **40** behind the camera module **30** to the vicinity of the leading end portion, it can also be said that the light guide unit **60** guides the light forward so that the light is emitted to a position in front of the camera module **30**.

[0088] In the present embodiment, the light guide unit **60** includes optical fibers. Note that elements other than optical fibers, for example, optical waveguides or the like made of resin, glass, or the like, may be used.

[0089] In the present embodiment, the light guide unit **60** includes four optical fibers respectively corresponding to the light source units **40**. Of the four optical fibers, two are referred to as first light guide units **61** and the other two are referred to as second light guide units **62**. The two first light guide units **61** respectively correspond to the two first light source units **41**, and the two second light guide units **62** respectively correspond to the two second light source units **42**. Note that, for one light source unit **40**, two or more elements such as optical fibers may be provided to

guide light so that the light is emitted from different positions in the radial or circumferential direction.
[0090] In the present embodiment, the four optical fibers of the light guide unit **60** are disposed around the camera module **30** so as to be spaced apart from each other in the circumferential direction and lined up in the circumferential direction. The optical fibers are lined up at substantially equal intervals in the circumferential direction. That is to say, the four optical fibers are lined up at approximately 90-degree intervals in the circumferential direction.
[0091] More specifically, as shown in FIG. **6**, the first light guide units **61** and the second light guide units **62** are lined up alternately in the circumferential direction. That is to say, the light guide unit **60** is configured to be capable of irradiating the imaging area with light within a wavelength band from two positions that are spaced apart from each other in the circumferential direction. As a result, the imaging area is relatively uniformly irradiated with the light within the respective wavelength bands of the first light source units **41** and the second light source units **42**.
[0092] Here, the optical fibers are disposed along the flat portions **35** of the camera module **30**. In the present embodiment, one optical fiber is disposed in each of the four spaces formed between the four flat portions **35** and the inner circumferential surface of the sleeve **20**. As a result of such an arrangement of the optical fibers, each unit of the camera head **10** can be housed in the sleeve **20** with a smaller diameter, and the camera head **10** can be made smaller in diameter.
[0093] An imaging filter **70** and the illumination filter **80** are attached to the leading end portion **12** of the camera head **10**.
[0094] In the present embodiment, the camera head **10** is configured to be used in bioimaging technology, for example, by irradiating the imaging area with excitation light of a specific wavelength to excite a fluorescent substance and imaging the emitted fluorescence. To enable the camera head **10** to be used for such applications, the imaging filter **70** is disposed on the leading end side of the camera module **30**, and the illumination filter **80** is disposed on the leading end side of the light guide unit **60**.
[0095] The illumination filter **80** is, for example, an excitation light filter. The illumination filter **80** allows only light in a specific wavelength range of the light guided by the light guide unit **60** to pass therethrough and irradiates the imaging area with the light. This light acts on and excites fluorescent substances or fluorescent markers in tissues or the like in the imaging region. The imaging filter **70** is, for example, a fluorescent filter. The imaging filter **70** is configured to allow only fluorescence in a specific wavelength range different from the excitation light to pass therethrough, and allows only a certain fluorescence signal generated after excitation to enter the light receiving unit **32** of the camera module **30** with high precision.
[0096] The imaging filter **70** is fixed to the camera module **30** so as to cover the front of the light receiving unit **32**. The illumination filter **80** is disposed forward of the light guide unit **60** so as to have a shape that closes the gap between the imaging filter **70** and the inner circumferential surface of the sleeve **20**. That is to say, in the present embodiment, the leading end portion **12** of the camera head **10** is sealed with the filters **70** and **80**. Note that the rear end portion of the camera head **10** is sealed with a bonding material or the like as indicated by the two-dot chain line in FIG. **3**, for example. However, the present invention is not limited to such a configuration.
[0097] Note that the filters **70** and **80** are not limited to those with the properties described above. Filters with properties appropriate for their applications may be used. In addition, one or both of the filters **70** and **80** may be omitted. In this case, the leading end portion **12** may be provided with a filter for protection purposes, or no optical elements may be provided in addition to the camera module **30** and the light guide unit **60**. The filters **70** and **80** may or may not be so-called optical filters.
[0098] As shown in FIG. **7**, in the present embodiment, a light blocking structure **22** configured to block light is provided between the filters **70** and **80** so as to prevent light originating from the light emitted from the light source units **40** from directly entering the camera module **30**. In other words,

