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(54) **Title**: SYSTEMS AND METHODS FOR INFRARED DETECTION

(57) **Abstract**: A fluorescence detection system includes a light source for coupling with a mobile device and software, having machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, capable of: activating the light source in coordination with capturing one or more images using a camera of the mobile device; analyzing an image captured with the light source on with an image captured with the light source off, to detect a shift of intensity within a predetermined color range within the images; and identifying and authenticating objects by measuring the intensity shift within the images.

SYSTEMS AND METHODS FOR INFRARED DETECTION

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Patent Application Serial Number 61/833,365, titled "Systems and Methods for Infrared Detection", filed June 10, 2013, and incorporated herein by reference.

[0002] This application also claims priority to U.S. Patent Application Serial Number 61/902,524, titled "Systems and Methods for Infrared Detection", filed November 11, 2013, and incorporated herein by reference.

BACKGROUND

[0003] Many mobile phones and tablets include cameras designed to take pictures. These cameras typically use a CMOS (complementary metal-oxide semiconductor) sensor with an infrared cut-off filter designed to block near infrared photons from reaching the imaging sensor, while passing visible light. The IR cut-off filter prevents infrared radiation from distorting colors in images from colors as generally perceived by the human eye. While this results in more natural looking images, conventional mobile devices are unsuitable for detecting fluorescent emission at IR wavelengths without removal of the included infrared cut-off filter.

SUMMARY

[0004] In one embodiment, a fluorescence detection system includes a light source for coupling with a mobile device and software, having machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, capable of: activating the light source in coordination with capturing one or more images using a camera of the mobile device; analyzing an image captured with the light source on with an image captured with the light source off, to detect a shift of intensity within a predetermined color range within the images; and identifying and authenticating objects by measuring the intensity shift within the images.

[0005] In another embodiment, a fluorescence detection system includes software, having machine readable instructions loadable into memory of a mobile device and executable by a processor of the mobile device, capable of: activating a display of the mobile device to emit light in coordination with capturing one or more images using a camera of the mobile device; analyzing an image captured with the display on with an image captured with the display off, to detect a shift of intensity within a predetermined color range within the images; and identifying and authenticating an object by measuring the intensity shift within the images.

[0006] In another embodiment, a fluorescence detection system couples with a mobile device having a camera. The system includes a filter for placing over a flash of the camera, software, having machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, that is capable of: capturing a first image of an object using a camera of the mobile device when the flash is not active; activating the flash in coordination with capturing a second image of the object using the camera; analyzing the first and second images to detect a shift of intensity within a predetermined color range within the images based upon fluorescence from the object in response to activation of the flash; and identifying and authenticating the object based upon the detected shift in intensity.

[0007] In another embodiment, a near-IR filter array layer for an electromagnetic sensor array includes a plurality of infrared filters arranged over the sensor array such that, for each pixel of the sensor array, each infrared filter is configured to pass a different wavelength of electromagnetic radiation within the infrared wavelength band to one sensor of the pixel.

[0008] In another embodiment, a 3D printer has filament authentication, and includes a print engine for generating a 3D object using a filament of material, and an IR authenticator positioned to authenticate the filament before use by the print engine. Operation of the print engine is based upon authentication of the filament by the IR authenticator.

[0009] In another embodiment, a method authenticates a filament used in a 3D printer. An IR beam at a first wavelength is projected onto the filament within the 3D printer. IR fluorescence at a second wavelength from a dye within the filament is detected in response to the IR beam. The detected IR fluorescence indicates authentication of the filament within the 3D printer.

BRIEF DESCRIPTION OF THE FIGURES

[0010] FIG. 1 schematically illustrates one exemplary fluorescence detection system coupled with a mobile device, illustrated as a smart phone, in an embodiment.

[0011] FIGs. 2 and 3 show a perspective view of operation of the mobile device of FIG. 1 to capture an IR image and an RGB image of an object to be authenticated.

[0012] FIG. 4 shows exemplary location of the IR fluorescent dye within the object of FIG. 2.

[0013] FIG. 5 is a schematic showing one exemplary IR image sensor for use in a digital camera, in an embodiment.

[0014] FIG. 6 is a graph showing three exemplary responses of the sensor and filter combinations of FIG. 5.

[0015] FIG. 7 shows one exemplary 3D printer for printing a 3D object that may be externally authenticated, in an embodiment.

[0016] FIG. 8 shows one exemplary 3D printer with 3D printer consumable authentication, in an embodiment.

DETAILED DESCRIPTION

[0017] U.S. Patent Application serial Number 13/691,724, titled "System and Method for Authenticating Objects Using IR", filed November 30, 2012, is incorporated herein by reference for enablement purposes.

Fluorescence detection for acquisition, identity and authentication within visible light using the RGB camera on mobile devices

[0018] Disclosed is a solution for fluorescent detection using the camera of a mobile device. In particular, a system for fluorescent detection using a mobile device includes a light source such as an LED powered by the mobile device. The LED may be configured with the mobile device (e.g., a "flash" for use with the camera of the mobile device) or adapted for plugging into the mobile device (e.g., using the headphone jack of the mobile device). Software running on the mobile device activates the LED to illuminate an object/subject of interest in coordination with capturing one or more images of the object/subject using the on-board camera of the mobile device. A first image of the object, captured when the LED is turned off, is compared to a second image of the object, captured when the LED is turned on, by software to detect a shift of intensity for a given color range within the images. In one aspect, a blue to violet LED (e.g., 450nm wavelength) is used to illuminate the object, and the software detects a shift of intensity within a red wavelength band when the object includes a material that fluoresces in the red wavelength band when excited by light at a wavelength of 450nm. In another embodiment, a band-pass filter is applied to the LED "flash" of the mobile device such that when activated, the LED emits light of a particular wavelength.

[0019] The measured intensity shift allows the software on the mobile device to identify and authenticate objects. Identifying data may be hidden within the intensity shift, by combining known information about (a) the size of a fluorescent marker within or on the object that is used to gauge distance from the object with (b) the amount of intensity shift detected within the captured images.

[0020] For example, an object may be impregnated or coated (in part or in whole) with one or more fluorescent dyes. A fluorescent "signature" of the object may be measured using the LED and the camera as described above, and the information stored in memory accessible by the software. In one aspect, fluorescent signatures of a plurality of objects used in playing a mobile game may be included in gaming data stored within memory of the mobile device or accessible via the Internet.

[0021] When used in connection with a game, for example, the mobile device may be used to authenticate an action figure or other object, and thus, to "unlock" a corresponding character within the game. The mobile device may therefore replace USB platforms currently used to link toys/objects with video game characters, thus granting a player the freedom to play his or her game away from the platform.

[0022] In another aspect, software running on the mobile device controls an RGB LED to emit light within a desired wavelength band in coordination with image capture (i.e., to emit light of a desired color when taking a picture). For example, software controls the RGB LED to emit blue-violet light, in order to elicit a fluorescent response measurable in the red wavelength band. One or more images taken with the LED emitting in the desired wavelength band are processed with one or more images taken with the LED off, to determine an intensity shift in the red band, in order to identify and authenticate objects.

[0023] In another aspect, a filter may be placed over the flash of a mobile device camera, in order to limit emission by the flash, in order to elicit a measurable fluorescent response by the object. For example, a filter may block green and red emissions of the flash, to limit light striking the object to blue. An intensity shift within the red color channel may then be detected within captured images and analyzed to authenticate the object.

[0024] Dyes may be designed to regulate object emission. Given that the fluorescence is within visible light, the authentication process may be noticeable, barely noticeable, or hardly detectable to the human eye.

[0025] The disclosed systems and methods beneficially provide not only mobile authentication, but also rapid authentication. Mobile device cameras typically run at 24 to 30 frames per second, and as little as one frame is needed to capture a fluorescence response to an excitation wavelength in order to authenticate the object. Thus, noticeability by the human eye of the LED activation and of the corresponding fluorescence response would be negligible. However, additional frames may be used to provide data to sort against false positives.

[0026] A mobile device (such as an iPhone) may be configured with a fluorescence detection system for acquisition, identity and authentication of an object. An LED powered by the phone jack of the mobile device and attached with a back surface of the device, proximate the device camera and camera flash, emits at 450nm. The object being detected is painted with a dye that fluoresces when illuminated by the LED, as shown in the image displayed on the mobile device screen. Note that the mobile device screen shows a standard, RGB image of the object as taken by the built-in mobile device camera, and an IR / differenced image in which object fluorescence is visible.

[0027] FIG. 1 schematically illustrates one exemplary fluorescence detection system 100 configured as a mobile device 102, illustrated as a smart phone. FIGs. 2 and 3 show a perspective view of operation of mobile device 102 of FIG. 1 capturing an IR image 116 and an RGB image 118 of an object 202 to be authenticated. FIG. 4 shows exemplary location of IR fluorescent dye 306 within object 202. FIGs. 1, 2, 3 and 4 are best viewed together with the following description.

[0028] Software 104, stored within memory 106 of mobile device 102, includes machine readable instructions that when executed by a processor 108 of mobile device 102 interact with mobile device 102 to activate an LED 110 coupled with mobile device 102 in coordination with capturing one or more images of object 202 with a camera 112 of mobile device 102. LED 110 is for example powered by mobile device 102 at an interface 114, such as a jack of mobile device 102 for example. It will be appreciated that features of system 100 are placed as shown in FIG. 1 for purposes of illustration only, and that shown features (e.g., LED 110, interface 114, camera 112, a display 122 and others) may be located in positions other than those shown in FIG. 1.

[0029] At least one captured IR image 116 (captured by camera 112 when LED 110 is on), and at least one RGB image 118 (captured by camera 112 when LED 110 is off) are processed/compared by processor 108 to generate a difference image 119 for detecting a shift of intensity for a given color range within images 116 and 118. In one aspect, software 104 triggers LED 110 to flash in synch with a frame rate of camera 112 such that LED 110 is active to illuminate object 202 only during capture of alternate frames by camera 112. Software 104 then generates difference image 119 for pairs of captured images and may then evaluate color shifts of the red channel of camera 112 based upon red pixel values within IR image 116, RGB image 118, and difference image 119. In one embodiment, LED 110 represents a built-in "flash" LED of mobile device 102 that is controlled to provide illumination for use with camera 112.

[0030] In one example, where LED 110 emits light having a wavelength of 450nm, software 104 detects a shift of intensity within a red wavelength band when the imaged object includes fluorescent dye 306 (or other material with fluorescing pigments) that fluoresces in the red wavelength band when excited by light at a wavelength of 450nm. The measured intensity shift within the red wavelength band allows software 104 to identify and authenticate object 202 captured within images 116, 118.

[0031] Software 104, executed by processor 108, compares a measured intensity shift and other image data of images 116, 118, 119 with a database 150 of fluorescent signatures 152 of known, authentic objects to identity and authenticate an object within images 116, 118, where each signature 152 may define one or more of wavelength, position, shape, and other specifics of fluorescent marker(s) present within object 202. As shown, database 150 is stored in memory 106, but may be stored elsewhere that is otherwise accessible by software 104, for example from a database stored on a server and accessible via the Internet via a wireless interface 120.

[0032] IR Image 116, RGB image 118 and/or difference image 119 highlighting fluorescence of object 202 may be displayed on a display 122 of mobile device 102. As shown in FIG. 3, object identity/authentication and other information from database 150 may also be displayed on display 122, once object 202 is identified and authenticated. Upon identification and authentication, software 104 may trigger or invoke other actions, both on mobile device 102 and external thereto using wireless interface 120.

[0033] In one embodiment, display 122 is controlled by software 104 to display blue (e.g., to emit light at a 450nm wavelength) to illuminate an object placed in front of display 122, thereby eliminating the need for LED 110. In this embodiment, camera 112 is forward facing on mobile device 102 to capture images of the object illuminated by light from display 112. Control (e.g., activation and deactivation) of display 122 is similar to control of LED 110 as described above, and camera 112 is controlled to capture RGB image 118 when display 122 is inactive, and to capture IR image 116 when display 1122 is emitting light at a 450nm wavelength. This embodiment is particularly advantageous where mobile device 102 is a tablet computer that does not have a built in "flash" LED.

A Near-IR Filter Array Layer for CMOS Sensors

[0034] Most digital cameras made today, such as used in mobile communication devices, use a technology developed by Bryce Bayer of Eastman Kodak, a Bayer filter. The Bayer filter, or Bayer layer, is a "visible light" filter array comprised of red, green and blue color filters mounted directly before sensors grouped as pixels. Each filter of the array allows only photons of a specific color onto the corresponding sensor, where each pixel has one red, two green, and one blue filter and four corresponding sensors. Software then applies various demosaicing algorithms to determine color (e.g., a set of RGB values) for each pixel based upon sensed light levels and the geometry of the group of filters and sensors forming each pixel.

