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(54) **IMAGING SYSTEM AND METHOD**

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(57) **ABSTRACT**

An imaging system includes an image acquisition module, an image processing module, a comparison module, a diagnostic module, and a user interface module. The image acquisition module is configured to obtain a set of images of a human subject. The image processing module is configured to edit the set of images to produce a set of edited images. The comparison module is configured to select a set of reference images and generate a set of differences by comparing the set of edited images to the set of reference images. The diagnostic module is configured to process the set of differences to generate diagnostic information describing the human subject. The user interface module is configured to graphically present the diagnostic information to a user.

Fig-1

10

42

14

44

80

96

16

76

22

24

100

98

94

78

26

12

40

Fig-2

Fig-3

Fig-4

Fig-5

Fig-6

Fig-7

Fig-8

Fig-9

300

Capture Patient Image — *302*

↓

Encrypting Patient Image — *304*

↓

Storing Patient Image — *306*

↓

Processing Patient Image — *308*

↓

310

Patient Image Matching Reference Image?

No → Output Difference(s) Between Patient Image and Reference Image — *314*

Yes ↓

Diagnose Condition Corresponding to Patient Image

— *312*
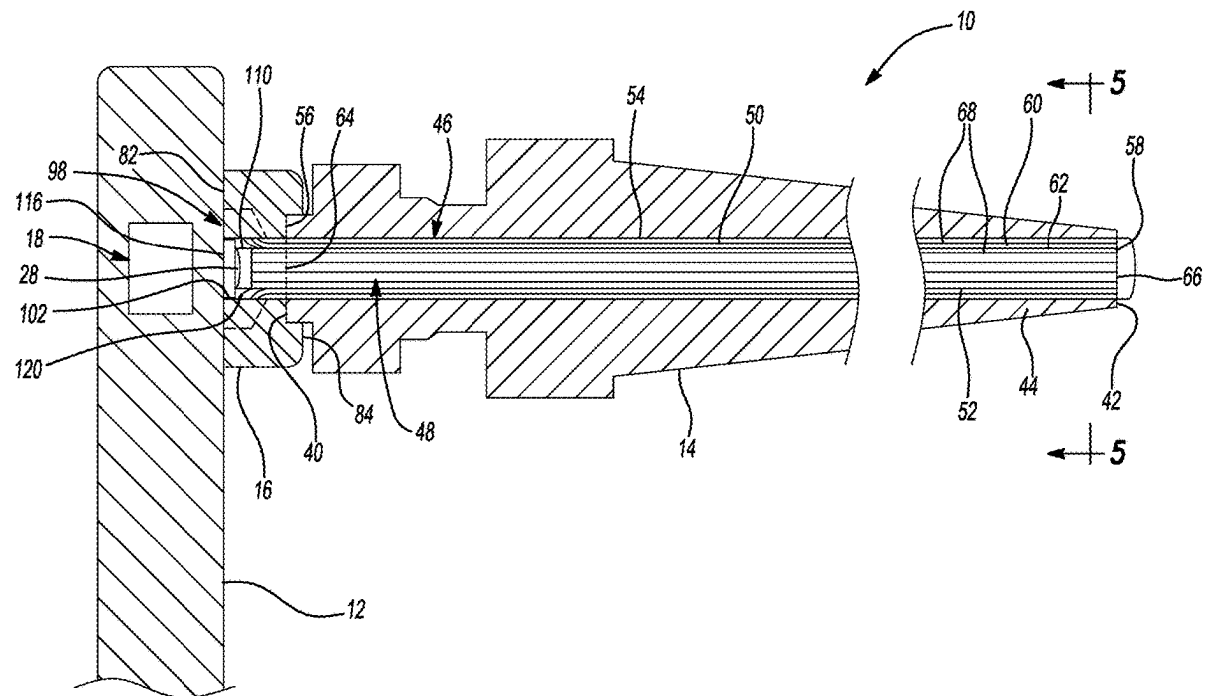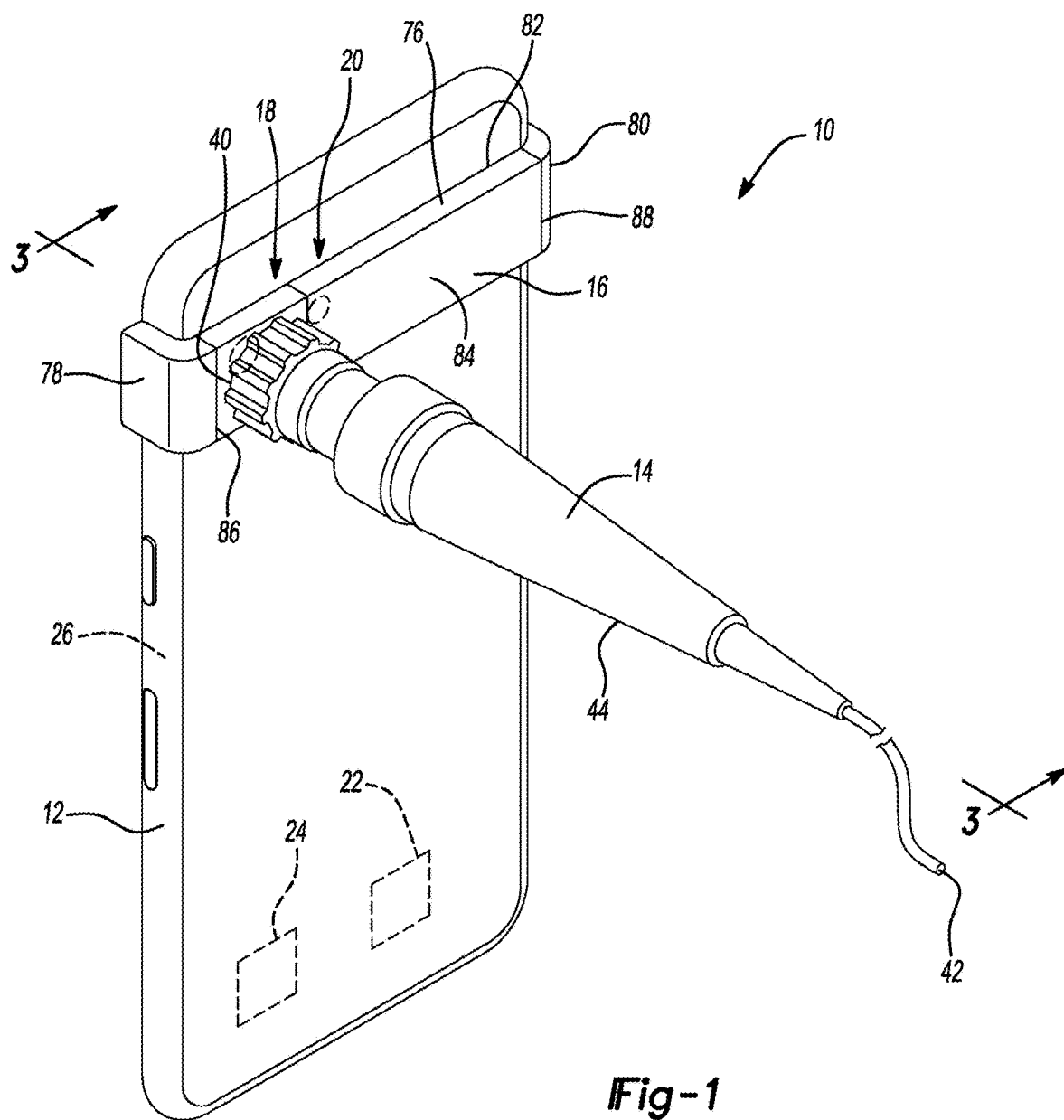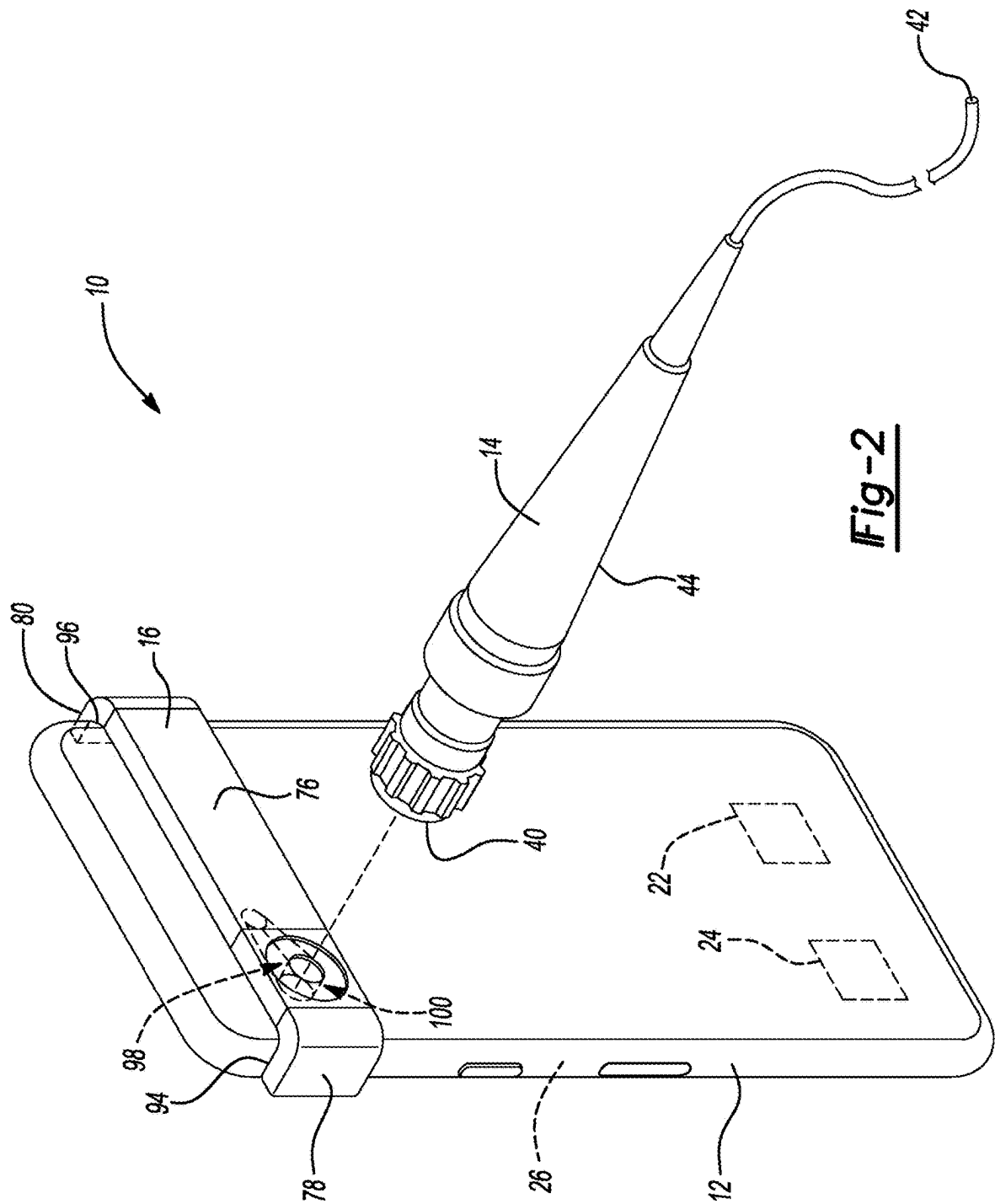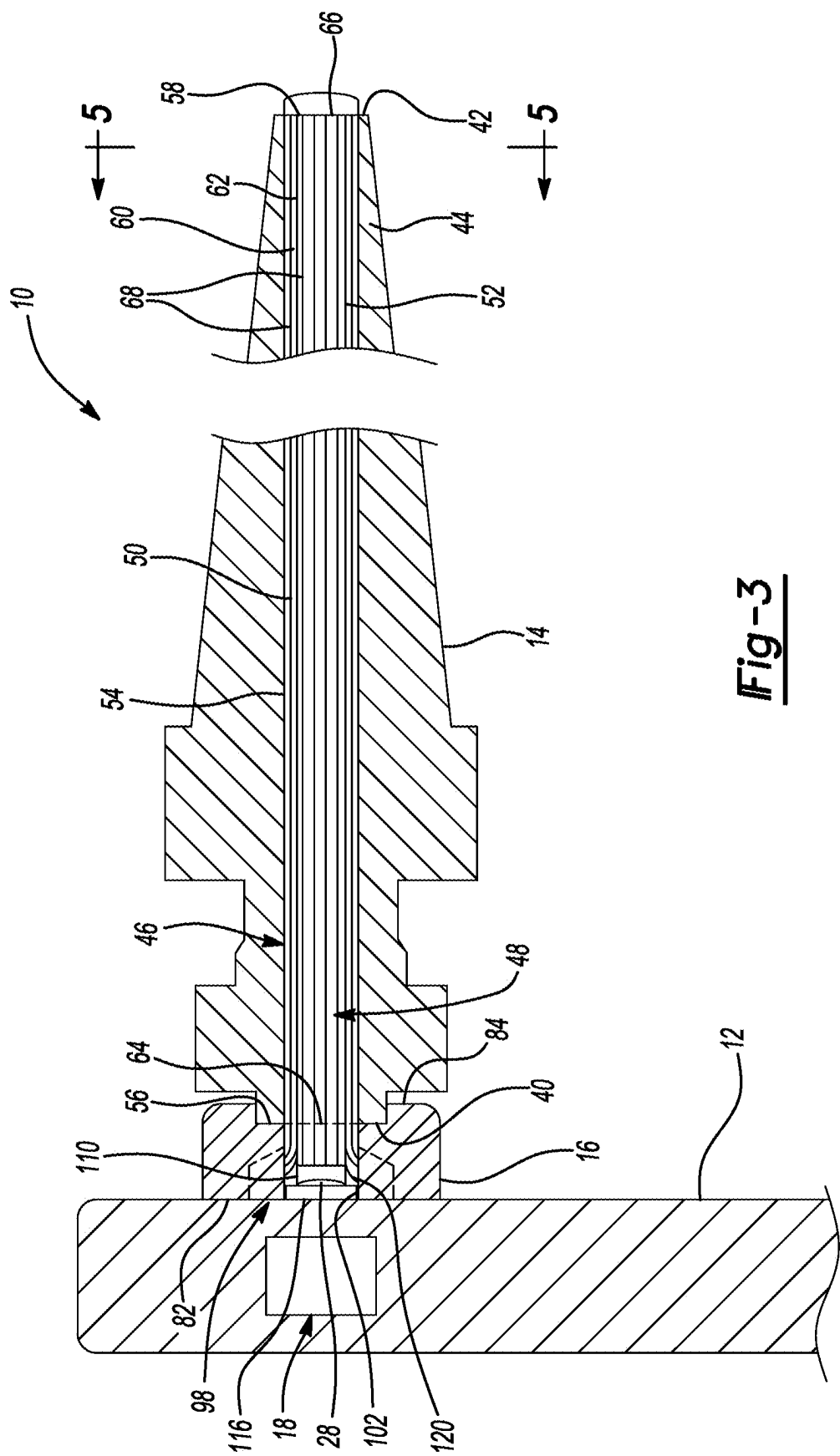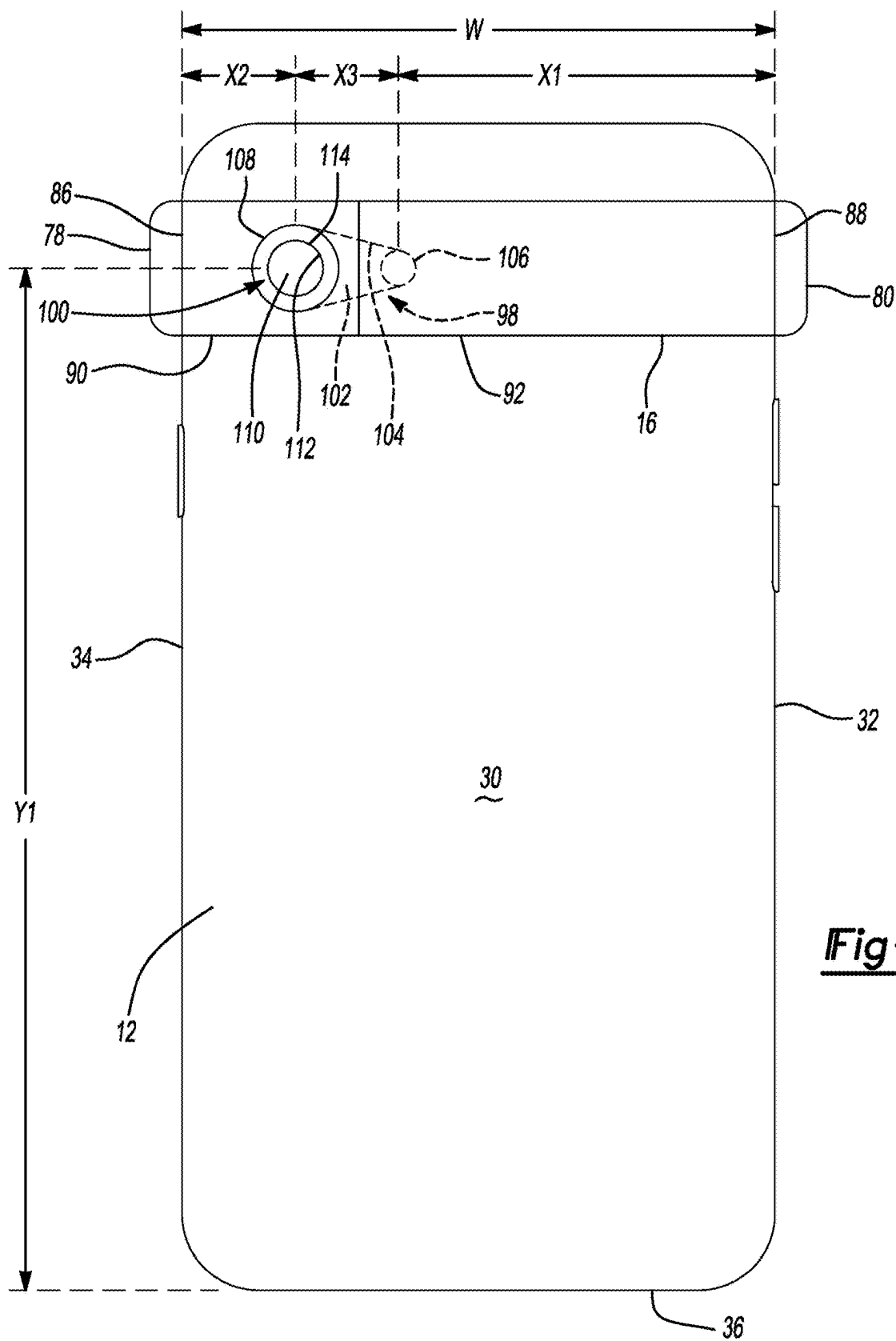
Fig-10

