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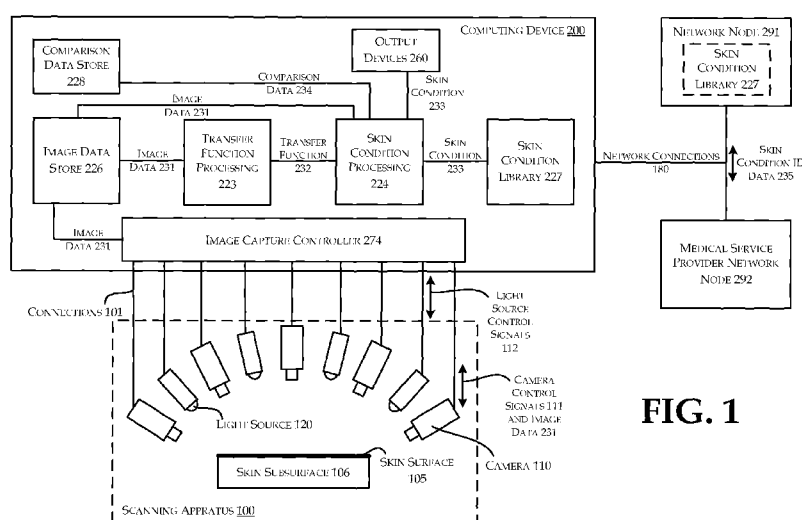


FIG. 1

(57) Abstract: Technologies generally applicable to detecting skin conditions are disclosed. A computer graphics scanning apparatus may be configured to capture skin image data, and use the captured skin image data to calculate a subsurface transfer function for the skin, which may identify subsurface properties of the skin. The identified subsurface properties may be correlated to one or more skin conditions for medical and/or cosmetic treatment diagnosis.

MULTIDIRECTIONAL SCAN AND ALGORITHMIC SKIN HEALTH ANALYSIS

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Attorney Docket Number: MTCW001602

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Priority is claimed to United States Application 12/714,011, entitled “MULTIDIRECTIONAL SCAN AND ALGORITHMIC SKIN HEALTH ANALYSIS”, filed on Feb. 26, 2010 and identified by attorney docket number MTCW001601.

[0002] This application is related by subject matter to United States Application 12/714,060, entitled “ECHOGRAM DETECTION OF SKIN CONDITIONS”, filed on Feb. 26, 2010 and identified by attorney docket number MTCW001801, which is hereby incorporated by reference.

BACKGROUND

[0003] Unless otherwise indicated herein, the materials described in this section are not prior art to the claims in this application and are not admitted to be prior art by inclusion in this section.

[0004] Large scale tests performed in 1986 and 1987 demonstrated that it may be feasible to conduct effective large scale visual screening for melanoma and other malignant skin lesions. Howard K. Koh et al., “Evaluation of melanoma/skin cancer screening in Massachusetts: Preliminary results,” *Cancer* 65, no. 2 (1990), pages 375-379. Such screening could dramatically reduce costs of care and improve life.

[0005] Unfortunately, the cost of routine screening by dermatologists is prohibitive. To this day the majority (about 90%) of health systems pay only for screening by a "gatekeeper", generally a patient's primary care physician. C. M. Barnard and M. E. Goldyne, “Evaluation of an asynchronous teleconsultation system for diagnosis of skin cancer and other skin diseases,” *Telemedicine Journal and e-Health* 6, no. 4 (2000), pages 379-384. Non-specialists such as most primary care physicians have only a 50% probability of identifying malignant skin lesions - functionally equivalent to flipping a coin. *See, e.g.*, Ramsay DL, Fox AB, “The ability of primary care physicians to recognize the common dermatoses,” *Arch Dermatol* 117, (1981), pages 620–622; and Cassileth B.R., Clark W.H. Jr., Lusk E.J., et al., “How well do physicians recognize melanoma and other problem lesions?” *J. Am. Acad. Dermatol.* 14 (1986), pages 555–560.

[0006] The present disclosure identifies and appreciates that conventional approaches of screening for certain skin conditions are limited and inadequate, due to prohibitive costs of

doing so effectively, and that improved accuracy screening technologies allowing automated screening and/or screening by non-specialist medical caregivers, for skin features that involve more than cosmetic skin alteration, would be beneficial for better advance detection of skin conditions.

SUMMARY

[0007] The present disclosure describes methods and devices for detecting skin conditions associated with a skin of a subject, as well computer readable media having instructions for detecting skin conditions from skin image data comprising images from different camera positions using multiple light sources at multiple positions. Some example methods may comprise illuminating the skin from a first light source angle and capturing a first plurality of images; illuminating the skin from a second light source angle and capturing a second plurality of images; evaluating the first and second sets of images to calculate a subsurface transfer function that describes one or more subsurface properties of the skin; and algorithmically identifying a skin condition corresponding to the subsurface properties. The subsurface transfer function may comprise a Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF), and algorithmically identifying a skin condition may comprise comparing subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions. An identified skin condition may comprise, for example, a melanoma.

[0008] Some example devices may comprise multiple light sources positioned to illuminate skin from multiple different positions; multiple cameras positioned to capture images of skin from multiple different positions; an image capture controller configured to selectively activate the light sources and capture images of the illuminated skin; and a processor configured to calculate a subsurface transfer function for the skin using the captured images, wherein the subsurface transfer function describes one or more subsurface properties of the skin, and the processor is configured to algorithmically identify a skin condition corresponding to the subsurface properties.

[0009] Some example computer readable media may comprise instructions to calculate a subsurface transfer function for skin using image properties corresponding to each of a plurality of points on the skin in each of a plurality of images illuminated from different light source positions, wherein the subsurface transfer function describes one or more subsurface properties of the skin; and instructions to algorithmically identify a skin condition corresponding to the subsurface properties.

[0010] The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The foregoing and other features of the present disclosure will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings depict only several embodiments in accordance with the disclosure and are, therefore, not to be considered limiting of its scope, the disclosure will be described with additional specificity and detail through use of the accompanying drawings, in which:

FIG. 1 is a diagram illustrating an example system that may perform a multidirectional scan of a skin surface and perform an algorithmic analysis of collected data to determine presence of a skin condition;

FIG. 2 is a block diagram illustrating a computing device as one example of the computing device illustrated in **FIG. 1**;

FIG. 3 is a flow diagram illustrating an example method that may collect images of a skin surface and perform an algorithmic analysis of collected data to determine presence of a skin condition;

FIG. 4 is a diagram illustrating an example dome scanning apparatus;

FIG. 5 is a diagram illustrating top and front views of an example handheld scanning apparatus; and

FIG. 6 is a diagram illustrating an example subsurface light path affected by subsurface properties of the skin; all arranged in accordance with at least some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0012] In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented here. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, may be arranged,

substituted, combined, and designed in a wide variety of different configurations, all of which are explicitly contemplated and made part of this disclosure.

[0013] The present disclosure is generally drawn, inter alia, to methods, devices, and/or systems related to detecting skin conditions. A computer graphics scanning apparatus may be configured to capture skin image data, and to use the captured skin image data to calculate a subsurface transfer function for the skin, which may identify subsurface properties of the skin. The identified subsurface properties may be correlated to one or more skin conditions for medical and/or cosmetic treatment diagnosis.

[0014] **FIG. 1** is a diagram illustrating an example system that may perform a multidirectional scan of a skin surface and perform an algorithmic analysis of collected data to determine presence of a skin condition, arranged in accordance with at least some embodiments of the present disclosure. **FIG. 1** includes a scanning apparatus **100**, a computing device **200**, and network nodes **291** and **292**. Scanning apparatus **100** may include one or more of a plurality of cameras **110** and/or a plurality of light sources **120**, arranged at selected positions over a skin surface **105**. Computing device **200** may comprise one or more of an image capture controller **274**, image data store **226**, transfer function processing **223**, skin condition processing **224**, skin condition library **227**, comparison data store **228**, and/or output devices **260**. Network node **291** may also include a skin condition library **227**. Network node **292** may be a medical service provider network node.

[0015] In **FIG. 1**, the cameras **110** and light sources **120** of the scanning apparatus **100** may be coupled to the computing device **200** and/or image capture controller **274** via wired or wireless connections **101**. The image capture controller **274** may be adapted to communicate light source control signals **112** to the various light sources **120** via one or more connections **101**, which are coupled between light sources **120** and the image capture controller **274**. Image capture controller **274** may be adapted to communicate camera control signals **111** to the various cameras **110** via connections **101**, which are coupled between the image capture controller **274** and the cameras **110**. The image capture controller **274** may be configured to receive image data **231** from the various cameras **110** via connections **101**.