the light blocking structure **22** prevents light other than the light entering from the imaging area from entering the camera module **30**. The light blocking structure **22** may be provided around the camera module **30**, around the light guide unit **60**, or the like.
[0099] For example, the light blocking structure **22** is a metal film or the like, or a film or the like having light blocking properties, but is not limited to these examples. When the imaging filter **70** or the illumination filter **80** is configured to totally reflect incident light, such a configuration may be regarded as the light blocking structure **22**. The light blocking structure **22** may also be a filler having light blocking properties that is applied or filled into the gaps between members. For example, the filler may be a mixture of an adhesive or a resin or the like that cures by a chemical reaction, and a pigment or the like. The light blocking structure **22** is not limited to these examples, and various structures that prevent the incidence of light other than the light entering from the imaging area can be used. Depending on the application and configuration of the camera head **10**, the light blocking structure **22** may be omitted.
[0100] FIG. **8** is a diagram illustrating the configuration of the illumination filter **80** of the camera head **10**.
[0101] Here, in the present embodiment, the illumination filter **80** includes first excitation light filters **81** corresponding to the first light source units **41** and second excitation light filters **82** corresponding to the second light source units **42**. Thus, the illumination filter **80** is configured to be capable of emitting excitation light of different wavelengths corresponding to the light emitted from the first light source units **41** and the second light source units **42**.
[0102] As shown in FIG. **8**, for example, the illumination filter **80** is formed by combining four members, namely the two first excitation light filters **81** disposed forward of the first light guide units **61**, and the two second excitation light filters **82** disposed forward of the second light guide units **62**. Adjacent filters in the circumferential direction of the filters **81** and **82** are attached to each other to form one illumination filter **80**. Note that the configuration of the illumination filter **80** is not limited to this example.
[0103] In the present embodiment, the imaging filter **70** and the illumination filter **80** are joined together. The camera module **30** is fixed to the imaging filter **70**. The light guide unit **60** is fixed to the illumination filter **80**. As a result, the camera module **30** and the light guide unit **60** are integrated into one piece. This makes it possible to easily manufacture the camera head **10**.
[0104] As described above, by disposing the camera module **30** and two or more light source units **40** at different positions in the longitudinal direction and spaced apart from each other in the longitudinal direction instead of disposing them on the same cross section, it is possible to form a small camera head **10** with built-in light sources. More specifically, the camera head **10** capable of irradiating the imaging area with light from each of the first light source units **41** and the second light source units **42** can be made even smaller. In the present embodiment, it can be said that the diameter of the camera head **10** can be particularly reduced.
[0105] In addition, since the camera head **10** can be formed with built-in light sources, there is no need to bundle optical fibers or the like with the cable **19**, and the flexibility of the cable **19** can be improved.
[0106] The fact that the diameter of the camera head **10** can be reduced will now be described with specific dimensional examples.
[0107] FIG. **9** is a diagram illustrating an example of a configuration of a camera head according to one comparative example of the present embodiment.
[0108] FIG. **9** shows an example of a configuration in which, for example, 0201 size LED chips are disposed in the leading end portion as light source units **840**. In order to ensure that light is emitted uniformly, the light source units **840** are disposed at four positions so as to surround the imaging filter **70** having the same size as that in the present embodiment. Here, each 0201 size element has two sides with lengths of 0.6 mm and 0.3 mm when viewed from the front.
[0109] In this comparative example, the dimensions shown in the figure are as follows: L**21** is 1.52

