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(54) **Title:** IMAGE PROCESSING METHOD, IMAGE PROCESSING APPARATUS, PORTABLE MULTIFUNCTION DEVICE,
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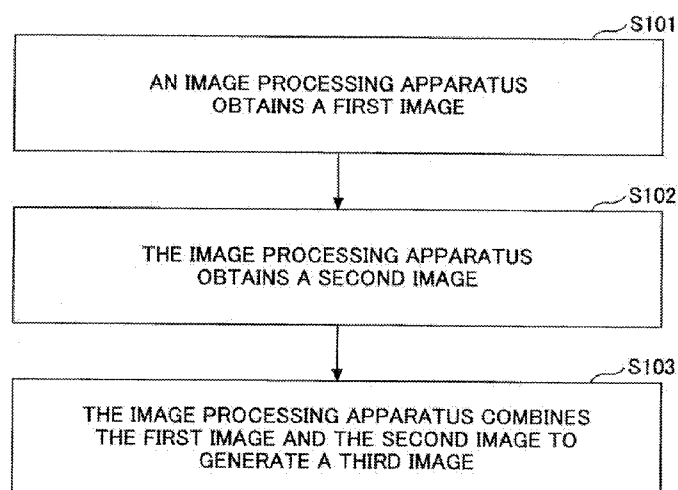


FIG. 4

(57) **Abstract:** The present invention discloses an image processing method, an image processing apparatus, a portable multifunction device, and a computer readable storage medium. The image processing method includes at a portable multifunction device with an LED (light emitting diode) flash, including at least two LEDs, a camera, including a color sensor, and one or more processors, obtaining, by the camera, a first image, when the LED flash emits first light or when the LED flash does not emit light; obtaining, by the camera, a second image, when the LED flash emits second light, wherein the second light has a specific wavelength; and combining, by the one or more processors, the first image and the second image to generate a third image. By using the specific wavelength, the first aspect improves beautification of a human skin in an image captured by a camera.



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IMAGE PROCESSING METHOD, IMAGE PROCESSING APPARATUS, PORTABLE MULTIFUNCTION DEVICE, AND COMPUTER READABLE STORAGE MEDIUM

TECHNICAL FIELD

5 [0001] The present invention relates to the field of image processing, and in particular, to an image processing method, an image processing apparatus, a portable multifunction device, and a computer readable storage medium.

BACKGROUND

[0002] With growth of digital cameras and mobile phones with a camera, image quality of a human face is getting more important. When a photograph of a human face is taken using a front camera of a mobile phone, for example, image quality of the human face becomes a big concern.

[0003] Some cameras have an image processing capability to beautify a human face, for example, to remove spots or freckles using a smoothing filter or a de-noise filter. By using a smoothing filter or a de-noise filter, some spots or freckles can be smoothed or removed. On the other hand, in order to avoid an over-smoothed output at contours or outlines of face parts such as eyes, a mouth, a nose, or the like, an edge-preserving filter is applied. When an edge-preserving filter is applied, all of the edges in an image are preserved.

[0004] FIG. 1 shows an original image and a smoothed image according to the prior art. As shown in FIG. 1(A), there are edges at spots or freckles in the original image. When a smoothing filter or a de-noise filter is applied together with an edge-preserving filter, the edges at the spots or freckles are enhanced and big pockmarks or deep colored spots remain at the edges of the spots or freckles as shown in FIG. 1(B).

[0005] When an edge-preserving filter is used, it is difficult to determine which portions

are contours or outlines of face parts to be preserved and which portions are spots or freckles to be smoothed. Thus, for the edges of the spots or freckles, a smoothing filter or a de-noise filter does not work well.

SUMMARY

5 [0006] Embodiments of the present invention provide an image processing method, an image processing apparatus, a portable multifunction device, and a computer readable storage medium to improve beautification of a human skin in an image captured by a camera.

[0007] In a first aspect, an image processing method is provided, including: at a portable multifunction device with an LED (light emitting diode) flash, including at least two LEDs, a
10 camera, including a color sensor, and one or more processors, obtaining, by the camera, a first image, when the LED flash emits first light or when the LED flash does not emit light; obtaining, by the camera, a second image, when the LED flash emits second light, wherein the second light has a specific wavelength; and combining, by the one or more processors, the first image and the second image to generate a third image.

15 [0008] According to the first aspect, a first image is obtained when the LED flash emits first light or when the LED flash does not emit light, a second image is obtained when the LED flash emits second light, wherein the second light has a specific wavelength, and the first image and the second image are combined to generate a third image. By using the specific wavelength, the first aspect improves beautification of a human skin in an image captured by
20 a camera. In addition, by using the LED flash including a red LED, a green LED, and a blue LED, a first image and a second image can be easily obtained without modifying hardware components of a camera.

[0009] In a second aspect, an image processing method is provided, including: at a portable multifunction device with a first camera, including a color sensor, a second camera,
25 including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor, and one or more processors, obtaining, by the first camera, a first image; obtaining, by the second camera, a second image; and combining, by the one or more processors, the first image and the second image to generate a third image.

[0010] According to the second aspect, a first image is obtained by a first camera including a color sensor, a second image is obtained by a second camera including a color sensor and a specific color filter which passes specific color, and the first image and the second image are combined to generate a third image. By using the specific color filter which passes specific color, the second aspect improves beautification of a human skin in an image captured by cameras. In addition, by using a dual camera including the first camera and the second camera, the first image and the second image can be obtained at the same time.

[0011] In a third aspect, an image processing method is provided, including: at a portable multifunction device with a camera, including a color sensor and a specific color filter which passes specific color, and one or more processors, obtaining, by the camera, a first image, when the specific color filter is not applied; obtaining, by the camera, a second image, when the specific color filter is applied; and combining, by the one or more processors, the first image and the second image to generate a third image.

[0012] According to the third aspect, a first image is obtained when a specific color filter which passes specific color is not applied, a second image is obtained when a specific color filter which passes specific color is applied, and the first image and the second image are combined to generate a third image. By using the specific color filter which passes specific color, the third aspect improves beautification of a human skin in an image captured by a camera.

[0013] In a fourth aspect, an image processing method is provided, including: at a portable multifunction device with a camera, including a first color sensor and a second color sensor which detects specific color, and one or more processors, obtaining, by the camera, a first image using the first color sensor; obtaining, by the camera, a second image using the second color sensor; and combining, by the one or more processors, the first image and the second image to generate a third image.

[0014] According to the fourth aspect, a first image is obtained using a first color sensor, a second image is obtained using a second color sensor which detects specific color, and the first image and the second image are combined to generate a third image. By using the second color sensor which detects specific color, the fourth aspect improves beautification of a human skin in an image captured by a camera. In addition, by using the first color sensor and

the second color sensor which detects specific color, the first image and the second image can be obtained at the same time.

[0015] In a first possible implementation manner of any one of the first to fourth aspects, combining, by the one or more processors, the first image and the second image to generate the third image includes: obtaining a first luminance component from the first image; obtaining a second luminance component from the second image; and combining a low frequency component of the first luminance component and a high frequency component of the second luminance component.

[0016] According to the first possible implementation manner, the third image is generated by combining a low frequency component of the first luminance component and a high frequency component of the second luminance component. Since light with a specific wavelength reaches a deeper layer of a human skin, spots or freckles can be smoothed by using the high frequency component of the second luminance component. At the same time, contours or outlines of face parts can be preserved by using the low frequency component of the first luminance component.

[0017] In a second possible implementation manner of any one of the first to fourth aspects, combining, by the one or more processors, the first image and the second image to generate the third image includes: obtaining a first chroma component from the first image; obtaining a second chroma component from the second image; and combining a low frequency component of the first chroma component and a high frequency component of the second chroma component.

[0018] According to the second possible implementation manner, the third image is generated by combining a low frequency component of the first chroma component and a high frequency component of the second chroma component. Colored spots or freckles can be smoothed by using the high frequency component of the second chroma component. At the same time, contours or outlines of face parts can be preserved by using the low frequency component of the first chroma component.

[0019] In a third possible implementation manner of the first aspect, the specific wavelength is a wavelength over which reflectance by hemoglobin is higher than reflectance by melanin.

[0020] In a fourth possible implementation manner of the first aspect, the specific wavelength is a wavelength within a red wavelength region.

[0021] Since a red LED is widely available, a second image can be easily obtained by using the red LED.

5 **[0022]** In a fifth possible implementation manner of any one of the second to fourth aspects, the specific color has a wavelength over which reflectance by hemoglobin is higher than reflectance by melanin.

[0023] In a sixth possible implementation manner of any one of the second to fourth aspects, the specific color is red.