[0016] The computing device **200** may also be coupled to the network nodes **291** and **291** via network connections **180**. Skin condition identification data **235** may be sent from the computing device **200** to either of the network nodes **291** and **291**, and skin condition identification data **235** may be received at the computing device **200** from either of the network nodes **291** and **291**, as described further below.

[0017] The system illustrated in **FIG. 1** may be configured to perform a multidirectional scan of a skin using the scanning apparatus **100**, and also configured to perform an algorithmic skin health analysis using one or more processing modules such as **223** and **224**. In some embodiments, the image capture controller **274** may be configured to perform a multidirectional scan by illuminating each of the light sources **120**, one or more at a time, and to capture image data at one or more of the cameras **110**, when one or more of the light sources **120** is illuminated. The captured image data **231** may be stored in the image data store **226**.

[0018] Because skin surfaces such as **105** may not be completely opaque, but instead may be partially translucent, the image data **231** captured via the scanning apparatus **100** may comprise information (e.g., identified characteristics) about the skin surface **105** and/or the skin subsurface **106**. In general, the computing device **200** may be configured to perform an algorithmic skin health analysis at least in part by analyzing the captured image data **231** to extract information about subsurface properties of the skin.

[0019] Transfer function processing **223** may be configured to operate on the captured image data **231** to calculate a subsurface transfer function **232** describing properties of the skin subsurface **106**, as described in greater detail below. Skin condition processing **224** may be adapted to use the transfer function **232** (optionally along with additional data as described herein) to identify or determine one or more properties of the skin subsurface **106**, and may also be adapted to correlate subsurface properties to skin conditions using the skin condition library **227**. Skin condition processing **224** may be adapted to retrieve a skin condition **233** applicable to the determined properties of the skin subsurface **106** from the skin condition library **227**, and may also be adapted to output the skin condition **233** to one or more output devices **260**. For example, skin condition processing **224** may be configured to output the skin condition **233** to a display, where a technician or patient may be informed of the skin condition **233**.

[0020] Various scanning apparatus **100** configurations may be applied in some embodiments. Example scanning apparatus **100** configurations are illustrated in **FIG. 4** and **FIG. 5**. In addition to various physical arrangements of lights and cameras illustrated in **FIG. 4** and **FIG. 5**, a scanning apparatus **100** may be configured to employ one or more light sources **120** emitting light frequencies that are selected as advantageous to the algorithmic skin health analysis described herein. Selected frequencies may be in the visible and/or in the non-visible (infrared and ultraviolet) portion of the spectrum. Also, a single light source may be adapted to emit a range of different frequencies, for example, a traditional white light corresponds to a range of frequencies in the visible light spectrum. Light sources may be selected and/or filtered to select and/or optimize the frequencies emitted by the light source.

[0021] A scanning apparatus **100** may be configured with any of a variety of camera types. In general, the cameras **110** may be configured to produce digital images of a skin surface. High-definition digital cameras may be capable of capturing color images with a high degree of accuracy and detailed data for algorithmic skin health analysis. However, camera size and camera cost may provide constraints on the properties of cameras **110** selected for use with the system.

[0022] In some embodiments, the scanning apparatus **100** may be arranged to position light sources **120** and/or cameras **110** at roughly similar distances from a skin surface, and at regularly spaced angles with respect to a skin surface. Various distances and angles used in the scanning apparatus **100** may be accounted for when processing the image data **231**, according to transfer function processing **223** embodiments provided herein. Light sources **120** and/or cameras **110** may be positioned at different positions as may be identified by coordinates along x, y and z axes, or as may be identified using any other coordinate system.

[0023] This disclosure is not limited to scanning apparatus **100** and/or image capture controller **274** configurations that illuminate a single light source at a time. In some embodiments, a plurality of light sources that are positioned close together may be illuminated as a group. In some embodiments, a plurality of light sources that are positioned even at widely different angles may be illuminated at substantially the same time. The positions of illuminated light sources may be accounted for by the computer **200** in conducting algorithmic analysis of the image data **231**. In general, illuminated light sources positioned at widely different light source angles may yield more complex image processing in some circumstances, however such configurations are possible.

[0024] In some embodiments, the methods, devices, and/or systems related to detecting skin conditions described herein may be combined with any of the technologies described in United States Patent Application 12/714,060, entitled "ECHOGRAM DETECTION OF SKIN CONDITIONS", filed on Feb. 26, 2010, attorney docket number MTCW001801.

[0025] Each of the components illustrated in the computing device **200** and network nodes **291** and **292** may be configured to carry out one or more of the functions described below, in connection with **FIG. 3**.

[0026] **FIG. 2** is a block diagram illustrating a computing device as one example of the computing device illustrated in **FIG. 1**, arranged in accordance with at least some embodiments of the present disclosure. In a very basic configuration **201**, computing device **200** may include one or more processors **210** and system memory **220**. A memory bus **230** may be used for communicating between the processor **210** and the system memory **220**.

[0027] Depending on the desired configuration, processor **210** may be of any type including but not limited to a microprocessor (μ P), a microcontroller (μ C), a digital signal processor (DSP), or any combination thereof. Processor **210** may include one or more levels of caching, such as a level one cache **211** and a level two cache **212**, a processor core **213**, and registers **214**. The processor core **213** may include an arithmetic logic unit (ALU), a floating point unit (FPU), a digital signal processing core (DSP Core), or any combination thereof. A memory controller **215** may also be used with the processor **210**, or in some implementations the memory controller **215** may be an internal part of the processor **210**.

[0028] Depending on the desired configuration, the system memory **220** may be of any type including but not limited to volatile memory (such as RAM), non-volatile memory (such as ROM, flash memory, etc.), or any combination thereof. System memory **220** typically includes an operating system **221**, one or more applications **222**, and program data **225**. Applications **223-224** may include, for example, transfer function processing module(s) **223** and skin condition processing module(s) **224**. Program data **226-228** may include image data store **226**, skin condition library **227**, and comparison data store **228** that may be used by applications **223-224**.

[0029] Computing device **200** may have additional features or functionality, and additional interfaces to facilitate communications between the basic configuration **201** and any required devices and interfaces. For example, a bus/interface controller **240** may be used to facilitate communications between the basic configuration **201** and one or more data storage devices **250** via a storage interface bus **241**. The data storage devices **250** may be removable storage devices **251**, non-removable storage devices **252**, or a combination thereof. Examples of removable storage and non-removable storage devices include magnetic disk devices such as flexible disk drives and hard-disk drives (HDD), optical disk drives such as compact disk (CD) drives or digital versatile disk (DVD) drives, solid state drives (SSD), and tape drives, to name a few. Example computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data.

[0030] System memory **220**, removable storage **251**, and non-removable storage **252** are all examples of computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium that may be used to store the desired information and that may be accessed by computing device **200**. Any such computer storage media may be part of device **200**.

[0031] Computing device **200** may also include an interface bus **242** for facilitating communication from various interface devices (e.g., output interfaces, peripheral interfaces, and communication interfaces) to the basic configuration **201** via the bus/interface controller **240**. Example output devices **260** include a graphics processing unit **261** and an audio processing unit **262**, which may be configured to communicate to various external devices such as a display or speakers via one or more A/V ports **263**. Any such external devices may be used to communicate a detected skin condition **223** to a patient, technician, doctor, or other entity. Example peripheral interfaces **270** may include a serial interface controller **271** or a parallel interface controller **272**, which may be configured to communicate through either wired or wireless connections with external devices such as an image capture controller **274**, in embodiments in which an image capture controller **274** may be configured as a peripheral device, as well as input devices (e.g., keyboard, mouse, pen, voice input device, touch input device, etc.) or other peripheral devices (e.g., printer, scanner, etc.) via one or more I/O ports **273**. Other conventional I/O devices may be connected as well such as a mouse, keyboard, and so forth. An example communications device **280** includes a network controller **281**, which may be arranged to facilitate communications with one or more other computing devices **290**, such as network nodes **291** and **292** (illustrated in **FIG. 1**) over a network communication via one or more communication ports **282**.

[0032] The computer storage media may be one example of a communication media. Communication media may typically be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and include any information delivery media. A “modulated data signal” may be a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media may include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency (RF), infrared (IR), and other wireless media.

[0033] Computing device **200** may be implemented as a one or more personal computers and/or laptop computers attached to image scanning apparatus for example at a doctor’s office or in a retail location such as a shopping mall. Computing device **200** may also be implemented in or across any of a wide variety of computing devices, including for example small-form factor portable (or mobile) electronic devices such as a cell phones, personal data assistants (PDA), and personal media player devices, application-specific devices, and/or hybrid devices that include any of the above functions.

