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(72) Inventor; and
(71) Applicant : **LANZO, Vittorio F.** [CA/CA]; 3205, rue Sauternes, Laval, Québec H7E 1W8 (CA).

(72) Inventors: **AGARWAL, Rajeev**; 27 Mayfair Road, Dollard-des-Ormeaux, Québec H9G 2A9 (CA). **PANDOZZI, Fabiano**; 3537 Rang Du Haut St-François, Laval, Québec H7E 4P2 (CA).

(74) Agent: **ROBIC LLP**; Centre CDP Capital, Bloc E - 8th Floor, 1001 Square-Victoria, Montreal, Québec H2Z 2B7 (CA).

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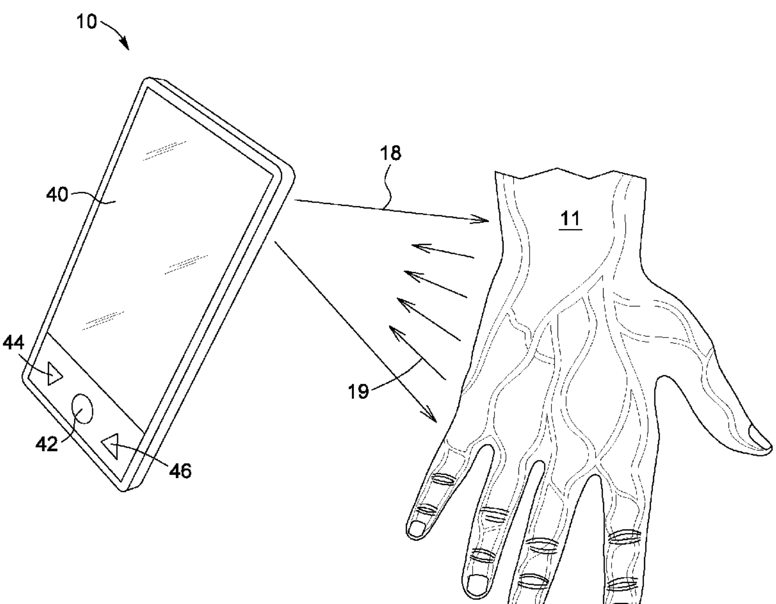

FIG. 4

(57) Abstract: Handheld venipuncture-assisting devices and methods for displaying a location of subcutaneous blood vessels within a tissue region of a skin area are provided. The device includes an illumination assembly and a camera positioned to capture backscattered light from the skin area upon illumination. An image processor provides a processed image of the skin area where a contrast between the subcutaneous blood vessels and surrounding tissue has been enhanced. The processed image is displayed on a display device opposite the illumination assembly. The device may be held above the skin area of interest and displays an image of the skin area underneath, on which the blood vessel locations are enhanced.

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HANDHELD VENIPUNCTURE-ASSISTING DEVICE

FIELD OF THE INVENTION

The present invention generally relates to imaging devices, and more particularly concerns a venipuncture-assisting device for visually contrasting the presence of subcutaneous veins for assisting in the surgical puncture of a vein during a medical procedure or otherwise.

BACKGROUND

Venipuncture is a surgical puncture procedure to obtain intravenous access and can be used for multiple purposes such as performing intravenous medical therapy or for the withdrawal of blood, for example. It has been estimated that venipuncture procedures may be performed over a billion times each year throughout the world. The medical practice industry acknowledged rate of failure for venipuncture attempts can be as high as 40%, in certain cases, the clinician may repeat the venipuncture process two or more times before it is successful, which may increase the amount of stress to the affected patients. This is particularly troublesome to the percentage of the adult population which exhibits trypanophobia, an anxiety disorder related to the fear of medically-related needles. The fear of needles can also affect a large number of children.

For some applications, it may be possible to use solutions to reduce the sensitivity of an area of the skin to which venipuncture is performed. However, these solutions may take time to be effective, and can result in prolonging the procedure.

Therefore, it would be desirable to increase the accuracy of venipuncture procedures. This would reduce the number of failed venipuncture attempts with a view to making the procedure faster, less painful, and ultimately less stressful for the patients.

SUMMARY

In accordance with a first aspect of the invention, there is provided a handheld venipuncture-assisting device for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner.

The device first includes a handheld-sized casing having opposite back and front sides. An illuminating assembly is provided and configured to project an illuminating light beam from the back side of the casing towards the skin area. A camera is positioned so as to capture backscattered light from the skin area upon illumination by the illuminating light beam. An unprocessed image of said skin area is thereby acquired.

The device further includes an image processor connected to the camera to receive the unprocessed image therefrom. The processor includes an image processing module configured for processing the unprocessed image and obtains therefrom a processed image. The processing performed by the processing module includes enhancing a contrast between the subcutaneous blood vessels and surrounding tissue.

The device finally includes a display device on the front side of the casing in alignment with the camera for displaying the processed image.

In accordance with another aspect of the invention, there is also provided a method for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner. The method includes:

a) providing a handheld venipuncture-assisting device comprising a handheld-sized casing having opposite back and front sides;

b) projecting an illuminating light beam from the back side of the casing towards the skin area;
c) capturing backscattered light from the skin area illuminated by the illuminating light beam, thereby acquiring an unprocessed image of the skin area;
d) processing the unprocessed image to obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue; and
e) displaying the processed image on a display device on the front side of the casing in alignment with the camera.

In accordance with yet another aspect of the invention, there is provided a venipuncture-assisting kit, for use with a handheld computing device having a display, for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-trough manner.

The venipuncture-assisting kit includes a handheld-sized imaging accessory, comprising:

- a cavity for receiving the handheld computing device therein with the display thereof exposed for viewing,
- an illuminating assembly configured and positioned to project an illuminating light beam in a direction opposite to said display when the handheld computing device is received in the cavity;
- a camera positioned so as to capture backscattered light from the skin area upon illumination by said illuminating light beam, thereby acquiring an unprocessed image of said skin area; and
- a connector configured to provide an interface between the camera and the handheld computing device;

The venipuncture-assisting accessory further includes an image processing module configured for processing the unprocessed image and obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue, and a displaying module for displaying the processed image on the display of the handheld computing device.

In accordance with another aspect of the invention, there is also provided a venipuncture-assisting kit, for use with a handheld computing device having a display and a camera opposite said display, for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner.

The venipuncture-assisting kit includes a handheld-sized imaging accessory, which includes:

- a cavity for receiving the handheld computing device therein with the display thereof exposed for viewing, the cavity comprising a camera opening aligned with the camera of the computing device when received in the cavity; and
- an illuminating assembly configured and positioned proximate the camera opening to project an illuminating light beam towards the skin area such that backscattered light emitted from the skin area upon illumination by said illuminating light beam is captured by the camera of the computing device, thereby acquiring an unprocessed image of said skin area.

The kit further includes an image processing module configured for processing the unprocessed image and obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue, and a displaying module for displaying the processed image on the display of the handheld computing device.

Embodiments of the present invention generally provide imaging devices and methods which can assist in venipuncture procedures. For example, in one embodiment the handheld device is held above the skin area of interest and displays an image of the skin area underneath, on which the blood vessel locations are enhanced. A nurse or other user can therefore locate a proper venipuncture location, mark that location with a finger or otherwise, put away the device and perform the venipuncture operation as per the standard of care for such medical procedures. Use of a device or method according to embodiments of the invention can greatly reduce the rate of failure of venipuncture, limiting pain and reducing stress for both the patient and the nurse.

Other features and advantages of embodiments of the invention will be better understood upon reading of embodiments thereof with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a rear view of a venipuncture-assisting device according to some embodiments; FIG. 1B is an exploded view of the rear of the device of FIG. 1A.

FIG. 2 is a front view of the device of Fig. 1A.

FIG. 3 is a perspective view of the device of Fig. 1A.

FIG. 4 is a perspective view of the device of FIG. 1A, shown in use over a skin region.

FIG. 5 is a block diagram according to some embodiments.

FIG. 6 illustrates an exemplary algorithm for image processing according to some embodiments.

FIG. 7A is a raw image of a skin region; FIG. 7B is a histogram of the selected region shown in image of FIG. 7A.

FIG. 8A is a contrast-enhanced image of the skin region of FIG. 7A; FIG. 8B is a histogram of the selected region shown in image of FIG. 8A.

FIG. 9A is a front perspective view of a handheld-sized venipuncture-assisting accessory according to some embodiments. FIG. 9B is a back perspective view of the accessory of FIG. 9A.

FIG. 10 is a front perspective view of a handheld-sized venipuncture-assisting accessory according to other embodiments.

FIG. 11 is a flow chart of the main steps of a method according to one embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

Referring now in more detail to the drawings, in which like numerals refer to like parts throughout the several views, embodiments of venipuncture-assisting devices and methods for displaying a location of subcutaneous blood vessels within a tissue region of a skin area are presented.

Devices according to embodiments of the invention may be useful in assisting venipuncture procedures. The expression “venipuncture” is used herein to refer to a procedure for providing access to a blood vessel of a patient, usually through a needle, either to withdraw blood therefrom on to inject a medical or other substance therein. Such procedures are routinely performed by a nurse, practitioner or other health attendant, collectively referred to herein as “users”. It will be understood that a user may be any person who may wish to locate a blood vessel in preparation of a venipuncture procedure. Typically, locating the blood vessel within a target skin area of the patient is one of the first steps of venipuncture procedures. This may, however, often prove difficult as blood vessels are not always readily identifiable to the naked eye. Several factors may affect the ability of a nurse or practitioner to locate a blood vessel, such as skin pigmentation, adipose tissue, dehydration, blemishes, scar tissue, hair, etc.

Broadly speaking, venipuncture-assisting devices according to embodiments of the invention may be held over the target skin area, and used to display an image of the skin area underneath in which blood vessels are enhanced. The user can then identify a suitable venipuncture location and perform a venipuncture procedure with a reduced risk of failure. Advantageously, the displaying of the location of subcutaneous blood vessels within the tissue region is performed in a see-through manner, that is, the user has the impression of viewing the skin area through the device. This thereby facilitates the location of the blood vessels without having to compare the skin area with a separate image thereof to match corresponding areas by the observation of recognizable shapes and features.

The skin area may be embodied by various locations on a body of a patient where a venipuncture procedure can be performed, such as for example a hand, forearm, arm, joint, leg, neck, face, foot, etc. Traditionally, venipuncture is performed on an area of the body where a blood vessel extends just below the surface of the skin, within a few millimetres. The tissue region separating the blood vessel from the outside usually includes skin layers such as the epidermis and dermis as well as subcutaneous tissues surrounding the blood vessel.

Referring to Figs. 1A to 3, there is shown a venipuncture-assisting device 10 according to one embodiment of the invention.

The venipuncture-assisting device 10 is preferably handheld, that is, of a size and shape suitable for holding and handling using one hand. In the illustrated embodiment the device 10 includes a handheld-sized casing 12 having a front side 14 and a back side 16. The casing 12 is shown as rectangular shaped in the illustrated embodiment but could alternatively have other shapes. Preferably, the casing 12 has a size and a shape comparable to commercially available smartphones.