10 **[0024]** In a fifth aspect, an image processing apparatus is provided, including: a first obtainment unit configured to obtain a first image, when an LED (light emitting diode) flash, including at least two LEDs, emits first light or when the LED flash does not emit light; a second obtainment unit configured to obtain a second image, when the LED flash emits second light, wherein the second light has a specific wavelength; and a combination unit
15 configured to combine the first image and the second image to generate a third image.

[0025] In a sixth aspect, an image processing apparatus is provided, including: a first obtainment unit configured to obtain a first image using a first camera including a color sensor; a second obtainment unit configured to obtain a second image using a second camera including a color sensor and a specific color filter which passes specific color and is placed in
20 front of the color sensor; and a combination unit configured to combine the first image and the second image to generate a third image.

[0026] In a seventh aspect, an image processing apparatus is provided, including: a first obtainment unit configured to obtain a first image using a camera including a color sensor and a specific color filter which passes specific color, when the specific color filter is not
25 applied; a second obtainment unit configured to obtain a second image using the camera, when the specific color filter is applied; and a combination unit configured to combine the first image and the second image to generate a third image.

[0027] In an eighth aspect, an image processing apparatus is provided, including: a first obtainment unit configured to obtain a first image using a first color sensor in a camera; a
30 second obtainment unit configured to obtain a second image using a second color sensor

which detects specific color; and a combination unit configured to combine the first image and the second image to generate a third image.

[0028] In a first possible implementation manner of any one of the fifth to eighth aspects, the combination unit is configured to: obtain a first luminance component from the first
5 image; obtain a second luminance component from the second image; and combine a low frequency component of the first luminance component and a high frequency component of the second luminance component.

[0029] In a second possible implementation manner of any one of the fifth to eighth aspects, the combination unit is configured to: obtain a first chroma component from the first
10 image; obtain a second chroma component from the second image; and combine a low frequency component of the first chroma component and a high frequency component of the second chroma component.

[0030] In a third possible implementation manner of the fifth aspect, the specific wavelength is a wavelength over which reflectance by hemoglobin is higher than reflectance
15 by melanin.

[0031] In a fourth possible implementation manner of the fifth aspect, the specific wavelength is a wavelength within a red wavelength region.

[0032] In a fifth possible implementation manner of the sixth to eighth aspects, the specific color has a wavelength over which reflectance by hemoglobin is higher than
20 reflectance by melanin.

[0033] In a sixth possible implementation manner of the sixth to eighth aspects, the specific color is red.

[0034] In a ninth aspect, a portable multifunction device is provided, including: an LED (light emitting diode) flash, including at least two LEDs; a camera, including a color sensor;
25 and one or more processors; wherein the camera captures a first image, when the LED flash emits first light or when the LED flash does not emit light; the camera captures a second image, when the LED flash emits second light, wherein the second light has a specific wavelength; and the one or more processors combine the first image and the second image to generate a third image.

[0035] In a tenth aspect, a portable multifunction device is provided, including: a first
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camera, including a color sensor; a second camera, including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor; and one or more processors; wherein the first camera captures a first image; the second camera captures a second image; and the one or more processors combine the first image and the second image to generate a third image.

[0036] In an eleventh aspect, a portable multifunction device is provided, including: a camera, including a color sensor and a specific color filter which passes specific color; and one or more processors; wherein the camera captures a first image, when the specific color filter is not applied; the camera captures a second image, when the specific color filter is applied; and the one or more processors combine the first image and the second image to generate a third image.

[0037] In a twelfth aspect, a portable multifunction device is provided, including: a camera, including a first color sensor and a second color sensor which detects specific color; and one or more processors; wherein the camera captures a first image using the first color sensor; the camera captures a second image using the second color sensor; and the one or more processors combine the first image and the second image to generate a third image.

[0038] In a thirteenth aspect, a portable multifunction device is provided, including: one or more processors; and a memory; wherein one or more programs stored in the memory, when executed by the one or more processors, cause the one or more processors to perform the method according to any one of the first to fourth aspects.

[0039] In a fourteenth aspect, a computer-readable storage medium is provided, the computer readable storage medium storing one or more programs which, when executed by a portable multifunction device, cause the portable multifunction device to perform the method according to any one of the first to fourth aspects.

[0040] According to the embodiments of the present invention, a first image and a second image, which are obtained using different light emissions, different cameras, a selectively-applicable color filter, or different sensors, are combined to generate a third image, thereby improving beautification of a human skin in an image captured by a camera.

BRIEF DESCRIPTION OF DRAWINGS

[0041] To describe the technical solutions in the embodiments of the present invention more clearly, the following briefly introduces the accompanying drawings required for describing the embodiments. The accompanying drawings in the following description show
5 some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

[0042] FIG. 1 shows an original image and a smoothed image according to the prior art;

[0043] FIG. 2 is a graph of reflectance by a human skin;

[0044] FIG. 3 is a schematic diagram of a relationship between a wavelength of light and
10 a depth of a skin which reflects the light;

[0045] FIG. 4 is a flowchart of an image processing method according to an embodiment of the present invention;

[0046] FIG. 5 is an exemplary LED flash for use in an embodiment of the present invention;

15 [0047] FIG. 6 is an exemplary dual camera for use in an embodiment of the present invention;

[0048] FIG. 7 is an exemplary color sensor for use in an embodiment of the present invention;

[0049] FIG. 8 is a schematic diagram of an image processing method according to an
20 embodiment of the present invention;

[0050] FIG. 9 is a schematic structural diagram of an image processing apparatus according to an embodiment of the present invention;

[0051] FIG. 10 is a schematic structural diagram of an image processing apparatus according to another embodiment of the present invention; and

25 [0052] FIG. 11 shows an original image, a smoothed image according to the prior art, and an image processed according to an embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0053] To make the objectives, technical solutions, and advantages of the embodiments of

the present invention clearer, the following clearly describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings, in which like numbers represent like elements. The drawings are for illustration purposes only and are not drawn to scale. The described embodiments are some rather than all embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

[0054] In an embodiment of the present invention, an image processing apparatus uses a specific wavelength to improve beautification of a human skin in an image captured by a camera. For example, the specific wavelength is a wavelength within a red wavelength region (for example, more than 620 nm and less than 650 nm). Since red light with more than 620 nm and less than 650 nm wavelengths reaches a deeper layer of a human skin as described below with reference to FIG. 2 and FIG. 3, an image obtained using the specific wavelength can smooth spots or freckles in the captured image. In the embodiment of the present invention, an image obtained using the specific wavelength is used together with an original image (i.e., an image obtained using red, green, and blue wavelengths) to beautify a human skin.

[0055] FIG. 2 is a graph of reflectance by a human skin. The horizontal axis of the graph is a wavelength and the vertical axis of the graph is a reflectance. In FIG. 2, a relationship between a reflectance by hemoglobin and a wavelength and a relationship between a reflectance by melanin and a wavelength are plotted on the graph.

[0056] Within a red wavelength region (for example, more than 620 nm and less than 650 nm), the reflectance by hemoglobin is higher than the reflectance by melanin. At spots or freckles, the reflectance by melanin affects an appearance of a human skin. Thus, using a specific wavelength within the red wavelength region to capture an image of a human skin, some spots or freckles become invisible.

[0057] FIG. 3 is a schematic diagram of a relationship between a wavelength of light and a depth of a skin which reflects the light. Typically, visible light has wavelengths ranging from 380 nm to 750 nm. Among these wavelengths, blue light has wavelengths around 450 nm, green light has wavelengths around 550 nm, and red light has wavelengths around 650

nm. The upper portion of FIG. 3 shows an original image obtained using white light, an image obtained using blue light, an image obtained using green light, and an image obtained using red light. The lower portion of FIG. 3 shows that blue light is reflected near a surface of a human skin, green light reaches a deeper layer than blue light, and red light reaches a deeper layer than green light. It is also understood from FIG. 3 that some spots or freckles become invisible using a specific wavelength within the red wavelength region to capture an image of a human skin.

[0058] Accordingly, in an image obtained using a specific wavelength within the red wavelength region, a human skin appears to be smoothed. Using the principle described with reference to FIG. 2 and FIG. 3, an embodiment of the present invention can improve beautification of a human skin in an image captured by a camera.

[0059] FIG. 4 is a flowchart of an image processing method according to an embodiment of the present invention. The image processing method may be performed by an image processing apparatus. The image processing apparatus may be a portable multifunction device or a computer including one or more processors and a memory. The portable multifunction device may also include an LED (light emitting diode) flash and/or a camera. The one or more processors may read computer-readable program code stored in the memory, so that the one or more processors can perform the following steps of the image processing method.

[0060] S101. An image processing apparatus obtains a first image.