IMAGING SYSTEM AND METHOD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. patent application is a continuation of, and claims priority under 35 U.S.C. § 120 from, U.S. patent application Ser. No. 18/675,564, filed May 28, 2024, which is a continuation of, and claims priority under 35 U.S.C. § 120 from, U.S. patent application Ser. No. 18/210,830, filed Jun. 16, 2023, which is a continuation of, and claims priority under 35 U.S.C. § 120 from, U.S. patent application Ser. No. 17/704,360, filed Mar. 25, 2022, which is a continuation of, and claims priority under 35 U.S.C. § 120 from, U.S. patent application Ser. No. 16/893,927, filed on Jun. 5, 2020, which is a continuation of, and claims priority under 35 U.S.C. § 120 from, 16/677,410, filed on Nov. 7, 2019, which is a continuation of, and claims priority under 35 U.S.C. § 120 from, U.S. patent application Ser. No. 15/985,040, filed on May 21, 2018, which claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application 62/509,267, filed on May 22, 2017. The disclosures of these prior applications are considered part of the disclosure of this application and are hereby incorporated by reference in their entireties.
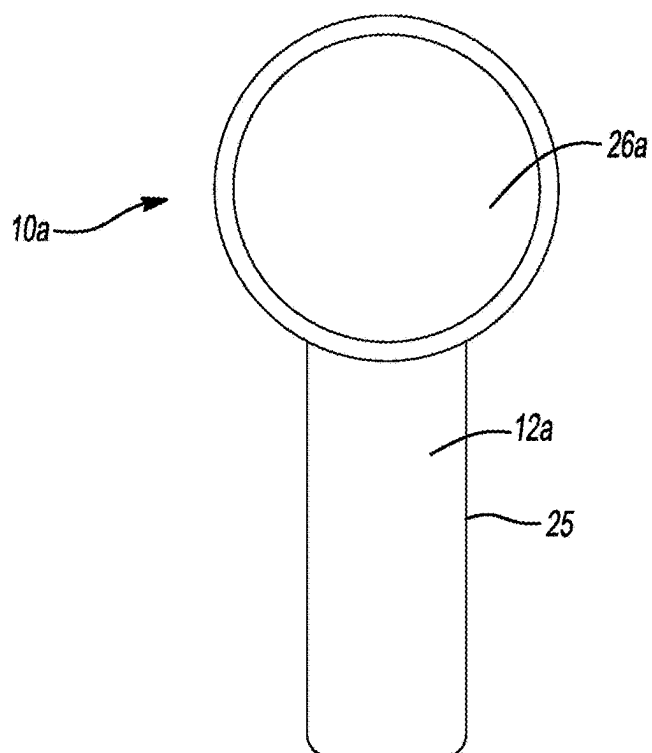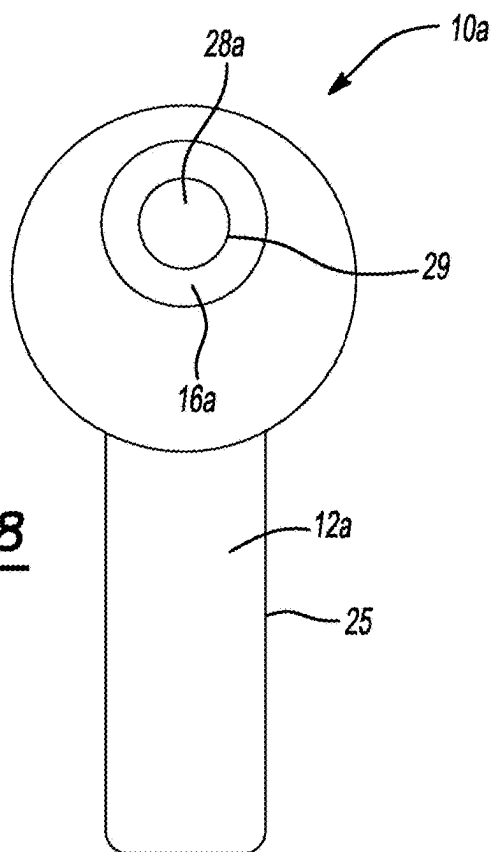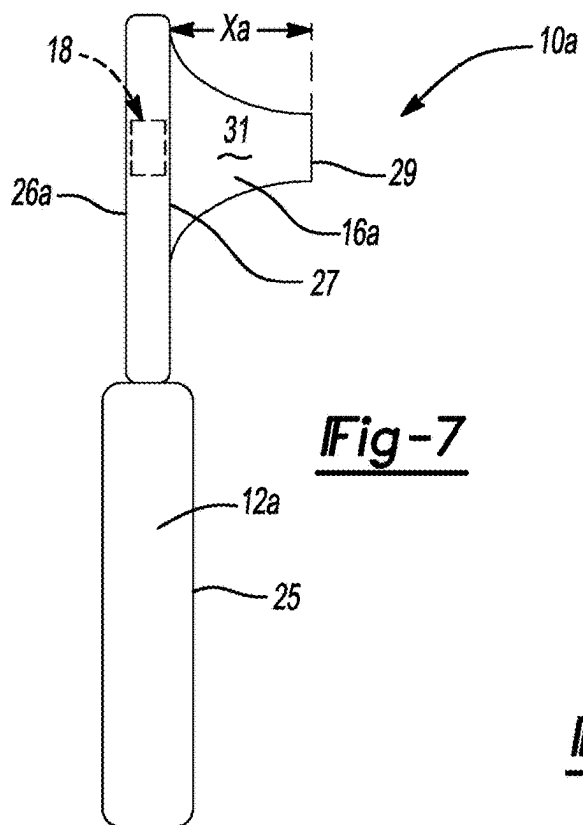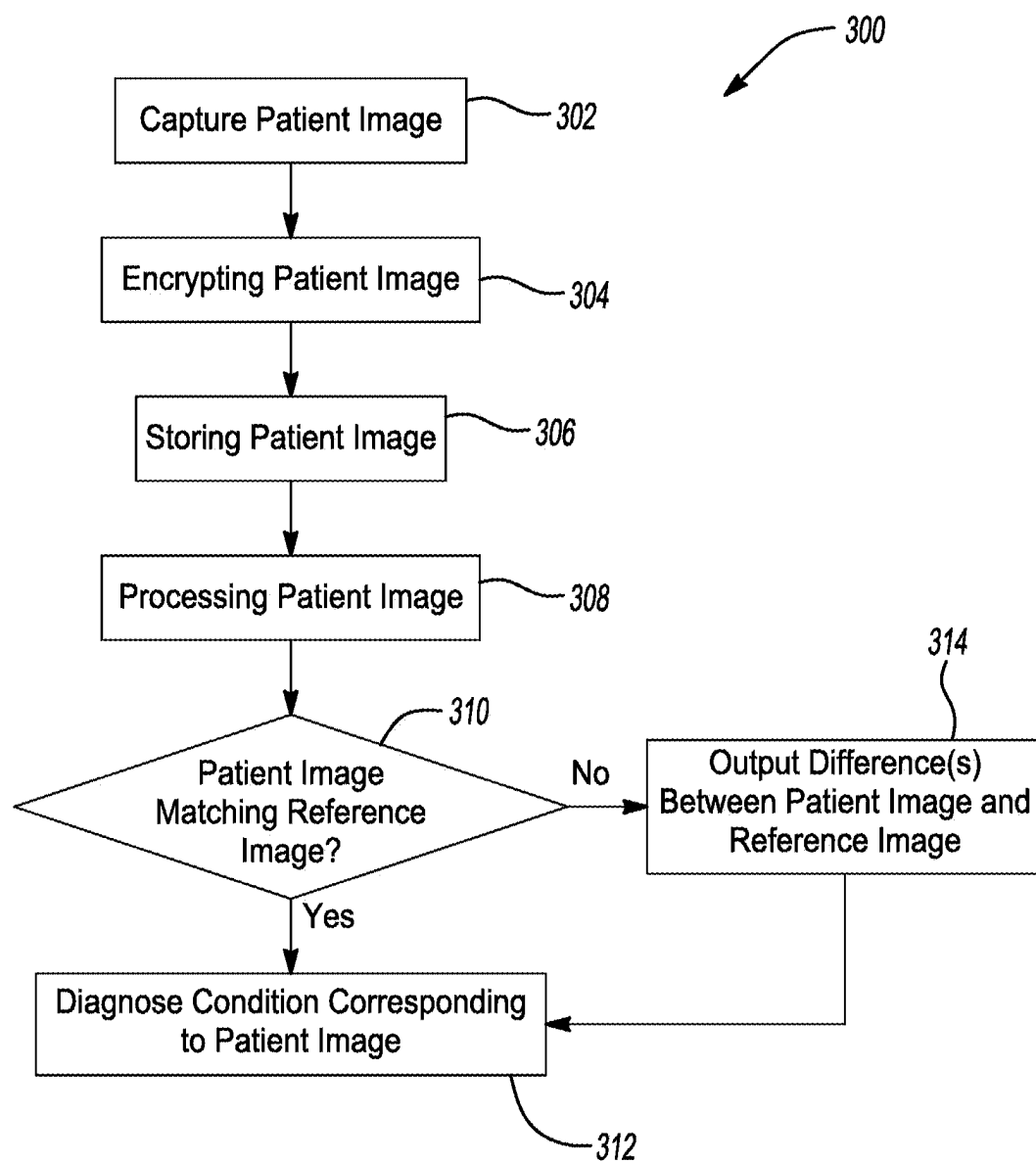
FIELD