[0035] CMOS and CCD sensors are sensitive to light with wavelengths between about 400 and about 1100nm, and therefore may be used to detect radiation in at least part of the near infrared (700-1200 nm) portion of the electromagnetic spectrum. However, since the Bayer layer allows only light within a human visible wavelength (e.g., 400nm to 700nm) to pass through, conventional cameras formed with the Bayer layer are unable to detect IR wavelengths and are not suited for infrared image capture. With the Bayer filters array removed, these conventional cameras detect only intensity levels of near IR radiation.

[0036] By replacing the Bayer layer with a filter array layer having portions that pass light in in only certain bands of near infrared, the digital camera may be used to sense energy at specific infrared wavelengths. FIG. 5 is a schematic showing one exemplary IR image sensor 500 for use in a digital camera. IR image sensor 500 has an array of sensors 502 and an array of IR filters 504 positioned thereon. Sensors 502 and filters 504 are grouped into pixels 506 that each has four sensors 502 and four corresponding filters 504 in this example. Each sensor 502 operates to sense electromagnetic energy in the wavelength range of 700-1200 nm. Within each pixel 506, filters 504 are selected to pass IR energy at two or more different wavelengths. FIG. 6 is a graph showing three exemplary responses of sensor 502 and filter 504 combinations. In a first response 602, filter 504(1) has a pass band wavelength centered at 720nm, in a second response 604, a filter 504(2) has a pass band wavelength centered at 775nm, and in a third response 606, a filter 504(3) has a pass band wavelength centered at 845nm. As appreciated, where additional sensitivity is desired, two or more filters 504 may be configured at the same pass band wavelength. Further, pixels may have more than four sensors 502 and filters 504 such that greater selectivity within the near IR waveband may be achieved. In one embodiment, within each pixel 506, certain filters 504 are selected to pass visible light (e.g., as with conventional Bayer filters) and other filters are configured to pass only IR wavelengths as shown in FIG. 6, wherein software (e.g., software 104) operates to selectively process output for sensors 502 for each pixel 506 to generate one or both of a visible image and an IR image. Where specific wavelengths are configured within filters 504, the software may operate to identify specific frequency responses from object 202 for purposes of authentication. For example, an object may be configured with multiple fluorescing dyes that fluoresce at different wavelengths, where filters 504 are configured to determine presence or absence of these fluorescent responses to achieve stronger authentication.

[0037] In one embodiment, camera 112 of system 100 is configured with image sensor 500 of FIG. 5 and used for infrared photography, detection and authentication. As described above, LED 110 is controlled by software 104 to elicit a fluorescent emission from object 202 tagged (impregnated or otherwise marked) with fluorescent dye 306. For example, software 104 activates LED 110 to illuminate object 202 in coordination with capturing IR image 116, deactivates LED 110 in coordination with capturing RGB image 118, where RGB image 118 does not represent a visible image, but is used to detect background IR levels. Software 104 then compares IR image 116 with RGB image 118 to generate difference image 119 that has background levels of IR removed. Software 104 may then process selective sensors 502 values for each pixel 506 within difference image 118 to identify a fluorescent response "signature" (a fluorescent stamp, pattern, marking, complex emission or simple emission) of object 202. Additional multiple wavelength analysis of IR image 116 and/or difference image 119 may be performed to determine object identity and authentication, for example by comparing a unique spectral signature of the dye or material (or combinations thereof) with a database of signatures of tagged objects.

Dye in filament for 3D printing

[0038] Used in cooperation with fluorescent detection, companies may digitally distribute their physical goods, by adding one or more IR fluorescing dyes of a known frequency response to filament, fibers or resins used to manufacture items through 3D printing. The filament/resin/fiber (which may be used interchangeably hereafter) may be impregnated with or produced with one or more dyes that fluoresce at a known wavelength when illuminated by a light source.

[0039] FIG. 7 shows one exemplary 3D printer 700 for printing a 3D object 708 that may be externally authenticated. 3D printer 700 includes a print engine 702 that uses a filament consumable 704 such as a resin, illustratively shown supplied on a reel 706, for creating 3D object 708. A consumer purchases filament consumable 704 and downloads a digital design 720 for printing 3D object 708 from the resin. The consumer may then print (create) 3D object 708 using 3D printer 700. By purchasing and using resin 704 to create 3D object 708, 3D object 708 may be used interactively with other devices. For example, as shown in FIG. 7, an IR authenticator 710 (e.g., system 100 of FIG. 1) is used to (a) authenticate 3D object 708 based upon pigments within resin 704 from which 3D object 708 has been made, and (b) provide input to an interactive game 750. Without authentication of 3D object 708, interactive game 750 may have reduced or no functionality. Thus, to use 3D object 708 for participation with interactive game 750, the consumer is required to purchase and use resin 704 within 3D printer 700 when creating 3D object 708.

[0040] For example, IR authenticator 710 may include a computer/microprocessor, an IR projector, and an IR camera, and optionally an RGB camera. 3D object 708 is detected within a field of view of the IR camera (and optional RGB camera). Images of the object are captured with the camera, with the IR projector turned off and with the IR projector turned on, and the images are processed to detect a fluorescent response of the dye incorporated with 3D object 708. A fluorescent signature of 3D object 708 may be authenticated via an authentication algorithm, thus allowing 3D object 708 become interactive with game 750. In another example, authentication of 3D object 708 by IR authenticator 710 may unlock promotions offered via an external system for identifying specific objects (for example, a team jersey worn at a sporting event or while viewing a sporting event in front of a Smart TV).

[0041] In another example, 3D object 708 represents a building block or other component of a children’s toy, that is then identified and authenticated by IR authenticator 710 to unlock functionality of a third party system or device looking for the authenticated 3D object 708.

[0042] This technology may lower the cost of manufactured goods, as authentic products may be created at home or at local stores or distribution centers. In addition, new revenue streams may grow from consumers licensing and downloading digital files needed to print desired objects from the tagged filament/resin/fiber (e.g., filament/resin/fiber 704). Furthermore, objects made with tagged resin may be authenticated and the owner of the objects may receive a warranty for authenticated objects.

[0043] In another example of use, where filament 704 is used to print potentially dangerous objects, such as plastic weapons, filament 704 may be may be tagged with an invisible IR dye or combination of dyes that fluoresce at known wavelengths, such that a printed weapon may be detected by systems for detecting IR response incorporated into airport security for example.

3D Printer Consumable Authentication

[0044] FIG. 8 shows one exemplary 3D printer 800 with 3D printer consumable authentication, in an embodiment. 3D printer 800 includes a print engine 802 that uses a filament consumable 804, illustratively shown supplied on a reel 806, for creating a 3D object 808. Print engine 802 is coupled with an IR authenticator 810 that is invoked to authenticate filament 804. IR authenticator 810 includes an IR source and an IR detector (e.g., a camera capable of detecting IR wavelengths) that cooperate to detect presence of IR fluorescing pigments (e.g., dyes) within filament 804 in the beam of the IR source, for example at location 812. In one embodiment, IR authenticator 810 utilizes simple, low-cost and commonly available sensors (e.g., photodiode, phototransistors, CMOS and/or other sensors) for detection of fluorescence from dyes within filament 804.

[0045] In one embodiment, location 812 is within 3D printer 800 and positioned on a path of filament 804 as it is taken from reel 806 into print engine 802. In another embodiment, IR authenticator 810 detects fluorescence of pigments within filament 804 while it is still on reel 806.

[0046] In one example of operation, print engine 802 controls IR authenticator 810 to authenticate filament 804 when installed into 3D printer 800, wherein IR authenticator 810 generates IR at a first wavelength, and detects corresponding IR fluorescence at a second wavelength from one or more IR fluorescing dyes present within filament 804. In one embodiment, first and second wavelengths are 30-80nm or more apart, for example.

[0047] In one embodiment, print engine 802 utilizes identification of IR fluorescence to configure operating parameters for using filament 804. For example, presence or absence of one or more of a plurality of fluorescence responses may be used to specify processing parameters (e.g., temperature, feed rate, heat bed temperature, etc.) for using filament 804, wherein print engine 802 is thereby configured automatically when filament 804 is changed and a new IR "signature" identified.

[0048] In another embodiment, functionality of print engine 802 is restricted when filament 804 is not authenticated by IR authenticator 810. For example, 3D printer 800 may not function if filament 804 is not authenticated by print engine 802. A product manufacturer may release a 3D print design file of an object 808 that is associated with filament 804, wherein 3D printer 800 does not print the 3D print design unless the specific filament 804 is authenticated. The product manufacturer, or a third party associated with the manufacturer, may sell filament 804 at a premium price for use with 3D printer 800 to print one or more copies of the object from the 3D design file. In this example, printer 800 compares a fluorescence response of filament loaded into the printer with the fluorescence response expected of authentic filament 804 from the manufacturer. If the fluorescence responses do not match, print engine 802 inhibits generation of object 808. That is, unless IR authenticator 810 authenticates filament 804 within 3D printer 800, object 808 will not be printed. In one example, printer 800 will not run or complete the 3D design file if the filament is not authentic filament 804. In another example, print engine 802 is locked if authentication fails. A fluorescent signature of the filament may be authenticated via an authentication algorithm run by IR authenticator 810.

[0049] In one embodiment, print engine 802 and IR authenticator 810 may periodically authenticate filament 804 during printing of object 808, wherein failure to authenticate filament 804 may interrupt generation of object 808.

[0050] In another embodiment, print engine 802 is configured based upon identification and authentication of filament 804 by IR authenticator 810. For example, output quality of print engine 802 may be determined based upon authentication of filament 804, where the quality of material of filament 804, as identified and authenticated by IR authenticator 810, defines the output quality of print engine 802.

[0051] By authenticating filament 804 by IR authenticator 810 within 3D printer 800 and restricting functionality of print engine 802 based upon authentication, a printer manufacturer may direct users of 3D printer 800 to use a particular filament 804, such as from a preferred supplier. For example, a third party filament supplier would not include fluorescing dyes within the filament, or would not include the unique fluorescent signature of the particular filament 804, and thereby this third party product could not be used within 3D printer 800, or could be used only with reduced performance of 3D printer 800.

[0052] Although the example embodiments herein utilize an IR band for fluorescence, other bands may be used without departing from the scope hereof.

[0053] Fluorescing dyes may be added to other 3D printer filament materials, such as one or more of rubbers, metals, gelatins/lipids (e.g., for printing artificial tissues), stainless steel, brass, wood pulp-plastic mixtures, nylon, polyester, graphene/carbon fiber, ceramic, bacteria, and paper.

Combination of Features

[0054] Features described above as well as those claimed below may be combined in various ways without departing from the scope hereof. The following examples illustrate possible, non-limiting combinations the present invention has been described above, it should be clear that many changes and modifications may be made to the process and product without departing from the spirit and scope of this invention:

[0055] (a) A fluorescence detection system, including a light source for coupling with a mobile device, and software, comprising machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, capable of: activating the light source in coordination with capturing one or more images using a camera of the mobile device; analyzing an image captured with the light source on with an image captured with the light source off, to detect a shift of intensity within a predetermined color range within the images; and identifying and authenticating an object by measuring the intensity shift within the images.

[0056] (b) In the system denoted as (a), the light source being an LED adapted to plug into a port of the mobile device.

[0057] (c) In either of the systems denoted as (a) or (b), the LED sized to fit with the headphone jack of the mobile device.

[0058] (d) In any of the systems denoted as (a)-(c), the light source emitting at a wavelength of about 450nm.

[0059] (e) In any of the systems denoted as (a)-(d), the step of analyzing including detecting a fluorescent response from an object tagged with an IR-fluorescing dye in the red wavelength band within the image in response to the emission from the light source.

[0060] (f) In any of the systems denoted as (a)-(e), the mobile device being selected from the group including a mobile phone, a tablet, a laptop computer, a notebook computer, an MP3 player, an iPad, an iTouch, an iPod and a personal data assistant.

[0061] (g) A fluorescence detection system for coupling with a mobile device having a camera, including: a filter for placing over a flash of the camera, and software, comprising machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, capable of: capturing a first image of an object using the camera when the flash is not active; activating the flash in coordination with capturing a second image of the object using the camera; analyzing the first and second images to detect a shift in intensity within a predetermined color range within the first and second images based upon fluorescence from the object in response to activation of the flash; and identifying and authenticating the object based upon the detected shift in intensity.

[0062] (h) In the system denoted as (g), the filter blocking green and red emissions from the flash.

[0063] (i) In either of the systems denoted as (g) or (h), the predetermined color range comprising a red wavelength band, wherein the object is configured with an IR-fluorescing dye that fluoresces at the red wavelength band in response to the filtered emission from the flash.

[0064] (j) A 3D printer with filament authentication, including: a print engine for generating a 3D object using a filament of material; and an infrared (IR) authenticator positioned to authenticate the filament before use by the print engine; wherein operation of the print engine is based upon authentication of the filament by the IR authenticator.