[0034] **FIG. 3** is a flow diagram illustrating an example method that may collect images of a skin surface and perform an algorithmic analysis of collected data to determine presence of a skin condition, arranged in accordance with at least some embodiments of the present disclosure. The example flow diagram may include one or more operations/modules, functions or actions as illustrated by blocks **301-305**, which represent operations as may be performed in a method, functional modules in a computing device **200**, and/or instructions as may be recorded on a computer readable medium **300**. The illustrated blocks **301-305** may be arranged to provide functional operations including one or more of “Illuminate Skin Surface at Selected Light Source Angle” at block **301**, “Capture Images of Skin Surface” at block **302**, “Calculate Subsurface Transfer Function from Captured Images” at block **303**, “Identify Skin Condition” at block **304**, and/or “Output Skin Condition” at block **305**.

[0035] In **FIG. 3**, blocks **301-305** are illustrated as being performed sequentially, with block **301** first and block **305** last. It will be appreciated however that these blocks may be re-ordered as convenient to suit particular embodiments, and that these blocks or portions thereof may be performed concurrently in some embodiments. It will also be appreciated that in some examples various blocks may be eliminated, divided into additional blocks, and/or combined with other blocks.

[0036] **FIG. 3** illustrates an example method by which a multidirectional scan and algorithmic skin health analysis may be carried out using a system such as illustrated in **FIG. 1**. As a preliminary operation to performing the illustrated method, a subject (e.g. a person whose skin is to be analyzed) may first be positioned underneath the light sources and cameras of a scanning apparatus. Positioning the subject depends on the configuration of the scanning apparatus. For example, in embodiments utilizing a dome scanning apparatus such as **FIG. 4**, the subject may be seated inside the dome, and a tracking ball or other reference point may be affixed to the subject so that points on the subject’s skin may be accurately compared across a plurality of images, even if the subject moves. In embodiments utilizing a handheld scanning apparatus such as **FIG. 5**, subject skin may be exposed for a technician to apply the handheld scanning apparatus over the skin to be analyzed.

[0037] At block **301**, “Illuminate Skin at Selected Light Source Angle”, an image capture controller **274** may be adapted to select one or more light sources from among the plurality of light sources **120** of a scanning apparatus **100**, and apply one or more light source control signals **112** via connection(s) **101** to the one or more selected light sources **120**, causing the selected light source to illuminate at an appropriate time interval when image data may be captured. As described above, each of the light sources **120** of a scanning apparatus **100** may be

disposed at different light source angles with respect to the skin being illuminated. Therefore, selection and illumination of a light source of a scanning apparatus **100** described herein may inherently comprise illuminating a skin by a light source disposed at a selected light source angle with respect to the skin.

[0038] The image capture controller **274** may for example be adapted to select a first light source from a list of light sources of the scanning apparatus **100**. In some embodiments, a multi-way light switch may be activated to select a light source. The light source control signal **112** may comprise a direct or alternating current power signal applied via a connection **101** and sufficient to illuminate the selected light source, or in the case of a “smart” light or “smart” scanning apparatus capable of receiving and processing instructions from the image capture controller **274**, the light source control signal **112** may comprise an instruction to illuminate a selected light source. Block **301** may be followed by block **302**.

[0039] At block **302**, “Capture Images of Skin Surface”, an image capture controller **274** may cause the cameras **110** of a scanning apparatus applicable to a scanning operation (in some embodiments, all of the cameras **110**) to capture images of a skin illuminated by a selected light source. For example, immediately following an illumination of a light source according to block **301**, and while the skin is illuminated by the light source, an image capture controller **274** may simultaneously send camera control signals **111** via all of the connections **101** coupled to the cameras **110**, to cause the cameras **110** to capture a plurality of images of the skin from a plurality of camera angles with respect to the skin.

[0040] The image capture controller **274** may be configured to maintain selected light source(s) in an illuminated state during an operation according to block **302**, for example by maintaining the power signal applied via the connection **101**. After an operation according to block **302** is complete, image capture controller **274** may deactivate the selected light source(s), select subsequent light source(s), and illuminate the subsequent light source(s). Blocks **301** and **302** may be repeated for each light source in a scanning apparatus that is applicable to a scanning operation, e.g. in some embodiments, all of the light sources in a scanning apparatus. After each light source has been illuminated and block **302** has been performed for each light source, the image capture controller **274** may notify an application such as **223** or **224** that image capture is complete, thereby initiating algorithmic analysis of captured image data.

[0041] The cameras **110** may be configured to automatically send captured image data **231** to image capture controller **274** and/or to computing device **200** for storage in the image data store **226**, in response to capturing images pursuant to the camera control signals **111**. The image data **231** may be organized in the image data store **226** according to the light source **120**

illuminating the skin for each image, as well as camera position for each image. This allows detailed analysis of the images using known angles of incident light (corresponding to a light source) and known angles of reflected/scattered light (corresponding to camera position). As indicated above in the description of block **301**, blocks **301** and **302** may be repeated for each light source in a scanning apparatus.

[0042] When images are captured for all cameras and all light sources corresponding to a desired scanning operation, block **302** may be followed by block **303**, thereby initiating algorithmic analysis of captured image data. Otherwise, processing may continue from block **302** to block **301** where the illumination/capture procedures may be repeated.

[0043] At block **303**, “Calculate Subsurface Transfer Function from Captured Images”, a subsurface transfer function calculation algorithm may be applied to calculate a subsurface transfer function **232** from the image data **231** in the image store **226** applicable to a skin scan performed by the scanning apparatus **100**. The use of an algorithm for calculating a subsurface transfer function in connection with identifying a skin condition is referred to herein as an algorithmic identification of a skin condition corresponding to the one or more subsurface properties of the skin. The term “electronic identification” is also used herein to refer to calculation by a computer or other electronic device. In general, a transfer function **232** may be calculated using image properties corresponding to each of a plurality of points on the skin in each of the plurality of images for each of the light source angles applied by the scanning apparatus **100**. For example, light reflecting or scattering off the skin at a particular point, as recorded in images corresponding to each of the camera angles and each of the illumination angles, may be used to determine subsurface skin properties such as color of subsurface layers or structures, thickness of subsurface layers or structures, texture of subsurface layers or structures, and density of subsurface layers or structures. Such information may be compared across a plurality of analyzed points to determine subsurface skin properties comprising color, thickness, texture, and density as well as shape and size properties of subsurface layers or structures. These various example subsurface properties may be described using a transfer function, using any of the approaches available in the art, referenced herein, or as may become known or available.

[0044] An example of a subsurface transfer function is the Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF). In general, BSSRDF (denoted S) relates an outgoing radiance, $L_o(x_o, \omega_o)$ at a point x_o in direction ω_o , to an incident flux, $\Phi_i(x_i, \omega_i)$ at a point x_i from direction ω_i , as follows:

$$dL_o(x_o, \omega_o) = S(x_i, \omega_i; x_o, \omega_o) d\Phi_i(x_i, \omega_i)$$

[0045] Given a BSSRDF, an outgoing radiance may be computed by integrating incident radiance over incoming directions and area, and vice versa. Furthermore, light propagation in a participating medium may be described by a radiative transport equation, referred to in computer graphics as a volume rendering equation. In a radiative transport equation, properties of a medium may be described by an absorption coefficient, a scattering coefficient, and a phase function.

[0046] In some embodiments, simplified approaches for calculating a BSSRDF may be used, for example by using diffusion approximations, scattering terms, and/or Bidirectional Reflectance Distribution (BRDF) approximations, as is generally understood in the field of computer graphics.

[0047] Any available BSSRDF or other transfer function calculation approach may be used to generate skin maps which highlight subsurface properties and distinguish bodily marks with subsurface damage from those which are primarily pigmentation. In some embodiments, one or more subsurface skin properties identified from BSSRDF skin maps, along with other features such as surface color and comparison data from previous scans, may be used to algorithmically identify skin conditions, as well as to produce output graphics highlighting the skin conditions. Block 303 may be followed by block 304.

[0048] At block 304, "Identify Skin Condition", the transfer function determined in block 303 and/or subsurface properties defined by the transfer function may be used to identify a skin condition corresponding to the one or more subsurface properties of the skin. In some embodiments, skin condition processing module(s) 224 may be configured to compare the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions. For example, a transfer function 232 describing one or more subsurface properties may be compared to transfer functions stored in a skin condition library 227. The library 227 may comprise a plurality skin conditions corresponding to stored transfer functions, stored transfer function categories, and/or stored transfer function features. For example, the library 227 may comprise a plurality melanoma type skin conditions as well as malignant nevi conditions, cosmetic conditions such as scars, acne, moles and freckles corresponding to stored transfer functions, stored transfer function categories, and/or stored transfer function features. The skin condition processing module(s) 224 may be adapted to retrieve any skin condition 233 corresponding to stored transfer functions in the library 227 that match the transfer function 223 corresponding to the skin subsurface 106.