[0061] S102. The image processing apparatus obtains a second image.

[0062] The first image is an image (hereinafter, also referred to as an “RGB (red, green, and blue) image”) obtained using red, green, and blue wavelengths. The second image is an image (hereinafter, also referred to as a “specific wavelength image”) obtained using a specific wavelength. For example, a typical camera can obtain an RGB image. In order to obtain a specific wavelength image, an LED flash which can emit light with a specific wavelength, a specific color filter which passes specific color, that is, a specific color filter which passes wavelengths within a predetermined wavelength region including the specific wavelength, or a color sensor which detects specific color, that is, a color sensor which detects the specific wavelength may be used. It should be noted that the number of specific wavelengths is not limited to one, but a plurality of specific wavelengths may be used. It

should be also noted that the number of specific wavelength images is not limited to one, but a plurality of specific wavelength images may be obtained. The combination of the number of specific wavelengths and the number of specific wavelength images may be arbitrarily determined. For example, one specific wavelength image may be obtained with a wavelength of 620 nm, where reflectance by hemoglobin is higher than reflectance by melanin, and another specific wavelength image may be obtained with a wavelength of 500 nm, where reflectance by hemoglobin is also higher than reflectance by melanin. As an another example, one specific wavelength image may be obtained using a wavelength of 620 nm, another specific wavelength image may be obtained using a wavelength of 500 nm, and still another specific wavelength image may be obtained using wavelengths of 620 nm and 500 nm.

[0063] In one embodiment of the present invention, when the image processing apparatus includes an LED flash, including at least two LEDs, and a camera, including a color sensor, an RGB image may be obtained by the camera when the LED flash emits first light or when the LED flash does not emit light. A specific wavelength image may be obtained by the camera when the LED flash emits second light with the specific wavelength. The color sensor may be an RGB color sensor which includes an RGB color filter or a complementary color sensor which includes a Ye/Cy/Mg/G color filter. In addition to the LED flash or instead of the LED flash, another light source may be used such as an electro-luminescence (EL) device, a light bulb, or the like.

[0064] FIG. 5 is an exemplary LED flash for use in an embodiment of the present invention. The LED flash includes a red LED 101, a green LED 102, and a blue LED 103. The red LED 101 may emit light with a wavelength within a red wavelength region, the green LED 102 may emit light with a wavelength within a green wavelength region, and the blue LED 103 may emit light with a wavelength within a blue wavelength region. For example, the red LED 101 may emit light with a wavelength of 632 nm, the green LED 102 may emit light with a wavelength of 523 nm, and the blue LED 103 may emit light with a wavelength of 465 nm. Using this LED flash, an RGB image and a specific wavelength image may be sequentially obtained. An RGB image may be obtained at a first frame timing, and then a specific wavelength image may be obtained at a second frame timing. Alternatively, a specific wavelength image may be obtained at a first frame timing, and then an RGB image may be

obtained at a second frame timing. An RGB image can be obtained using a camera by turning the red LED 101 on, the green LED 102 on, and the blue LED 103 on. Alternatively, an RGB image can be obtained using a camera by turning the red LED 101 off, the green LED 102 off, and the blue LED 103 off. A specific wavelength image may be obtained using a camera by turning the red LED 101 on, the green LED 102 off, and the blue LED 103 off. A specific wavelength image may be also obtained by flashing the red LED 101 strongly. When light emitted by the red LED 101 reaches a human face more strongly than ambient light, the camera can capture a reddish image, that is, a specific wavelength image. By using the LED flash as shown in FIG. 5, an RGB image and a specific wavelength image can be easily obtained without modifying hardware components of a camera.

[0065] In another embodiment of the present invention, when the image processing apparatus includes a first camera, including a color sensor, and a second camera, including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor, an RGB image may be obtained by the first camera. A specific wavelength image may be obtained by the second camera. For example, an RGB image and a specific image may be obtained by a dual camera including two cameras, one of which includes a specific color filter which passes specific color. Alternatively, an RGB image and a specific image may be obtained by a single camera by selectively applying a specific color filter which passes specific color. When the image processing apparatus includes a camera, including a color sensor and a specific color filter which passes specific color, an RGB image may be obtained by the camera when the specific color filter is not applied. A specific wavelength image may be obtained by the camera when the specific color filter is applied. The specific color filter passes wavelengths within a predetermined wavelength region including the specific wavelength and rejects wavelengths other than the predetermined wavelength region. For example, when the specific wavelength is 620 nm, the specific color filter may pass wavelengths ranging from 600 nm to 650 nm or wavelengths more than 600 nm.

[0066] FIG. 6 is an exemplary dual camera for use in an embodiment of the present invention. The dual camera may include a first camera 201 configured to capture an RGB image and a second camera 202 configured to capture a specific wavelength image. The second camera 202 includes a specific color filter 203 which passes wavelengths within a

predetermined wavelength region including the specific wavelength and rejects wavelengths other than the predetermined wavelength region. Using this dual camera, an RGB image and a specific wavelength image may be sequentially or simultaneously obtained. An RGB image may be obtained by the first camera 201 at a first timing, and then a specific wavelength
5 image may be obtained by the second camera 202 at a second timing. Alternatively, a specific wavelength image may be obtained by the second camera 202 at a first timing, and then an RGB image may be obtained by the first camera 201 at a second timing. Alternatively, an RGB image and a specific wavelength image may be obtained at the same time by using both the first camera 201 and the second camera 202.

10 **[0067]** In another embodiment of the present invention, when the image processing apparatus includes a camera, including a first color sensor and a second color sensor which detects specific color, an RGB image may be obtained by the camera using the first color sensor. The first color sensor can detect the red, green, and blue wavelengths. A specific
15 wavelength image may be obtained by the camera using the second color sensor which detects specific color. The first color sensor or the second color sensor which detects specific color may include a charge-coupled device (CCD) image sensor or a complementary metal oxide semiconductor (CMOS) image sensor. A typical color sensor includes a sensor element which detects red light, a sensor element which detects green light, and a sensor element which detects blue light. The specific wavelength image may be obtained using only a sensor
20 element which detects red light. The first color sensor and the second color sensor which detects specific color may be separately placed in a camera or may be integrated into a single sensor in a camera. When the first color sensor and the second color sensor which detects specific are integrated into a single sensor, some sensor elements detect a red wavelength, some detect a green wavelength, some detect a blue wavelength, and some detect the specific
25 wavelength.

[0068] FIG. 7 is an exemplary color sensor for use in an embodiment of the present invention. The color sensor includes a plurality of sensor elements. Some sensor elements 301 (denoted "R" in FIG. 7) detect a red wavelength, some sensor elements 302 (denoted as "G" in FIG. 7) detect a green wavelength, some sensor elements 303 (denoted as "B" in FIG. 7) detect a blue wavelength, and some sensor elements 304 (denoted as "S" in FIG. 7) detect the
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specific wavelength. The arrangement of sensor elements may be arbitrarily determined.

[0069] Using this color sensor, an RGB image and a specific wavelength image may be sequentially or simultaneously obtained. An RGB image may be obtained at a first timing, and then a specific wavelength image may be obtained at a second timing. Alternatively, a specific wavelength image may be obtained at a first timing, and then an RGB image may be obtained at a second timing. Alternatively, an RGB image and a specific wavelength image may be obtained at the same time.

[0070] S103. The image processing apparatus combines the first image and the second image to generate a third image.

[0071] The first image is an RGB image obtained using the red, green, and blue wavelengths and the second image is a specific wavelength image using the specific wavelength.

[0072] The image processing apparatus combines the RGB image and the specific wavelength image to generate a third image. The third image is output from the image processing device and displayed on a screen. The specific procedure to generate the third image is described below with reference to FIG. 8.

[0073] FIG. 8 is a schematic diagram of an image processing method according to an embodiment of the present invention.

[0074] For example, an RGB image is obtained at a first frame timing using the LED flash shown in FIG. 5, the dual camera shown in FIG. 6, or the color sensor shown in FIG. 7, and a specific wavelength image is obtained at a second frame timing using the LED flash shown in FIG. 5, the dual camera shown in FIG. 6, or the color sensor shown in FIG. 7. As described above, using a specific wavelength within the red wavelength region to capture an image of a human skin, some spots or freckles become invisible. Thus, the specific wavelength image is used for image portions corresponding to spots or freckles. On the other hand, the RGB image is used for image portions corresponding to contours or outlines of face parts such as eyes, a mouth, a nose, or the like.