[0065] (k) In the 3D printer denoted as (j), the print engine initiating authentication of the filament when the filament is installed into the 3D printer.

[0066] (l) In either of the 3D printers denoted as (j) or (k), the print engine initiating authentication of the filament periodically during operation of the print engine.

[0067] (m)In any of the 3D printers denoted as (j)-(l), configuration of the print engine being based at least in part upon the authentication of the filament.

[0068] (n) In any of the 3D printers denoted as (j)-(m), the IR authenticator including: an IR generator for generating IR at a first wavelength, and an IR detector for detecting fluorescence of a dye within the filament at a second IR wavelength. The authentication of the filament being based upon detection of the fluorescence at the second IR wavelength.

[0069] (o) In any of the 3D printers denoted as (j)-(n), at least one parameter of the print engine being configured based upon the detected florescent response of the dyes within the filament.

[0070] (p) In any of the 3D printers denoted as (j)-(o), the detected fluorescent response of the dyes identifying a type of the filament.

[0071] (q) A method for authenticating a filament used in a 3D printer, including: projecting, within the 3D printer, an IR beam at a first wavelength onto the filament; and detecting, in response to the IR beam, IR fluorescence at a second wavelength from a dye within the filament; wherein the detected IR fluorescence indicates authentication of the filament within the 3D printer.

[0072] (r) In the method denoted as (q), the steps of projecting and detecting being repeated periodically during operation of the 3D printer.

[0073] Changes may be made in the above methods and systems without departing from the scope hereof. It should thus be noted that the matter contained in the above description or shown in the accompanying drawings should be interpreted as illustrative and not in a limiting sense. The following claims are intended to cover all generic and specific features described herein, as well as all statements of the scope of the present method and system, which, as a matter of language, might be said to fall therebetween.

CLAIMS

What is claimed is:

1. A fluorescence detection system, comprising:

   a light source for coupling with a mobile device; and

   software, comprising machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, capable of:

   activating the light source in coordination with capturing one or more images using a camera of the mobile device;

   analyzing an image captured with the light source on with an image captured with the light source off, to detect a shift of intensity within a predetermined color range within the images; and

   identifying and authenticating an object by measuring the intensity shift within the images.

2. The system of claim 1, the light source comprising an LED adapted to plug into a port of the mobile device.

3. The system of claim 2, the LED sized to fit with the headphone jack of the mobile device.

4. The system of claim 2, the LED emitting at a wavelength of about 450nm.

5. The system of claim 4, the step of analyzing comprising detecting a fluorescent response from an object tagged with an IR-fluorescing dye in the red wavelength band within the image in response to the emission from the LED.

6. The system of claim 1, the mobile device selected from the group of a mobile phone, a tablet, a laptop computer, a notebook computer, an MP3 player, an iPad, an iTouch, an iPod and a personal data assistant.

7. A fluorescence detection system, comprising:

software, having machine readable instructions loadable into memory of a mobile device and executable by a processor of the mobile device, capable of:

activating a display of the mobile device to emit light in coordination with capturing one or more images using a camera of the mobile device;

analyzing an image captured with the display on with an image captured with the display off, to detect a shift of intensity within a predetermined color range within the images; and

identifying and authenticating an object by measuring the intensity shift within the images.

8. A fluorescence detection system for coupling with a mobile device having a camera, comprising:

a filter for placing over a flash of the camera; and

software, comprising machine readable instructions loadable into memory of the mobile device and executable by a processor of the mobile device, capable of:

capturing a first image of an object using the camera when the flash is not active;

activating the flash in coordination with capturing a second image of the object using the camera;

analyzing the first and second images to detect a shift in intensity within a predetermined color range within the first and second images based upon fluorescence from the object in response to activation of the flash; and

identifying and authenticating the object based upon the detected shift in intensity.

9. The system of claim 8, the filter blocking green and red emissions from the flash.

10. The system of claim 9, the predetermined color range comprising a red wavelength band, wherein the object is configured with an IR-fluorescing dye that fluoresces at the red wavelength band in response to the filtered emission from the flash.

11. A near-IR filter array layer for an electromagnetic sensor array, comprising:

a plurality of infrared filters arranged over the sensor array such that, for each pixel of the sensor array, each infrared filter is configured to pass a different wavelength of electromagnetic radiation within the infrared wavelength band to one sensor of the pixel.

12. A 3D printer with filament authentication, comprising:

a print engine for generating a 3D object using a filament of material; and

an infrared (IR) authenticator positioned to authenticate the filament before use by the print engine;

wherein operation of the print engine is based upon authentication of the filament by the IR authenticator.

13. The 3D printer of claim 12, wherein the print engine initiates authentication of the filament when the filament is installed into the 3D printer.

14. The 3D printer of claim 12, wherein the print engine initiates authentication of the filament periodically during operation of the print engine.

15. The 3D printer of claim 12, wherein configuration of the print engine is based at least in part upon the authentication of the filament.

16. The 3D printer of claim 12, the IR authenticator comprising:

an IR generator for generating IR at a first wavelength; and

an IR detector for detecting fluorescence of a dye within the filament at a second IR wavelength;

wherein the authentication of the filament is based upon detection of the fluorescence at the second IR wavelength.

17. The 3D printer of claim 16, wherein at least one parameter of the print engine is configured based upon the detected florescent response of the dyes within the filament.

18. The 3D printer of claim 16, wherein the detected fluorescent response of the dyes identifies a type of the filament.

19. A method for authenticating a filament used in a 3D printer, comprising:

projecting, within the 3D printer, an IR beam at a first wavelength onto the filament; and

detecting, in response to the IR beam, IR fluorescence at a second wavelength from a dye within the filament;

wherein the detected IR fluorescence indicates authentication of the filament within the 3D printer.

20. The method of claim 19, wherein the steps of projecting and detecting are repeated periodically during operation of the 3D printer.

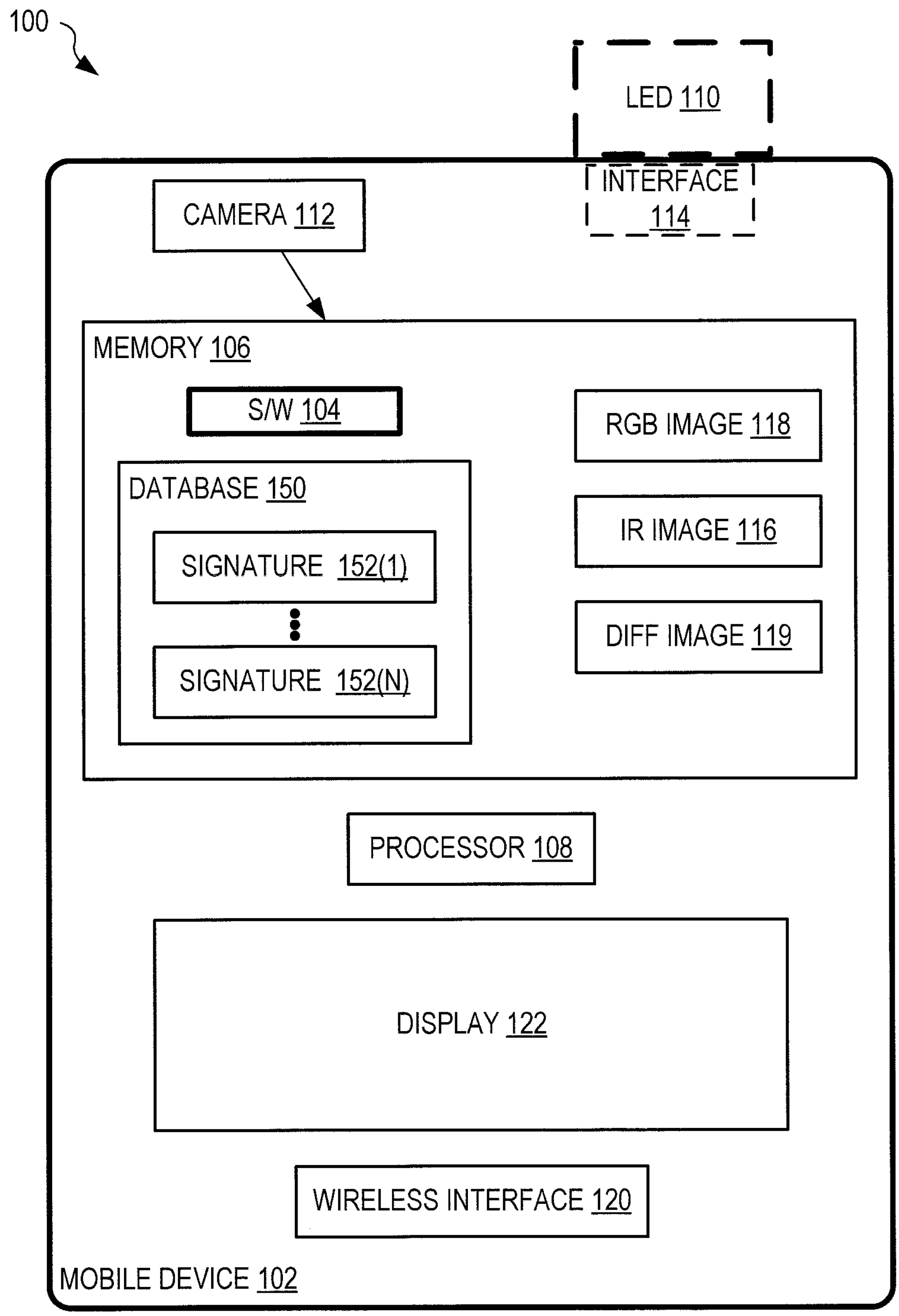

100
LED 110
INTERFACE 114
CAMERA 112
MEMORY 106
S/W 104
DATABASE 150
SIGNATURE 152(1)
SIGNATURE 152(N)
RGB IMAGE 118
IR IMAGE 116
DIFF IMAGE 119
PROCESSOR 108
DISPLAY 122
WIRELESS INTERFACE 120
MOBILE DEVICE 102