mm; L**22** is 1.31 mm; L**23** is 0.5 mm; L**24** is 0.3 mm; and L**25** is 0.6 mm.
[0110] That is to say, the inner diameter of a sleeve **820** is 1.31 mm, and when the thickness of the sleeve **820** is approximately 0.1 mm, the outer diameter of the sleeve **820** is 1.52 mm. That is to say, the outer diameter of the camera head in this comparative example is 1.52 mm.
[0111] On the other hand, in the present embodiment, the specific dimensional examples shown in FIG. **6** are as follows. Here, it is assumed that each of the optical fibers for the light guide unit **60** has a diameter of 0.125 mm. In this case, L**11** is 1.00 mm. L**12** is 0.8 mm. L**13** is 0.5 mm. L**14** is 0.125 mm. L**15** is 0.125 mm.
[0112] When a sleeve **20** of such a size is used and 0201 size LED chips are used as the light source units **40**, the light source units can be disposed rearward of the camera module **30**, for example at different positions in the longitudinal direction.
[0113] In this manner, in the present embodiment, the camera head **10** can be formed to have a thinner and smaller outer diameter than the comparative example.
[0114] If the camera head **10** can be made smaller in size in this way, the camera head **10** and the imaging system **1** using the same will become more useful in several applications.
[0115] FIG. **10** is a diagram illustrating a use example of the imaging system **1** according to the present embodiment.
[0116] FIG. **10** shows a use example of a case in which an image capturing a tissue condition image of a test animal **9** is acquired using the imaging system **1**. Here, the imaging system **1** is constituted by the camera head **10** and an image acquisition device **2100** to which the camera head **10** is connected via the cable **19**. The image acquisition device **2100** is constituted by a transmitting and receiving device **2102** that can be small enough to be attached to the test animal **9**, and a main device **2101** that has the same functions as the image acquisition device **100** described above. That is to say, in the example shown in the figure, the image acquisition device **2100** can wirelessly capture images showing the imaging results of the camera head **10**.
[0117] As described above, the camera head **10** can be formed with a small diameter of about **1** mm. Such a configuration makes it possible to perform an experiment in a less invasive manner than before with respect to the test animal **9** in which the camera head **10** is embedded. This configuration also allows continuous imaging while the camera head **10** remains embedded in the test animal **9**. Therefore, this configuration allows experiments to be performed under conditions and in observation patterns that are difficult to achieve with conventional large camera heads.
Descriptions of Modifications
[0118] The above embodiment shows an example of the camera head **10** configured to be capable of emitting light of two different wavelengths, but the present invention is not limited to this example.
[0119] FIG. **11** is a diagram illustrating an example of a configuration of a camera head according to a first modification of the embodiment of the present invention.
[0120] The diagram shows a cross-sectional view of the vicinity of a leading end portion **12** of a camera head **310** configured to be capable of emitting, for example, four different types of light.
[0121] The camera head **310** includes, for example, four types of optical fibers,
[0122] **361**, **362**, **363**, and **364**, as light guide units corresponding to four light source units (not shown) that emit light within wavelength bands different from each other. Two optical fibers **361**, two optical fibers **362**, two optical fibers **363**, and two optical fibers **364** are provided. That is to say, a total of eight optical fibers **361**, **362**, **363**, and **364** are provided as light guide units. The optical fibers **361**, **362**, **363**, and **364** are disposed radially outside the camera module **30** and are lined up in the circumferential direction so as to surround the camera module **30**. The pairs of optical fibers **361**, **362**, **363**, or **364**, each pair corresponding to light from a different light guide unit, are respectively disposed in the four gaps between the camera module **30** and the inner circumferential surface of the sleeve **20**.
[0123] As a result of the large number of optical fibers **361**, **362**, **363**, and **364** disposed in this

manner, the camera head **310** can be formed into a relatively small size.

[0124] In the present modification, of the optical fibers **361**, **362**, **363**, and **364**, each pair of optical fibers provided for guiding light within one wavelength band is disposed around the camera module **30** so as to be spaced apart from each other in the circumferential direction. More specifically, as shown in the diagram, when viewed from the front in the longitudinal direction, the two optical fibers **361** that guide light within a first wavelength band are disposed at positions that are point-symmetric with respect to the center of the camera head **310**. Similarly, the two optical fibers **362** that guide light within the second wavelength band, the two optical fibers **363** that guide light within the third wavelength band, and the two optical fibers **364** that guide light within the fourth wavelength band are each disposed in a point-symmetric relationship with respect to the center of the camera head **310**. However, the present invention is not limited to such a configuration and, for example, two optical fibers that guide light within a wavelength band may be respectively disposed in two of the four gaps between the camera module **30** and the inner surface of the sleeve **20** that are not adjacent to each other.