[0075] Specifically, a first luminance component and a first chroma component are obtained from the RGB image. Similarly, a second luminance component and a second chroma component are obtained from the specific wavelength image. The third image may be

generated by combining a low frequency component of the first luminance component and a high frequency component of the second luminance component. Specifically, the third image may be generated from the RGB image and the specific wavelength image by replacing a high frequency component of the first luminance component with a high frequency component of the second luminance component. Upon replacing the high frequency component of the first luminance component with the high frequency component of the second luminance component, luminance levels of the first luminance component and the second luminance component may be adjusted. Since light with the specific wavelength reaches a deeper layer of a human skin, spots or freckles can be smoothed by using the high frequency component of the second luminance component. At the same time, contours or outlines of face parts can be preserved by using the low frequency component of the first luminance component.

[0076] In addition or alternatively, the third image may be generated by combining a low frequency component of the first chroma component and a high frequency component of the second chroma component. Specifically, the third image may be generated from the RGB image and the specific wavelength image by replacing a high frequency component of the first chroma component with a high frequency component of the second chroma component. Upon replacing the high frequency component of the first chroma component with the high frequency component of the second chroma component, chroma levels of the first chroma component and the second chroma component may be adjusted. Colored spots or freckles can be smoothed by using the high frequency component of the second chroma component. At the same time, contours or outlines of face parts can be preserved by using the low frequency component of the first chroma component.

[0077] According to this image processing method, the image processing apparatus obtains a first image and a second image using different light emissions, different cameras, a selectively-applicable color filter, or different sensors, and combines the first image and the second image to generate a third image, thereby improving beautification of a human skin in an image captured by a camera.

[0078] FIG. 9 is a schematic structural diagram of an image processing apparatus according to an embodiment of the present invention. The image processing apparatus includes a first obtainment unit 401, a second obtainment unit 402, and a combination unit

403.

[0079] The first obtainment unit 401 is configured to obtain a first image. For more specific functions and operations in the first obtainment unit 401, reference may be made to the step S101 in the method embodiment shown in FIG. 4, and no repeated description is given here.

[0080] The second obtainment unit 402 is configured to obtain a second image. For more specific functions and operations in the second obtainment unit 402, reference may be made to the step S102 in the method embodiment shown in FIG. 4, and no repeated description is given here.

[0081] Specifically, the first obtainment unit 401 may be configured to obtain a first image, when an LED flash, including at least two LEDs, emits first light or when the LED flash does not emit light. The second obtainment unit 402 may be configured to obtain a second image, when the LED flash emits second light, wherein the second light has a specific wavelength.

[0082] Specifically, the first obtainment unit 401 may be configured to obtain a first image using a first camera including an a color sensor. The second obtainment unit 402 may be configured to obtain a second image using a second camera including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor.

[0083] Specifically, the first obtainment unit 401 may be configured to obtain a first image using a camera including a color sensor and a specific color filter which passes specific color, when the specific color filter is not applied. The second obtainment unit 402 may be configured to obtain a second image using the camera, when the specific color filter is applied.

[0084] Specifically, the first obtainment unit 401 may be configured to obtain a first image using a first color sensor in a camera. The second obtainment unit 402 may be configured to obtain a second image using a second color sensor which detects specific color.

[0085] The combination unit 403 is configured to combine the first image and the second image to generate a third image. For more specific functions and operations in the combination unit 403, reference may be made to the step S103 in the method embodiment shown in FIG. 4, and no repeated description is given here.

[0086] Specifically, the combination unit 403 may be configured to obtain a first luminance component from the first image; obtain a second luminance component from the second image; and combine a low frequency component of the first luminance component and a high frequency component of the second luminance component.

5 **[0087]** Specifically, the combination unit 403 may be configured to obtain a first chroma component from the first image; obtain a second chroma component from the second image; and combine a low frequency component of the first chroma component and a high frequency component of the second chroma component.

[0088] Specifically, the specific wavelength may be a wavelength over which reflectance
10 by hemoglobin is higher than reflectance by melanin.

[0089] Specifically, the specific wavelength is a wavelength within a red wavelength region.

[0090] Specifically, the specific color has a wavelength over which reflectance by hemoglobin is higher than reflectance by melanin.

15 **[0091]** Specifically, the specific color is red.

[0092] According to this image processing apparatus, the image processing apparatus obtains a first image and a second image using different light emissions, different cameras, a selectively-applicable color filter, or different sensors, and combines the first image and the second image to generate a third image, thereby improving beautification of a human skin in
20 an image captured by a camera.

[0093] FIG. 10 is a schematic structural diagram of an image processing apparatus according to another embodiment of the present invention. The image processing apparatus may be a portable multifunction device including a camera 501, a processor 502, a memory 503, and an input/output (I/O) interface 504. The camera 501, the processor 502, the memory
25 503, and the I/O interface 504 may be coupled to a bus 505. The image processing apparatus also includes an LED flash.

[0094] The camera 501 is configured to obtain a first image. The camera 501 is also configured to obtain a second image. For more specific functions and operations in the camera 501, reference may be made to the steps S101 and S102 in the method embodiment
30 shown in FIG. 4, and no repeated description is given here.

[0095] Specifically, the camera 501 may include a color sensor and may be configured to capture a first image, when the LED flash emits first light or when the LED flash does not emit light, and the camera 501 may be configured to capture a second image when the LED flash emits second light, wherein the second light has a specific wavelength.

5 **[0096]** Specifically, the camera 501 may be a dual camera including a first camera, including a color sensor, and a second camera, including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor. The first camera may be configured to capture a first image, and the second camera may be configured to capture a second image.

10 **[0097]** Specifically, the camera 501 may include a color sensor and a specific color filter which passes specific color. The camera 501 may be configured to capture a first image, when the specific color filter is not applied, and the camera 501 may be configured to capture a second image, when the specific color filter is applied.

[0098] Specifically, the camera 501 may include a first color sensor and a second color
15 sensor which detects specific color. The camera 501 may be configured to capture a first image using the first color sensor, and may be configured to capture a second image using the second color sensor.

[0099] The processor 502 may read a computer-readable program code stored in a memory 503 and may be configured to combine the first image and the second image to
20 generate a third image. For more specific functions and operations in the processor 502, reference may be made to the step S103 in the method embodiment shown in FIG. 4, and no repeated description is given here.

[00100] Specifically, the processor 502 may be configured to generate a first luminance component from the first image; generate a second luminance component from the second
25 image; and combine a low frequency component of the first luminance component and a high frequency component of the second luminance component.

[00101] Specifically, the processor 502 may be configured to generate a first chroma component from the first image; generate a second chroma component from the second
30 image; and combine a low frequency component of the first chroma component and a high frequency component of the second chroma component.

[00102] The I/O interface 504 may be connected to a display so as to display the third image on a screen.

[00103] According to this image processing apparatus, the image processing apparatus obtains a first image and a second image using different light emissions, different cameras, a selectively-applicable color filter, or different sensors, and combines the first image and the second image to generate a third image, thereby improving beautification of a human skin in an image captured by a camera.

[00104] FIG. 11 shows an original image, a smoothed image according to the prior art, and an image processed according to an embodiment of the present invention.

[00105] As shown in FIG. 11(A), there are spots or freckles in the original image. By using a smoothing filter or a de-noise filter, as shown in FIG. 11(B), some of the spots or freckles are smoothed, but some of the spots or freckles cannot be removed and big pockmarks or deep colored spots remain. By using an embodiment of the present invention, as shown in FIG. 11(C), some of the spots or freckles which cannot be removed according to the prior art can be removed. Thus, the present invention can improve beautification of a human skin in an image captured by a camera.

[00106] A person of ordinary skill in the art may understand that, each aspect of the present invention or a possible implementation manner of each aspect may be specifically implemented as a device, a method, or a computer program product. Therefore, each aspect of the present invention or a possible implementation manner of each aspect may use forms of hardware only embodiments, software only embodiments (including firmware, resident software, and the like), or embodiments with a combination of software and hardware. In addition, each aspect of the present invention or a possible implementation manner of each aspect may take a form of a computer program product, where the computer program product refers to a computer-readable program code stored in a computer-readable medium.

[00107] The computer-readable medium may be a computer-readable signal medium or a computer-readable storage medium. The computer-readable storage medium includes but is not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semi-conductive system, device, or apparatus, or any appropriate combination thereof, such as a random access memory (RAM), a read-only memory (ROM), an erasable programmable read only memory

(EPROM or flash memory), an optical fiber, and a compact disc read-only memory (CD-ROM).

[00108] A processor in a computer reads computer-readable program code stored in a computer-readable medium, so that the processor can perform a function and an action specified in each step or a combination of steps in a flowchart; and an apparatus is generated to implement a function and an action specified in each block or a combination of blocks in a block diagram.