[0049] In some embodiments, block 304 may be configured to identify skin condition 233 data in any of a variety of forms. For example, in some embodiments skin condition 233

data may comprise a medical risk associated with a skin condition. If a transfer function **232** is identified as an X% melanoma risk (where X is 0% - 100%) the melanoma (or other condition) probability may be retrieved. Similarly, where a benign cosmetic blemish is identified, data identifying a skin condition as a cosmetic blemish and optionally suggesting or providing cosmetic removal options may be provided.

[0050] In some embodiments, block **304** may be configured to securely send a calculated transfer function **232** or other subsurface property description data to the medical service provider network node **292** via network connections **180** as skin condition ID data **235**. A medical service provider may analyze the skin condition ID data **235**, attempt to identify a corresponding skin condition **233**, and send any skin condition data back to the computer **200** via network connections **180** as skin condition ID data **235**.

[0051] In embodiments configured with a library **227** stored at a network node **291**, block **304** may be configured to securely send a calculated transfer function **232** or other subsurface property description data to the network node **291** via network connections **180** as skin condition ID data **235**. The skin condition ID data **235** may be secured for example by being encrypted prior to sending, and subsequently decrypted at the network node **291**. The network node **291** may then compare the transfer function **232** to stored transfer functions in the library **227**, and may securely send an identified skin condition **233** to the computing device **200** via network connections **180** as skin condition ID data **235**. Embodiments storing a skin condition library **227** at a network node **291** may collect skin condition ID data **235** from a plurality of sources, for example, from many different doctor offices equipped with a system described herein. Collected skin condition ID data **235** may be compiled and used to improve the accuracy of the library **227** as well as any algorithms used in conjunction with the library **227**. In various alternative embodiments, the computing device may retrieve the library **227** from the network node **291**, e.g., to avoid sending the transfer function **232** to the network node, which may increase the privacy or perceived privacy of the methods described herein.

[0052] In some embodiments, block **304** may use additional data to facilitate skin condition identification. For example, skin condition processing module(s) **224** may be configured to retrieve image data **231** from the image data store **226** to investigate image properties corresponding to a skin surface **105** location disposed over a feature of interest in the skin subsurface **106** that may be identified in a calculated transfer function **232**. The opposite operation may also be performed, that is, identifying surface properties of interest in the image data **231** corresponding to the skin surface **105**, then determining whether subsurface properties are present underneath identified surface properties.

[0053] Similarly, a comparison data store **228** may comprise comparison data **234**, comprising data from previous scans of a same skin, allowing comparisons across multiple scans to determine changes in the skin from scan to scan. A change in skin properties often indicates medical risk. Therefore, if for example a particular surface or subsurface feature expands or multiplies between scans, data identifying properties as expanding, multiplying, or otherwise changing may be used, either independently or in addition to the subsurface properties, to identify a skin condition **233**. Surface properties of the image data **231** as well as comparison data **231** of interest may also be sent to nodes **291** and **292** as skin condition ID data **235**, along with the subsurface transfer function **232** as described above.

[0054] With regard to the comparison data store **228**, the disclosed method may be further configured to store a transfer function **232** and /or other data described herein as comparison data **234** in the comparison data store **228**, for subsequent use in future skin condition identification operations. Comparison data **234** may also comprise image data **231** and optionally identification information comprising, for example, identifiers for the scanned subject (e.g. person's name), a location of the scanned skin surface (e.g. right shoulder blade), and/or date of the scan. Block **304** may be followed by block **305**.

[0055] At block **305**, "Output Skin Condition", a skin condition **233** may be output to an output device **260**. In some embodiments, data comprising a written identification of the skin condition **233** may be output to a display that is coupled to the computer **200** as an output device **260**. In some embodiments, the output may be a privacy-protected output such as a printout that may be provided directly to the scanned subject. The output may also take the form of an email or fax to a subject's email address or fax number, and/or a doctor's email address or fax number. In some embodiments, an audio recording may be provided for listening by the subject or a technician or other professional administering the scan. The skin condition **233** output may be accompanied by additional information such as information describing known aspects and properties of the skin condition, known treatment options, and contact information for dermatologists or other professionals available to treat the skin condition **233**.

[0056] In some embodiments, block **305** may comprise displaying an image of the skin and highlighting the one or more subsurface properties of the skin on the displayed image. For example an image may comprise a graphics representation of the scanned skin, with a line drawn around the part of the skin having subsurface properties of interest. Cross-sectional views and colored highlighting of surface and subsurface properties may also be provided. In some embodiments, displayed images may comprise animation showing probable progression of the

skin condition if left untreated and/or showing treatment procedures for how the skin condition may be removed or otherwise treated.

[0057] **FIG. 4** is a diagram illustrating an example dome scanning apparatus **400**, arranged in accordance with at least some embodiments of the present disclosure. Dome scanning apparatus **400** may comprise support braces **410**, a plurality of light sources **120** (denoted L in **FIG. 4**), and a plurality of cameras **110** (denoted C in **FIG. 4**).

[0058] The dome scanning apparatus **400** may be coupled to an image capture controller **274** via connections **101**, which may be configured to communicate one or more of light source control signals **112**, camera control signals **111**, and/or image data **231** between the image capture controller **274** and the dome scanning apparatus **400**, as illustrated in **FIG. 1**. Two connections **101** are illustrated in **FIG. 4** to represent connections **101** which may be used to couple all of the light sources **120** and cameras **110** to the image capture controller **274**. The connections **101** may be separately wired parallel connections in some embodiments. In some embodiments, for example, where smart cameras **110** and/or light sources **120** are used which are addressable, the connections **101** may be implemented by a bus coupled to cameras **110** and/or light sources **120**.

[0059] The dome scanning apparatus **400** provides an example of a scanning apparatus **100**. In some embodiments, the dome scanning apparatus **400** may be arranged as an overhead dome. The dome scanning apparatus **400** may comprise, for example, a computer graphics scanning apparatus of a type similar to scanning apparatus for the movie-making industry. A subject may be positioned underneath the dome, where the subject may expose one or more skin surfaces to the lights **120** and cameras **110** of the dome. In some arrangements, a camera **110** may be positioned at one or more intersections of the support braces **410**, and a light source **120** may be positioned along the body of one or more support braces. It will be appreciated that this arrangement involves lights and cameras at a plurality of different positions and angles with respect to the skin surface of a subject disposed in the dome. In some embodiments, the dome scanning apparatus **400** allows for scanning large and/or multiple skin surfaces in a single scan.

[0060] A scan done by a dome scanning apparatus **400** may be utilized by a system such as **FIG. 1**, for example, to identify on the order of a million points on a skin surface and characterize each point from images from 16 directions (corresponding to 16 cameras) for each of the light sources (e.g. 150 light sources). By rapidly sequencing the light sources and capturing images when the subject is illuminated, an entire scan may take several minutes. Mathematically, in some examples, each point may correspond to about 900-1200 data points which may be used to generate the subsurface transfer function characterizing the skin.

[0061] In some embodiments, the dome scanning apparatus **400** may comprise different configurations for support braces **410**, and may comprise different numbers and positioning of light sources **120** and cameras **110**, as will be appreciated. Sixteen (16) digital cameras and one hundred fifty (150) Light Emitting Diode (LED) light sources can be used in some special effects-type scanners, and a similar configuration may be used in the dome scanning apparatus **400** in some embodiments. Shapes other than domes may also be applied, for example, a flat structure disposed above a subject may be suitable for some embodiments. Camera, light source, and/or algorithmic processing configurations may be modified to accommodate camera and light source positioning according to different configurations of support braces **410**.

[0062] In some embodiments, a tracking ball or other object may be affixed to a subject to accommodate for movement of the subject between images. Image processing may account for positioning of skin surfaces by referencing tracking ball position and orientation. In some embodiments, the function of a tracking ball may be accomplished by algorithmically determining relative positioning of a skin surface in each analyzed image. Image orientation analysis technologies may be applied for identifying an object, such as a skin surface, across a plurality of images, and determining camera distance and angle from the object in each of the images.

[0063] **FIG. 5** is a diagram illustrating top and front views of an example handheld scanning apparatus **500**, arranged in accordance with at least some embodiments of the present disclosure. The top view of the handheld scanning apparatus **500** comprises a light shield **530** affixed atop a housing **510**, and a flexible sheath **520** affixed to the underside of the housing **510**. The top view also illustrates an image capture controller **274**.

[0064] A plurality of connections **101** are shown traversing the interior of the flexible sheath **520** and housing **510** from the image capture controller **274** to the top of the housing **510**. Connections **101** may be bundled in the flexible sheath **520** and may spread out to couple to light sources **120** and cameras **110** illustrated in the front view of the handheld scanning apparatus **500**. Connections **101** may be configured to communicate one or more of light source control signals **112**, camera control signals **111**, and/or image data **231** between the image capture controller **274** and the handheld scanning apparatus **500**, as illustrated in **FIG. 1**. Two connections **101** are illustrated in **FIG. 5** to represent connections **101** which may couple the light sources **120** and cameras **110** to the image capture controller **274**. Connections **101** may for example comprise a bus implemented in conjunction with addressable cameras **110** and/or light sources **120**, to allow for individual control of the cameras **110** and/or light sources **120**.