Referring to FIGs. 1A and 4, the venipuncture-assisting device 10 first includes an illuminating assembly 15 configured to project an illuminating light beam 18 towards the skin area 11. The illuminating assembly 15 is preferably provided within the casing 12 and positioned such that the light beam 18 is projected from the back side 16 of the casing 12. The illuminating assembly 15 includes one or more light sources generating the illuminating light beam. The light sources may for example be embodied by a plurality of LEDs 22 arranged in an array. The LEDs 22 may be pulsed in order to reduce power consumption. In some embodiments, 4 to 8 such LEDS are provided in a circular pattern, although a smaller or greater number of light sources may be considered. The arrangement of the light sources may also differ from a circular pattern, and may define a square, a linear array, or a more complex pattern, which may or may not be regular and/or symmetric. In the illustrated embodiment of FIG. 1 there is shown, by way of example only, an array of 8 LEDs 22. Other types of light sources may be considered, such as laser diode, ring illuminator, white light source or lamp with/without a combined band-pass filter, and the like. In other embodiments, the illuminating assembly may include a combination of light sources of different types.

The light beam 18 projected by the illuminating assembly 15 preferably has a spectral profile including wavelengths suitable for absorption by a biological tissue, and more particularly by the blood in blood vessels. Compounds in biological tissue that can absorb light radiation are generally termed tissue chromophores. Among the chromophores present in the tissue of the skin, each having its own unique absorption spectrum, haemoglobin (Hb) in its various forms is for example known to absorb near infrared (NIR) light. Other chromophores present in tissues that can absorb infrared (IR) and near infrared (NIR) light include for example water, lipids, melanin, and myoglobin. Preferably, the illuminating light beam 18 has a spectral content in the IR and/or NIR range, for example between 700 nm and 1400 nm. Also preferably, the spectral profile of the projected light is quasi-monochromatic or has a narrow wavelength range. In one embodiment, NIR LEDs generating light around 850 nm may be used.

Referring more particularly to FIGs. 1A and 1B, in some embodiments the illuminating assembly 15 may include a diffuser 24 provided in a path of the light generated by the light sources. The diffuser 24 may be embodied by any suitable optical component which is apt to diffuse the light beam 18, in order to provide a more uniform illuminating of the skin area. In the illustrated embodiment, the diffuser is a ring-shaped polished glass or plastic optical component affixed to the backside 16 of the casing 12 and aligned with the circular array of LEDs. It will be readily understood that this configuration is shown by way of example only.

Referring again to FIGs. 1A, 1B and 4, the venipuncture-assisting device 10 further includes a camera 20 positioned so as to capture backscattered light 19 from the skin area 11 upon illumination by the illuminating light beam 18, thereby acquiring an unprocessed image of the skin area 11.

As will be readily understood by one skilled in the art, at least a portion of the illuminating beam 18 projected towards the skin area 11 will penetrate the skin and tissue region. In turn, some of the penetrating light will be scattered back towards the device 10 from the tissue region. If a blood vessel is present, however, it is likely to absorb the light and less or no light will be backscattered along the blood vessels such as veins. As a result, the image acquired by the camera 20 will contain darker areas along the location of blood vessels.

As mentioned above, the camera 20 is positioned in order to capture the backscattered light 19 from the skin area 11. Preferably, the camera 20 is positioned so that its field of view extends from the back side 16 of the casing 12 and coincides substantially with the area covered by the illuminating beam 18. In the illustrated example, the camera 20 has an objective 26 positioned at the center of the circular array of LEDs 22. Other configurations could however be considered.

Referring more particularly to FIGs. 1B and 4, the camera 20 preferably includes an optical sensor 27, such as for example, a charge-coupled (CCD) device or a complementary metal–oxide–semiconductor (CMOS) device, which defines a pixelated array providing a 2D representation of the scene observed by the camera 20, in use defining the unprocessed image of the skin area 11. The camera, which preferably has sensitivity to light in the NIR wavelength range, may also include one or more lenses 38, through which the optical sensor 27 can receive the backscattered light which can be converted to data in the form of an image or a series of images. In various embodiments, the camera 20 may capture still images or video. In one non-limiting embodiment, the video may be captured at 15 fps or more. The image resolution is preferably at least 480 x 800 pixels (width x height). In one embodiment, the camera's three color channels (RGB) can be used to improve the detection of light at 850nm by exploiting the differences in the sensitivity of the camera sensors' three visible color bands to NIR light.

The device 10 further may include a band-pass filter 28 located in front of the optical sensor 27 provided upstream the optical sensor and having a band-pass profile aligned with the spectral profile of the backscattered light. One skilled in the art will readily understand that the spectral profile of the band-pass filter is aligned with the spectral profile of the backscattered light if the filter allows a sufficient proportion of the backscattered light therethrough to obtain a usable image, while excluding a substantial amount of unwanted radiation such as ambient light. By way of example, the band-pass filter 28 may be embodied by a suitable optical component or assembly having a central wavelength (CWL) corresponding or close to the emitting wavelength of the illuminating assembly 15, for example about 850 nm in the embodiment described above, and a full width at half maximum (FWHM) suitable to exclude a substantial portion of ambient light, for example about 40 nm.

In some embodiments, the device 10 may include a crossed-polarizers assembly provided upstream the optical sensor, minimizing the contribution of surface reflections from the skin area 11 in the unprocessed image. The cross-polarizers assembly preferably includes first and second linear polarizers 29 and 31 respectively positioned in the path of the illuminating beam 18 from the illuminating assembly 15, and the path of the backscattered light 19 from the skin area 11. The first and second polarizers preferably have orthogonal polarization directions. For example, the first polarizer 29 may only allow light polarized along one direction therethrough, while the orientation of the second polarizer 31 is selected to minimise the backscattered light corresponding to surface reflections. Indeed, surface reflections are likely to have a same polarization state than the illuminating light, and will be blocked by the second polarizer before reaching the camera sensor, as the second polarizer is orthogonal to the first polarizer. Light which interacts with the underlying tissue layers will have its polarization randomized. The backscattered 19 light reaching the second polarizer 31 will therefore be more likely to include a polarization component aligned with the second polarizer 31, and this polarization component will be allowed through and reach the camera 20.

In some embodiments the camera 20 may include a focussing unit upstream the optical sensor, which may be part of the camera objective 26 or may be an independent unit controlling and operating the camera objective 26 so as to achieve in-focus of the desired target skin area 11. Focussing units are well known in the art. The focussing unit may be configured to provide a range of operation, such as, for example, a depth of field, from 10 cm to 30 cm. The focussing unit may also be configured to provide a working distance of about 20 cm. In one embodiment, the focussing unit can be controlled by an autofocus algorithm that may be designed to achieve and maintain in-focus the subcutaneous features of the skin area. In one embodiment, the autofocus can be achieved using a contrast detection algorithm. This involves iteratively moving the focusing element forwards and backwards while certain pixels located at different regions of interest on the camera's pixel array are examined to identify the focus position that produces the maximum gradient between pixels. The focusing pixels can be assembled in the shape of a cross-hair, or some other geometric shape, and be located at more than one location on the pixel array in order to select the focus position that produces the highest amount of in-focus pixels on the camera.

Referring to FIG. 5, the venipuncture-assisting device 10 further includes an image processor 30 connected to the camera to receive the unprocessed image therefrom.

The image processor 30 preferably include various units and modules useful for digitally processing the unprocessed image received from the optical sensor, in order to provide a processed image which allows visualizing better the location of blood vessels. The image processor 30 therefore includes an image processing module configured for processing the unprocessed image and obtain therefrom the processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue. The image processing module 32 may for example include algorithms related to pixel recognition and feature extraction and can perform various techniques on the image received from the optical sensor. In one embodiment, the image processing module may be configured to firstly identify and remove undesired surface features such as hair, blemishes, beauty marks, scars, etc. from the unprocessed image, thereby generating a cleaner image of the skin. The image processing module 32 may further perform detection and recognition of the darker pixels which can be associated with blood vessels. The image processing module 32 may contain algorithms capable of enhancing a contrast between the darker vein pixels and the lighter pixels which may be associated with the surrounding tissue region thereby generating a contrast-enhanced image. Preferably, contrast enhancement is performed subsequently to the removal of undesired surface features, in order to avoid inadvertently enhancing these features. The image processor 30 may also include an overlay module 33 for overlaying an enhanced image, resulting from the enhancing of the contrast between the subcutaneous blood vessels and surrounding tissue, on the unprocessed image. In this embodiment, the result of the overlaying is a “composite” image which defines the processed image. The processed image of this embodiment therefore constitutes a representation of the skin area which includes its natural aspect from the unprocessed image, as well as an enhancement of the blood vessels locations from the enhancing process. The overlay module 33 may include algorithms suitable for the superposition of images and/or digital overlay of two or more images, so as to generate a composite image. The operation of the imaging processor 30 will be further discussed below with reference to Fig. 6.

Still referring to Fig. 5, in some embodiments the venipuncture-assisting device 10 may also include a display controller 34, a memory 35, a camera controller 36, and an LED controller 37, and circuitry to connect and link the various modules and controllers together in an operational structure. The venipuncture-assisting device 10 may be implemented with other input or control devices and an external port. The external port may include a computer interface and/or a battery charging port compatible with industry standards, such as, for example USB/micro-USB.

The venipuncture-assisting device 10 further includes a display device 40 for displaying the processed images. Referring to FIG. 2, the display device preferably extends on the front side 14 of the casing 12, in vertical alignment with the camera on order to give the “see-through” impression to a user. The display device 40 is preferably connected to or otherwise in communication with the image processor 30 so as to receive therefrom, preferably in real time, the processed image to display. The display may further be configured to display any of the images from the processor, including the clean image of the skin, the contrast-enhanced image, as well as the unprocessed image. In some embodiments, the display device 40 may use LCD (liquid crystal display) or LPD (light emitting polymer display) technology. In other embodiments, the display may use other display technologies. Preferably, the display 40 may be rectangular and may have a width x height resolution of about 480 x 800 pixels. Optionally, the display 40 may have a resolution in excess of 72 dpi. In other scenarios, other shapes and resolutions are possible. In some embodiments, the display device 40 may include a touch screen and the user may interact with the venipuncture-assisting device 10 with any one of a stylus, a finger, or other suitable object.

Referring to FIG. 6, there is schematically illustrated an image processing algorithm 50 which may be performed by the image processor of the venipuncture-assisting device described above. The image processing algorithm 50 may include one or more processing steps and/or processes, in order to display the composite image representing the subcutaneous blood vessels within the tissue region of the skin area. It will however be readily understood that this algorithm is provided by way of example only and that numerous variants may be used without departing from the scope of the invention.

In the illustrated example, the image processing algorithm 50 first includes a step 52 of acquiring a new unprocessed image. The unprocessed image may for example have a resolution of at least 480 x 800 pixels (width x height). In one scenario, the unprocessed image may be an 8-bit black and white image. Optionally, the image may be a 24 bit color image.