[0125] As a result of the optical fibers **361**, **362**, **363**, and **364** disposed in this

[0126] manner, the imaging area can be relatively uniformly irradiated with light within each wavelength band.

[0127] Note that, in the camera head **310**, a filter **380** is provided instead of the illumination filter **80**. The properties and functions of the filter **380** can be adjusted as required.

[0128] FIG. **12** is a diagram illustrating an example of a configuration of a camera head according to a second modification of the embodiment of the present invention.

[0129] The diagram shows a cross-sectional side view of a camera head **410** in the same manner as in FIG. **3**.

[0130] The camera head **410** includes the camera module **30**, the light source units **40**, the imaging filter **70**, and so on, which have the same configurations as in the camera head **10** according to the embodiment described above. That is to say, the imaging filter **70**, the camera module **30**, the first light source units **41**, and the second light source units **42** are lined up in this order in the longitudinal direction from the leading end portion **12** side at different positions from each other.

[0131] In the camera head **410**, a sleeve **420** is provided in place of the sleeve **20**. The camera module **30** and the imaging filter **70** are housed in the sleeve **420**.

[0132] The sleeve **420** is a light transmissive member, and is configured to function as a light guide unit that guides the light from the light source units **40** toward the leading end portion **12**. That is to say, in the present modification, the light guide unit is constituted by the entire sleeve **420**. The sleeve **420** functioning as a light guide unit can be made of, for example, a light transmissive resin or the like, but is not limited to this example. Note that the light guide unit may be constituted by a portion of the sleeve **420**. For example, only the portion of the sleeve **420** that functions as a light guide unit may be configured to serve as an optical waveguide.

[0133] In the present modification, the sleeve **420** is formed, for example, by combining a first member **421** including, on the rear end portion side, light entrance portions **421***b* connected to the first light source units **41**, and a second member **422** including, on the rear end portion side, light entrance portions **422***b* connected to the second light source units **42**. This configuration allows the light emitted from the first light source units **41** and the second light source units **42** to be emitted independently.

[0134] Note that the sleeve **420** may be molded as a single member including both the light entrance portions **421***b* and **422***b*. Alternatively, the sleeve **420** may be formed to house the light source units **40**. That is to say, the sleeve **420** need only include the light entrance portions **421***b* and **422***b* as portions thereof, and the light entrance portions **421***b* and **422***b* need not be provided at the rear end portion of the sleeve **420**.

[0135] In this manner, by using the sleeve **420** that functions as a light guide unit, the camera head **410** can be made smaller.

Others

[0136] In the embodiment described above, a single computer or a plurality of computers may be used. That is to say, centralized processing may be performed, or distributed processing may be performed.

[0137] In addition, in the embodiment described above, two or more components present in one device may be physically realized with a single medium.

[0138] In the embodiment described above, each component may be constituted by dedicated hardware. Alternatively, components that can be realized with software may be realized by executing a program. For example, each component can be realized by a program execution unit such as a CPU reading and executing a software program recorded on a recording medium such as a hard disk or a semiconductor memory. During execution, the program execution unit may execute the program while accessing a storage unit or a recording medium. The program may be downloaded from a server or the like and executed, or a program recorded on a predetermined recording medium (for example, an optical disk, a magnetic disk, a semiconductor memory, or the like) may be read out and executed. In addition, this program may also be used as a program constituting a program product. The program may be executed by a single computer or a plurality of computers. That is to say, centralized processing may be performed, or distributed processing may be performed.

[0139] In addition, in the embodiment described above, each type of processing (each function) may be realized as centralized processing by a single device (system), or may be realized as distributed processing by a plurality of devices (in this case, the entire system constituted by a plurality of devices performing distributed processing can be considered as a single “device”).

[0140] In addition, in the embodiment described above, the transfer of information between the components may be performed, for example, by one component outputting information and the other component receiving information if the two components transferring the information are physically different, or, if the two components transferring the information are physically the same, the transfer of information between the components may be performed by transitioning from a processing phase corresponding to one component to a processing phase corresponding to the other component.