[0065] The front view of the handheld scanning apparatus **500** comprises a rim of the light shield **530** surrounding a plurality of light sources **120** and a plurality of cameras **110**. The light sources **120** and cameras **110** may be interspersed to allow for different light source and camera angles and positions when the front of the handheld scanning apparatus **500** is positioned over a skin surface.

[0066] The handheld scanning apparatus **500** provides an example of a scanning apparatus **100**. In some embodiments, the handheld scanning apparatus **500** may be designed to be held over a skin surface to perform a scan of the skin surface, as described above. In some embodiments, light sources **120** and cameras **110** may comprise light source and camera elements disposed on the handheld scanning apparatus **500** as illustrated in the front view. In some embodiments, connections **101** may comprise fibers adapted to transmit light to and/or from light source and camera elements disposed elsewhere. Using fibers as part of light sources **120** and/or cameras **110** may reduce bulk of the handheld scanning apparatus **500** in some embodiments.

[0067] A light shield **530** may allow for contacting a skin surface with the handheld scanning apparatus **500**. The light shield **530** may provide a known separation between the light sources **120** and cameras **110** and the skin surface, which in turn governs the positions and angles of the light sources **120** and cameras **110** for the purpose of subsequent algorithmic skin health analysis. The light shield **530** may furthermore block ambient light from reflecting off the skin at uncontrolled angles.

[0068] **FIG. 6** is a diagram illustrating an example subsurface light path affected by subsurface properties of the skin, in accordance with at least some embodiments of the present disclosure. **FIG. 6** includes incident light **620** striking a skin at a selected light source angle θ . The light travels a subsurface light path **603**, through skin layer **600** and skin layer **601**. Reflected/scattered light **630** corresponding to the incident light **620** travels away from the skin after following light path **603**. Reflected/scattered light **630** may be detected by a camera positioned in the path of the reflected/scattered light **630**, to produce an image that may be used to capture properties of the reflected/scattered light **630** and use such properties to determine subsurface properties of skin layers **600** and **601** as demonstrated herein. **FIG. 6** comprises example scale indications of about 0.5 millimeters (mm) to about 4.0 mm depth of the layer **600**, about 4.0 mm to about 9.0 mm depth of the layer **601**, and around 1 cm length of the subsurface light path **603**.

[0069] There is little distinction left between hardware and software implementations of aspects of systems; the use of hardware or software is generally (but not always, in that in certain contexts the choice between hardware and software may become significant) a design choice

representing cost vs. efficiency tradeoffs. There are various vehicles by which processes and/or systems and/or other technologies described herein may be effected (e.g., hardware, software, and/or firmware), and that the preferred vehicle will vary with the context in which the processes and/or systems and/or other technologies are deployed. For example, if an implementer determines that speed and accuracy are paramount, the implementer may opt for a mainly hardware and/or firmware vehicle; if flexibility is paramount, the implementer may opt for a mainly software implementation; or, yet again alternatively, the implementer may opt for some combination of hardware, software, and/or firmware.

[0070] The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, flowcharts, and/or examples. Insofar as such block diagrams, flowcharts, and/or examples contain one or more functions and/or operations, it will be understood by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples may be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or virtually any combination thereof. In one embodiment, several portions of the subject matter described herein may be implemented via Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs), digital signal processors (DSPs), or other integrated formats. However, those skilled in the art will recognize that some aspects of the embodiments disclosed herein, in whole or in part, may be equivalently implemented in integrated circuits, as one or more computer programs running on one or more computers (e.g., as one or more programs running on one or more computer systems), as one or more programs running on one or more processors (e.g., as one or more programs running on one or more microprocessors), as firmware, or as virtually any combination thereof, and that designing the circuitry and/or writing the code for the software and/or firmware would be well within the skill of one of skill in the art in light of this disclosure. In addition, those skilled in the art will appreciate that the mechanisms of the subject matter described herein are capable of being distributed as a program product in a variety of forms, and that an illustrative embodiment of the subject matter described herein applies regardless of the particular type of signal bearing medium used to actually carry out the distribution. Examples of a signal bearing medium include, but are not limited to, the following: a recordable type medium such as a floppy disk, a hard disk drive, a Compact Disc (CD), a Digital Video Disk (DVD), a digital tape, a computer memory, etc.; and a transmission type medium such as a digital and/or an analog communication medium (e.g., a fiber optic cable, a waveguide, a wired communications link, a wireless communication link, etc.).

[0071] Those skilled in the art will recognize that it is common within the art to describe devices and/or processes in the fashion set forth herein, and thereafter use engineering practices to integrate such described devices and/or processes into data processing systems. That is, at least a portion of the devices and/or processes described herein may be integrated into a data processing system via a reasonable amount of experimentation. Those having skill in the art will recognize that a typical data processing system generally includes one or more of a system unit housing, a video display device, a memory such as volatile and non-volatile memory, processors such as microprocessors and digital signal processors, computational entities such as operating systems, drivers, graphical user interfaces, and applications programs, one or more interaction devices, such as a touch pad or screen, and/or control systems including feedback loops and control motors (e.g., feedback for sensing position and/or velocity; control motors for moving and/or adjusting components and/or quantities). A typical data processing system may be implemented utilizing any suitable commercially available components, such as those typically found in data computing/communication and/or network computing/communication systems. The herein described subject matter sometimes illustrates different components contained within, or connected with, different other components. It is to be understood that such depicted architectures are merely examples, and that in fact many other architectures may be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality may be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermediate components. Likewise, any two components so associated may also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated may also be viewed as being "operably couplable", to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically connectable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0072] With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art may translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0073] It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to inventions containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should typically be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should typically be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, typically means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0074] While certain example techniques have been described and shown herein using various methods, devices and systems, it should be understood by those skilled in the art that various other modifications may be made, and equivalents may be substituted, without departing from claimed subject matter. Additionally, many modifications may be made to adapt a particular situation to the teachings of claimed subject matter without departing from the central concept described herein. Therefore, it is intended that claimed subject matter not be limited to the particular examples disclosed, but that such claimed subject matter also may include all implementations falling within the scope of the appended claims, and equivalents thereof.

CLAIMS:

1. A method for detecting skin conditions associated with a skin of a subject, the method comprising:

activating a first light source to illuminate the skin, wherein the first light source is disposed at a first light source angle with respect to the skin;

while the skin is illuminated by the first light source, capturing a first plurality of images of the skin from a first plurality of camera angles with respect to the skin;

activating a second light source to illuminate the skin, wherein the second light source is disposed at a second light source angle with respect to the skin;

while the skin is illuminated by the second light source, capturing a second plurality of images of the skin from a second plurality of camera angles with respect to the skin, wherein the first plurality of camera angles are at least partially different from the second plurality of light source angles;

evaluating the first plurality of images and the second plurality of images to identify properties corresponding to each of a plurality of points on the skin for each of the first and second light source angles to calculate a subsurface transfer function for the skin, wherein the subsurface transfer function describes one or more subsurface properties of the skin; and

algorithmically identifying a skin condition corresponding to the one or more subsurface properties of the skin.

2. The method for detecting skin conditions of claim 1, wherein the subsurface transfer function comprises a Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF).

3. The method for detecting skin conditions of claim 1, wherein algorithmically identifying a skin condition comprises comparing the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions.

4. The method for detecting skin conditions of claim 3, wherein comparing the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions comprises sending a subsurface skin property to a network node configured to perform the comparing.

5. The method for detecting skin conditions of claim 3, wherein the electronic library of subsurface skin properties and corresponding skin conditions comprises one or more skin properties corresponding to one or more of a melanoma skin condition, a cosmetic blemish skin condition, and/or a medical risk associated with a skin condition.
6. The method for detecting skin conditions of claim 1, further comprising electronically communicating the one or more subsurface properties of the skin to a medical service provider for further analysis.
7. The method for detecting skin conditions of claim 1, further comprising electronically comparing the one or more subsurface properties of the skin to one or more previous subsurface properties of the skin to determine a change in the one or more subsurface properties of the skin.
8. The method for detecting skin conditions of claim 1, further comprising displaying an image of the skin and highlighting the one or more subsurface properties of the skin on the displayed image.
9. A device configured to detect skin conditions associated with a skin of a subject, the device comprising:
 - a plurality of light sources, wherein each of the plurality of light sources is located at a different light source position;
 - a plurality of cameras, wherein each of the plurality of cameras is located at a different camera position;
 - an image capture controller configured to selectively activate each of the plurality of light sources in a predetermined sequence, and configured to selectively capture images of the skin at each of the plurality of cameras when illuminated by one or more activated light sources; and
 - a processor configured to calculate a subsurface transfer function for the skin using image properties corresponding to each of a plurality of points on the skin in each of the captured images, wherein the subsurface transfer function describes one or more subsurface properties of the skin;wherein the processor is configured to algorithmically identify a skin condition corresponding to the one or more subsurface properties of the skin.