[0002] The present disclosure relates generally to an imaging system and method, and more particularly to a system and method for capturing and processing images with a personal communication device.

BACKGROUND

[0003] This section provides background information related to the present disclosure and is not necessarily prior art.

[0004] Medical professionals utilize various types of medical devices, such as scopes, to view, diagnose, and treat medical conditions. For example, an endoscope may be used to examine the interior of a hollow organ or cavity of a patient's body. In particular, a nasopharyngoscope may be used to examine a patient's nasal passages and pharynx. Similarly, an otoscope may be used to examine a patient's ear canal.

[0005] Image capturing devices and related systems are, likewise, commonly used in the medical profession to capture images of a patient's body, and, thereafter, diagnose and treat medical conditions. For example, cameras, X-Ray systems, and magnetic resonance imaging systems are used to capture various types of images of a patient's body.

[0006] While known medical devices, such as scopes, and known imaging systems have proven acceptable for their intended purposes, a continuous need for improvement in the relevant art remains.

SUMMARY

[0007] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0008] One aspect of the disclosure provides an imaging system. The imaging system may include a personal communication device, a scope, and a connector. The personal communication device may include a camera system and a light source. The scope may include an input end, an output end, a light-transmitting portion, and an image-transmitting portion. The light-transmitting portion may be operable to transmit light from the input end to the output end. The image-transmitting portion may be operable to transmit an image from the output end to the input end. The connector may be disposed between the personal communication device and the scope. The connector may include an image transmitter and a light transmitter. The image transmitter may be configured to transmit an image from the scope to the camera system. The light transmitter may be configured to transmit light from the light source to the scope.

[0009] Another aspect of the disclosure provides an imaging connector. The imaging connector may include a proximal side and a distal side. The proximal side may include a light input opening and an image output opening. The distal side may include a light output opening and an image input opening. The imaging connector may be operable to transmit light from the light input opening to the light output opening. The imaging connector may be operable to transmit an image from the image input opening to the image output opening.

[0010] Implementations of the disclosure may include one or more of the following optional features. In some implementations, the light output opening surrounds the image input opening. The image input opening may be concentrically disposed within the light output opening.

[0011] In some implementations, the imaging connector includes a channel and an aperture. The channel may extend from the light input opening to the light output opening. The aperture may extend from the image input opening to the image output opening.

[0012] In some implementations, the light input opening is offset from the image output opening by a distance. The distance may be variable.

[0013] In some implementations, the imaging connector includes a medial portion and a lateral portion translatably coupled to the medial portion.

[0014] Another aspect of the disclosure provides an image-processing system. The image-processing system may include an encryption module, a memory, a processing module, and a comparison module. The encryption module may be operable to encrypt an image. The memory may be operable to store the encrypted image. The processing module may be operable to edit the processed image. The comparison module may be operable to compare the processed image to a pre-selected image.

[0015] Yet another aspect of the disclosure provides a method of processing an image. The method may include capturing an image of a first target area. The method may also include encrypting the captured image. The method may further include storing the encrypted image. The method may also include editing the stored image. The method may further include comparing the processed image to a pre-selected image of a second target area.

[0016] In some implementations, the first target area is the same as the second target area.

[0017] In some implementations, the method includes diagnosing a condition based on a difference between the processed image and the pre-selected image.

[0018] Another aspect of the disclosure provides an imaging system comprising a personal communication device, an image-transmitting attachment, and a connector configured to couple the personal communication device to the image-transmitting attachment. The personal communication device may include a smartphone, a tablet computer, or other

similar device, having a light source and an image-capturing device (e.g., a camera). The light source may include a circular, single-point light light-emitting diode light source having a first diameter.

[0019] The connector may include a channel configured to allow the light source to transmit light. The connector may be configured to transform the circular, single-point light to a circumferential light output having a ring shape. In this regard, the connector may include a light receiver aligned with the light source of the personal communication device. In some implementations, the light receiver defines a circular shape having a second diameter. The second diameter may be equal to the first diameter. In some implementations, the connector may include a plurality of fiber optic strands disposed within the channel and extending from the light receiver to a ring-shaped light output.

[0020] The ring-shaped light output may be configured to illuminate a distal end of the image-transmitting attachment. For example, the ring-shaped light output may illuminate a distal end of an otoscope or a distal end of a nasopharyngoscope. The connector may also be configured to align the image-capturing device of the personal communication device with an image transmitting portion of the image-transmitting attachment. For example, the connector may align the image-capturing device with an image-transmitting channel defined by the connector, allowing images from the image-transmitting channel to be captured by the image-capturing device. The light output of the connector may be circumferentially disposed about the image-transmitting channel.

[0021] The image-transmitting attachment may include an image guide, a light guide, and a lens. In some implementations, the light guide surrounds the image guide. The light guide may include a light guide surface. In some implementations, the light guide includes an annular channel disposed about the image guide. In some implementations, the light guide may include a plurality of fiber optic strands disposed within the channel. The image guide may include one or more fiber optic strands. For example, the image guide may include a bundle of fiber optic strands about which the light guide is disposed.