The image processing algorithm 50 next includes a step 54 of segmenting the tissue area 54. The step 54 may be performed to reduce data processing needs. In some examples, a region of interest may be identified within the unprocessed image in order to separate the background and foreground sections. It should be understood that the foreground may contain the region of the skin including a blood vessel and the background may contain undesirable elements such as, for example, a chair, table, etc., located behind the body part. In some embodiments, the pixels representing the skin area may be segmented from the undesired background pixels so that further processing is performed only on the foreground pixels, which may increase performance and speed of the overall process. In one example, the segmenting of step 54 may be accomplished by identifying non-linear changes in intensity levels that occur at transitions between a tissue to a non-tissue region across a single pixel row in the unprocessed image. Optionally, thresholds may be determined adaptively for each row. A histogram technique can also be used to identify the transitions corresponding to the boundary between tissue and the background of the image. Thresholds can then be used to separate the two, resulting in a segmented image containing only the desired tissue. Optionally, a line-by-line scan of the image may be performed and can be repeated vertically and horizontally on all pixels.

Still referring to Fig. 6, the image processing algorithm 50 optionally includes a pre-processing step 56 in which the image, or the segment tissue area of the image, can be analyzed to recognize and detect undesired surface features such as hair, blemishes, beauty marks, scars, etc., and replace the contents of the pixels associated with these features with content derived from the surrounding areas that are considered “clean”. The term “clean pixels” is used generally to refer to surrounding pixels which are not identified by the algorithm as one of the undesired surface features.

By way of example only, hair identification can be accomplished by using a high-pass filter with adaptive thresholds that are used to identify lines (which may represent hair) in the image. Identified pixels can be replaced by the average of the neighbourhood average of clean pixels. For example, a 10 x10 pixels window can be used to compute the average clean neighbourhood.

Further by way of example only, blemishes, scars, and spots can be identified by looking at isolated changes in intensity that may occur in clusters that are non-linear.

Optionally, instead of replacing pixels of undesired features by the average contents of the surrounding clean pixels, pixels of undesired features may be excluded from further processing.

In some scenarios, inhomogeneous images may result from non-uniform lighting or shadowing and may be dealt with by determining an average background intensity level and identifying regions that are non-uniform. These non-uniform regions may be then flattened to match the level of the other regions. For example, an image can be broken down into larger *n* sub-regions in order to examine the distribution of average intensities. In the case of a non-uniform distribution, for example, a correction may be performed by scaling the intensity for a given sub-region to achieve uniformity across all regions in the image.

Still referring to Fig. 6, the illustrated image processing algorithm 50 further includes a step 58 of enhancing the blood vessel within the image. In one embodiment, this step may involve adaptively remapping of the intensities within each region to make veins or blood vessels more pronounced than surrounding tissues. In one example, pixels associated with blood vessels may be remapped to appear darker and pixels associated with the surrounding tissue lighter. In another variant, color may be used to make the pixels associated with blood vessels more pronounced.

For example, referring now to Figs. 7A, 7B, 8A, and 8B, the adaptive remapping of the intensities may include an algorithm based on histogram stretching of the intensities. The algorithm may be implemented in the processor by computing a histogram of intensities in an appropriately-sized region and identifying the threshold that delineates vein intensities from background tissue intensities.

Once the two groups of intensities have been identified, they are remapped to increase the separation, in intensities, between the two groups to create a bimodal histogram distribution.

FIG. 7A shows an image representing a segmented portion 64 of a skin area 11, and the surrounding background 66, which is made of black pixels. Fig. 7B represents a corresponding histogram for the image shown in Fig. 7A above a grayscale color bar. The histogram has been drawn on the basis of the selected region (box) in the grayscale image in Fig. 7A and the number of bins in the histogram is 256.

Each column in the histogram of Fig. 7B represents the number of pixels in the image of Fig. 7A for each tonal value. For example, in one scenario, by identifying the threshold between the darker vein intensities and the lighter surrounding background, an adjustment can be computed to distribute the intensities so as to enhance a contrast of the image by effectively spreading out the most frequent intensities. Various computer implemented algorithms capable of computing the function used to redistribute the intensities are known in the art.

The result of such computation is shown in Fig. 8B where it can be observed that the intensities have been effectively redistributed along two peak intensities corresponding to darker and lighter pixels. Thus, a new image of the skin region (Fig. 8A) may be generated so as to correspond to the new computed intensities. As it can be seen the new image of Fig. 8A gained higher contrast and is more effective in visually contrasting the presence of subcutaneous veins.

Referring back to Fig. 6, the illustrated image processing algorithm 50 may further includes a step 60 of overlaying or merging the contrast-enhanced image generated in the step 58 with the unprocessed image acquired in step 52. The step of overlaying or merging 60 may include overlaying a proportion of the contrast-enhanced or processed image generated in step 58 over the original image acquired in step 52. For example, the overlaying may be computed pixel-by-pixel. Optionally, in one scenario, only the pixels identified in step 58 as being associated with the blood vessel can be selectively overlaid, instead of overlaying the entire contrast-enhanced image in order to further enhance the locations of the blood vessels on the original image acquired during step 52. The relative proportion of data from the unprocessed image versus data from the enhanced image for each pixel may be selected according to several factors such as the number of undesired surface features that were present in the original image, the overall intensity of the original image, as selected in a user setting, etc. In one example, a 30% overlay proportion of the enhanced image onto the original image may for example be used.

Finally, the image processing algorithm 50 of FIG. 6 includes a step of displaying 62 the processed image on the built-in display.

As will be readily understood by one skilled, the steps above are preferably performed repeatedly, further preferably at a minimum of 15fps, in order to render on the display a real-time video feed. For this purpose, the image processor is preferably configured to execute an image processing routine of controlling the camera to acquire the unprocessed image, generating the processed image therefrom and displaying this processed image on the display. The image processor executes this processing routine repeatedly such that the processed image is displayed as a real time video feed.

Optionally, the image processing algorithm 50 may be configured to perform other image processing steps such as ray level & contrast manipulation, noise reduction, edge enhancement, detection, and sharpening, filtering, interpolation and magnification, pseudo coloring, and the like.

Referring back to FIGs. 2 and 3, the venipuncture-assisting device 10 preferably includes a user interface. In the illustrated embodiment, the user interface includes one or more physical buttons provided on the front side 14 of the casing 12. The buttons can include an on/off button 42 and control buttons 44, 46 for accessing and controlling various features such as, for example adjusting the level of contrast, and for accessing other user settings. In one non-limiting embodiment, the on/off button 42 can be located centrally with the two buttons 44, 46 being located on either side of the central button 42. Alternatively, in some embodiments, the buttons for controlling various features of the device 10 may be implemented as soft keys displayed on a touch screen portion of the display 40. In yet another embodiment, a combination of physical controls such as buttons and touch screen functionalities may be provided.

The venipuncture-assisting device 10 preferably includes a power system for powering the various components, including the illuminating assembly 15, the camera 20, the imaging processor 30, and the display device 40. In some embodiments, the power system can include an internal rechargeable battery that allows a full-autonomy of at least one working day. The rechargeable battery can be removable or fixed depending on selected applications of the device 10. For example, in one scenario, assuming that an average nurse performs at most 4 venipuncture operations per hour, works 8 hours per day, and that locating veins for the venipuncture requires 5 minutes of continuous use of the venipuncture-assisting device 10, the autonomy may be at least 160 minutes. Preferably, a safety margin of 50% would allow the device to operate at least 240 minutes without the need to be recharged. The power system may include other power sources such as, for example, an alternating current (AC) power source, a recharging power system, and any other components associated with the generation, management and distribution of power in portable devices.

It will be appreciated that the venipuncture-assisting device 10 shown in Figs. 1 to 3 and embodied herein is an example of a portable handheld venipuncture-assisting device 10, and that the device 10 may have more or fewer components than shown or have a different configuration, structure or arrangement of the components.

Referring to FIGs. 9A and 9B, a venipuncture-assisting device 10 according to an alternative embodiment of the invention is illustrated. In this variant, the venipuncture-assisting device includes a handheld computing device 68, such as a smartphone or pocket computer, having a display 40 providing the displaying abilities of the venipuncture-assisting device. A venipuncture-assisting kit 90, for use with the handheld computing device 68, may be provided. The kit preferably includes a handheld-sized imaging accessory 70. The accessory 70 includes a cavity 81 for receiving the handheld computing device 68, such that the display 40 of the computing device remains exposed for viewing. The cavity may have any size and shape suitable for receiving the computing device 68, preferably in a snug fit. For example, the cavity 81 of the accessory 70 can be of substantially the same size as the computing device 68 or of a slightly greater size allowing the accessory 70 to encase the computing device. In the illustrated embodiment, the accessory 70 includes a casing 72 having an outer surface 74 and an inner surface 76, defining the cavity 81. The accessory casing 72 is shown as being essentially rectangular shaped. Preferably, the casing 72 may have a size and a shape comparable to commercially available smartphones.

The accessory 70 further includes optical components of the venipuncture assisting device. It therefore includes an illuminating assembly configured and positioned to project an illuminating light beam in a direction opposite to the display when the handheld computing device is received in the cavity, and a camera positioned so as to capture backscattered light from the skin area upon illumination by said illuminating light beam, thereby acquiring an unprocessed image of the skin area.

The venipuncture-assisting device accessory 70 further includes a connector 80 configured to provide an interface between the camera and the handheld computing device. The connector is preferably positioned so as to engage a built-in connector of the computing device. In the illustrated embodiment, the connector 80 extends so as to be positioned against the bottom side edge of a typical mobile phone, although other positions may be considered, depending on the connection configuration of the computing device.

The kit also includes a series of modules:

- an image processing module 32 configured for processing the unprocessed image and obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue, and
- a displaying module 41 for displaying the processed image on the display of the handheld computing device.

In some embodiments these modules may be compatible to be received on a built-in processor of the handheld computing device, so that the intelligence of the computing device is used to perform the image processing. In alternative embodiments, the imaging accessory itself may include a processor hosting the image processing module, the overlay module and the displaying module are compatible to be received on a built-in processor of the handheld computing device.

The connector 80 is preferably connected via wires and electrical circuits to electric and electronic components of the venipuncture-assisting device. It should be understood that, in one implementation, the imaging accessory 70 may include the illuminating assembly 15, the camera 20, and the image processor. In an alternative embodiment the imaging accessory 70 may further includes all the modules, power system and electrical circuits and other electric and electronic components as described in detail above necessary to acquire and generate an image of a location of subcutaneous blood vessels within a tissue region of a skin area. In such an embodiment, the connector 80 can be used to transmit any of the images produced by the imaging accessory 70 for displaying on the display 40 of the phone. This can be done by using a pre-loaded GUI interface of the computing device or by using a custom GUI interface adapted to receive, process, and display the images generated by the accessory 70.

In the illustrated embodiment, the user interface of the computing device 68 is used to control the venipuncture-assisting device. In an alternative embodiment (not shown), the venipuncture-assisting device accessory may include one or more physical buttons. The buttons can include an on/off button and control buttons for accessing and controlling various features such as, for example adjusting the level of contrast, and for accessing other user settings. In one non-limiting embodiment, the on/off button can be located centrally with the two buttons being located on either side of the central button.

Referring to FIG. 10, in alternative embodiment, the venipuncture-assisting kit 90 may be adapted for use with a handheld computing device 68 having a display 40 and a camera 20 opposite this display 40. In this embodiment, the cavity 81 of the accessory 70 includes a camera opening 83 aligned with the camera of the computing device 68 when the latter is received in the cavity. The illuminating assembly is configured and positioned proximate the camera opening 83 to project an illuminating light beam towards the skin area such that backscattered light emitted from the skin area upon illumination by this illuminating light beam is captured by the camera of the computing device 68.