FIG. 1

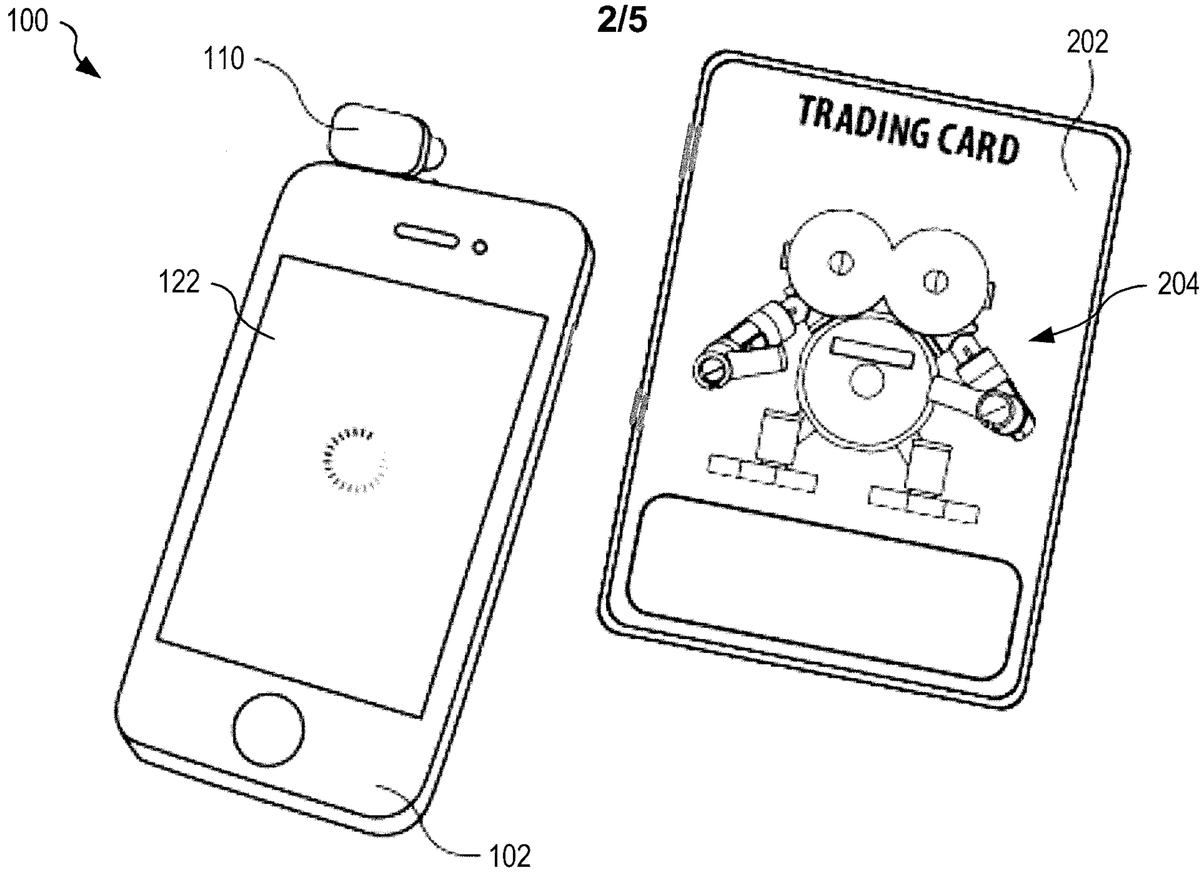

100
110
122
202
TRADING CARD
204
102

FIG. 2

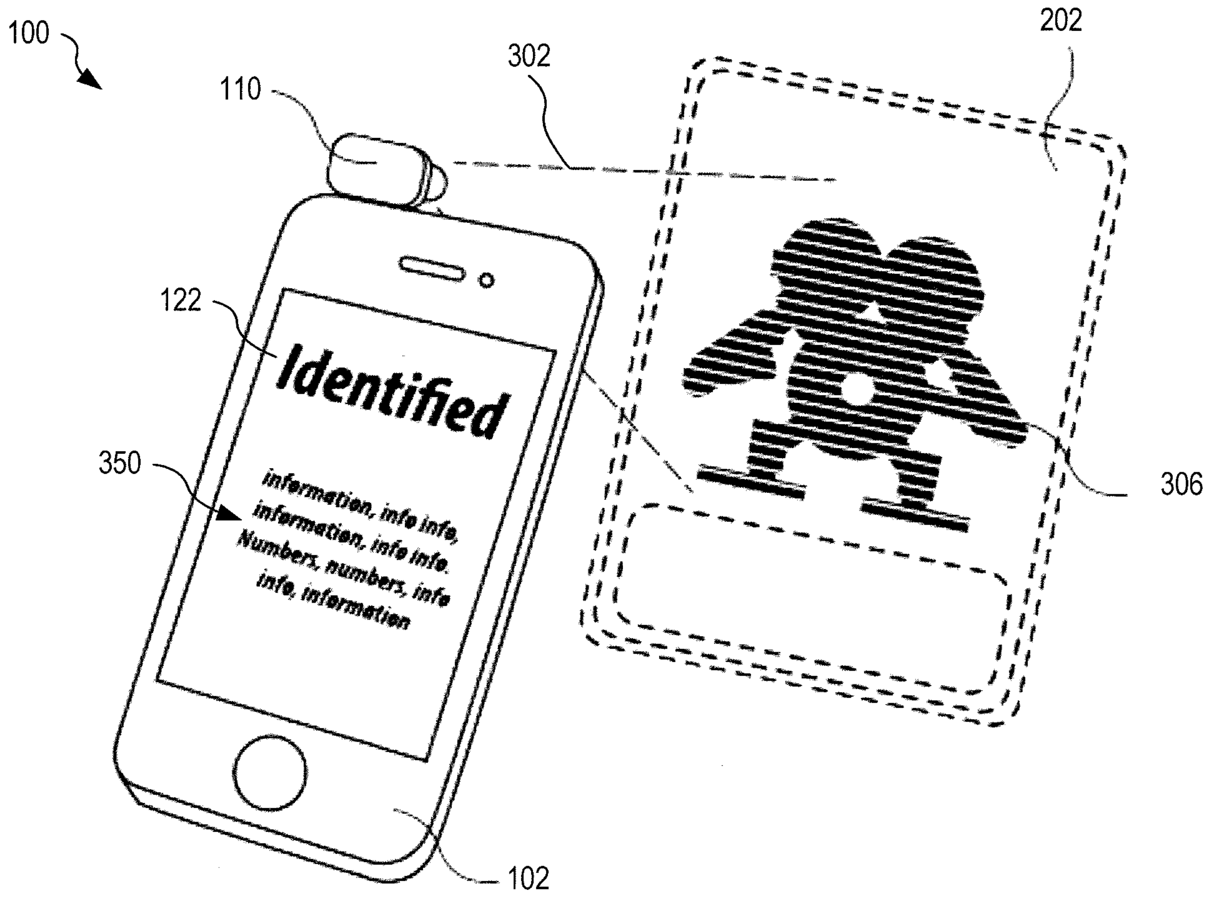

100
110
302
202
122
Identified
350
information, info info,
information, info info.
Numbers, numbers, info
info, information
306
102

FIG. 3

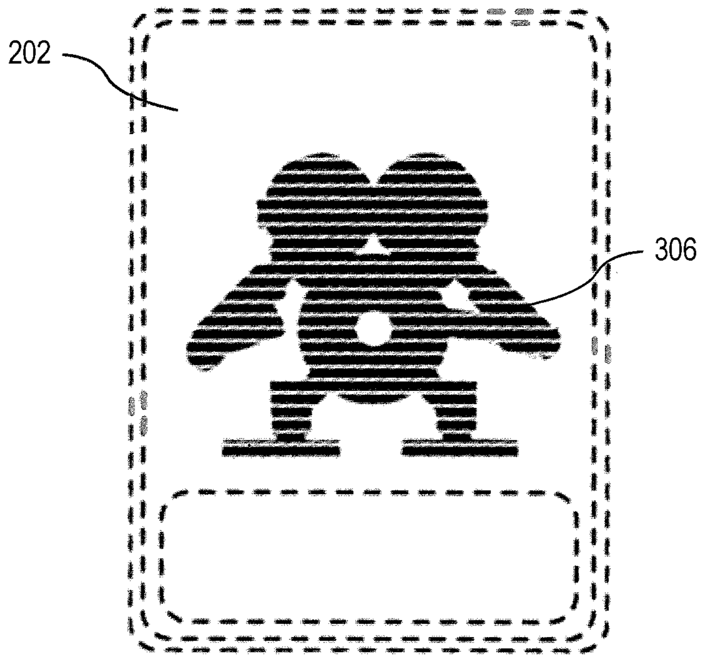
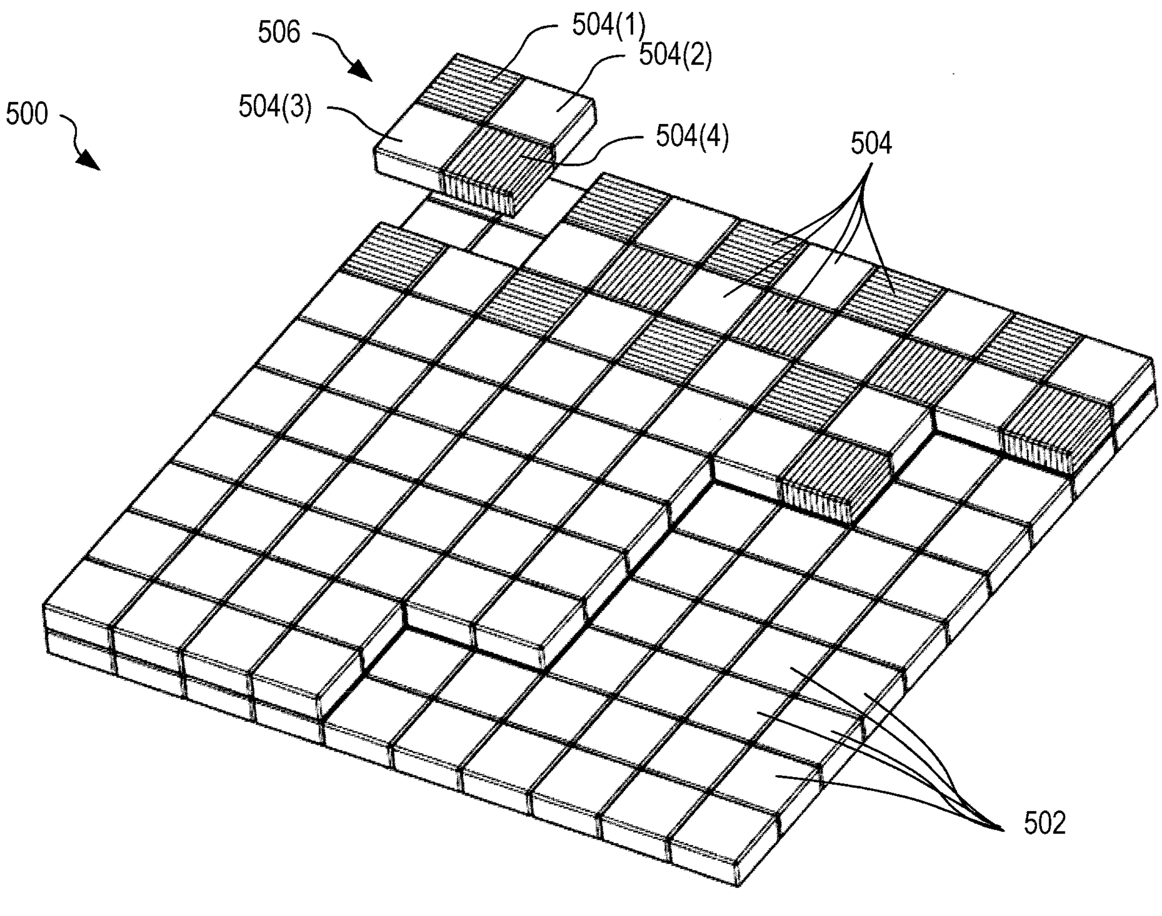


FIG. 4



IR Color Layer Array on Cmos Sensor

FIG. 5

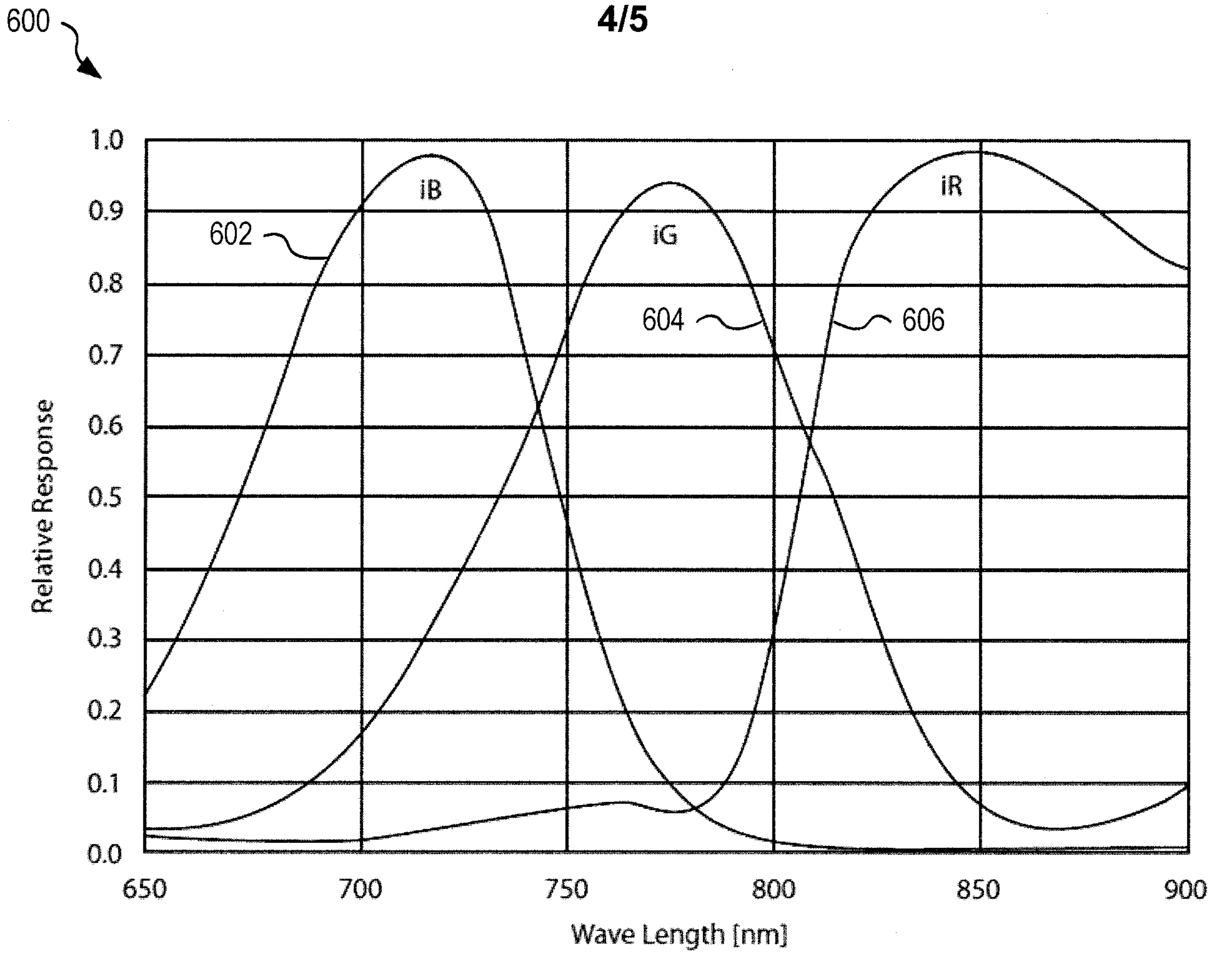

600
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Relative Response
650
700
750
800
850
900
Wave Length [nm]
iB
iG
iR
602
604
606