[0022] The annular channel of the image-transmitting attachment may receive light from the ring-shaped light output end of the connector. In this regard, the connector may be configured to align the ring-shaped light output end with the light guide surface or the annular channel of the image-transmitting attachment, such that the light guide surface receives light from the ring-shaped light output end and transmits the light through the annular channel to the distal end of the image-transmitting attachment to illuminate the target area.

[0023] The image guide may include a plurality of fiber optic strands aligned with, coupled to, or disposed within the channel of the connector, such that the image guide is operable to transmit an image from, and of, the target area, through the lens disposed at the distal end of the image-transmitting attachment, back to the channel of the connector and back to the image-capturing device of the personal communication device. In this regard, the channel of the connector may transmit the image to a lens of the image-capturing device.

[0024] Yet another aspect of the disclosure provides an image-transmitting attachment, such as a scope (e.g., nasopharyngoscope, otoscope, ophthalmoscope, dermoscope,

low-level microscope, etc.), attached to a personal communication device (e.g., a smart phone). Illumination of a target area (e.g., a patient's body) is provided by a light source (e.g., light-emitting diode) of the personal communication device transmitting light via a channel (e.g., a fiber optic light channel) to a distal end of the image-transmitting attachment. An image of the illuminated target area may be carried back through a coherent image-transmitting device (e.g., a fiber optic cable) of the image-transmitting attachment to a lens configured to focus the image for capture by a lens of the personal communication device.

[0025] A further aspect of the present disclosure provides an imaging system and method configured to leverage the imaging, storage, processing, and communications capabilities of a personal communication device.

[0026] In some implementations, the method may include capturing an image of a target area of a patient. The target area may include a condition.

[0027] In some implementations, the method may include storing the captured image in a memory of the personal communication device. For example, the captured image may be encrypted and stored securely in the memory for retrieval using a fingerprint. In some implementations, storage of the captured image may satisfy requirements of the Health Insurance Portability and Accountability Act.

[0028] In some implementations, the method may include processing the captured or stored image. For example, the method may include enhancing, marking-up, or "ghosting" the captured or stored image. In particular, the method may include overlaying one of a pre-selected image and the captured or stored image relative to the other of the pre-selected image and the captured or stored image. In some implementations, the pre-selected image may include an image of a target area of a reference or benchmark specimen. The target area of the reference or benchmark specimen may correspond to the target area of the patient. The target area of the reference or benchmark may not include the condition.

[0029] In some implementations, the method may include comparing the target area of the patient to the target area of the reference. For example, the method may include determining whether there are any differences between the target area of the patient to the target area of the reference. In particular, the method may include identifying the condition of the target area of the patient relative to the target area of the reference.

[0030] In some implementations, the method may include diagnosing the condition. For example, the method may include diagnosing the condition based on the comparison of the target area of the patient to the target area of the reference.

[0031] Yet another aspect of the present disclosure provides an imaging system. The imaging system may include a personal communication device and a connector. The personal communication device may include a camera system, a display portion, and a handle portion. The display portion may be configured to display images captured by the camera system. The handle portion may extend from the display portion in a first direction. The connector may extend from the display portion in a second direction transverse to the first direction. The connector may be operable to couple to a scope.

[0032] Implementations of this aspect may include one or more of the following features. In some implementations, the display portion defines a circular shape.

[0033] In some implementations, the connector includes a lens configured to receive the images.

[0034] In some implementations, the connector includes an outer surface extending from a proximal end to a distal end. The proximal end may be supported by the display portion. The distal end may be offset from the proximal end by a distance extending in the second direction. The outer surface may be concave. In some implementations, the outer surface defines a frustoconical shape extending from the proximal end to the distal end. The first direction may be perpendicular to the second direction.

[0035] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The drawings described herein are for illustrative purposes only of selected configurations and not all possible implementations, and are not intended to limit the scope of the present disclosure.

[0037] FIG. 1 is a perspective view of an imaging system in accordance with the principles of the present disclosure;

[0038] FIG. 2 is a partially exploded view of the imaging system of FIG. 1;

[0039] FIG. 3 is a cross-sectional view of the imaging system of FIG. 1 taken through the line 3-3;

[0040] FIG. 4 is a rear view of a personal communication device and a connector of the imaging system of FIG. 1 in accordance with the principles of the present disclosure;

[0041] FIG. 5 is a cross-sectional view of an image-transmitting device of the imaging system of FIG. 1 taken through the line 5-5 of FIG. 3;

[0042] FIG. 6 is a functional block diagram of an example image processing system in accordance with the principles of the present disclosure;

[0043] FIG. 7 is a side view of another imaging system in accordance with the principles of the present disclosure;

[0044] FIG. 8 is a front view of the imaging system of FIG. 7;

[0045] FIG. 9 is a rear view of the imaging system of FIG. 7; and

[0046] FIG. 10 is a flowchart illustrated an example image processing method in accordance with the principles of the present disclosure.

[0047] Corresponding reference numerals indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION

[0048] Example configurations will now be described more fully with reference to the accompanying drawings. Example configurations are provided so that this disclosure will be thorough, and will fully convey the scope of the disclosure to those of ordinary skill in the art.

[0049] Specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of configurations of the present disclosure. It will be apparent to those of ordinary skill in the art that specific details need not be employed, that example

configurations may be embodied in many different forms, and that the specific details and the example configurations should not be construed to limit the scope of the disclosure.

[0050] With reference to FIGS. 1-3, an imaging system 10 in accordance with the principles of the present disclosure is shown. As will be explained in more detail below, in some implementations, the imaging system 10 may be utilized by a physician or other medical professional in a medical environment in order to capture, store, and process images of a patient. It will be appreciated, however, that the imaging system 10 may be utilized in other environments and by other users within the scope of the present disclosure.

[0051] The imaging system 10 may include a personal communication device 12, an image-transmitting device 14, and a connector 16. The personal communication device 12 may be a smartphone, a tablet computer, or other suitable computing device. In this regard, the personal communication device 12 is intended to represent various forms of digital computers, such as smartphones, laptops, desktops, workstations, personal digital assistants, servers, blade servers, mainframes, and other appropriate computers (e.g., personal communication device 12). The components shown here, their connections and relationships, and their functions, are meant to be exemplary only, and are not meant to limit implementations of the inventions described and/or claimed in this document.

[0052] The personal communication device 12 may include a camera system 18, a light source 20, a memory 22, an image-processing system 24, and a display 26. With reference to FIG. 3, the camera system 18 may include a lens 28 through which an image can be transmitted. The light source 20 may include a light-emitting diode (not shown) or other suitable light-producing device. As illustrated in FIG. 4, the light source 20 and the camera system (e.g., the lens 28) may be disposed on a rear surface 30 of the personal communication device 12. In some implementations, the light source 20 is disposed a distance X1 from a medial side 32 of the personal communication device 12, and the lens is disposed a distance X2 from a lateral side 34 of the personal communication device 12. The lateral side 34 may be opposite the medial side 32. The light source 20 and the lens 28 may each be disposed a distance Y1 from an end 36 of the personal communication device 12. The end 36 may extend from and between the lateral and medial sides 32, 34. The light source 20 may be disposed a distance X3 from the lens 28 in a direction transverse (e.g., orthogonal) to the distance Y1. In some implementations, a center of the lens 28 may be collinear with a center of the light source 20 along a line extending perpendicular to the lateral and medial sides 32, 34. It will be appreciated that the distances X1, X2, X3, and Y1 may vary depending on the particular configuration (e.g., size, shape, etc.) of the personal communication device 12 utilized in the imaging system 10.

[0053] The image-transmitting device 14 may include a scope, such as a nasopharyngoscope, an otoscope, an ophthalmoscope, a dermoscope, a low-level microscope, or other similar device having an input end 40, an output end 42, and operable to transmit an image from the input end 40 to the output end 42. With particular reference to FIG. 3, the image-transmitting device 14 may include a housing 44 having a light-transmitting portion 46 and an image-transmitting portion 48.

[0054] In some implementations, the light-transmitting portion 46 defines a channel 50 extending from the input end

40 to the output end 42. In this regard, as illustrated in FIG. 5, the channel 50 may be defined by a first inner surface 52 and a second inner surface 54 of the housing 44. In some implementations, the first inner surface 52 defines a cylinder having a first diameter D1, and the second inner surface 54 defines a cylinder having a second diameter D2 that is greater than the first diameter D1, such that the channel 50 defines an annular or hollow cylindrical construct. The first inner surface 52 may be concentrically disposed within the second inner surface 54. The first and second inner surfaces 52, 54 may extend from and between the input and output ends 40, 42 to define light inlet and outlet openings 56, 58, respectively, at the input and output ends 40, 42.