It will be readily understood that any of the processes and functionalities mentioned above with respect to the venipuncture-assisting device of FIGs. 1 to 3 may be provided in either kits mentioned above.

In accordance with another aspect of the invention, and with reference to FIG. 11, there is provided a method 100 for displaying a location of subcutaneous blood vessels within a tissue region of a skin area.

The method 100 first includes a step of providing a handheld venipuncture-assisting device 102. The venipuncture-assisting device may be similar to the one described above or a variant thereof. The venipuncture-assisting device has a handheld-sized casing having opposite back and front sides.

The method next includes projecting an illuminating light beam from the back side of the casing towards the skin area 104. As mentioned above, the illuminating light beam preferably has a spectral profile including wavelengths suitable for absorption by said blood vessels.

The next step involves capturing backscattered light from the skin area illuminated by the illuminating light beam, thereby acquiring an unprocessed image of said skin area 106.

The method also includes processing the unprocessed image to obtain therefrom a processed image 108. The processing involves at least enhancing a contrast between the subcutaneous blood vessels and surrounding tissue. Preferably, the processing includes a preliminary sub-step of segmenting the unprocessed image into segmented image regions, and identifying at least one foreground region and at least one background region amongst the segmented image regions. Such identification may for example be based on non-linear changes in intensity levels on the unprocessed image. Preferably, the enhancing is performed only on the segmented image regions identified as foreground regions.

In some implementation, the processing may involve identifying undesired features from the unprocessed image prior to enhancing a contrast between the subcutaneous blood vessels and the surrounding tissue region. Pixels of the unprocessed image containing the undesired features may be replaced with contents of surrounding pixels free of these undesired features.

The processing may also optionally involve correcting the unprocessed image for effects of non-homogeneous lighting of the skin area during the capturing of this image.

In some embodiments, the enhancing procedure may involve associating dark pixels having a light intensity under a darkness threshold with the blood vessels. This may be accomplished through a remapping of the unprocessed image to make the dark pixels appear darker and pixels associated with the surrounding tissues appear lighter, as explained above. Also as explained above, a histogram stretching of intensities may be used.

The processing may further includes overlaying an enhanced image, resulting from the enhancing of the contrast between the subcutaneous blood vessels and surrounding tissue, on the unprocessed image, thereby generating the processed image. In one embodiment, this may be done by adding the enhanced image to the unprocessed image pixel by pixel. Alternatively, only the dark pixels could be added to the unprocessed image.

The method finally includes displaying the processed image on a display device on the front side of the casing in alignment with the camera 110. Of course, the steps above are preferably performed repeatedly in order to obtain a real-time video display of the composite image.

Variations, modifications, and adaptations can be made to the embodiments described above without departing from the scope of the invention.

CLAIMS:

1. A handheld venipuncture-assisting device for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner, comprising:

- A handheld-sized casing having opposite back and front sides;
- an illuminating assembly configured to project an illuminating light beam from the back side of the casing towards the skin area;
- a camera positioned so as to capture backscattered light from the skin area upon illumination by said illuminating light beam, thereby acquiring an unprocessed image of said skin area;
- an image processor connected to the camera to receive the unprocessed image therefrom, the processor comprising:
  - o an image processing module configured for processing the unprocessed image and obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue, and
- a display device on the front side of the casing in alignment with the camera for displaying the processed image.

2. The handheld venipuncture-assisting device according to claim 1, wherein the illuminating light beam has a spectral profile including wavelengths suitable for absorption by said blood vessels.

3. The handheld venipuncture-assisting device according to claim 2, wherein said spectral profile comprises wavelengths in at least one of infrared and near-infrared spectral ranges.

4. The handheld venipuncture-assisting device according to any one of claims 1 to 3, wherein the illuminating assembly comprises at least one light source generating the illuminating light beam.

5. The handheld venipuncture-assisting device according to claim 4, wherein said at least one light source comprises an array of LED light sources.

6. The handheld venipuncture-assisting device according to claim 4 or 5, wherein the illuminating assembly further comprises a diffuser positioned in a path of the illuminating light beam from the at least one light source.

7. The handheld venipuncture-assisting device according to any one of claims 1 to 6, wherein the camera comprises an optical sensor.

8. The handheld venipuncture-assisting device according to claim 7, wherein the optical sensor is one of a charge-coupled device and a complementary metal-oxide-semiconductor device.

9. The handheld venipuncture-assisting device according to claim 7 or 8, further comprising a bandpass filter provided upstream the optical sensor, the bandpass filter having a bandpass profile aligned with a spectral profile of the backscattered light.

10. The handheld venipuncture-assisting device according to any one of claims 7 to 9, further comprising a controllable focussing unit positioned upstream the optical sensor.

11. The handheld venipuncture-assisting device according to any one of claims 1 to 10, further comprising a cross-polarizers assembly provided upstream the optical sensor, the cross-polarizer assembly comprising a first linear polarizer positioned in a path of the illuminating light beam and a second linear polarizer in a path of the backscattered light, the first and second linear polarizer having orthogonal polarization directions.

12. The handheld venipuncture-assisting device according to any one of claims 1 to 11, wherein the image processor is configured to execute an image processing routine of controlling the camera to acquire the unprocessed image, generating the processed image therefrom and displaying said processed image on the display, said image processor executing said processing routine repeatedly such that the composite image is displayed as a real time video feed.

13. The handheld venipuncture-assisting device according to any one of claims 1 to 12, wherein the image processing module is further configured to identify and remove undesired featured from the unprocessed image prior to enhancing a contrast between the subcutaneous blood vessels and the surrounding tissue region.

14. The handheld venipuncture-assisting device according to any one of claims 1 to 13, wherein the image processor further comprises an overlay module for overlaying an enhanced image, resulting from the enhancing of the contrast between the subcutaneous blood vessels and surrounding tissue, on the unprocessed image, thereby generating the processed image.

15. The handheld venipuncture-assisting device according to any one of claims 1 to 14, wherein the display is one of a liquid crystal display and a light emitting polymer display.

16. The handheld venipuncture-assisting device according to any one of claims 1 to 15, further comprising a use interface comprising at least one control button.

17. A venipuncture-assisting kit, for use with a handheld computing device having a display, for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner, the venipuncture-assisting kit comprising:

- A handheld-sized imaging accessory, comprising:

  - a cavity for receiving the handheld computing device therein with the display thereof exposed for viewing;
  - an illuminating assembly configured and positioned to project an illuminating light beam in a direction opposite to said display when the handheld computing device is received in the cavity;
  - a camera positioned so as to capture backscattered light from the skin area upon illumination by said illuminating light beam, thereby acquiring an unprocessed image of said skin area; and
  - a connector configured to provide an interface between the camera and the handheld computing device; and
- an image processing module configured for processing the unprocessed image and obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue,
- a displaying module for displaying the processed image on the display of the handheld computing device.

18. The venipuncture-assisting kit according to claim 17, wherein the image processing module and the displaying module are compatible to be received on a built-in processor of the handheld computing device.

19. The venipuncture-assisting kit according to claim 17, wherein the imaging accessory further comprises a processor hosting the image processing module and the displaying module.

20. A venipuncture-assisting kit, for use with a handheld computing device having a display and a camera opposite said display, for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner, the venipuncture-assisting kit comprising:

- A handheld-sized imaging accessory, comprising:

- a cavity for receiving the handheld computing device therein with the display thereof exposed for viewing, the cavity comprising a camera opening aligned with the camera of the computing device when received in the cavity;
- an illuminating assembly configured and positioned proximate the camera opening to project an illuminating light beam towards the skin area such that backscattered light emitted from the skin area upon illumination by said illuminating light beam is captured by the camera of the computing device, thereby acquiring an unprocessed image of said skin area; and

– an image processing module configured for processing the unprocessed image and obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue,

– a displaying module for displaying the processed image on the display of the handheld computing device.

21. A method for displaying a location of subcutaneous blood vessels within a tissue region of a skin area in a see-through manner, comprising:

a) providing a handheld venipuncture-assisting device comprising a handheld-sized casing having opposite back and front sides;

b) projecting an illuminating light beam from the back side of the casing towards the skin area;

c) capturing backscattered light from the skin area illuminated by said illuminating light beam, thereby acquiring an unprocessed image of said skin area;

d) processing the unprocessed image to obtain therefrom a processed image, the processing comprising enhancing a contrast between the subcutaneous blood vessels and surrounding tissue; anddisplaying the composite image on a display device on the front side of the casing in alignment with the camera.

22. The method according to claim 21 wherein the processing of step d) comprises a preliminary sub-step of segmenting the unprocessed image into segmented image regions.

23. The method according to claim 22, wherein the sub-step of segmenting comprises identifying at least one foreground region and at least one background region amongst said segmented image regions.

24. The method according to claim 21, wherein the identifying at least one foreground region and at least one background region comprises non-linear changes in intensity levels on said unprocessed image.

25. The method according to claim 23 or 24, wherein the enhancing of the processing of step d) is performed only on the segmented image regions identified as foreground regions.

26. The method according to any one of claims 21 to 25, wherein the processing of step d) comprises identifying undesired features from the unprocessed image prior to enhancing a contrast between the subcutaneous blood vessels and the surrounding tissue region.

27. The method according to claim 26, further comprising replacing pixels of the unprocessed image containing said undesired features with a contents of surrounding pixels free of said undesired features.

28. The method according to any one of claim 21 to 27, wherein the processing of step d) comprises correcting said unprocessed image for effects of non-homogeneous lighting of the skin area during the capturing of step c).

29. The method according to any one of claims 21 to 28, wherein the enhancing of the processing of step d) comprises associating dark pixels having a light intensity under a darkness threshold with said blood vessels.

30. The method according to claim 29, wherein the enhancing of the processing of step d) comprises remapping said unprocessed image to make said dark pixels more prononced than pixels associated with the surrounding tissues.

31. The method according to claim 30, wherein said remapping comprises performing a histogram stretching of intensities.

32. The methond according to any one of claims 21 to 31, wherein the processing of step d) comprises overlaying an enhanced image, resulting from the enhancing of the contrast between the subcutaneous blood vessels and surrounding tissue, on the unprocessed image, thereby generating the processed image.

33. The method according to claim 32, wherein the overlaying of step d) comprising adding the enhanced image to the unprocessed image pixel by pixel.

34. The method according to claim 32, wherein the overlaying of step d) comprises adding only pixels associated with the subcutaneous blood vessels to the unprocessed image.