[00109] It should be noted that, in some alternative implementation solutions, each step in the flowcharts or functions specified in each block in the block diagrams may not occur in the illustrated order. For example, dependent on related functions, two steps or two blocks illustrated consecutively may in fact be executed substantially at the same time, or these blocks may sometimes be executed in reverse order.

[00110] Obviously, a person skilled in the art can make various modifications and variations to the present invention without departing from the spirit and scope of the present invention. The present invention is intended to cover these modifications and variations provided that they fall within the scope of protection defined by the following claims and their equivalents.

CLAIMS

What is claimed is:

1. An image processing method, comprising:

at a portable multifunction device with an LED (light emitting diode) flash, including at

5 least two LEDs, a camera, including a color sensor, and one or more processors,

obtaining, by the camera, a first image, when the LED flash emits first light or when the LED flash does not emit light;

obtaining, by the camera, a second image, when the LED flash emits second light, wherein the second light has a specific wavelength; and

10 combining, by the one or more processors, the first image and the second image to generate a third image.

2. An image processing method, comprising:

at a portable multifunction device with a first camera, including a color sensor, a second
15 camera, including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor, and one or more processors,

obtaining, by the first camera, a first image;

obtaining, by the second camera, a second image; and

combining, by the one or more processors, the first image and the second image to
20 generate a third image.

3. An image processing method, comprising:

at a portable multifunction device with a camera, including a color sensor and a specific color filter which passes specific color, and one or more processors,

25 obtaining, by the camera, a first image, when the specific color filter is not applied;

obtaining, by the camera, a second image, when the specific color filter is applied; and

combining, by the one or more processors, the first image and the second image to generate a third image.

4. An image processing method, comprising:

at a portable multifunction device with a camera, including a first color sensor and a second color sensor which detects specific color, and one or more processors,

5 obtaining, by the camera, a first image using the first color sensor;
obtaining, by the camera, a second image using the second color sensor; and
combining, by the one or more processors, the first image and the second image to generate a third image.

10 5. The image processing method according to any one of claims 1-4, wherein combining, by the one or more processors, the first image and the second image to generate the third image comprises:

obtaining a first luminance component from the first image;
obtaining a second luminance component from the second image; and
15 combining a low frequency component of the first luminance component and a high frequency component of the second luminance component.

6. The image processing method according to any one of claims 1-5, wherein combining, by the one or more processors, the first image and the second image to generate the third
20 image comprises:

obtaining a first chroma component from the first image;
obtaining a second chroma component from the second image; and
combining a low frequency component of the first chroma component and a high frequency component of the second chroma component.

25

7. The image processing method according to claim 1, wherein the specific wavelength is a wavelength over which reflectance by hemoglobin is higher than reflectance by melanin.

8. The image processing method according to claim 1 or 7, wherein the specific
30 wavelength is a wavelength within a red wavelength region.

9. The image processing method according to any one of claims 2-4, wherein the specific color has a wavelength over which reflectance by hemoglobin is higher than reflectance by melanin.

5

10. The image processing method according to any one of claims 2-4 and 9, wherein the specific color is red.

11. An image processing apparatus, comprising:

10 a first obtainment unit configured to obtain a first image, when an LED (light emitting diode) flash, including at least two LEDs, emits first light or when the LED flash does not emit light;

a second obtainment unit configured to obtain a second image, when the LED flash emits second light, wherein the second light has a specific wavelength; and

15 a combination unit configured to combine the first image and the second image to generate a third image.

12. An image processing apparatus, comprising:

20 a first obtainment unit configured to obtain a first image using a first camera including a color sensor;

a second obtainment unit configured to obtain a second image using a second camera including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor; and

25 a combination unit configured to combine the first image and the second image to generate a third image.

13. An image processing apparatus, comprising:

30 a first obtainment unit configured to obtain a first image using a camera including a color sensor and a specific color filter which passes specific color, when the specific color filter is not applied;

a second obtainment unit configured to obtain a second image using the camera, when the specific color filter is applied; and

a combination unit configured to combine the first image and the second image to generate a third image.

5

14. An image processing apparatus, comprising:

a first obtainment unit configured to obtain a first image using a first color sensor in a camera;

10 a second obtainment unit configured to obtain a second image using a second color sensor which detects specific color; and

a combination unit configured to combine the first image and the second image to generate a third image.

15 15. The image processing apparatus according to any one of claims 11-14, wherein the combination unit is configured to:

obtain a first luminance component from the first image;

obtain a second luminance component from the second image; and

combine a low frequency component of the first luminance component and a high frequency component of the second luminance component.

20

16. The image processing apparatus according to any one of claims 11-15, wherein the combination unit is configured to:

obtain a first chroma component from the first image;

obtain a second chroma component from the second image; and

25 combine a low frequency component of the first chroma component and a high frequency component of the second chroma component.

17. The image processing apparatus according to claim 11, wherein the specific wavelength is a wavelength over which reflectance by hemoglobin is higher than reflectance
30 by melanin.

18. The image processing apparatus according to claim 11 or 17, wherein the specific wavelength is a wavelength within a red wavelength region.

5 19. The image processing apparatus according to any one of claims 12-14, wherein the specific color has a wavelength over which reflectance by hemoglobin is higher than reflectance by melanin.

20. The image processing apparatus according to any one of claims 12-14 and 19,
10 wherein the specific color is red.

21. A portable multifunction device, comprising:
an LED (light emitting diode) flash, including at least two LEDs;
a camera, including a color sensor; and
15 one or more processors;
wherein the camera captures a first image, when the LED flash emits first light or when the LED flash does not emit light;
the camera captures a second image when the LED flash emits second light, wherein the second light has a specific wavelength; and
20 the one or more processors combine the first image and the second image to generate a third image.

22. A portable multifunction device, comprising:
a first camera, including a color sensor;
25 a second camera, including a color sensor and a specific color filter which passes specific color and is placed in front of the color sensor; and
one or more processors;
wherein the first camera captures a first image;
the second camera captures a second image; and
30 the one or more processors combine the first image and the second image to generate a

third image.

23. A portable multifunction device, comprising:

a camera, including a color sensor and a specific color filter which passes specific color;

5 and

one or more processors;

wherein the camera captures a first image, when the specific color filter is not applied;

the camera captures a second image, when the specific color filter is applied; and

the one or more processors combine the first image and the second image to generate a

10 third image.

24. A portable multifunction device, comprising:

a camera, including a first color sensor and a second color sensor which detects specific color; and

15 one or more processors;

wherein the camera captures a first image using the first color sensor;

the camera captures a second image using the second color sensor; and

the one or more processors combine the first image and the second image to generate a third image.

20

25. A portable multifunction device, comprising:

one or more processors; and

a memory;

wherein one or more programs stored in the memory, when executed by the one or more
25 processors, cause the one or more processors to perform the method according to any one of claims 1-10.

26. A computer-readable storage medium storing one or more programs which, when
executed by a portable multifunction device, cause the portable multifunction device to
30 perform the method according to any one of claims 1-10.