[0055] The image-transmitting portion 48 may be concentrically disposed within the light-transmitting portion 46. In this regard, the image-transmitting portion 48 may define an aperture 60 extending from the input end 40 to the output end 42. As illustrated in FIG. 5, the aperture 60 may be defined by a third inner surface 62 of the housing 44. In some implementations, the third inner surface 62 defines a cylinder having a third diameter D3 that is less than the first and second diameters D1, D2 of the light-transmitting portion 46. The third inner surface 62 may extend from and between the input and output ends 40, 42 to define image outlet and inlet openings 64, 66 (FIG. 3), respectively, at the input and output ends 40, 42. The outlet and inlet openings 64, 66 of the image-transmitting portion 48 may be concentrically disposed within the inlet and outlet openings 56, 58 of the light-transmitting portion 46.

[0056] The image-transmitting device 14 may also include plurality of elements 68 configured to transmit images or light from the input end 40 to the output end 42, or from the output end 42 to the input end 40, of the image-transmitting device 14. In some implementations, the elements 68 may include fiber optic strands. The elements 68 may include a proximal end disposed proximate the input end 40, and a distal end disposed proximate the output end 42. A first plurality of the elements 68 may be disposed within the light-transmitting portion 46 of the device 14, and a second plurality of the elements 68 may be disposed within the image-transmitting portion 48 of the device 14. In this regard, the first plurality of the elements 68 may be disposed within the channel 50 and the second plurality of the elements may be disposed within the aperture 60, such that the first plurality of the elements 68 surrounds the second plurality of the elements 68.

[0057] With reference to FIG. 1, the connector 16 may include a base 76, a lateral arm 78, and a medial arm 80. The base 76 may include a proximal side 82, a distal side 84 opposite the proximal side 82, a lateral end 86, and a medial end 88 opposite the lateral end 86. The lateral and medial ends 86, 88 may extend from and between the proximal and distal sides 82, 84. With reference to FIG. 4, the connector 16 may define a width W extending from the lateral end 86 to the medial end 88. In some implementations, the width W may be adjustable such that a user can vary the width W to equal a width extending from and between the medial and lateral sides 32, 34 of the personal communication device 12. In this regard, the connector 16 may include a lateral portion 90 and a medial portion 92. The lateral portion 90 may be adjustably coupled to the medial portion 92. For example, one of the lateral and medial portions 90, 92 may be supported for translation in a direction substantially parallel to the width W relative to the other of the lateral and

medial portions 90, 92, such that the user can vary the width W by translating the lateral portion 90 relative to the medial portion 92. In particular, one of the lateral or medial portions 90, 92 may include male portion and the other of the lateral or medial portions 90, 92 may include female portion that receives the male portion (e.g., a dovetail, tongue in groove, etc.) such that the male portion can slide relative to the female portion.

[0058] With reference to FIG. 2, the lateral arm 78 may include a lateral stop surface 94, and the medial arm 80 may include a medial stop surface 96. The lateral arm 78 may be supported by the base 76 proximate to the lateral end 86 and the medial arm 80 may be supported by the base 76 proximate to the medial end 88, such that the width W extends from the lateral stop surface 94 to the medial stop surface 96.

[0059] With reference to FIGS. 2-4, the connector 16 may further include a light transmitter 98 and an image transmitter 100. As will be explained in more detail, below, the light transmitter 98 may transmit light from the light source 20 to the light-transmitting portion 46 of the image-transmitting device 14, and the image transmitter 100 may transmit images from the image-transmitting portion 48 of the image-transmitting device 14 to the camera system 18 (e.g., lens 28).

[0060] With particular reference to FIG. 3, in some implementations, the light transmitter 98 defines a channel 102 extending from the proximal side 82 to the distal side 84. In this regard, as illustrated in FIG. 4, the channel 102 may be defined by an inner surface 104 of the connector 16. The inner surface 104 may extend from and between the proximal and distal sides 82, 84 to define inlet and outlet openings 106, 108 at the proximal and distal sides 82, 84, respectively. In some implementations, the channel 102 extends through the lateral and medial portions 90, 92 of the connector 16.

[0061] With reference to FIG. 3, the image transmitter 100 may define an aperture 110 extending from the proximal side 82 to the distal side 84. As illustrated in FIG. 4, the aperture 110 may be defined by an inner surface 112 of the connector 16. In some implementations, the inner surface 112 defines a cylinder extending from and between the proximal and distal sides 82, 84 to define an inlet opening 114 and an outlet opening 116 at the distal and proximal sides 84, 82, respectively. The inlet opening 114 of the image transmitter 100 may be concentrically disposed within the outlet opening 108 of the light transmitter 98.

[0062] As illustrated in FIG. 4, in some implementations, the inlet opening 106 of the light transmitter 98 is disposed on the medial portion 92 of the connector 16 and the outlet opening 116 of the image transmitter 100 is disposed on the lateral portion 92 of the connector 16. Accordingly, a user may adjust the distance between the inlet opening 106 of the light transmitter 98 and the outlet opening 116 of the image transmitter 100 by moving the lateral portion 90 of the connector 16 relative to the medial portion 92 of the connector 16 in the manner previously described.

[0063] As illustrated in FIG. 3, the connector 16 may also include a plurality of elements 120 configured to transmit images or light from the proximal side 82 to the distal side 84. In some implementations, the elements 120 may be substantially similar to the elements 68, and may include fiber optic strands. A first plurality of the elements 120 may be disposed within the light transmitter 98 of the connector 16, and a second plurality of the elements 120 may be

disposed within the image-transmitter **100** of the connector **16**. In this regard, the first plurality of the elements **120** may be disposed within the channel **102** and the second plurality of the elements may be disposed within the aperture **110**, such that the first plurality of the elements **120** surrounds the second plurality of the elements **120** along at least a portion of the length of the aperture **110**.

[0064] With reference to FIGS. **2** and **3**, in an assembled configuration, the connector **16** may be supported by, or otherwise coupled to, the personal communication device **12**, and the image-transmitting device **14** may be supported by, or otherwise coupled to, the connector **16**. In particular, the proximal side **82** of the connector **16** may be disposed adjacent the rear surface **30** of the personal communication device **12** such that the inlet opening **106** of the light transmitter **98** is aligned with the light source **20**, and the outlet opening **116** of the image transmitter **100** is aligned with the lens **28**. Similarly, the input end **40** of the image-transmitting device **14** may be disposed adjacent the distal side **84** of the connector **16** such that the inlet opening **56** of the light-transmitting portion **46** of the image-transmitting device **14** is aligned with the outlet opening **108** of the light transmitter **98** of the connector **16**, and the inlet opening **64** of the image-transmitting portion **48** of the image-transmitting device **14** is aligned with the inlet opening **114** of the image transmitter **100** of the connector **16**. In this way, the light transmitter **98** of the connector **16** is operable to transmit light to the light-transmitting portion **46** of the device **14**, and the image-transmitting portion **48** of the device **14** is operable to transmit images to the image transmitter **100** of the connector **16**. Accordingly, the light source **20** can transmit light through the connector **16** and the device **14** to the output end **42** of the device **14**, and the camera system **18** (e.g., lens **28**) can receive images transmitted from the output end **42** of the device to the proximal side **82** of the connector **16**. In particular, the connector **16** transmits (i) light through the elements **120** to the first plurality of elements **68**, and (ii) images from the second plurality of elements **68**, through the elements **120**, to the lens **28**.

[0065] With reference to FIG. **6**, an image-processing system **200** is illustrated. The image processing system **200** may include a camera system **201** (e.g., camera system **18**), an encryption module **202**, a storage device or memory **204**, and an image-processing module **206**. In some implementations, a computing device, such as the personal communication device **12**, or other suitable computer, may implement, or otherwise include, the image-processing system **200**. In this regard, the memory **204** may correspond to the memory **22**, and the image-processing system **200** may correspond to the image-processing system **24**. Each of the components **201, 202, 204**, and **206**, may be interconnected using various busses, and may be mounted on a common motherboard or in other manners as appropriate. In this regard, the image-processing system **200** and the components thereof may be implemented in a processor that can process instructions for execution within the personal communication device **12**, including instructions stored in the memory **204** to display graphical information for a graphical user interface (GUI) on an external input/output device, such as the display **26**. In other implementations, multiple processors and/or multiple buses may be used, as appropriate, along with multiple memories and types of memory.