10. The device configured to detect skin conditions of claim 9, wherein the subsurface transfer function comprises a Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF).

11. The device configured to detect skin conditions of claim 9, wherein the processor configured to algorithmically identify a skin condition is further configured to compare the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions.

12. The device configured to detect skin conditions of claim 11, wherein the processor configured to algorithmically identify a skin condition is further configured to compare the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions by sending a subsurface skin property to a network node configured to perform the comparing.

13. The device configured to detect skin conditions of claim 11, wherein the electronic library of subsurface skin properties and corresponding skin conditions comprises one or more skin properties corresponding to one or more of a melanoma skin condition, a cosmetic blemish skin condition, and/or a medical risk associated with a skin condition.

14. The device configured to detect skin conditions of claim 9, wherein the processor is configured to electronically communicate the one or more subsurface properties of the skin to a medical service provider for further analysis.

15. The device configured to detect skin conditions of claim 9, wherein the processor configured to algorithmically identify a skin condition is further configured to electronically compare the one or more subsurface properties of the skin to one or more previous subsurface properties of the skin to determine a change in the one or more subsurface properties of the skin.

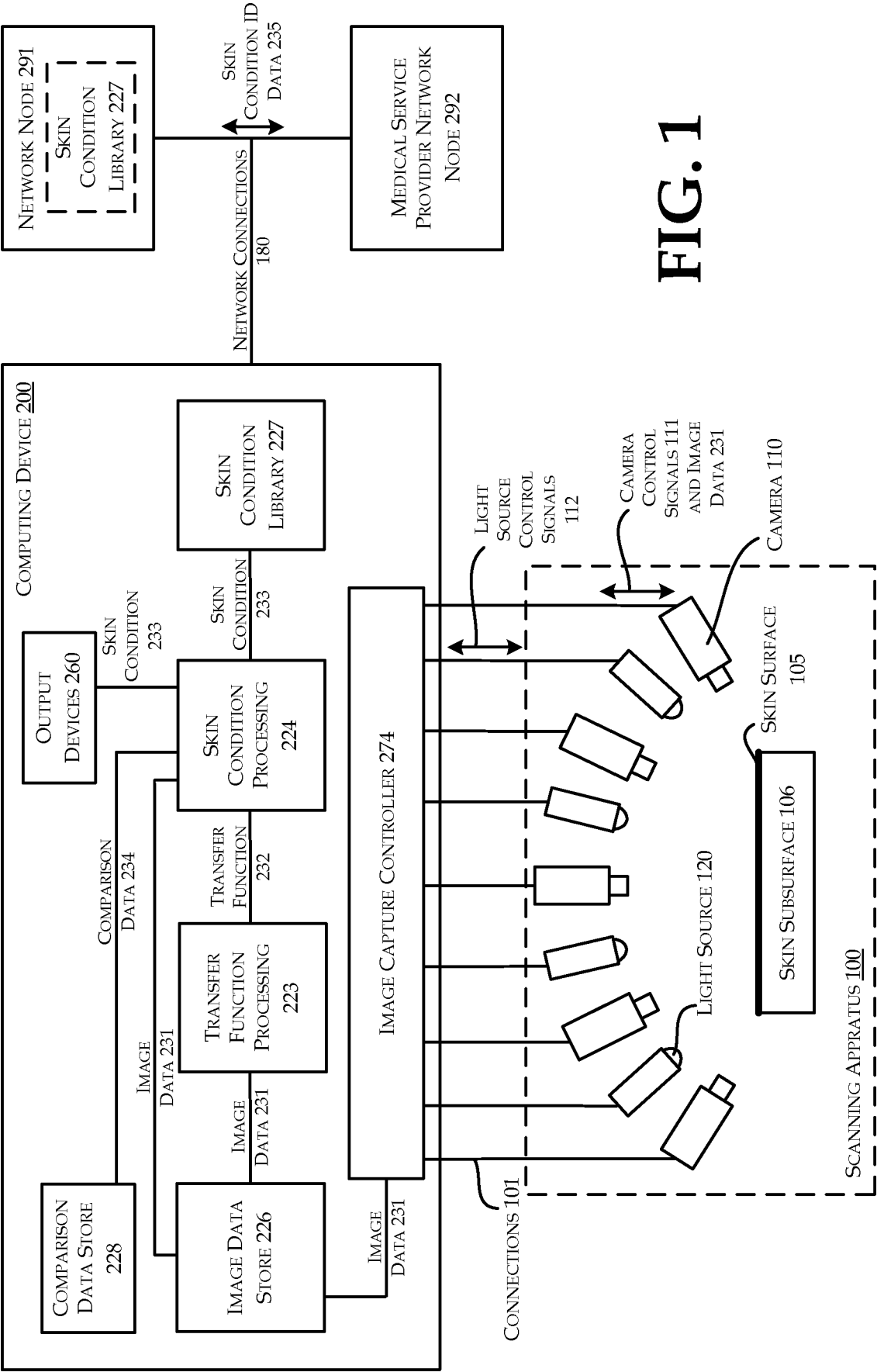
16. The device configured to detect skin conditions of claim 9, wherein the processor is configured to display an image of the skin and highlight the one or more subsurface properties of the skin on the displayed image.

17. A computer readable medium having computer executable instructions for detecting skin conditions from data comprising a plurality of images of a skin from a plurality of different camera positions, and using a plurality of light sources at a plurality of different light source positions such that the data comprises images from each of the plurality of different camera positions for each of the plurality of different light source positions, the instructions comprising:
- instructions to calculate a subsurface transfer function for the skin using image properties corresponding to each of a plurality of points on the skin in each of the plurality of images corresponding to each of the plurality of different light source positions, wherein the subsurface transfer function describes one or more subsurface properties of the skin; and
 - instructions to algorithmically identify a skin condition corresponding to the one or more subsurface properties of the skin.
18. The computer readable medium of claim 17, wherein the subsurface transfer function comprises a Bidirectional Surface Scattering Reflectance Distribution Function (BSSRDF).
19. The computer readable medium of claim 17, wherein the instructions to algorithmically identify a skin condition comprise instructions to compare the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions.
20. The computer readable medium of claim 19, wherein the instructions to compare the one or more subsurface properties of the skin to an electronic library of subsurface skin properties and corresponding skin conditions comprise instructions to send a subsurface skin property to a network node configured to perform the comparing.
21. The computer readable medium of claim 19, wherein the electronic library of subsurface skin properties and corresponding skin conditions comprises one or more skin properties corresponding to one or more of a melanoma skin condition, a cosmetic blemish skin condition, and/or a medical risk associated with a skin condition.
22. The computer readable medium of claim 17, further comprising instructions to electronically communicate the one or more subsurface properties of the skin to a medical service provider for further analysis.

23. The computer readable medium of claim 17, further comprising instructions to electronically compare the one or more subsurface properties of the skin to one or more previous subsurface properties of the skin to determine a change in the one or more subsurface properties of the skin.