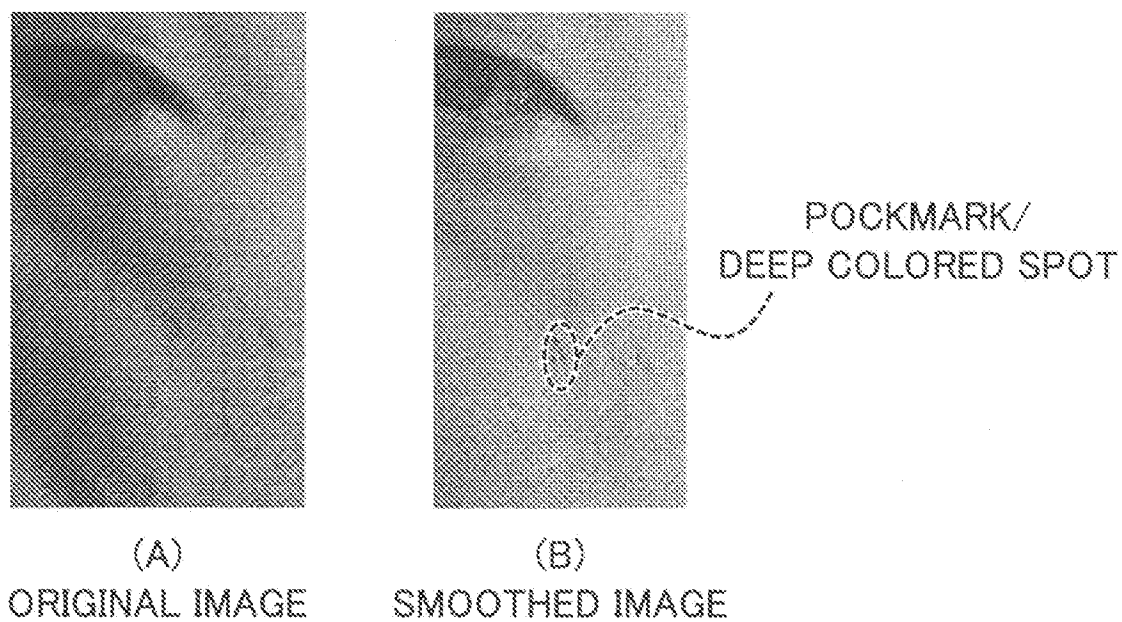


FIG. 1

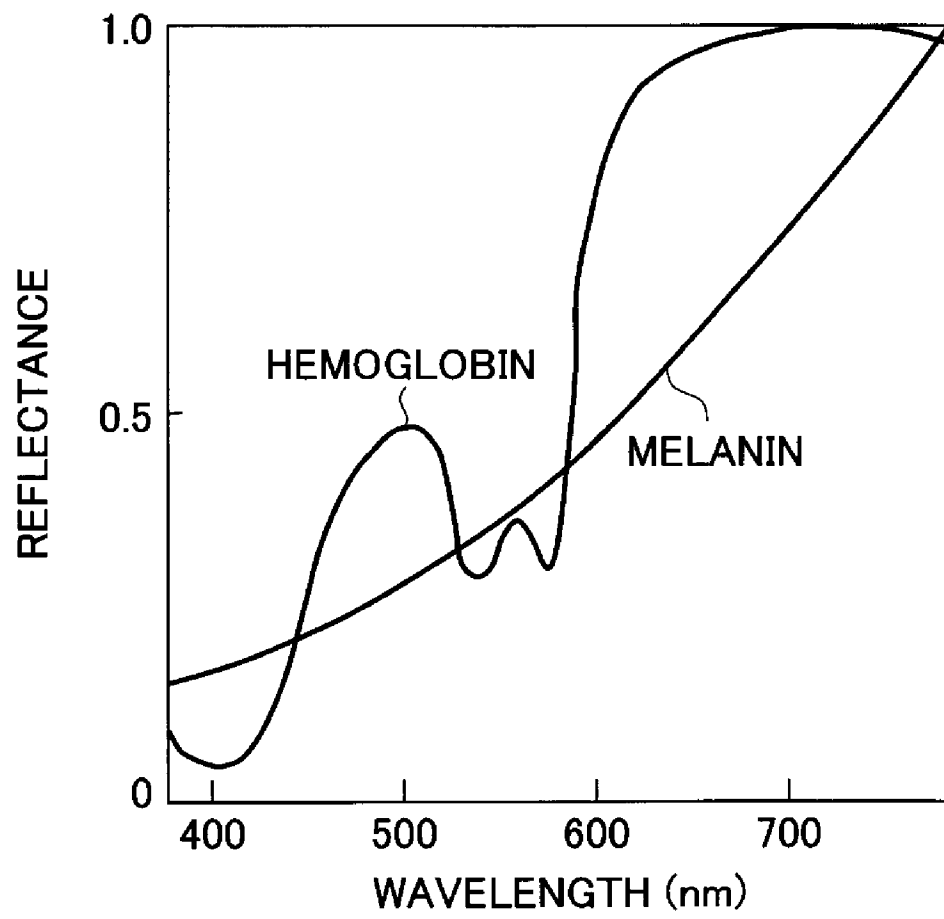


FIG. 2

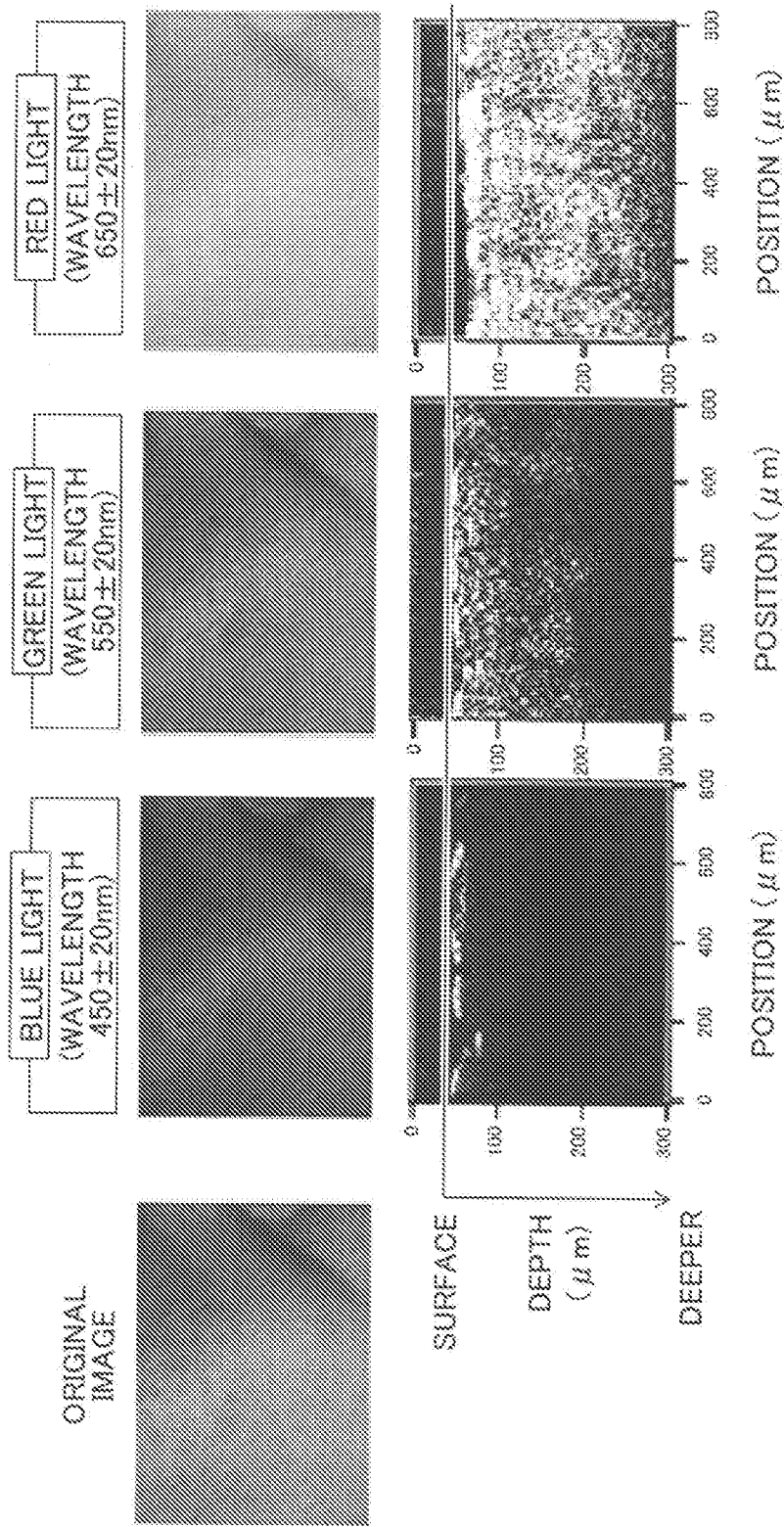