[0066] The memory **204** may store information non-transitorily within the image-processing system **200** (e.g., personal communication device **12**). In this regard, the memory **204** may communication with the camera system **201**, the encryption module **202**, and the image-processing module **206**. The memory **204** may be a computer-readable medium, a volatile memory unit(s), or non-volatile memory unit(s). The non-transitory memory **204** may be physical devices used to store programs (e.g., sequences of instructions) or data (e.g., program state information) on a temporary or permanent basis for use by the image-processing system **200**. Examples of non-volatile memory include, but are not limited to, flash memory and read-only memory (ROM)/ programmable read-only memory (PROM)/erasable programmable read-only memory (EPROM)/electronically erasable programmable read-only memory (EEPROM) (e.g., typically used for firmware, such as boot programs). Examples of volatile memory include, but are not limited to, random access memory (RAM), dynamic random access memory (DRAM), static random access memory (SRAM), phase change memory (PCM) as well as disks or tapes.

[0067] The memory **204** may be capable of providing mass storage for the image-processing system **200**. In some implementations, the memory **204** is a computer-readable medium. In various different implementations, the memory **204** may be a floppy disk device, a hard disk device, an optical disk device, or a tape device, a flash memory or other similar solid state memory device, or an array of devices, including devices in a storage area network or other configurations. In additional implementations, a computer program product is tangibly embodied in an information carrier. The computer program product contains instructions that, when executed, perform one or more methods, such as those described below. The information carrier is a computer-or machine-readable medium, such as the memory **204** or memory on image-processing module **206**.

[0068] The encryption module **202** may communicate with the camera system **201**, the memory **204**, and the image-processing module **206**. In some implementations, the encryption module **202** receives and encrypts a captured image from the camera system **201** prior to transmitting the encrypted image to the memory **204** for storage. For example, the captured image may be encrypted and stored securely in the memory **204** for retrieval using a fingerprint. In some implementations, storage of the captured image in the memory **204** may satisfy requirements of the Health Insurance Portability and Accountability Act.

[0069] The image-processing module **206** may communicate with the camera system **201**, the encryption module **202**, and the memory **204**. In some implementations, the image-processing module **206** receives an image from the camera system **201**, or an encrypted image from the encryption module **202**, prior to processing the image. The image-processing module **206** may include an editing module **208**, a comparison module **210**, and a diagnostic module **212**. The editing module **208** may edit an image (e.g., an image of a target area of a patient) received from the camera system **201** and/or the memory **204** to produce an edited image. For example, the editing module **208** may receive an image of a target area (e.g., an internal organ) of a patient captured by the camera system **201**, and thereafter enhance, mark-up, or ghost the captured image. In some implementations, the editing module **208** may overlay one of a pre-selected image

and the captured image relative to the other of the pre-selected image and the captured image.

[0070] The comparison module **210** may communicate with the editing module **208**. For example, the comparison module **210** may receive the captured image (e.g., the edited image) from the editing module **208**. The comparison module **210** may compare the captured image to a pre-selected image. In particular, the comparison module **210** may determine whether the captured image matches or appears similar (e.g., identical) to the pre-selected image. The pre-selected image may include a reference or benchmark image of a target area (e.g., an internal organ). In this regard, the pre-selected image may correspond to a normal or ideal image of the target area. In some implementations, the comparison module **210** may output the differences between the captured image and the pre-selected image.

[0071] The diagnostic module **212** may communicate with the comparison module **210**. For example, the diagnostic module **212** may receive the differences between the captured image and the pre-selected image from the comparison module. The diagnostic module **212** may diagnose a condition corresponding to the captured image. For example, the diagnostic module **212** may determine a disease or other abnormality of the target area based on the differences between the captured image and the pre-selected image.

[0072] With reference to FIGS. **7-9**, another imaging system **10***a* for use with the image-transmitting device **14** is shown. The structure and function of the imaging system **10***a* may be substantially similar to that of the imaging system **10**, apart from any exceptions described below and/or shown in the Figures. Accordingly, the structure and/or function of similar features will not be described again in detail. In addition, like reference numerals are used hereinafter and in the drawings to identify like features, while like reference numerals containing letter extensions (i.e., "a") are used to identify those features that have been modified.

[0073] The imaging system **10***a* may include a personal communication device **12***a* and a connector **16***a*. As previously described relative to the imaging system **10**, in an assembled configuration, the connector **16***a* may be supported by, or otherwise coupled to, the personal communication device **12***a*, and the image-transmitting device **14** may be supported by, or otherwise coupled to, the connector **16***a*.

[0074] The personal communication device **12***a* may be a smartphone, a tablet computer, or other suitable computing device. In this regard, the personal communication device **12***a* may be substantially similar to the personal communication device **12** and is intended to represent various forms of digital computers, such as smartphones, laptops, desktops, workstations, personal digital assistants, servers, blade servers, mainframes, and other appropriate computers. The components shown here, their connections and relationships, and their functions, are meant to be exemplary only, and are not meant to limit implementations of the inventions described and/or claimed in this document.

[0075] The personal communication device **12***a* may further include a handle portion **25** and a display portion **26***a*. The handle portion **25** may extend from the display portion **26***a* in a first direction and may be sized and shaped to allow a user to comfortably grip the handle portion **25** in the user's hand.

[0076] The display portion **26***a* may be coupled to the handle portion **25** and may include a graphical user interface (GUI) for displaying graphical information (e.g., images) on an external input/output device. For example, as previously described relative to the imaging system **10**, the display portion **26***a* may display images captured by a camera system (e.g., camera system **18**). As illustrated in FIGS. **8** and **9**, in some implementations, the display portion **26***a* defines a circular shape or construct having a diameter between two inches and three inches. For example, the diameter of the display portion **26***a* may be substantially equal to two and one-half inches. It will be appreciated, however, that the display portion **26***a* may define other shapes (e.g., an oval, a rectangle, or other polygon) within the scope of the present disclosure.

[0077] The connector **16***a* may be supported by the display portion **26***a* and may include a lens **28***a* through which an image can be transmitted to the camera system **18**. In some implementations, a proximal end **27** of the connector **16***a* is coupled to the display portion **26***a*, and a distal end **29** of the connector **16***a* is offset from the display portion by a distance X*a*. In this regard, the connector **16***a* may protrude outwardly from the display portion **26***a* by the distance X*a* in a second direction that is transverse (e.g., perpendicular) to the first direction. The distance X*a* may be between ten millimeters and fifty millimeters. In some implementations the distance is substantially equal to thirty millimeters.

[0078] The connector **16***a* may include an outer surface **31**. In some implementations, the outer surface **31** is concave. For example, the outer surface **31** may define a frustoconical shape extending from the proximal end **27** to the distal end **29**.

[0079] With reference to FIG. **10**, an image-processing method **300** in accordance with the principles of the present disclosure is illustrated. The method **300** may be implemented by the system **200**. In this regard, in some implementations, the method **300** is implemented by the imaging system **10**, **10***a* (e.g., the personal communication device **12**, **12***a*).

[0080] At step **302**, the method **300** may include capturing an image. For example, the method may include capturing an image of a patient. In particular, at step **302**, the method may include capturing an image of a target area (e.g., an organ or portion thereof) of a patient utilizing the camera system **18**, **201**.

[0081] At step **304**, the method **300** may include encrypting an image. For example, the method may include encrypting an image of a target area of a patient. In some implementations, at step **304**, the method includes encrypting the image of the target area captured at step **302**. In particular, step **304** may include encrypting the image of the target area utilizing the encryption module **202**.

[0082] At step **306**, the method **300** may include storing an image. For example, the method may include storing an image of a target area of a patient. In some implementations, at step **306**, the method includes storing the encrypted image of the target area encrypted at step **304**. In particular, step **306** may include securely storing the encrypted image in the memory **204** for retrieval using a fingerprint or other access credentials (e.g., password).

[0083] At step **308**, the method **300** may include processing an image. For example, the method may include processing an image of a target area of a patient. In some implementations, at step **308**, the method includes editing

the image stored at step **306** to produce an edited image. In particular, step **308** may include enhancing, marking-up, or ghosting the stored image with the image-processing module **206**. For example, at step **308**, the editing module **208** may overlay one of a pre-selected image and the captured image relative to the other of the pre-selected image and the captured image. The pre-selected image may include a benchmark or reference image of the target area. In some implementations, the pre-selected image may include a previously-captured image of the target area of the patient.