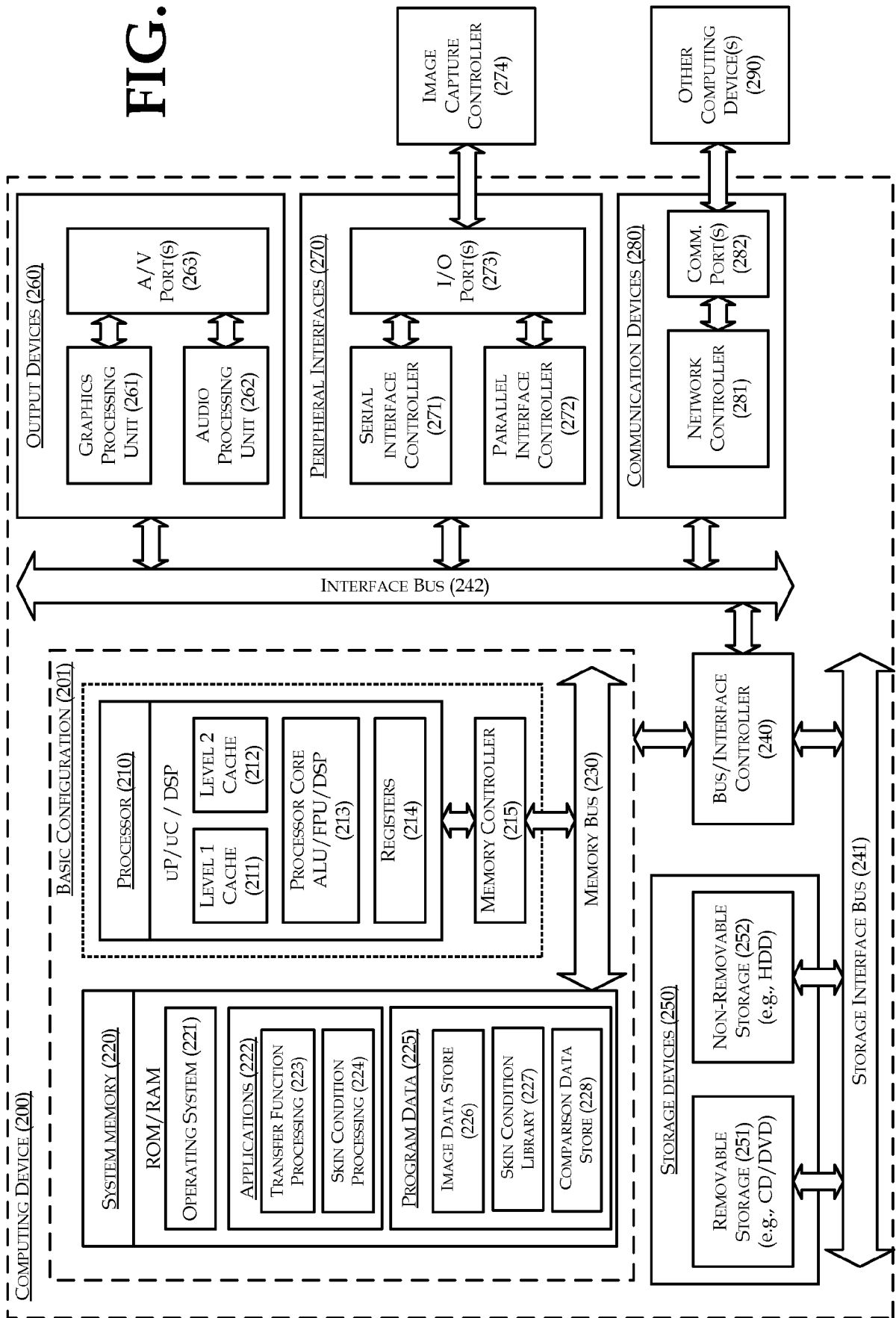
24. The computer readable medium of claim 17, further comprising instructions to display an image of the skin and highlighting the one or more subsurface properties of the skin on the displayed image.

25. The computer readable medium of claim 17, further comprising instructions to control image capture of the plurality of images.