FIG. 3

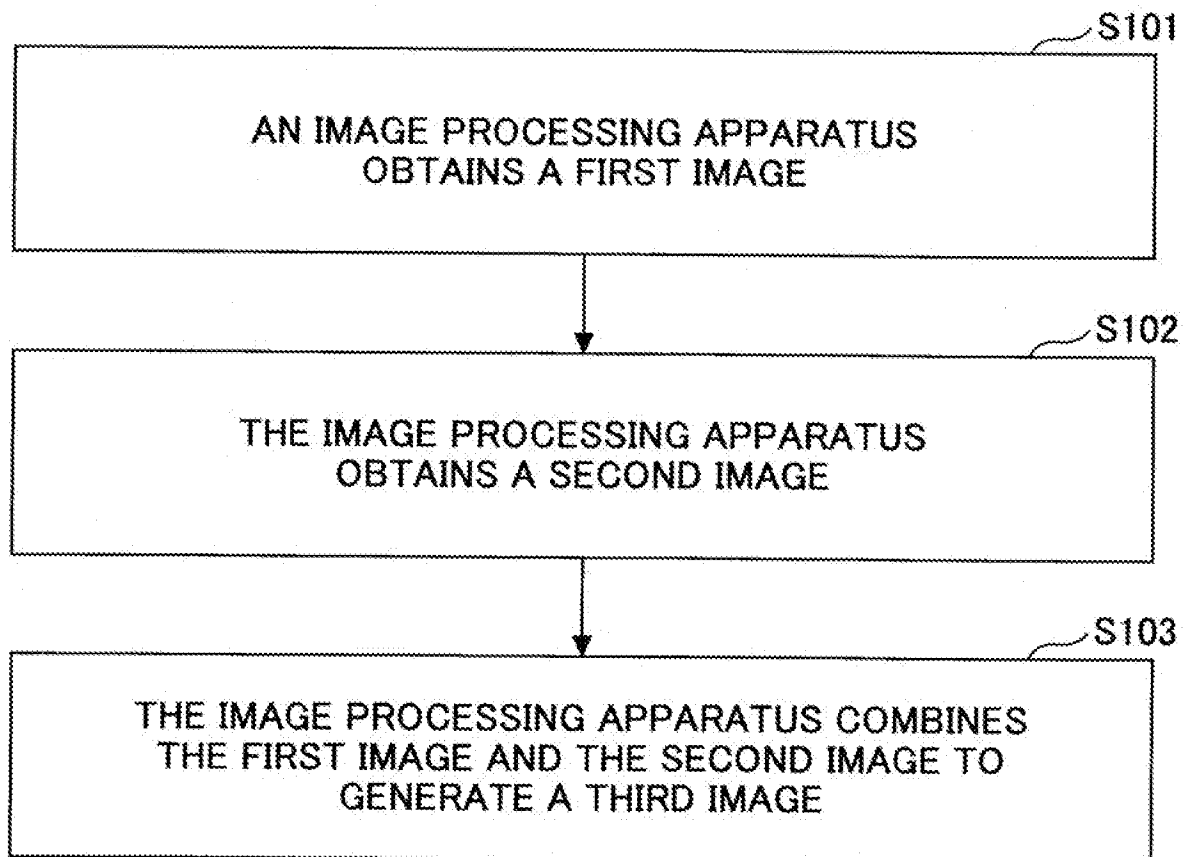


FIG. 4

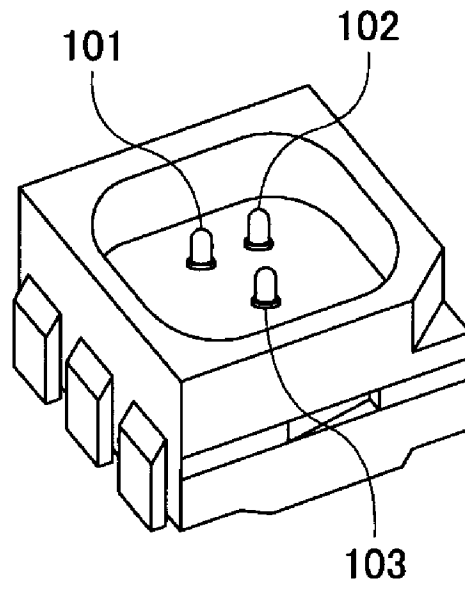
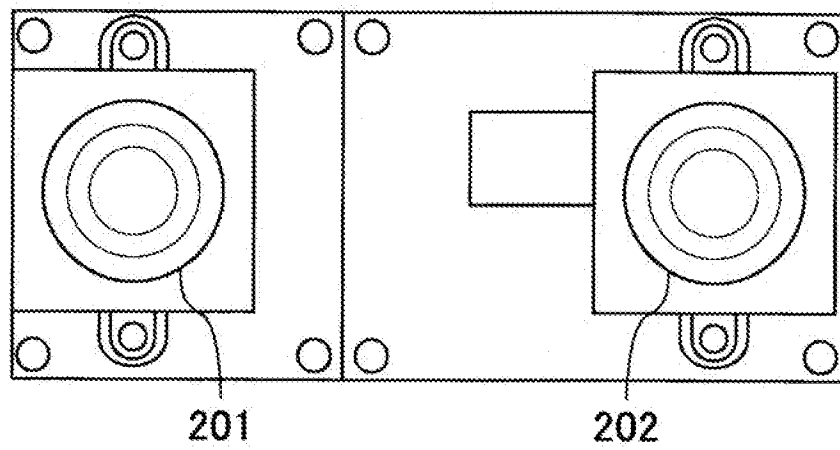