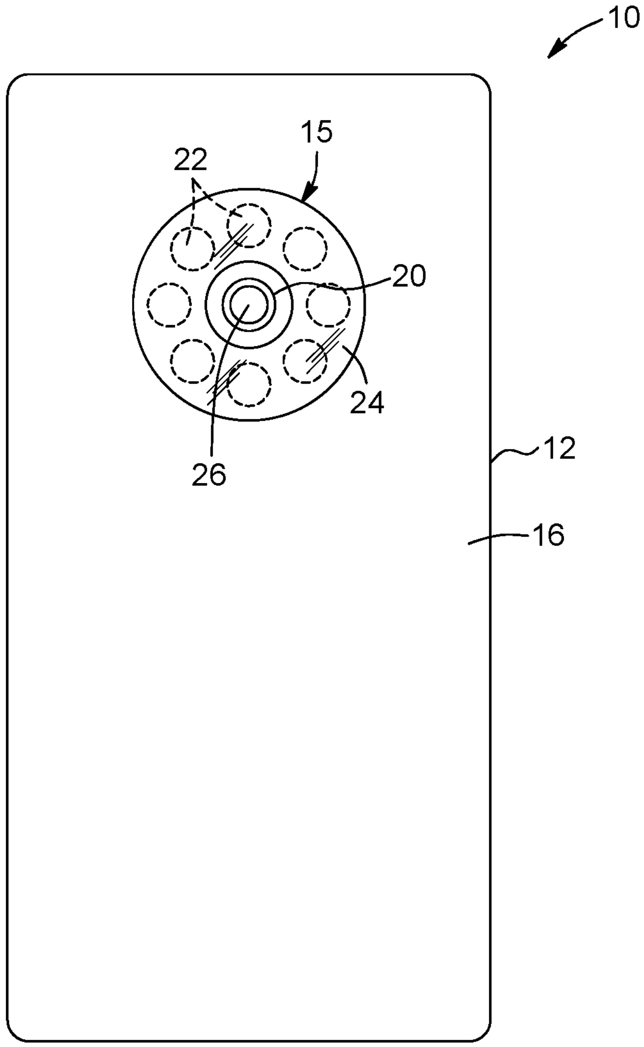

FIG. 1A

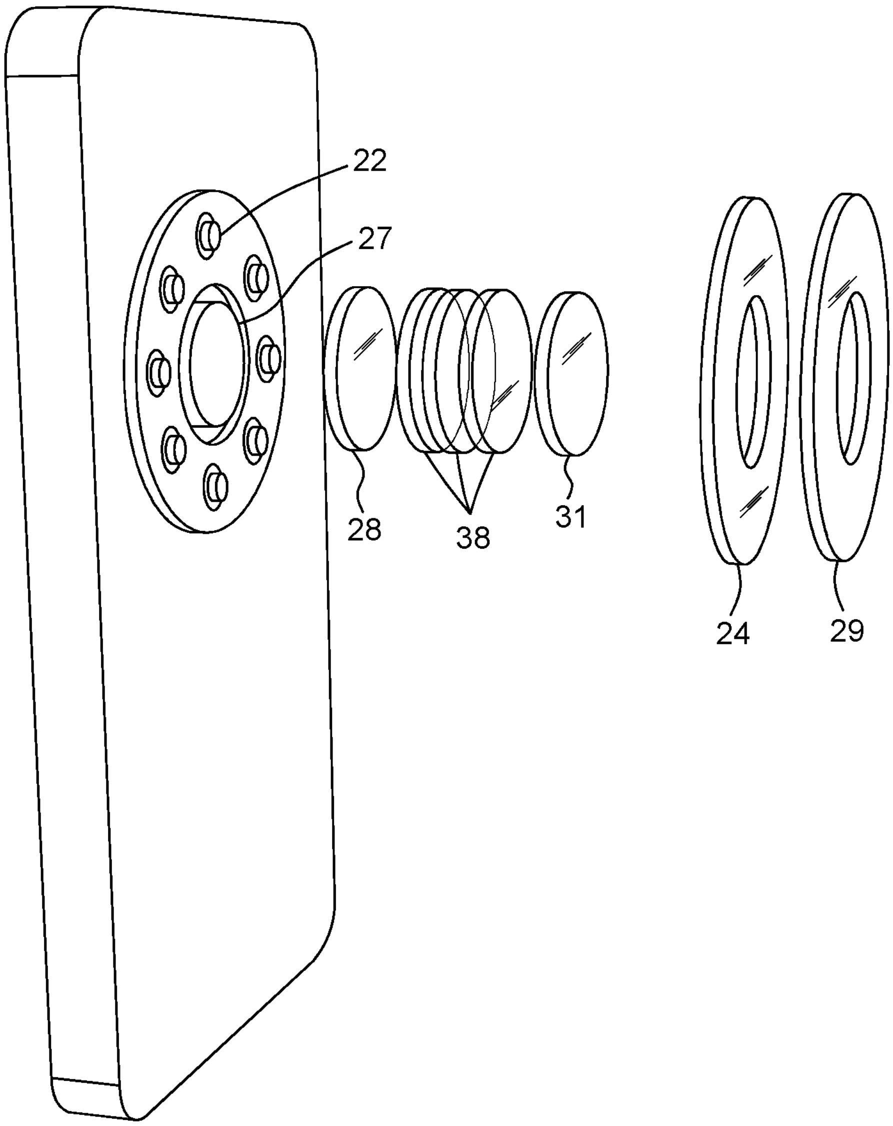

FIG. 1B

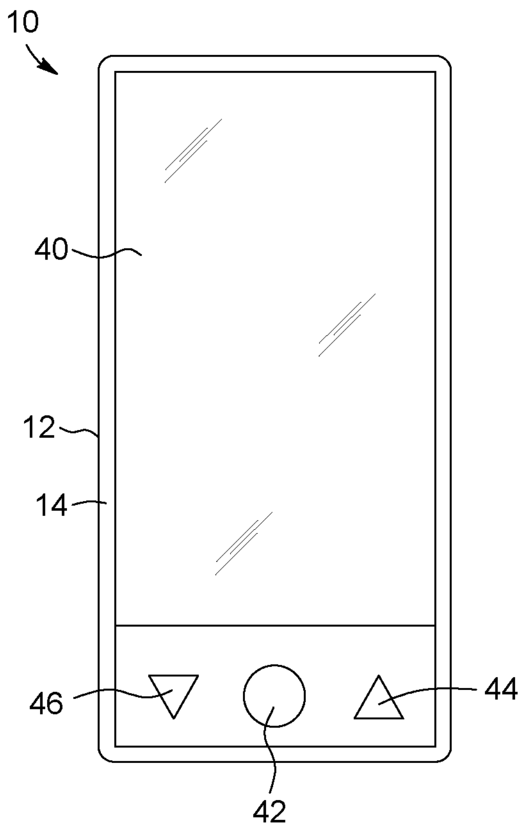

FIG. 2

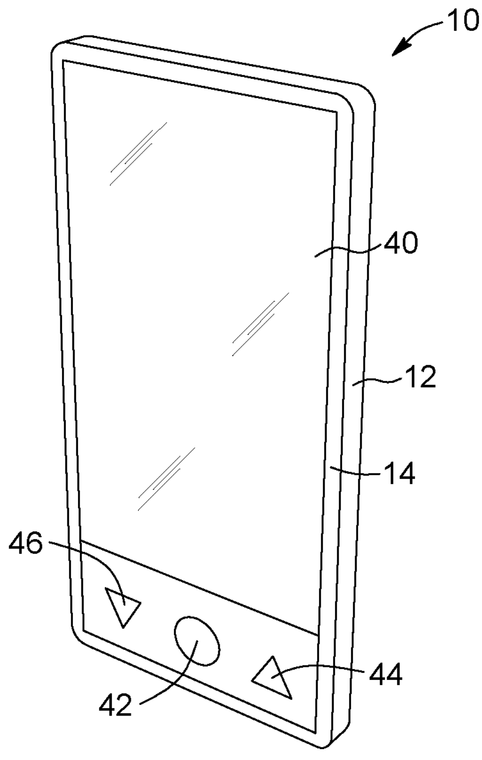

FIG. 3

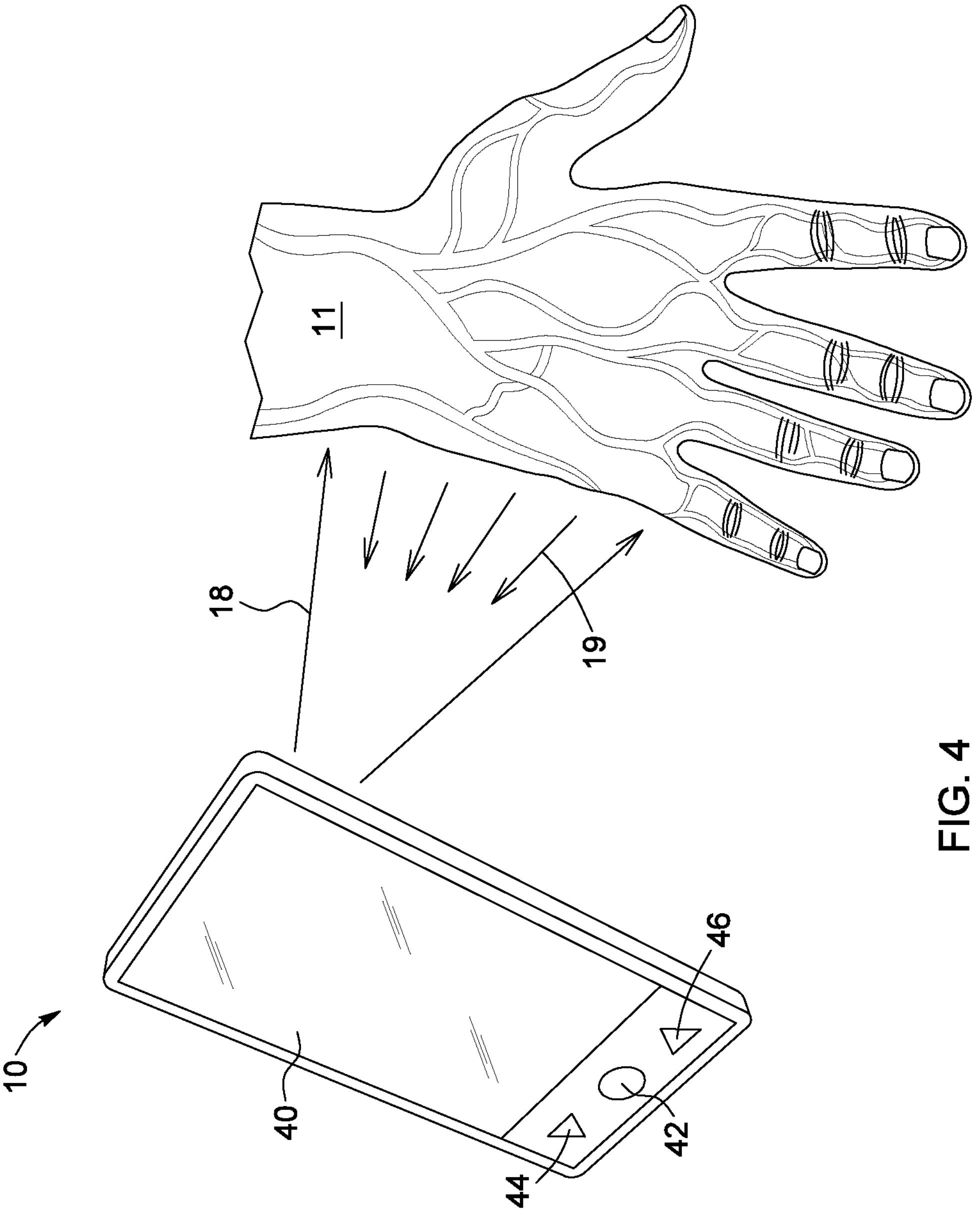

FIG. 4

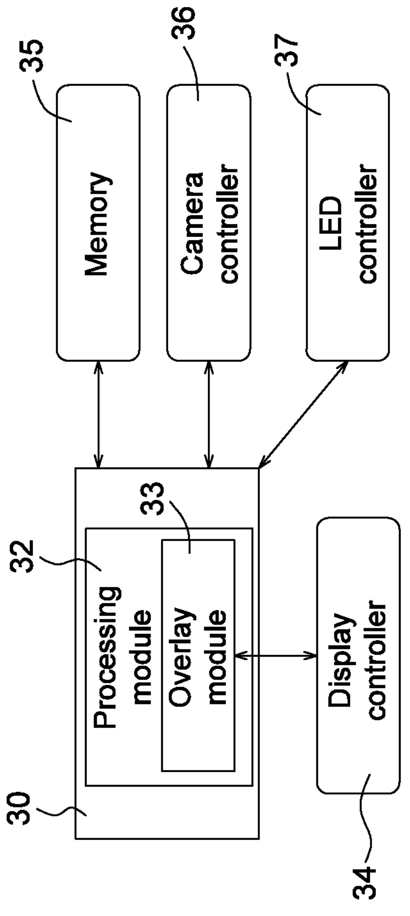
35
Memory
36
Camera controller
37
LED controller
32
Processing module
33
Overlay module
30
Display controller
34