FIG. 6

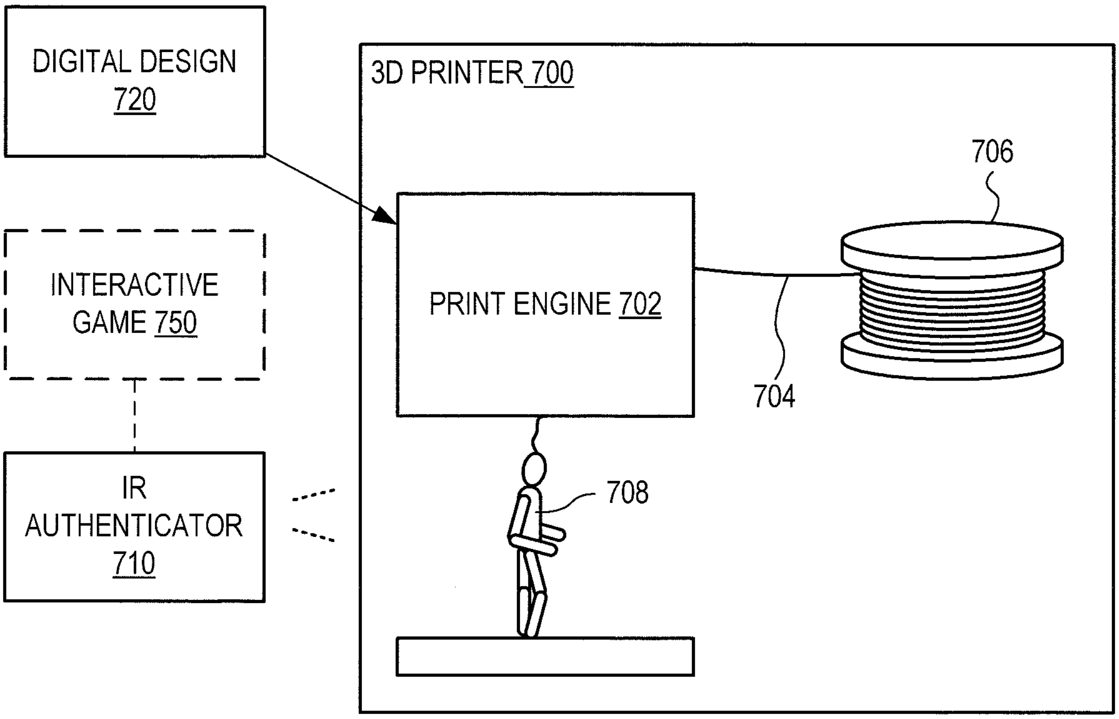

DIGITAL DESIGN 720
INTERACTIVE GAME 750
IR AUTHENTICATOR 710
3D PRINTER 700
PRINT ENGINE 702
706
704
708

FIG. 7

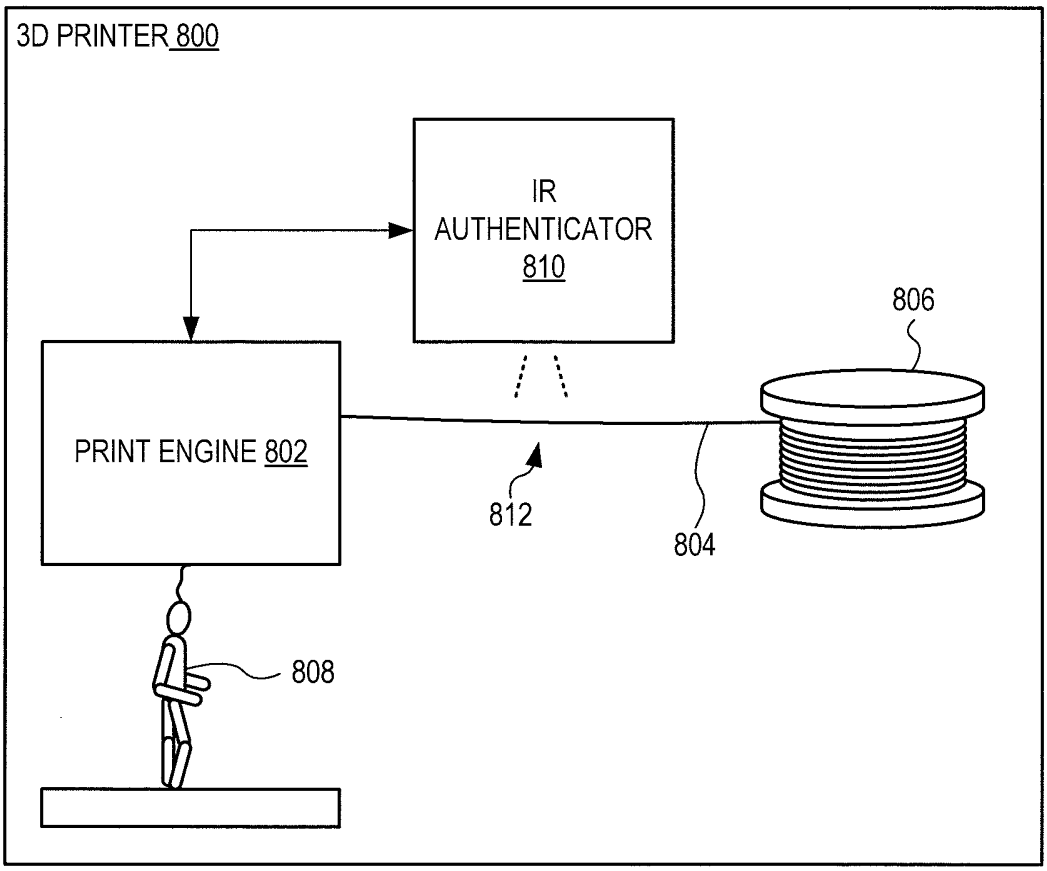

3D PRINTER 800
IR AUTHENTICATOR 810
PRINT ENGINE 802
806
812
804
808

FIG. 8

(19)中华人民共和国国家知识产权局

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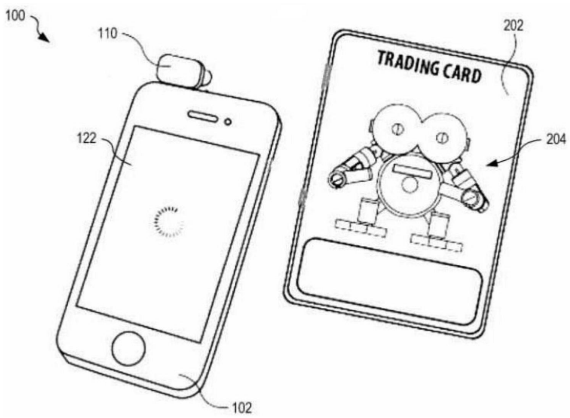
(54)发明名称

用于红外检测的系统和方法

(57)摘要

荧光检测系统包括用于与移动设备耦合的光源以及软件，软件具有可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令，其能够：协同于利用移动设备的相机捕获一个或多个图像来激活光源；分析在光源打开的情况下捕获的图像与在光源关闭的情况下捕获的图像，以检测在图像内预定颜色范围内的强度的变化；以及通过测量图像内的强度变化识别和认证对象。



CN 105518437 A

1.一种荧光检测系统,包括:

用于与移动设备耦合的光源;及

软件,包括可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令,其能够:

协同于利用移动设备的相机捕获一个或多个图像来激活光源;

分析在光源打开的情况下捕获的图像和在光源关闭的情况下捕获的图像,以检测图像内的预定颜色范围内的强度的变化;及

通过测量图像内的强度变化识别和认证对象。

2.如权利要求1所述的系统,所述光源包括适于插入到移动设备的端口中的LED。

3.如权利要求2所述的系统,所述LED的尺寸被调整为适于移动设备的耳机插孔。

4.如权利要求2所述的系统,所述LED以大约450nm的波长发射。

5.如权利要求4所述的系统,所述分析步骤包括响应于来自LED的发射检测来自在图像内用红色波长带中的IR荧光染料标注的对象的荧光响应。

6.如权利要求1所述的系统,所述移动设备选自移动电话、平板电脑、膝上型计算机、笔记本计算机、MP3播放器、iPad、iTouch、iPod和个人数据助理的组。

7.一种荧光检测系统,包括:

软件,具有可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令,其能够:

协同于利用移动设备的相机捕获一个或多个图像来激活移动设备的显示器来发射光;

分析在显示器打开的情况下捕获的图像和在显示器关闭的情况下捕获的图像,以检测图像内的预定颜色范围内的强度的变化;及

通过测量图像内的强度变化识别和认证对象。

8.一种用于与具有相机的移动设备耦合的荧光检测系统,包括:

用于放置在相机的闪光灯上方的滤光器;及

软件,包括可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令,其能够:

当闪光灯不启用时利用相机捕获对象的第一图像;

协同于利用相机捕获对象的第二图像来激活闪光灯;

基于响应于闪光灯的激活来自对象的荧光分析第一和第二图像以检测在第一和第二图像内的预定颜色范围内的强度的变化;及

基于检测到的强度的变化识别和认证对象。

9.如权利要求8所述的系统,所述滤光器阻挡来自闪光灯的绿光和红光发射。

10.如权利要求9所述的系统,所述预定颜色范围包括红色波长带,其中所述对象被配置为具有响应于来自闪光灯的过滤的发射在红色波长带发荧光的IR荧光染料。

11.一种用于电磁传感器阵列的近-IR滤光器阵列层,包括:

布置在传感器阵列上方的多个红外滤光器,使得对于传感器阵列中的每个像素,每个红外滤光器都配置为使红外波长带内不同波长的电磁辐射通过到像素的一个传感器。

12.一种具有细丝认证的3D打印机,包括:

用于利用细丝材料生成3D对象的打印引擎;及

被放置于在被打印引擎使用之前认证细丝的红外(IR)认证器;

其中打印引擎的操作基于IR认证器对细丝的认证。

13.如权利要求12所述的3D打印机,其中所述打印引擎在细丝被安装到3D打印机时启动细丝的认证。

14.如权利要求12所述的3D打印机,其中所述打印引擎在打印引擎的操作期间定期地启动细丝的认证。

15.如权利要求12所述的3D打印机,其中所述打印引擎的配置至少部分地基于细丝的认证。

16.如权利要求12所述的3D打印机,所述IR认证器包括:

用于以第一波长生成IR的IR生成器;及

用于检测在第二IR波长的细丝内染料的荧光的IR检测器;

其中细丝的认证基于在第二IR波长的荧光的检测。

17.如权利要求16所述的3D打印机,其中所述打印引擎的至少一个参数基于检测到的细丝内的染料的荧光响应进行配置。

18.如权利要求16所述的3D打印机,其中所述检测到的染料的荧光响应识别细丝的类型。

19.一种用于认证在3D打印机中使用的细丝的方法,包括:

在3D打印机内以第一波长将IR光束投影到细丝上;及

响应于IR光束,检测来自细丝内的染料的在第二波长的IR荧光;

其中检测到的IR荧光指示3D打印机内的细丝的认证。

20.如权利要求19所述的方法,其中所述投影和检测的步骤在3D打印机的操作期间被定期地重复。

用于红外检测的系统和方法

[0001] 相关申请

[0002] 本申请要求于2013年6月10日提交的、标题为“Systems and Methods for Infrared Detection”、并且通过引用被结合于此的美国专利申请序列号61/833,365的优先权。

[0003] 本申请也要求于2013年11月11日提交的、标题为“Systems and Methods for Infrared Detection”、并且通过引用被结合于此的美国专利申请序列号61/902,524的优先权。

背景技术

[0004] 许多移动电话和平板电脑包括设计为拍摄图片的相机。这些相机通常使用具有红外截止滤光器的CMOS(互补金属氧化物半导体)传感器，其中红外截止滤光器被设计为在使可见光通过的同时阻止近红外光子到达成像传感器。IR截止滤光器防止红外辐射使图像中的颜色失真为不同于通常被人眼感知的颜色。虽然这导致看起来更自然的图像，但是常规的移动设备不适合在不去除所包括的红外截止滤光器的情况下以IR波长检测荧光发射。

发明内容

[0005] 在一种实施例中，荧光检测系统包括用于与移动设备耦合的光源以及软件，其具有可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令，其能够:协同于利用移动设备的相机捕获一个或多个图像激活光源;分析在光源打开的情况下捕获的图像和在光源关闭的情况下捕获的图像，以检测图像内的预定颜色范围内的强度的变化;以及通过测量图像内的强度变化识别和认证对象。