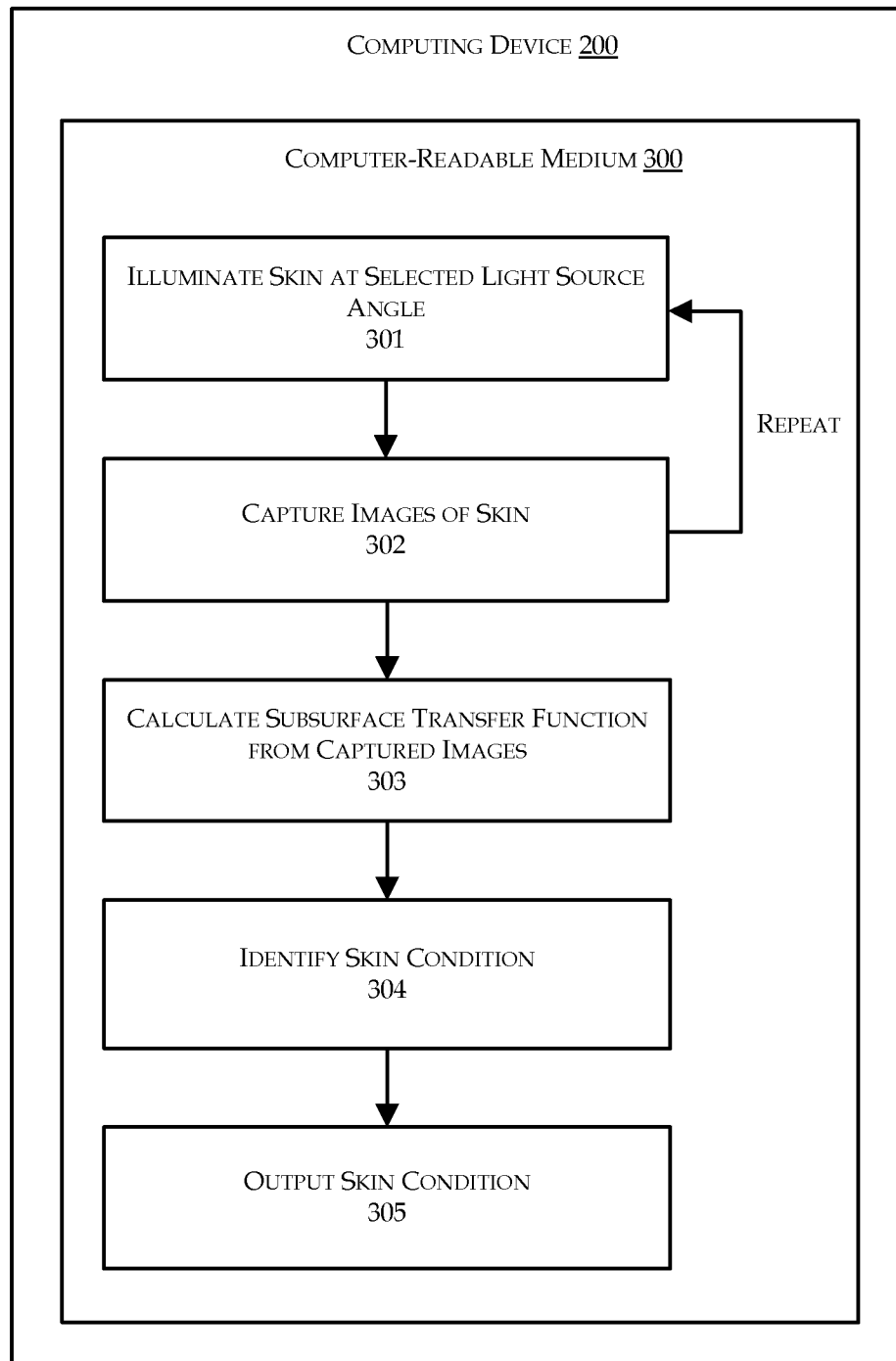


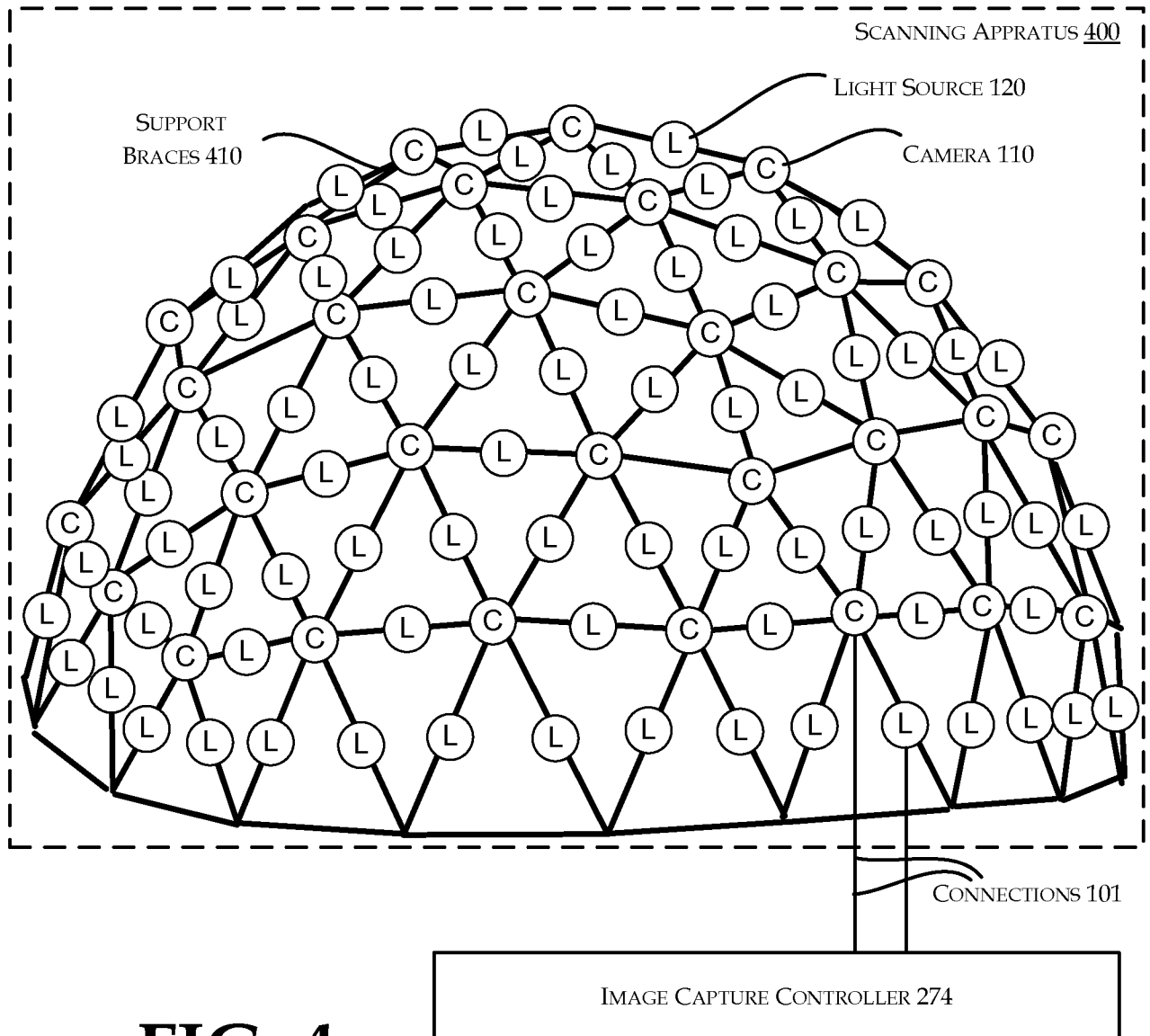
SHEET 2/6

FIG. 2



SHEET 3/6

**FIG. 3**



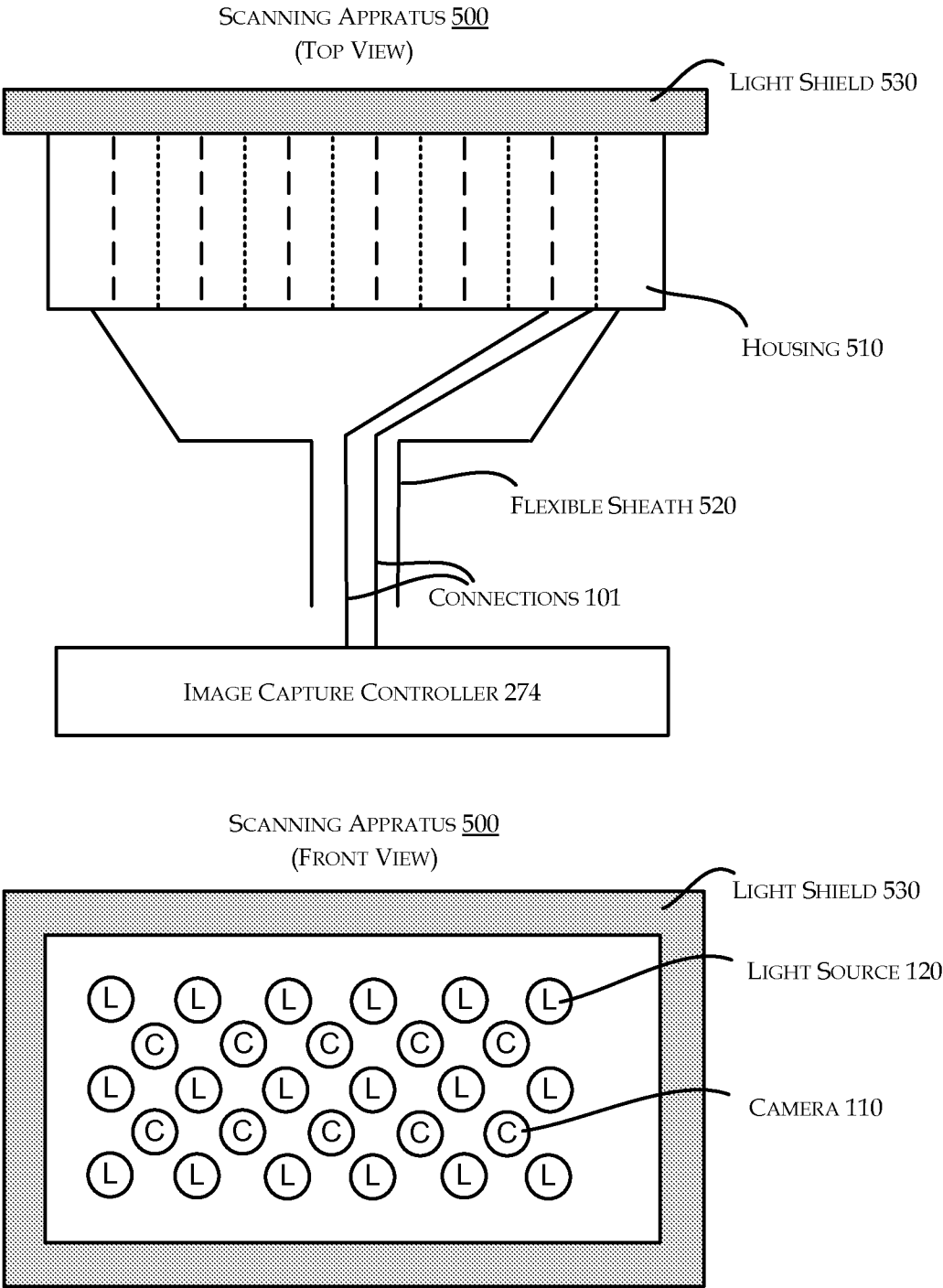
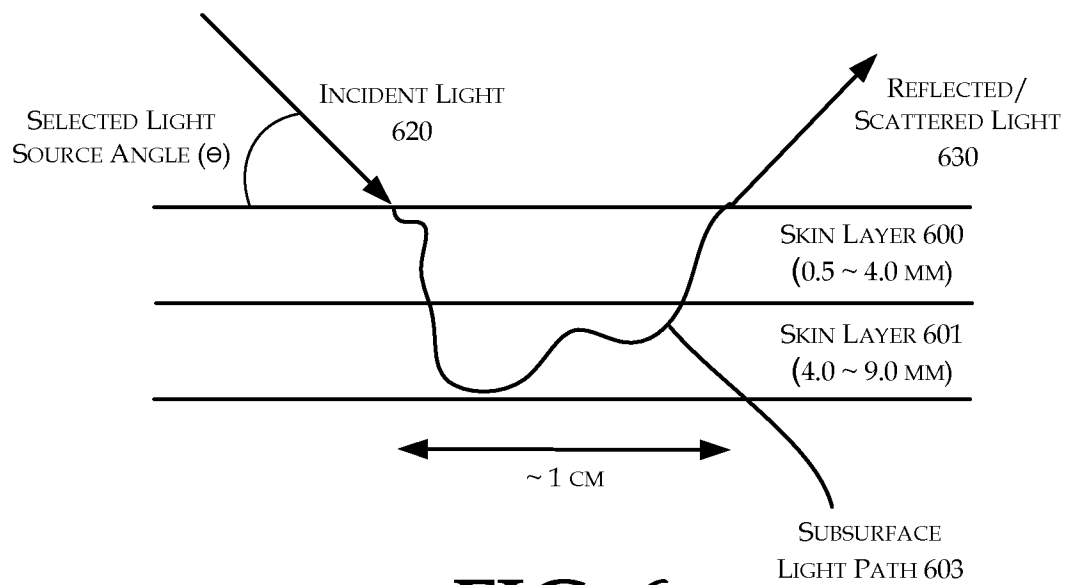


FIG. 5

SHEET 6/6

**FIG. 6**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2010/046694

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61B 5/00 (2011.01)

USPC - 600/306

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A61B 5/00; G01N 21/00, 21/47, 21/55, 33/48; G06T 1/00 (2011.01)

USPC - 348/77; 356/448; 382, 108, 110, 128; 600/306

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

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

PatBase, Google Patents

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2009/115947 A1 (UZUNBAJAKAVA et al) 24 September 2009 (24.09.2009) entire document	1-25
Y	US 2006/0239574 A1 (ROBINSON et al) 26 October 2006 (26.10.2006) entire document	1-8
Y	US 2006/0227137 A1 (WEYRICH et al) 12 October 2006 (12.10.2006) entire document	1-25
Y	WO 2009/145735 A1 (LIM et al) 03 December 2009 (03.12.2009) entire document	4, 12, 17-25
A	US 2009/0174878 A1 (WADMAN) 09 July 2009 (09.07.2009) entire document	1-25

☐ Further documents are listed in the continuation of Box C.


* Special categories of cited documents:

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Date of the actual completion of the international search

06 June 2011

Date of mailing of the international search report

05 JUL 2011

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