FIG. 5

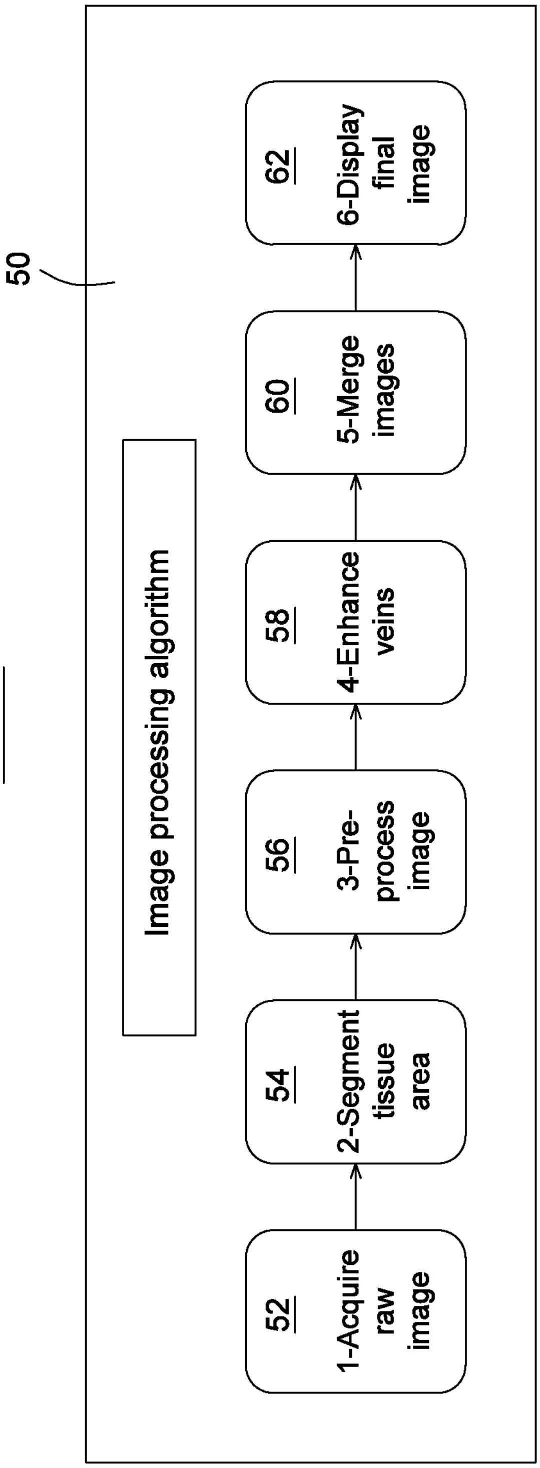
50
Image processing algorithm
52
1-Acquire raw image
54
2-Segment tissue area
56
3-Pre-process image
58
4-Enhance veins
60
5-Merge images
62
6-Display final image

FIG. 6

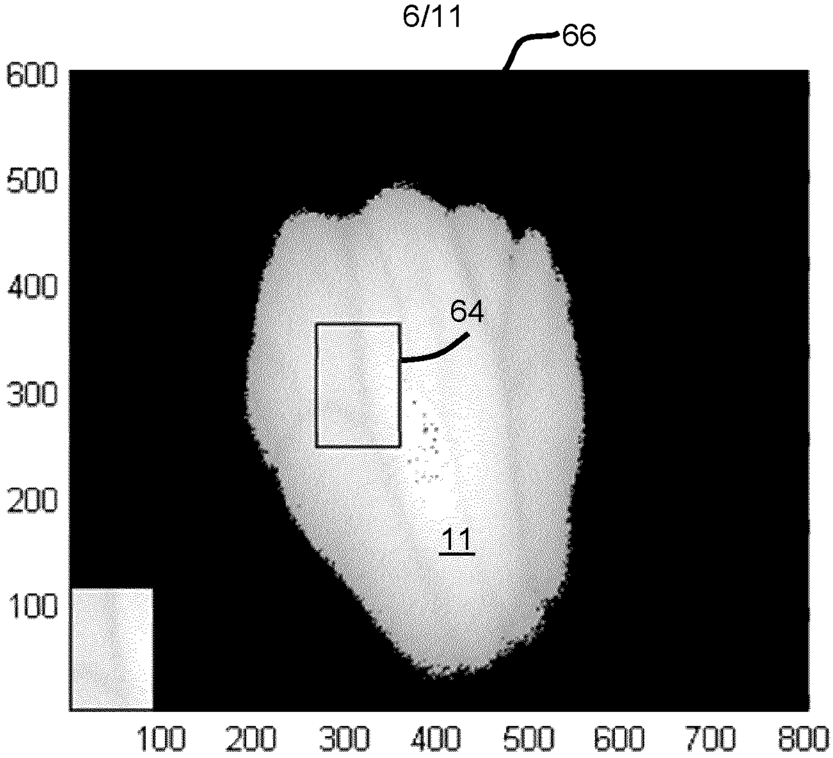
66
600
500
400
300
200
100
64
11
100
200
300
400
500
600
700
800

FIG. 7A

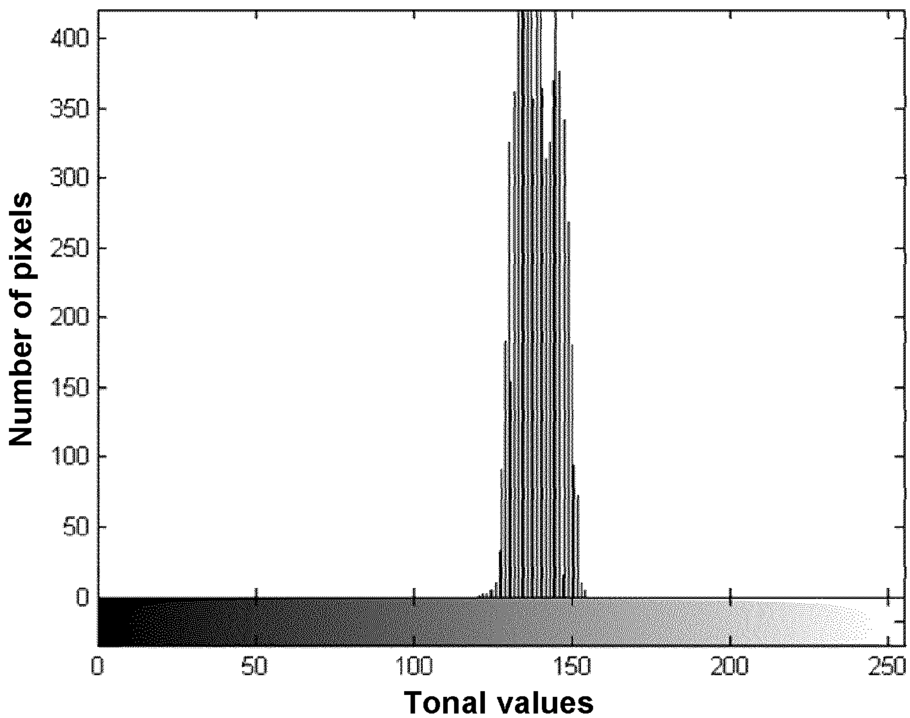
Number of pixels
400
350
300
250
200
150
100
50
0
0
50
100
150
200
250
Tonal values

FIG. 7B

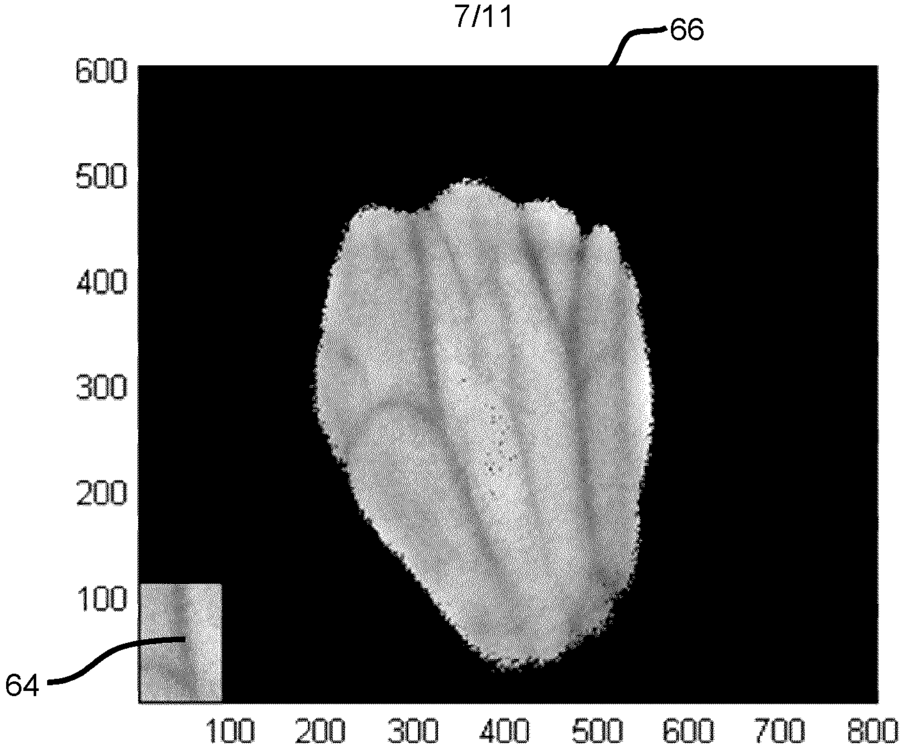
66
600
500
400
300
200
100
64
100 200 300 400 500 600 700 800