[0006] 在另一种实施例中，荧光检测系统包括软件，其具有可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令，其能够:协同于利用移动设备的相机捕获一个或多个图像激活移动设备的显示器来发射光;分析在显示器打开的情况下捕获的图像和在显示器关闭的情况下捕获的图像，以检测图像内的预定颜色范围内的强度的变化;以及通过测量图像内的强度变化识别和认证对象。

[0007] 在另一种实施例中，荧光检测系统与具有相机的移动设备耦合。该系统包括用于放置在相机的闪光灯上方的滤光器、具有可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令的软件，其能够:当闪光灯不启用时利用移动设备的相机捕获对象的第一图像;协同于利用相机捕获对象的第二图像激活闪光灯;基于响应于闪光灯的激活来自对象的荧光分析第一和第二图像以检测在图像内的预定颜色范围内的强度的变化;以及基于检测到的强度的变化识别和认证对象。

[0008] 在另一种实施例中，用于电磁传感器阵列的近-IR滤光器阵列层包括布置在传感器阵列上方的多个红外滤光器，使得对于传感器阵列中的每个像素，每个红外滤光器都配置为使红外波长带内不同波长的电磁辐射通过到像素的一个传感器。

[0009] 在另一种实施例中，3D打印机具有细丝(filament)认证，并且包括用于利用细丝

材料生成3D对象的打印引擎,以及被放置于在细丝被打印引擎使用之前认证细丝的位置的IR认证器。打印引擎的操作基于IR认证器对细丝的认证。

[0010] 在另一种实施例中,一种方法认证在3D打印机中使用的细丝。在第一波长的IR光束被投影到3D打印机内的细丝上。响应于IR光束,来自细丝内染料的在第二波长的IR荧光被检测到。检测到的IR荧光指示3D打印机内的细丝的认证。

附图说明

[0011] 图1示意性地示出了在实施例中与被示为智能电话的移动设备耦合的一种示例性荧光检测系统。

[0012] 图2和3示出了捕获要被认证的对象的IR图像和RGB图像的图1移动设备操作的透视图。

[0013] 图4示出了在图2的对象内的IR荧光染料的示例性位置。

[0014] 图5是示出在实施例中用于在数字相机中使用的一种示例性IR图像传感器的示意图。

[0015] 图6是示出图5的传感器和滤光器组合的三个示例性响应的曲线图。

[0016] 图7示出了在实施例中的可以被外部认证的用于打印3D对象的一种示例性3D打印机。

[0017] 图8示出了在实施例中的具有3D打印机消耗品认证的一种示例性3D打印机。

具体实施方式

[0018] 于2012年11月30日提交的、标题为"Systems and Method for Authenticating Objects Using IR"的美国专利申请序列号13/691,724通过引用被结合于此,用于实现目的。

[0019] 用于利用移动设备上的RGB相机在可见光内获取、标识和认证的荧光检测

[0020] 所公开的是用于利用移动设备的相机进行荧光检测的解决方案。具体地,用于利用移动设备进行荧光检测的系统包括光源,诸如由移动设备供电的LED。LED可以被配置为和移动设备在一起(例如,用于与移动设备的相机一起使用的"闪光灯")或者适于插入到移动设备中(例如,利用移动设备的耳机插孔)。在移动设备上运行的软件协同于利用移动设备的板载相机捕获感兴趣的对象/主体的一个或多个图像激活LED以照亮感兴趣的对象/主体。利用软件将当LED关闭时捕获的对象的第一图像与当LED打开时捕获的对象的第二图像进行比较,以检测对于图像内给定颜色范围的强度的变化。在一个方面,使用了蓝色到紫色LED(例如,450nm波长)来照亮对象,并且当对象包括在被以450nm波长的光激发时在红色波长带发荧光的材料时,软件检测到在红色波长带内的强度的变化。在另一种实施例中,带通滤光器被应用到移动设备的LED"闪光灯",使得当LED被激活时,LED发射特定波长的光。

[0021] 测得的强度变化(intensity shift)允许移动设备上的软件识别和认证对象。识别数据可以通过合并关于(a)用来测量与对象的距离的在对象内或对象上的荧光标记物的大小和(b)在捕获图像内检测到的强度变化的量的已知信息被隐藏在强度变化中。

[0022] 例如,对象可以利用一种或多种荧光染料进行浸渍或涂覆(部分或全部)。对象的荧光"签名"可以利用如上所述的LED和相机以及存储在存储器中可由软件访问的信息进行

测量。在一个方面,在玩移动游戏中使用的多个对象的荧光签名可以被包括在存储在移动设备的存储器内或可经由互联网访问的游戏数据中。

[0023] 例如,当与游戏结合使用时,移动设备可以用来认证行动人物或其它对象,并且因此,“解锁”在游戏内的相应角色。移动设备可以因此替换当前用于将玩具/对象与视频游戏角色链接的USB平台,从而给予游戏者远离平台玩其游戏的自由。

[0024] 在另一方面,在移动设备上运行的软件协同于图像捕获控制RGB LED发射在期望波长带内的光(即,当拍摄图片时发射期望颜色的光)。例如,软件控制RGB LED发射蓝-紫光,以便引发在红色波长带可测量的荧光响应。利用在LED关闭的情况下拍摄的一个或多个图像处理在LED在期望波长带发射的情况下拍摄的一个或多个图像,以确定在红色带中的强度变化,以便识别和认证对象。

[0025] 在另一方面,滤光器可以被放置在移动设备相机的闪光灯的上方,以便限制闪光灯的发射,从而引发对象的可测量的荧光响应。例如,滤光器可以阻挡闪光灯的绿光和红光发射,以限制引起对象为蓝色的光。红色通道内的强度变化然后可以在捕获图像内被检测到和分析,以认证该对象。

[0026] 染料可以被设计为调节对象发射。鉴于荧光是在可见光内,因此认证过程可以是明显的、几乎注意不到的、或者对人眼难以检测到的。

[0027] 所公开的系统和方法不仅有益地提供了移动认证,而且是高速的认证。移动设备相机通常以每秒24至30帧运行,并且最少只需要一帧来捕获对激发波长的荧光响应以便认证对象。因此,人眼对LED激活和相应荧光响应的注意可以忽略不计。但是,可以使用附加的帧来提供数据以针对误报分类。

[0028] 移动设备(诸如iPhone)可以被配置为具有用于对象的获取、标识和认证的荧光检测系统。靠近设备相机和相机闪光灯、由移动设备的电话插孔供电和附接到设备的后表面的LED以450nm发射。被检测对象涂有当被LED照射时发荧光的染料,如在移动设备屏幕上显示的图像中所示出的。注意,移动设备屏幕示出了如由内置移动设备相机拍摄的对象的标准的RGB图像,以及其中可以看见对象荧光的IR/差异图像。

[0029] 图1示意性地示出了被配置为示为智能电话的移动设备102的一种示例性荧光检测系统100。图2和3示出了捕获要被认证的对象202的IR图像116和RGB图像118的图1移动设备102操作的透视图。图4示出了IR荧光染料306在对象202内的示例性位置。图1、2、3和4最好与以下描述一起查看。

[0030] 存储在移动设备102的存储器106内的软件104包括机器可读指令,当指令被移动设备102的处理器108执行时,与移动设备102交互,以协同于利用移动设备102的相机112捕获的对象202的一个或多个图像激活与移动设备102耦合的LED 110。LED 110例如由移动设备102在诸如像移动设备102的插孔的接口114供电。应当理解,系统100的特征被置为如图1所示仅仅为说明起见,并且所示出的特征(例如,LED 110、接口114、相机112、显示器122及其它)可以位于除图1中所示出的那些位置之外的其它位置。

[0031] 至少一个捕获的IR图像116(当LED 110打开时由相机112捕获的),和至少一个RGB图像118(当LED 110关闭时由相机112捕获的)被处理器108处理/比较,以生成用于对图像116和118内的给定颜色范围检测强度的变化的差异图像119。在一个方面,软件104触发LED 110与相机112的帧速率同步闪烁,使得只有在由相机112捕获交替帧期间LED 110才活动来

照亮对象202。软件104然后为捕获图像对生成差异图像119，并且然后可以基于IR图像116、RGB图像118和差异图像119内的红色像素值评估相机112的红色通道的颜色变化。在一种实施例中，LED 110表示被控制以提供与相机112一起使用的照明的移动设备102的内置“闪光灯”LED。

[0032] 在一个例子中，其中LED 110发射具有450nm波长的光，当成像对象包括当由在450nm波长的光激发时在红色波长带发荧光的荧光染料306(或其它具有荧光颜料的材料)时，软件104检测到红色波长带内的强度的变化。在红色波长带内测得的强度变化允许软件104识别和认证在图像116、118内捕获的对象202。

[0033] 由处理器108执行的软件104将测得的图像116、118、119的强度变化和其它图像数据与已知的、真实对象的荧光签名152的数据库150比较来标识和认证图像116、118内的对象，其中每个签名152可以定义在对象202内存在的(一个或多个)荧光标记物的波长、位置、形状和其它特性中的一个或多个。如所示出的，数据库150被存储在存储器106中，但是也可以存储在由软件104以其它方式可访问的其它地方，例如存储在服务器上并且可经由无线接口120经由互联网访问的数据库。

[0034] 突出显示对象202的荧光的红外图像116、RGB图像118和/或差异图像119可以被显示在移动设备102的显示器122上。如在图3中所示出的，一旦对象202被识别和认证，对象标识/认证以及来自数据库150的其它信息就也可以被显示在显示器122上。当识别和认证时，软件104可以利用无线接口120触发或调用在移动设备102上和其外部两者的其它动作。

[0035] 在一种实施例中，显示器122由软件104控制来显示蓝色(例如，在450nm波长发射光)，以照亮放置在显示器122前面的对象，从而无需LED 110。在这种实施例中，相机112向前面向移动设备102，以捕获由来自显示器112的光照亮的对象的图像。显示器122的控制(例如，激活和停用)类似于如上所述的LED 110的控制，并且相机112被控制为当显示器122不活动时捕获RGB图像118，并且当显示器112在450nm波长发射光时捕获IR图像116。这种实施例在其中移动设备102是不具有内置“闪光灯”LED的平板计算机的情况下是尤其有利的。

[0036] 用于CMOS传感器的近-IR滤光器阵列层

[0037] 当前生产的、诸如在移动通信设备中使用的大多数数码相机使用由Eastman Kodak的Bryce Bayer开发的技术，Bayer滤光器。Bayer滤光器或Bayer层是由在传感器被分组为像素之前直接安装的红色、绿色和蓝色滤光器组成的“可见光”滤光器阵列。该阵列的每个滤光器只允许特定颜色的光子到相应的传感器上，其中每个像素具有一个红色、两个绿色和一个蓝色滤光器以及四个相应的传感器。软件然后基于感测到的光水平和构成每个像素的这组滤光器和传感器的几何形状应用各种去马赛克算法来为每个像素确定颜色(例如，一组RGB值)。

[0038] CMOS和CCD传感器对介于大约400至大约1100nm之间的波长的光是敏感的，并且因此可以用来检测在电磁光谱的近红外(700-1200nm)部分中的至少一部分的辐射。但是，由于Bayer层只允许在人类可见光波长内的光(例如，400nm至700nm)穿过，因此利用Bayer层构成的常规相机不能检测IR波长并且不适于红外图像捕捉。在Bayer滤光器阵列被去除的情况下，这些常规相机只能检测近IR辐射的强度水平。

[0039] 通过把Bayer层替换为具有只在近红外的某些频带中让光通过的部分的滤光器阵列层，数字相机就可以用来感测在特定红外波长的能量。图5是示出用于在数字相机中使用

的一种示例性IR图像传感器500的示意图。IR图像传感器500具有传感器502的阵列和放置在其上的IR滤光器504的阵列。传感器502和滤光器504被分组到像素506中，在这个例子中，其中每个像素506具有四个传感器502和四个相应的滤光器504。每个传感器502操作为在700-1200nm的波长范围中感测电磁能量。在每个像素506内，选择滤光器504在两个或更多个不同波长通过IR能量。图6是示出传感器502和滤光器504组合的三个示例性响应的曲线图。在第一响应602中，滤光器504(1)具有中心在720nm的通带波长，在第二响应604中，滤光器504(2)具有中心在775nm的通带波长，并且在第三响应606中，滤光器504(3)具有中心在845nm的通带波长。如所理解的，当期望附加的灵敏度时，可以在相同的通带波长配置两个或更多个滤光器504。此外，像素可以具有多于四个的传感器502和滤光器504，使得可以实现在近IR波段内的更大选择性。在一种实施例中，在每个像素506内，特定的滤光器504被选择来通过可见光(例如，如利用常规Bayer滤光器)并且其它滤光器被配置为如在图6中所示出的只通过IR波长，其中软件(例如，软件104)操作为选择性地为每个像素506的传感器502处理输出，以生成可视图像和IR图像中的一个或两者。当特定波长被配置在滤光器504内时，软件可以操作为为认证目的从对象202识别特定的频率响应。例如，对象可以被配置为具有在不同波长发荧光的多种荧光染料，其中滤光器504被配置为确定这些荧光响应的存在或不存在，以实现更强的认证。