[0141] In addition, in the embodiment described above, information related to the processing performed by each component, for example information accepted, acquired, selected, generated, transmitted, or received by each component, and information such as thresholds, formulas, addresses, etc. used by each component in its processing, may be stored temporarily or for a long period of time on a recording medium (not shown), even if not explicitly stated in the above description. The accumulation of information in the recording medium (not shown) may be performed by each component or by an accumulation unit (not shown). The reading of information from the recording medium (not shown) may be performed by each component or by a reading unit (not shown).

[0142] The present invention is not limited to the embodiment described above, and various modifications are possible, which are also included within the scope of the present invention.

[0143] The components of the embodiment and modifications described above may be combined as appropriate to form an embodiment. For example, each of the components of the embodiment and modifications described above may be replaced or combined with components of other modifications or the like as appropriate. In addition, some of the components or functions of the embodiment and modifications described above may be omitted.

INDUSTRIAL APPLICABILITY

[0144] As described above, the camera head according to the present invention has the effect of enabling the camera head to be made even smaller, and is useful as a camera head or the like.

Claims

1. A camera head that has an elongated shape and is used for imaging an imaging area located in a vicinity of a leading end portion in a longitudinal direction, comprising: a camera module; two or more light source units disposed at positions farther from the leading end portion than the camera module is in the longitudinal direction; and a light guide unit disposed radially outside an outer surface of the camera module and configured to guide light emitted from each of the two or more light source units to the vicinity of the leading end portion so that the imaging area is irradiated with the light, wherein at least two light source units of the two or more light source units are disposed at different positions in the longitudinal direction, wherein the light guide unit includes two or more optical fibers respectively corresponding to at least two light source units of the two or more light source units, and the two or more optical fibers are disposed around the camera module so as to be spaced apart from each other in a circumferential direction and lined up in the circumferential direction.
2. The camera head according to claim 1, wherein at least two light source units of the two or more light source units are configured to emit light of wavelengths different from each other.
3. (canceled)
4. The camera head according to claim 1, wherein, of the two or more optical fibers, two or more optical fibers provided for guiding light within one wavelength band are disposed around the camera module so as to be spaced apart from each other in the circumferential direction, and the light guide unit is configured to irradiate the imaging area with the light within the one wavelength band from two or more positions that are spaced apart from each other in the circumferential direction.
5. The camera head according to claim 1, wherein the camera module has a columnar portion having a polygonal columnar shape, and the two or more optical fibers are disposed along planar side surfaces of the columnar portion.
6. The camera head according to claim 1, further comprising a sleeve formed into a tubular shape, wherein the camera module, the light source units, and the light guide unit are housed in the sleeve.
7. The camera head according to claim 1, further comprising a sleeve formed into a tubular shape, wherein the sleeve is a light transmissive member, the light guide unit is a portion or an entirety of the sleeve, and the camera module is housed in the sleeve.
8. The camera head according to claim 1, wherein the camera module and the light guide unit are integrated into one piece.
9. The camera head according to claim 1, wherein, of the two or more light source units, at least two light source units located at different positions in the longitudinal direction are disposed so as to partially overlap each other when viewed from a front in the longitudinal direction.
10. The camera head according to claim 1, wherein each of the two or more light source units is disposed at a position farther from the leading end portion than the camera module is in the longitudinal direction at which a portion thereof overlaps the camera module when viewed from a front in the longitudinal direction.
11. The camera head according to claim 1, wherein, of the two or more light source units, at least two light source units located at different positions in the longitudinal direction are disposed so that positions from which light is emitted are different from each other when viewed from a front in the longitudinal direction.
12. The camera head according to claim 1, further comprising a cable extending rearward from the camera module, and including a signal line for communication with the camara module, wherein at least two light source units of the two or more light source units are disposed so as to sandwich the cable when viewed from a front in the longitudinal direction.
13. The camera head according to claim 1, further comprising an imaging filter disposed at a

position that is on a leading end side of the camera head and on a leading end side of the camera module so as to cover a front of a light receiving portion; an illumination filter disposed at a position that is on a leading end side of the camera head and on a leading end side of the light guide unit; and a light blocking structure provided between the imaging filter and the illumination filter and configured to block light.
14. An imaging system comprising: the camera head according to claim 1; and an image acquisition device connected to the camera head and configured to acquire an image captured by the camera head.