FIG. 5

(A) FRONT VIEW



(B) CROSS-SECTION VIEW

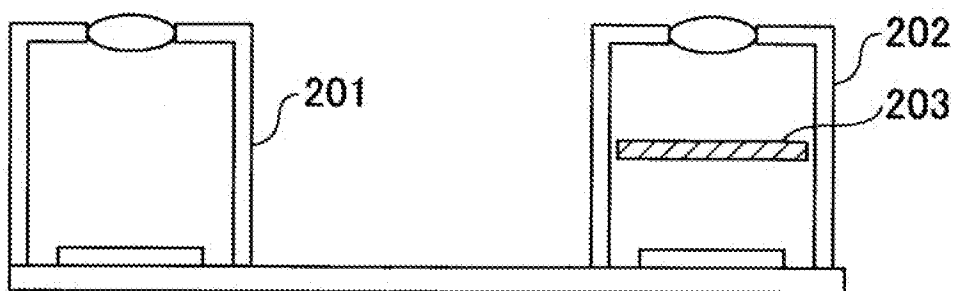


FIG. 6

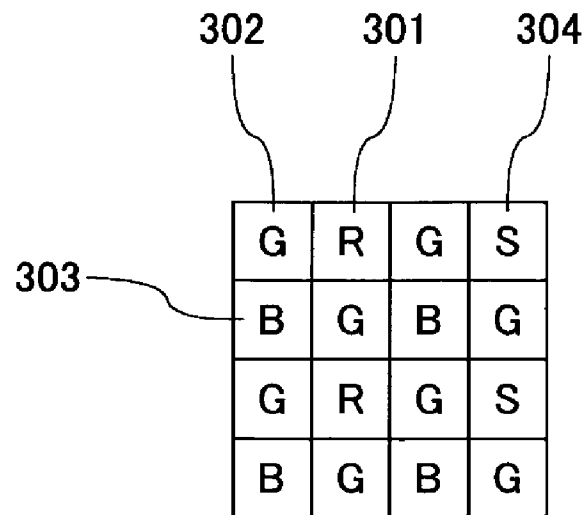


FIG. 7

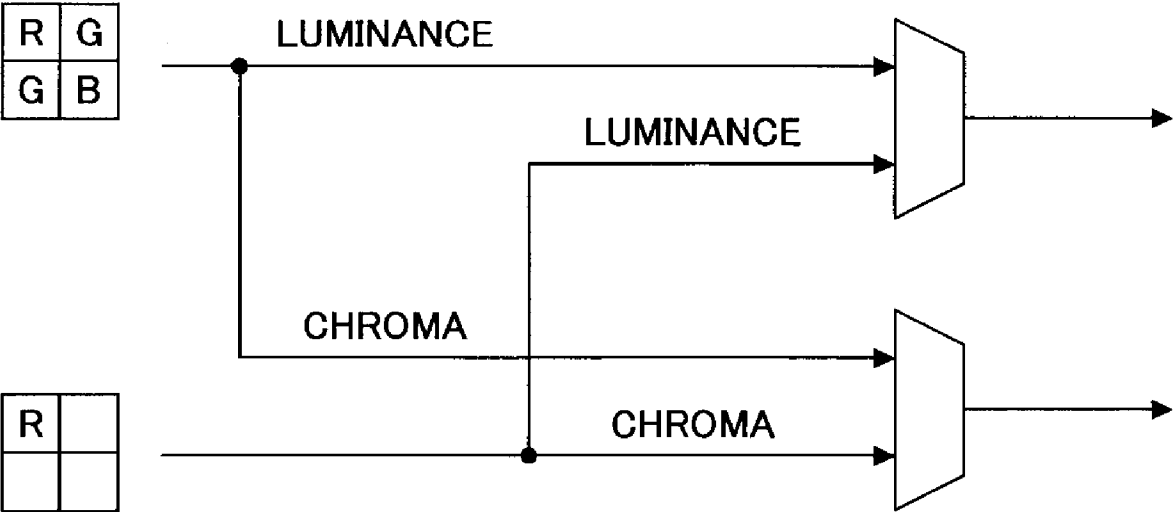


FIG. 8

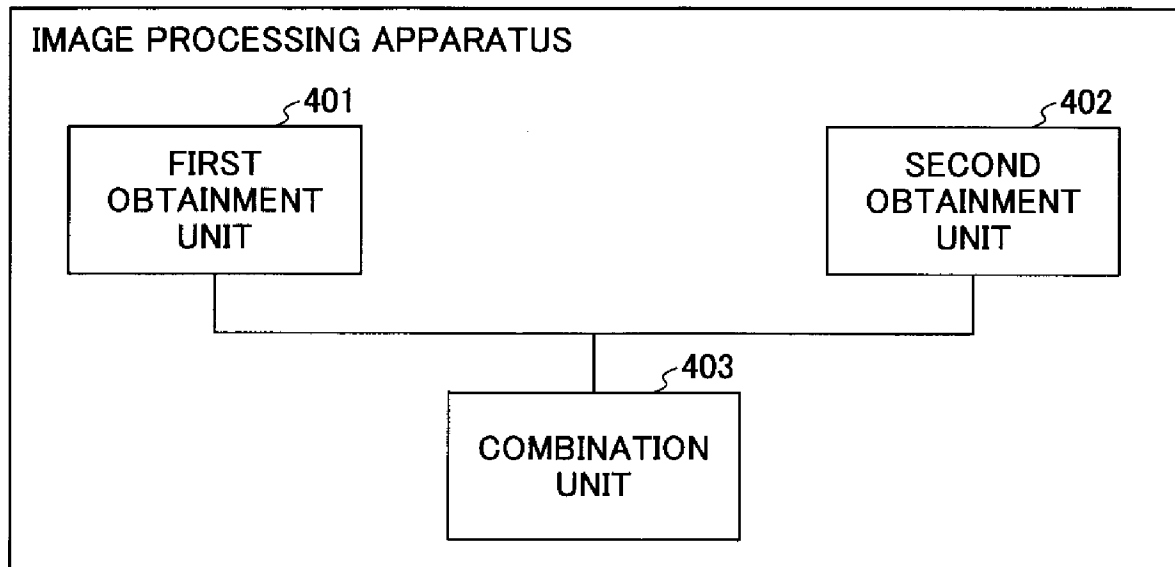


FIG. 9

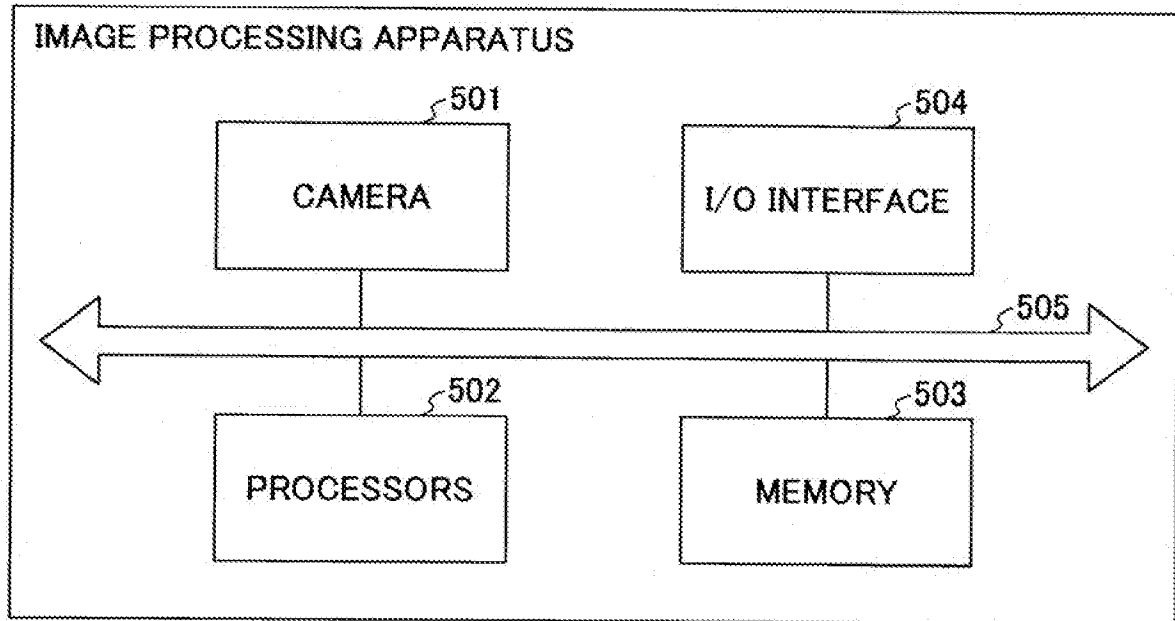


FIG. 10

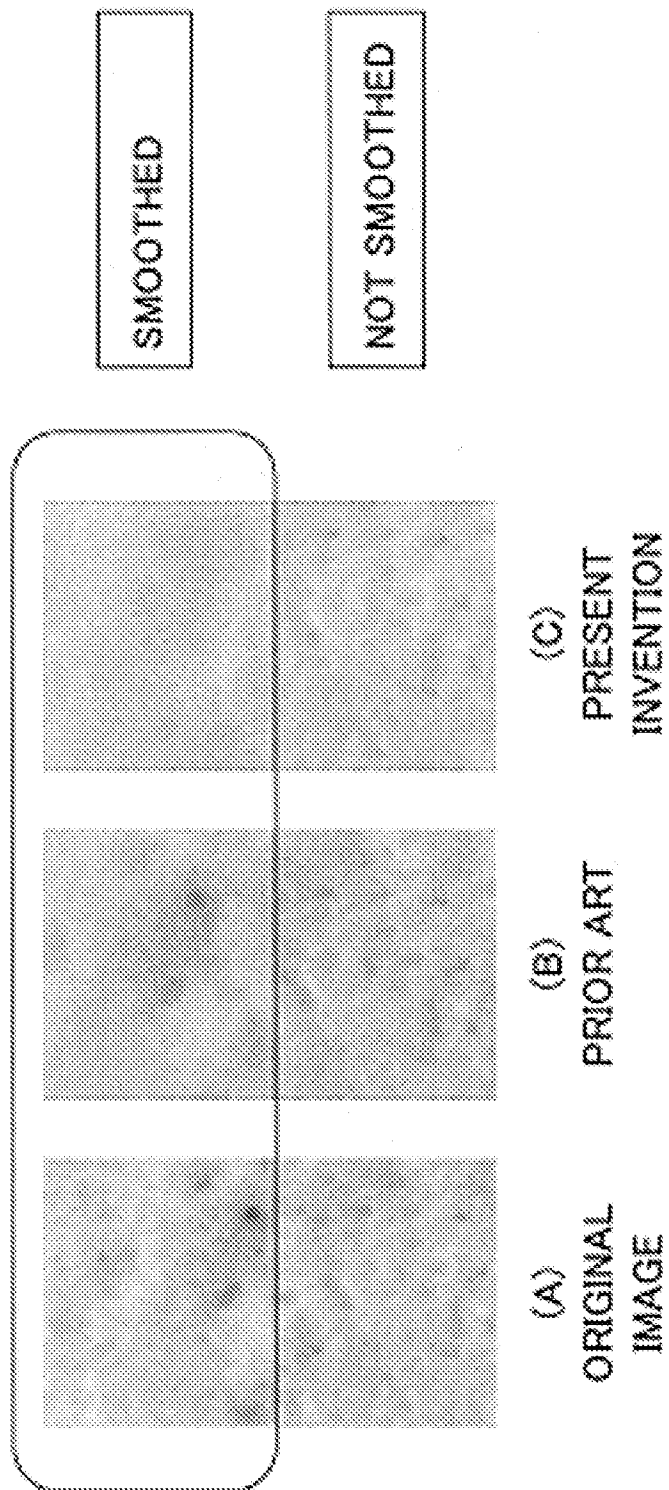


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2016/077687

A. CLASSIFICATION OF SUBJECT MATTER

H04N 5/225(2006.01)i; G06T 5/50(2006.01)i

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)

H04N; G06T; G06K

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)

CNPAT,CNKI,WPLEPODOC: image, combine, mix, fuse, skin, face, first, second, wavelength, LED, filter, sensor, mobile, handset, phone, terminal, portable, camera

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 104125442 A (SONY CORP.) 29 October 2014 (2014-10-29) description, paragraphs [0056]-[0064], [0067], [0085], [0101]-[0105], [0123]-[0129]	1-26
A	JP 2006115316 A (MATSUSHITA DENKI SANGYO K.K.) 27 April 2006 (2006-04-27) the whole document	1-26
A	CN 105187726 A (GUANGZHOU XUNTENG INFORMATION TECHNOLOGY CO., LTD.) 23 December 2015 (2015-12-23) the whole document	1-26
A	CN 102244789 A (SONY CORP.) 16 November 2011 (2011-11-16) the whole document	1-26
A	WO 2008062967 A1 (KIM, CHANG-HWAN) 29 May 2008 (2008-05-29) the whole document	1-26

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"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

28 November 2016

Date of mailing of the international search report

21 December 2016

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/077687

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