[0040] 在一种实施例中，系统100的相机112被配置为具有图5的图像传感器500并且被用于红外摄影、检测和认证。如上所述，LED 110由软件104控制以引发来自标注(浸渍或以其它方式标记)有荧光染料306的对象202的荧光发射。例如，软件104协同于捕获IR图像116激活LED 110来照亮对象202、协同于捕获RGB图像118停用LED 110，其中RGB图像118不代表可视图像，但是被用来检测背景IR水平。软件104然后将IR图像116与RGB图像118比较来生成已去除IR的背景水平的差异图像119。软件104然后可以为差异图像118内的每个像素506处理选择性传感器502值来识别对象202的荧光响应“签名”(荧光邮戳、图案、标记、复杂发射或简单发射)。可以执行IR图像116和/或差异图像119的附加的多个波长分析，以便例如通过将染料或材料(或其组合)的唯一光谱签名与标注对象的签名的数据库进行比较确定对象标识和认证。

[0041] 在用于3D打印的细丝中的染料

[0042] 与荧光检测合作使用，通过向用于通过3D打印制造物品的细丝、纤维或树脂添加已知频率响应的一种或多种IR荧光染料，公司可以数字地发布其物理产品。细丝/树脂/纤维(其在下文中可以被互换使用)可以利用当被光源照射时在已知波长发荧光的一种或多种染料来浸渍或生产。

[0043] 图7示出了可以被外部认证的用于打印3D对象708的一种示例性3D打印机700。3D打印机700包括使用用于创建3D对象708的诸如树脂的细丝消费品704的打印引擎702，其说明性地被示为在卷轴706上提供。消费者购买细丝消费品704并且下载用于从树脂打印3D对象708的数字设计720。消费者然后可以利用3D打印机700打印(创建)3D对象708。通过购买和利用树脂704来创建3D对象708，3D对象708可以与其它设备交互使用。例如，如在图7中所示出的，IR认证器710(例如，图1的系统100)被用来(a)基于3D对象708由其制成的树脂704内的颜料认证3D对象708，和(b)向交互式游戏750提供输入。在没有认证3D对象708的情况下，交互式游戏750可以具有减少的功能或者没有功能。因此，为了使用3D对象708参与交互

式游戏750，当创建3D对象708时，消费者必须购买和使用3D打印机700内的树脂704。

[0044] 例如，IR认证器710可以包括计算机/微处理器、IR投影仪、IR相机和可选的RGB相机。3D对象708在IR相机(和可选的RGB相机)的视野内被检测到。对象的图像利用相机在IR投影仪关闭的情况下和在IR投影仪打开的情况下被捕获，并且这些图像被处理以检测与3D对象708结合的染料的荧光响应。3D对象708的荧光签名可以经由认证算法进行认证，从而使3D对象708变得可与游戏750交互。在另一个例子中，由IR认证器710认证3D对象708可以解锁经由外部系统提供的优惠，用于识别特定对象(例如，在体育赛事时或者当在智能电视前观看体育赛事时穿的队服)。

[0045] 在另一个例子中，3D对象708表示儿童玩具的积木块或其它构件，其然后被IR认证器710识别和认证以解锁第三方系统或者寻找认证3D对象708的设备的功能。

[0046] 这种技术可以降低制造物品的成本，因为真正的产品可以在家里或者在当地的商店或者配送中心来创建。此外，新的收入流会从许可和下载从标注的细丝/树脂/纤维(例如细丝/树脂/纤维704)打印期望的对象所需的数字文件的消费者中增长。此外，利用标注的树脂制成的对象可以被认证并且对象的所有者可以收到认证对象的保修单。

[0047] 在使用的另一个例子中，其中细丝704用来打印潜在危险的对象，诸如塑料武器，细丝704可以利用在已知波长发荧光的不可见的IR染料或染料的组合进行标注，使得打印的武器可以被用于检测结合到例如机场安检中的IR响应的系统检测到。

[0048] 3D打印机消耗品认证

[0049] 图8示出了在实施例中具有3D打印机消耗品认证的一种示例性3D打印机800。3D打印机800包括使用用于创建3D对象808的细丝消耗品804的打印引擎802，其说明性地被示为在卷轴806上提供。打印引擎802与被调用以认证细丝804的IR认证器810耦合。IR认证器810包括IR源和IR检测器(例如，能够检测IR波长的相机)，IR源和IR检测器合作以检测在例如位置812处的IR源的光束下细丝804内的IR荧光颜料(例如染料)的存在。在一种实施例中，IR认证器810利用简单、低成本和通常可用的传感器(例如，光电二极管、光电晶体管、CMOS和/或其它传感器)，用于检测来自细丝804内的染料的荧光。

[0050] 在一种实施例中，由于细丝804被从卷轴806取到打印引擎802中，因此位置812在3D打印机800内并且位于细丝804的路径上。在另一种实施例中，当细丝804仍然在卷轴806上时，IR认证器810检测细丝804内的颜料的荧光。

[0051] 在操作的一个例子中，当细丝804被安装到3D打印机800中时，打印引擎802控制IR认证器810以认证细丝804，其中IR认证器810在第一波长生成IR，并且在第二波长从细丝804内存在的一个或多个IR荧光染料检测相应的IR荧光。例如，在一种实施例中，第一和第二波长是30-80nm或分开得更多。

[0052] 在一种实施例中，打印引擎802利用IR荧光的标识来配置用于使用细丝804的操作参数。例如，可以使用存在或不存在多个荧光响应中的一个或多个荧光响应为使用细丝804指定处理参数(例如，温度、进料速率、加热床的温度等)，其中当细丝804被改变并且新的IR“签名”被识别时，打印引擎802被由此自动地配置。

[0053] 在另一种实施例中，当细丝804没有被IR认证器810认证时，打印引擎802的功能受到限制。例如，如果细丝804没有被打印引擎802认证，则3D打印机800可能无法工作。产品制造商可以发布与细丝804相关联的对象808的3D打印设计文件，其中除非特定细丝804被认

证，否则3D打印机800不打印3D打印设计。产品制造商、或与制造商相关联的第三方可以以溢价销售细丝804，用于与3D打印机800一起使用来根据3D设计文件打印对象的一个或多个拷贝。在这个例子中，打印机800比较加载到打印机中的细丝的荧光响应与来自制造商的真正细丝804的预期荧光响应。如果荧光响应不匹配，则打印引擎802禁止生成对象808。即，除非IR认证器810认证3D打印机800内的细丝804，否则对象808将不会被打印。在一个例子中，如果细丝不是真正的细丝804，则打印机800将不运行或者完成3D设计文件。在另一个例子中，如果认证失败，则打印引擎802被锁住。细丝的荧光签名可以经由IR认证器810运行的认证算法来认证。

[0054] 在一种实施例中，打印引擎802和IR认证器810可以在打印对象808期间定期地认证细丝804，其中细丝804认证失败会中断生成对象808。

[0055] 在另一种实施例中，打印引擎802基于IR认证器810对细丝804的标识和认证进行配置。例如，打印引擎802的输出质量可以基于细丝804的认证来确定，其中如由IR认证器810识别和认证的细丝804的材料的质量限定了打印引擎802的输出质量。

[0056] 通过利用在3D打印机800内的IR认证器810认证细丝804和基于认证限制打印引擎802的功能，打印机制造商就可以指导3D打印机800的用户使用特定的细丝804，诸如来自优选供应商的细丝。例如，如果第三方细丝供应商不在细丝内包括荧光染料，或者不包括特定细丝804的唯一荧光签名，则由此该第三方产品不能在3D打印机800内被使用，或者只能使用性能降低的3D打印机800。

[0057] 虽然本文的示例实施例利用了用于荧光的IR频带，但是也可以在不背离其范围的情况下使用其它频带。

[0058] 荧光染料可以被添加到其它3D打印机细丝材料，诸如橡胶、金属、明胶/脂类(例如，用于打印人工组织)、不锈钢、黄铜、木材纸浆塑料混合物、尼龙、聚酯、石墨烯/碳纤维、陶瓷、细菌和纸中的一种或多种。

[0059] 特征的组合

[0060] 上述特征以及下面申明的那些特征可以在不背离其范围的情况下以各种方式进行组合。以下例子示出了本发明以上已描述的可能的、非限定性的组合，应该明确，在不背离本发明的主旨和范围的情况下，可以对过程和产品做出许多改变和修改：

[0061] (a)一种荧光检测系统，包括用于与移动设备耦合的光源，以及软件，软件包括可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令，其能够：协同于利用移动设备的相机捕获一个或多个图像来激活光源；分析在光源打开的情况下捕获的图像和在光源关闭的情况下捕获的图像，以检测图像内的预定颜色范围内的强度的变化；以及通过测量图像内的强度变化识别和认证对象。

[0062] (b)在如(a)所述的系统中，所述光源是适于插入到移动设备的端口中的LED。

[0063] (c)在如(a)或(b)所述的任何一种系统中，所述LED的尺寸被调整为适于移动设备的耳机插孔。

[0064] (d)在如(a)-(c)所述的任何一种系统中，所述光源以大约450nm的波长发射。

[0065] (e)在如(a)-(d)所述的任何一种系统中，所述分析步骤包括响应于来自光源的发射检测来自在图像内用红色波长带中的IR荧光染料标注的对象的荧光响应。

[0066] (f)在如(a)-(e)所述的任何一种系统中，所述移动设备选自包括移动电话、平板

电脑、膝上型计算机、笔记本计算机、MP3播放器、iPad、iTouch、iPod和个人数据助理的组。

[0067] (g)一种用于与具有相机的移动设备耦合的荧光检测系统，包括：用于放置在相机的闪光灯上方的滤光器，以及软件，软件包括可加载到移动设备的存储器中并且可被移动设备的处理器执行的机器可读指令，其能够：当闪光灯不启用时利用相机捕获对象的第一图像；协同于利用相机捕获对象的第二图像来激活闪光灯；基于响应于闪光灯的激活来自对象的荧光分析第一和第二图像以检测在第一和第二图像内的预定颜色范围内的强度的变化；以及基于检测到的强度的变化识别和认证对象。

[0068] (h)在如(g)所述的系统中，所述滤光器阻挡来自闪光灯的绿光和红光发射。

[0069] (i)在如(g)或(h)所述的任何一种系统中，所述预定颜色范围包括红色波长带，其中所述对象被配置为具有响应于来自闪光灯的过滤的发射在红色波长带发荧光的IR荧光染料。

[0070] (j)一种具有细丝认证的3D打印机，包括：用于利用细丝材料生成3D对象的打印引擎；以及被放置于在被打印引擎使用之前认证细丝的红外(IR)认证器；其中打印引擎的操作基于IR认证器对细丝的认证。

[0071] (k)在如(j)所述的3D打印机中，所述打印引擎在细丝被安装到3D打印机时启动细丝的认证。

[0072] (l)在如(j)或(k)所述的任何一种3D打印机中，所述打印引擎在打印引擎的操作期间定期地启动细丝的认证。

[0073] (m)在如(j)-(l)所述的任何一种3D打印机中，所述打印引擎的配置至少部分地基于细丝的认证。

[0074] (n)在如(j)-(m)所述的任何一种3D打印机中，所述IR认证器包括用于以第一波长生成IR的IR生成器，以及用于检测在第二IR波长的细丝内染料的荧光的IR检测器。细丝的认证基于在第二IR波长的荧光的检测。

[0075] (o)在如(j)-(n)所述的任何一种3D打印机中，所述打印引擎的至少一个参数基于检测到的细丝内的染料的荧光响应进行配置。

[0076] (p)在如(j)-(o)所述的任何一种3D打印机中，所述检测到的染料的荧光响应识别细丝的类型。

[0077] (q)一种用于认证在3D打印机中使用的细丝的方法，包括：在3D打印机内以第一波长将IR光束投影到细丝上；以及响应于IR光束检测来自细丝内的染料的在第二波长的IR荧光；其中检测到的IR荧光指示3D打印机内的细丝的认证。

[0078] (r)在如(q)所述的方法中，所述投影和检测的步骤在3D打印机的操作期间被定期地重复。

[0079] 在不背离其范围的情况下，可以对以上方法和系统做出改变。因此，应当指出，以上描述中所包含的或者在附图中所示出的事项应当被解释为说明性的而不是限制意义上的。以下权利要求旨在涵盖本文所述的所有一般和特定特征，以及所给出方法和系统的范围的所有陈述，其就语言而言，可以说属于其中。