FIG. 8A

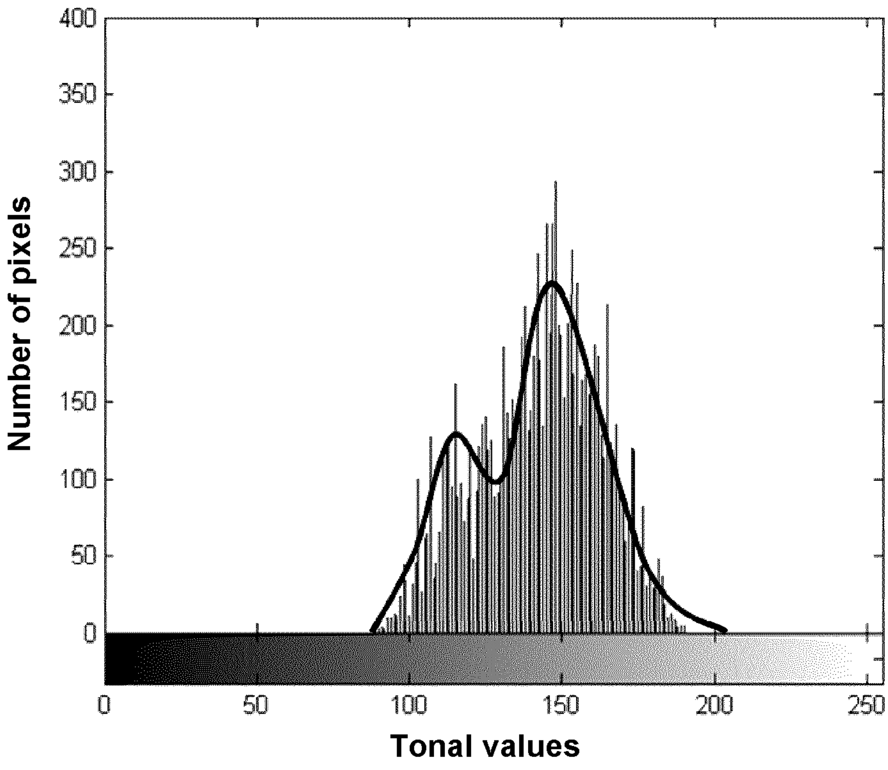
400
350
300
250
200
150
100
50
0
Number of pixels
0 50 100 150 200 250
Tonal values

FIG. 8B

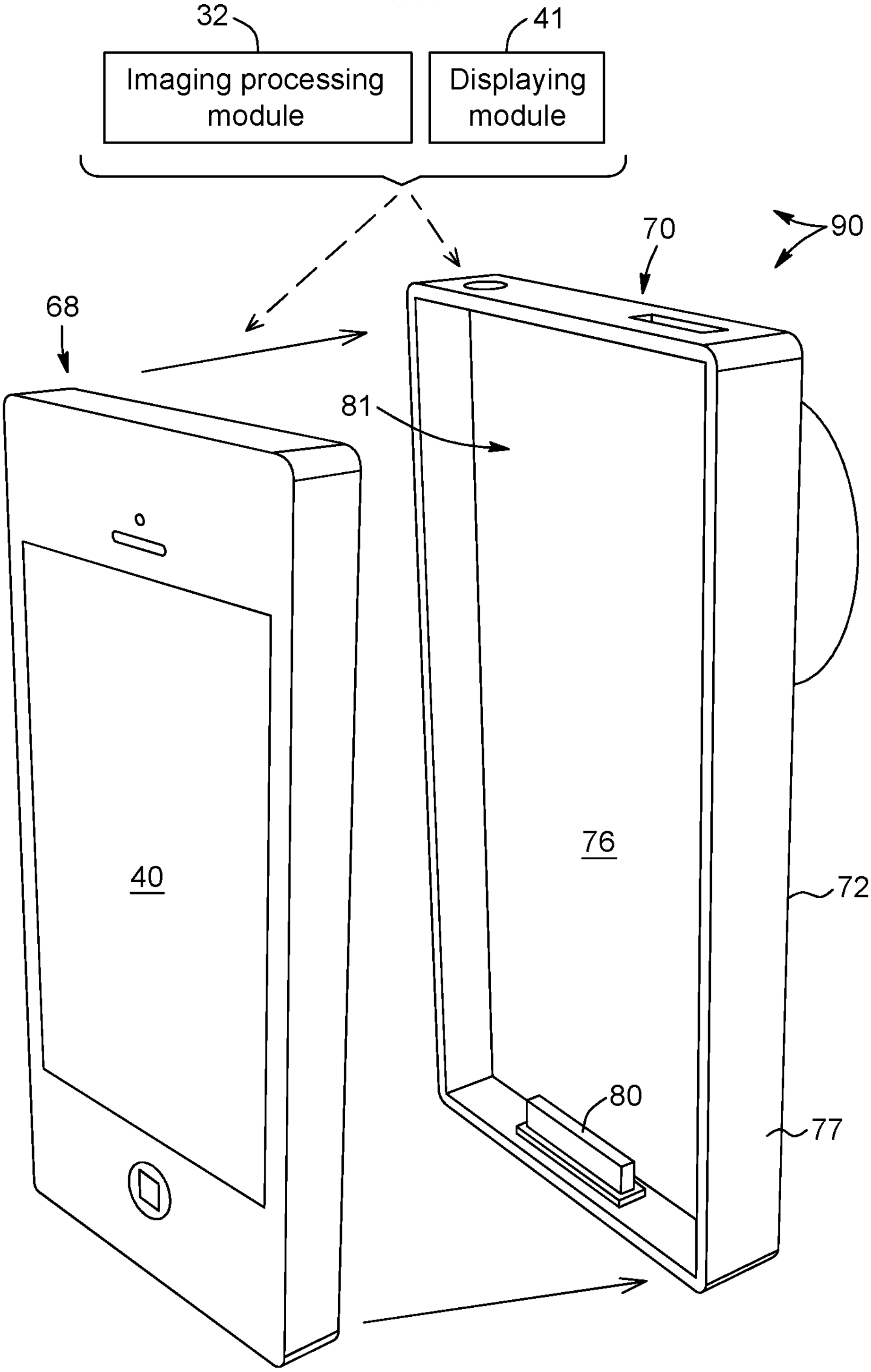
32
Imaging processing module
41
Displaying module
90
70
68
81
76
40
72
80
77

FIG. 9A

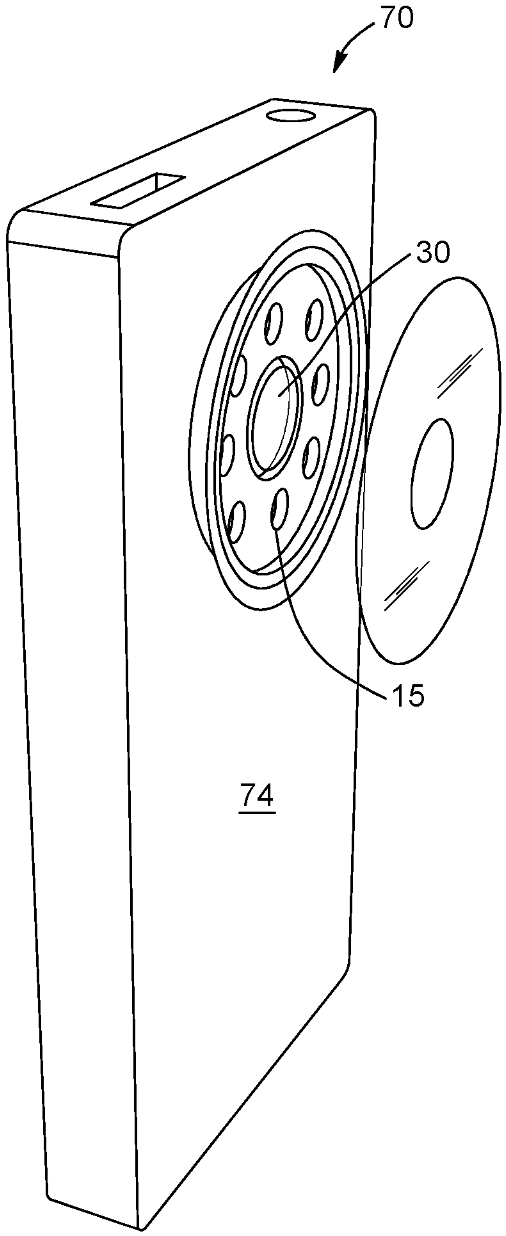

FIG. 9B

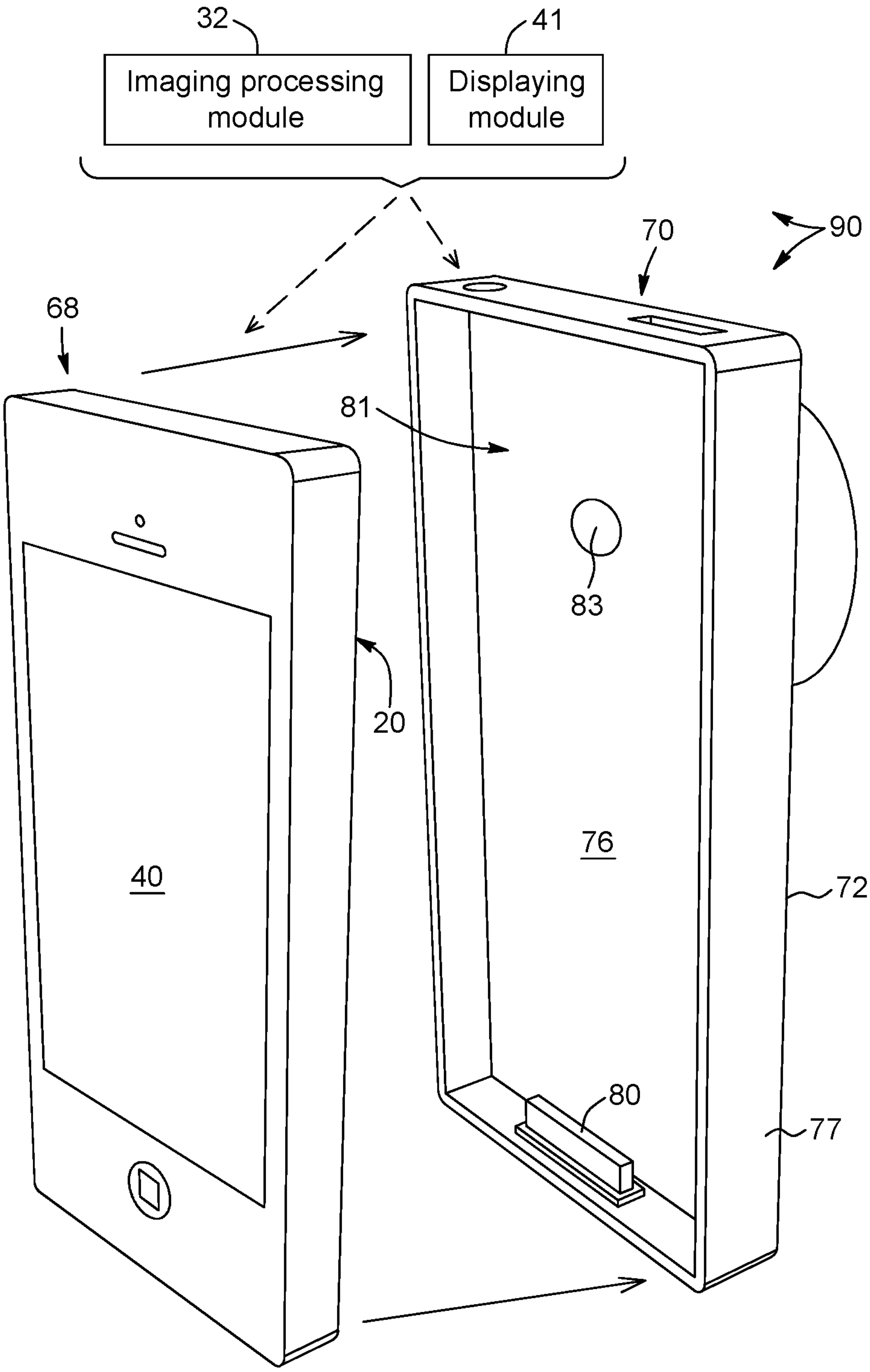
32
Imaging processing module
41
Displaying module
90
70
68
81
83
20
40
76
72
80
77