[0084] At step **310**, the method **300** may include comparing an image to a pre-selected image. For example, the method may include comparing a captured image of a target area of a patient to a pre-selected image of the target area. In particular, step **310** may include determining whether the image processed at step **308** matches (e.g., appears similar or identical to) the pre-selected image of the target area. If step **310** is true, the method may proceed to step **312**. If step **310** is false, the method may proceed to step **314**.

[0085] At step **314**, the method may include outputting differences between an image and a pre-selected image. For example, the method may include outputting differences between an image of a target area of a patient and a pre-selected image of a target area. In some implementations, at step **314**, the method may include identifying and/or outputting differences between the image processed at step **308** and the pre-selected image of the target area.

[0086] At step **316**, the method may include diagnosing a condition of the target area of the patient. For example, the method may include diagnosing a disease or other abnormality of the target area of the patient. In some implementations, at step **316**, the method may include diagnosing the condition based on the differences identified at step **314**.

[0087] The imaging system **10**, including the image-processing system **200**, and the image-processing method **300** may allow a user (e.g., a medical professional) to efficiently and accurately capture images (e.g., images of a patient), process the images, and diagnose conditions based on the images.

[0088] The foregoing description has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular configuration are generally not limited to that particular configuration, but, where applicable, are interchangeable and can be used in a selected configuration, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

[0089] A software application (i.e., a software resource) may refer to computer software that causes a computing device to perform a task. In some examples, a software application may be referred to as an "application," an "app," or a "program." Example applications include, but are not limited to, system diagnostic applications, system management applications, system maintenance applications, word processing applications, spreadsheet applications, messaging applications, media streaming applications, social networking applications, and gaming applications.

[0090] The non-transitory memory may be physical devices used to store programs (e.g., sequences of instructions) or data (e.g., program state information) on a temporary or permanent basis for use by a computing device. The

non-transitory memory may be volatile and/or non-volatile addressable semiconductor memory. Examples of non-volatile memory include, but are not limited to, flash memory and read-only memory (ROM)/programmable read-only memory (PROM)/erasable programmable read-only memory (EPROM)/electronically erasable programmable read-only memory (EEPROM) (e.g., typically used for firmware, such as boot programs). Examples of volatile memory include, but are not limited to, random access memory (RAM), dynamic random access memory (DRAM), static random access memory (SRAM), phase change memory (PCM) as well as disks or tapes.

[0091] Various implementations of the systems and techniques described herein can be realized in digital electronic and/or optical circuitry, integrated circuitry, specially designed ASICs (application specific integrated circuits), computer hardware, firmware, software, and/or combinations thereof. These various implementations can include implementation in one or more computer programs that are executable and/or interpretable on a programmable system including at least one programmable processor, which may be special or general purpose, coupled to receive data and instructions from, and to transmit data and instructions to, a storage system, at least one input device, and at least one output device.

[0092] These computer programs (also known as programs, software, software applications or code) include machine instructions for a programmable processor, and can be implemented in a high-level procedural and/or object-oriented programming language, and/or in assembly/machine language. As used herein, the terms "machine-readable medium" and "computer-readable medium" refer to any computer program product, non-transitory computer readable medium, apparatus and/or device (e.g., magnetic discs, optical disks, memory, Programmable Logic Devices (PLDs)) used to provide machine instructions and/or data to a programmable processor, including a machine-readable medium that receives machine instructions as a machine-readable signal. The term "machine-readable signal" refers to any signal used to provide machine instructions and/or data to a programmable processor.

[0093] The processes and logic flows described in this specification can be performed by one or more programmable processors executing one or more computer programs to perform functions by operating on input data and generating output. The processes and logic flows can also be performed by special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application specific integrated circuit). Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read only memory or a random access memory or both. The essential elements of a computer are a processor for performing instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Computer readable media suitable for storing computer program instructions and data include all forms of non-volatile memory, media and

memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD-ROM disks. The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry.

[0094] To provide for interaction with a user, one or more aspects of the disclosure can be implemented on a computer having a display device, e.g., a CRT (cathode ray tube), LCD (liquid crystal display) monitor, or touch screen for displaying information to the user and optionally a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input. In addition, a computer can interact with a user by sending documents to and receiving documents from a device that is used by the user; for example, by sending web pages to a web browser on a user's client device in response to requests received from the web browser.

[0095] The terminology used herein is for the purpose of describing particular exemplary configurations only and is not intended to be limiting. As used herein, the singular articles "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. Additional or alternative steps may be employed.

[0096] When an element or layer is referred to as being "on," "engaged to," "connected to," "attached to," or "coupled to" another element or layer, it may be directly on, engaged, connected, attached, or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to," "directly connected to," "directly attached to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0097] The terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections. These elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms do not imply a sequence or order unless clearly indicated by the context. Thus, a first element,

component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example configurations.

What is claimed is:

1. An imaging system comprising:
an image acquisition module configured to obtain a set of images of a human subject;
an image processing module configured to edit the set of images to produce a set of edited images;
a comparison module configured to:
   select a set of reference images, and
   generate a set of differences by comparing the set of edited images to the set of reference images;
a diagnostic module configured to process the set of differences to generate diagnostic information describing the human subject; and
a user interface module configured to graphically present the diagnostic information to a user.

2. The imaging system of claim 1 wherein the image acquisition module includes a camera system including:
a lens, and
a light source.

3. The imaging system of claim 1 further comprising an encryption module configured to encrypt the set of edited images for storage.

4. The imaging system of claim 3 wherein the encryption module is configured to decrypt the set of edited images in response to successful biometric authentication.

5. The imaging system of claim 1 wherein the user interface module is implemented in a handheld device including, in a single housing, a processor, memory, and a touchscreen display.

6. The imaging system of claim 1 wherein the comparison module is configured to compare a target area of the set of edited images with a corresponding target area of the set of reference images.

7. The imaging system of claim 6 wherein the target area corresponds to a region associated with the diagnostic information.

8. The imaging system of claim 7 wherein:
the diagnostic information corresponds to an organ system of the human subject; and
the region associated with the diagnostic information encompasses the organ system.

9. The imaging system of claim 8 wherein the diagnostic information indicates whether at least one of a disease or an abnormality is present in the organ system.

10. The imaging system of claim 1 wherein the set of reference images were obtained from the human subject.

11. The imaging system of claim 10 wherein the image acquisition module is configured to obtain the set of reference images from the human subject.

12. A computer system comprising:
computer-readable storage configured to store instructions; and
at least one processor configured to execute the instructions, wherein the instructions implement:
   an image acquisition module configured to obtain a set of images of a human subject;
   an image processing module configured to edit the set of images to produce a set of edited images;

a comparison module configured to:
  select a set of reference images, and
  generate a set of differences by comparing the set of edited images to the set of reference images;
a diagnostic module configured to process the set of differences to generate diagnostic information describing the human subject; and
a user interface module configured to graphically present the diagnostic information to a user.

13. The computer system of claim 12 wherein:
the comparison module is configured to compare a target area of the set of edited images with a corresponding target area of the set of reference images; and
the target area corresponds to a region associated with the diagnostic information.

14. The computer system of claim 13 wherein:
the diagnostic information corresponds to an organ system of the human subject; and
the region associated with the diagnostic information encompasses the organ system.

15. The computer system of claim 14 wherein the diagnostic information indicates whether at least one of a disease or an abnormality is present in the organ system.

16. The computer system of claim 12 wherein the instructions implement an encryption module configured to:
encrypt the set of edited images for storage, and
decrypt the set of edited images in response to successful biometric authentication.

17. A non-transitory computer-readable medium comprising instructions that implement:

an image acquisition module configured to obtain a set of images of a human subject;
an image processing module configured to edit the set of images to produce a set of edited images;
a comparison module configured to:
  select a set of reference images, and
  generate a set of differences by comparing the set of edited images to the set of reference images;
a diagnostic module configured to process the set of differences to generate diagnostic information describing the human subject; and
a user interface module configured to graphically present the diagnostic information to a user.

18. The non-transitory computer-readable medium of claim 17 wherein:
the comparison module is configured to compare a target area of the set of edited images with a corresponding target area of the set of reference images; and
the target area corresponds to a region associated with the diagnostic information.

19. The non-transitory computer-readable medium of claim 18 wherein:
the diagnostic information corresponds to an organ system of the human subject; and
the region associated with the diagnostic information encompasses the organ system.

20. The non-transitory computer-readable medium of claim 19 wherein the diagnostic information indicates whether at least one of a disease or an abnormality is present in the organ system.

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