FIG. 10

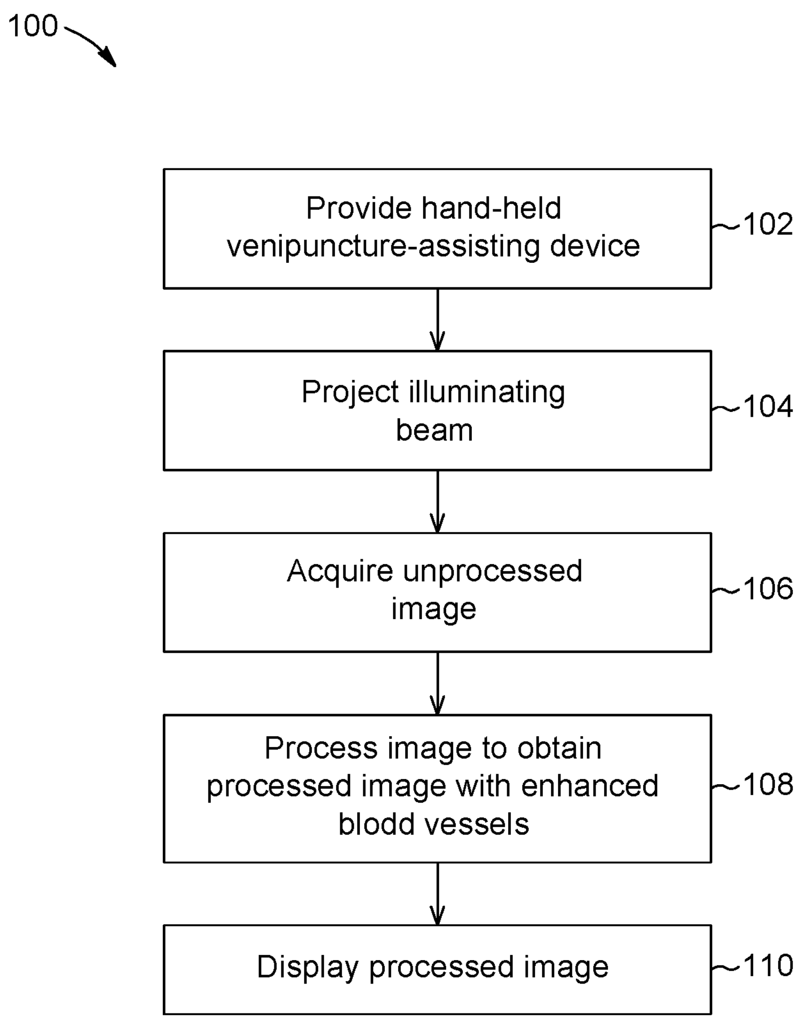
100
Provide hand-held venipuncture-assisting device
102
Project illuminating beam
104
Acquire unprocessed image
106
Process image to obtain processed image with enhanced blodd vessels
108
Display processed image
110

FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2013/051000

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***A61B 6/00*** (2006.01) , ***A61B 19/00*** (2006.01)
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: A61B*(2006.01)(in combination with keywords)

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

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patent Database, TotalPatent, West, Google Patent (keywords: venipuncture, display, image, light, skin, camera, sensor, LED, infrared OR infra-red)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2001/0027273 A1 (Flock et al.) 4 October 2001 (04-10-2001) * paragraphs 19, 23, 29, 34, 36, 39, 40, 41	1-6, 8-12, 14, 15, 17-22, 24, 25, 28-34 7, 13, 16, 23, 26, 27
Y	US 2003/0210810 A1 (Gee, JR. et al.) 13 November 2003 (13-11-2003) * paragraphs 41-48, 63	13, 23, 26, 27
Y	US 2011/0125028 A1 (Wood et al.) 26 May 2011 (26-05-2011) * paragraphs 107, 108	7, 16
A	US 2012/0130221 A1 (Goldman et al.) 24 May 2012 (24-05-2012) * see entire document	1-34
A	US 2008/0021329 A1 (Wood et al.) 24 January 2008 (24-01-2008) * see entire document	1-34

[ ] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents :
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 February 2014 (12-02-2014)	24 February 2014 (24-02-2014)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 001-819-953-2476	Saadia Khan (819) 934-6752

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US2001027273A1	04 October 2001 (04-10-2001)	AT200020T	15 April 2001 (15-04-2001)
		AT282985T	15 December 2004 (15-12-2004)
		AU706419B2	17 June 1999 (17-06-1999)
		AU5929696A	30 December 1996 (30-12-1996)
		CA2223089A1	19 December 1996 (19-12-1996)
		CA2223089C	12 July 2005 (12-07-2005)
		DE69612283D1	03 May 2001 (03-05-2001)
		DE69612283T2	08 November 2001 (08-11-2001)
		DE69633946D1	30 December 2004 (30-12-2004)
		DE69633946T2	02 March 2006 (02-03-2006)
		DK0830077T3	18 June 2001 (18-06-2001)
		EP0830077A1	25 March 1998 (25-03-1998)
		EP0830077B1	28 March 2001 (28-03-2001)
		EP1066791A2	10 January 2001 (10-01-2001)
		EP1066791A3	17 October 2001 (17-10-2001)
		EP1066791B1	24 November 2004 (24-11-2004)
		EP1514510A1	16 March 2005 (16-03-2005)
		ES2156280T3	16 June 2001 (16-06-2001)
		HK1032520A1	20 May 2005 (20-05-2005)
		JPH11509748A	31 August 1999 (31-08-1999)
		JP3734508B2	11 January 2006 (11-01-2006)
		US6032070A	29 February 2000 (29-02-2000)
		US6272374B1	07 August 2001 (07-08-2001)
		US7006861B2	28 February 2006 (28-02-2006)
		WO9639925A1	19 December 1996 (19-12-1996)
US2003210810A1	13 November 2003 (13-11-2003)	US2003210810A1	13 November 2003 (13-11-2003)
		US7158660B2	02 January 2007 (02-01-2007)
US2011125028A1	26 May 2011 (26-05-2011)	BRPI0621174A2	06 December 2011 (06-12-2011)
		CA2635851A1	12 July 2007 (12-07-2007)
		CA2677189A1	07 August 2008 (07-08-2008)
		CA2677217A1	07 August 2008 (07-08-2008)
		EP1981395A2	22 October 2008 (22-10-2008)
		EP1981395B1	05 June 2013 (05-06-2013)
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		JP2009523038A	18 June 2009 (18-06-2009)
		JP2013240690A	05 December 2013 (05-12-2013)
		KR20080091359A	10 October 2008 (10-10-2008)
		MX2008008632A	28 November 2008 (28-11-2008)
		TW200840544A	16 October 2008 (16-10-2008)
		TW200843703A	16 November 2008 (16-11-2008)
		TW200901939A	16 January 2009 (16-01-2009)
		US2007161909A1	12 July 2007 (12-07-2007)
		US7904138B2	08 March 2011 (08-03-2011)
		US2008004525A1	03 January 2008 (03-01-2008)
		US7983738B2	19 July 2011 (19-07-2011)
		US2008115001A1	15 May 2008 (15-05-2008)
		US7983860B2	19 July 2011 (19-07-2011)
		US2007161908A1	12 July 2007 (12-07-2007)
		US8073531B2	06 December 2011 (06-12-2011)
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		US8244333B2	14 August 2012 (14-08-2012)
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		US8295904B2	23 October 2012 (23-10-2012)
		US2008045841A1	21 February 2008 (21-02-2008)
		US8380291B2	19 February 2013 (19-02-2013)
		US2008287806A1	20 November 2008 (20-11-2008)
		US8391960B2	05 March 2013 (05-03-2013)
		US2011125028A1	26 May 2011 (26-05-2011)
		US8463364B2	11 June 2013 (11-06-2013)
		US2007161907A1	12 July 2007 (12-07-2007)
		US8478386B2	02 July 2013 (02-07-2013)
		US2008045818A1	21 February 2008 (21-02-2008)
		US8489178B2	16 July 2013 (16-07-2013)
		US2011112407A1	12 May 2011 (12-05-2011)
		US8594770B2	26 November 2013 (26-11-2013)
		US2008027317A1	31 January 2008 (31-01-2008)
		US2009002488A1	01 January 2009 (01-01-2009)
		US2011021925A1	27 January 2011 (27-01-2011)
		US2011118611A1	19 May 2011 (19-05-2011)
		US2011208121A1	25 August 2011 (25-08-2011)
		US2012095350A1	19 April 2012 (19-04-2012)
		US2012151242A1	14 June 2012 (14-06-2012)
		US2012265078A1	18 October 2012 (18-10-2012)
		US2013102905A1	25 April 2013 (25-04-2013)
		US2013123640A1	16 May 2013 (16-05-2013)
		US2014024952A1	23 January 2014 (23-01-2014)

US2013123640A1	16 May 2013 (16-05-2013)
US2014024952A1	23 January 2014 (23-01-2014)
WO2007078447A2	12 July 2007 (12-07-2007)
WO2007078447A3	21 December 2007 (21-12-2007)
WO2008005282A2	10 January 2008 (10-01-2008)
WO2008005282A3	29 May 2008 (29-05-2008)
WO2008094252A2	07 August 2008 (07-08-2008)
WO2008094252A3	26 March 2009 (26-03-2009)
WO2008094253A2	07 August 2008 (07-08-2008)
WO2008094253A3	05 March 2009 (05-03-2009)
WO2012011951A1	26 January 2012 (26-01-2012)

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US2001027273A1, 04 October 2001 (04-10-2001)
US2003210810A1, 13 November 2003 (13-11-2003)
US2011125028A1, 26 May 2011 (26-05-2011)
US2012130221A1, 24 May 2012 (24-05-2012)
US2008021329A1, 24 January 2008 (24-01-2008)

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US2001027273A1, 04 October 2001 (04-10-2001)
US2003210810A1, 13 November 2003 (13-11-2003)
US2011125028A1, 26 May 2011 (26-05-2011)
US2012130221A1, 24 May 2012 (24-05-2012)
US2008021329A1, 24 January 2008 (24-01-2008)