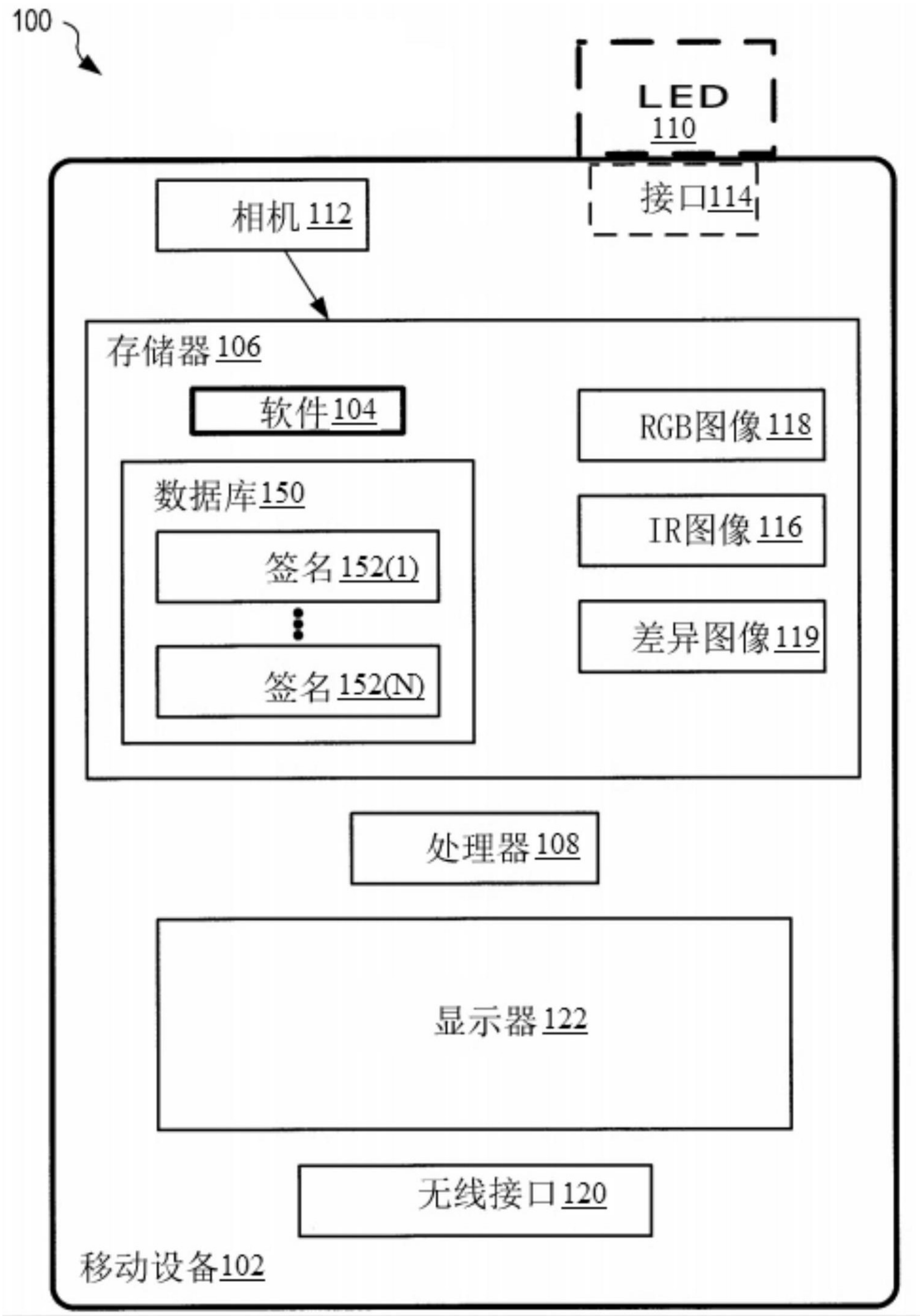

100
LED
110
接口114
相机112
存储器106
软件104
数据库150
签名152(1)
签名152(N)
RGB图像118
IR图像116
差异图像119
处理器108
显示器122
无线接口120
移动设备102

图1

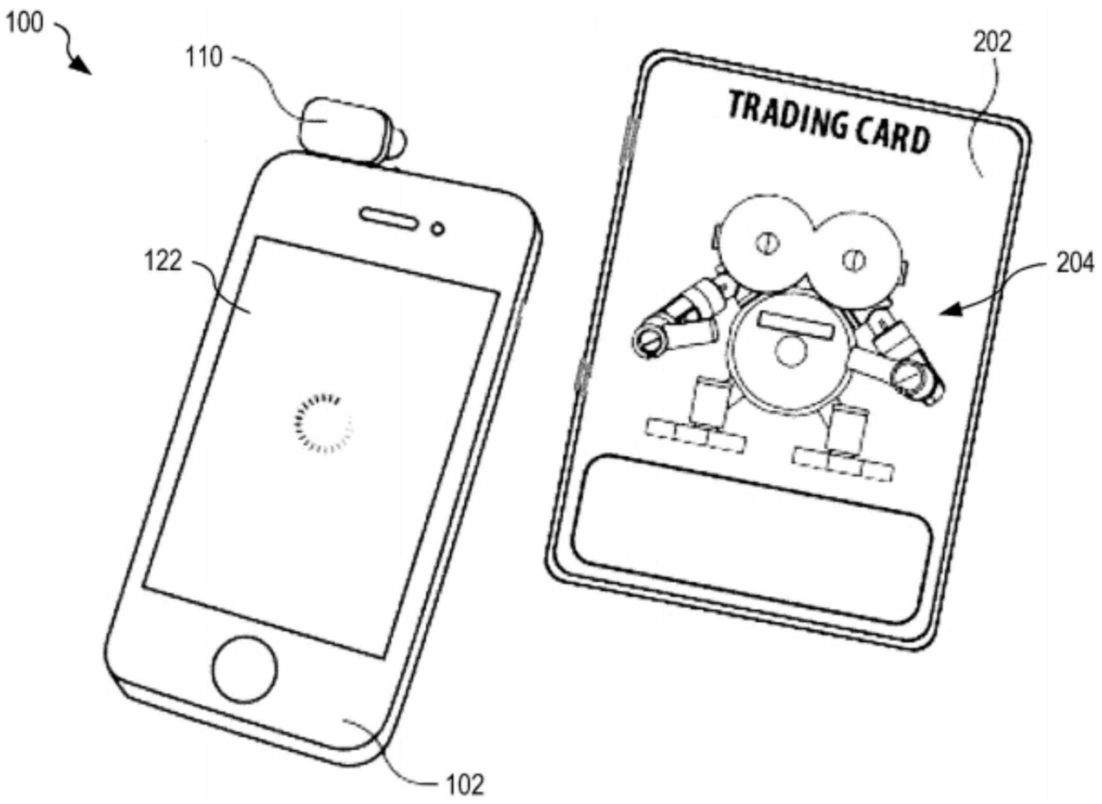

100
110
202
TRADING CARD
204
122
102

图2

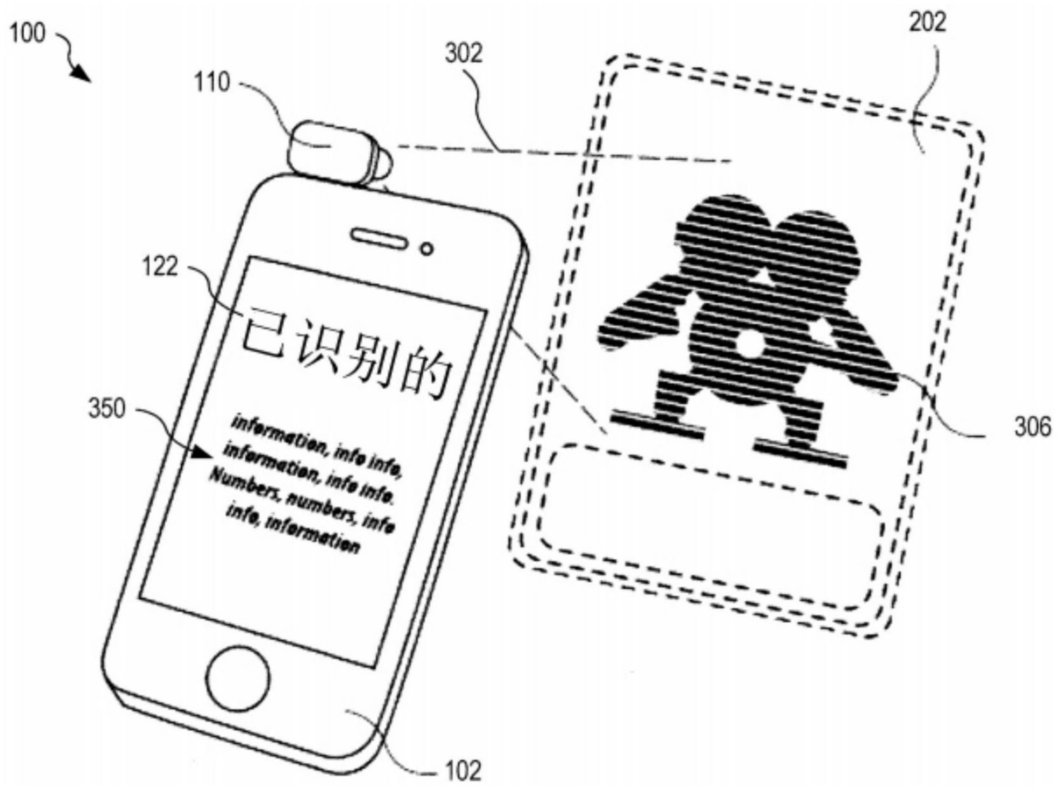

100
110
302
202
122
已识别的
350
information, info info, information, info info, Numbers, numbers, info info, information
306
102

图3

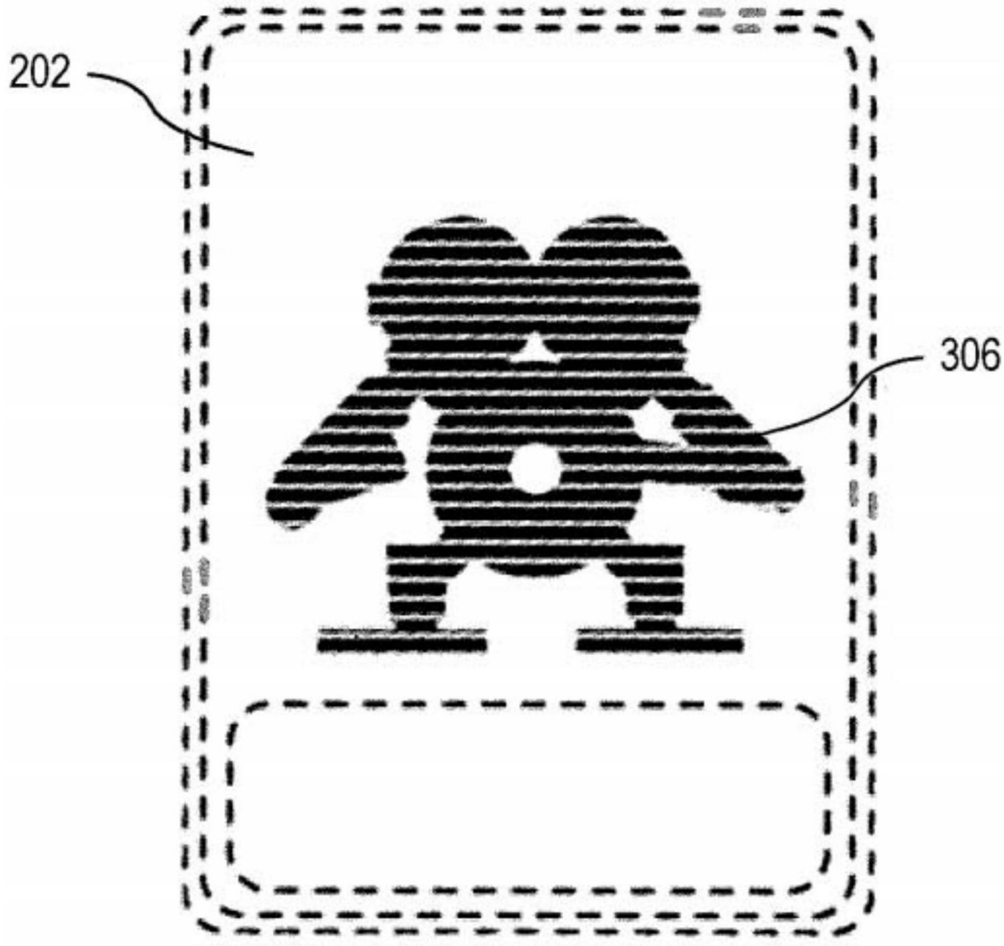


图4

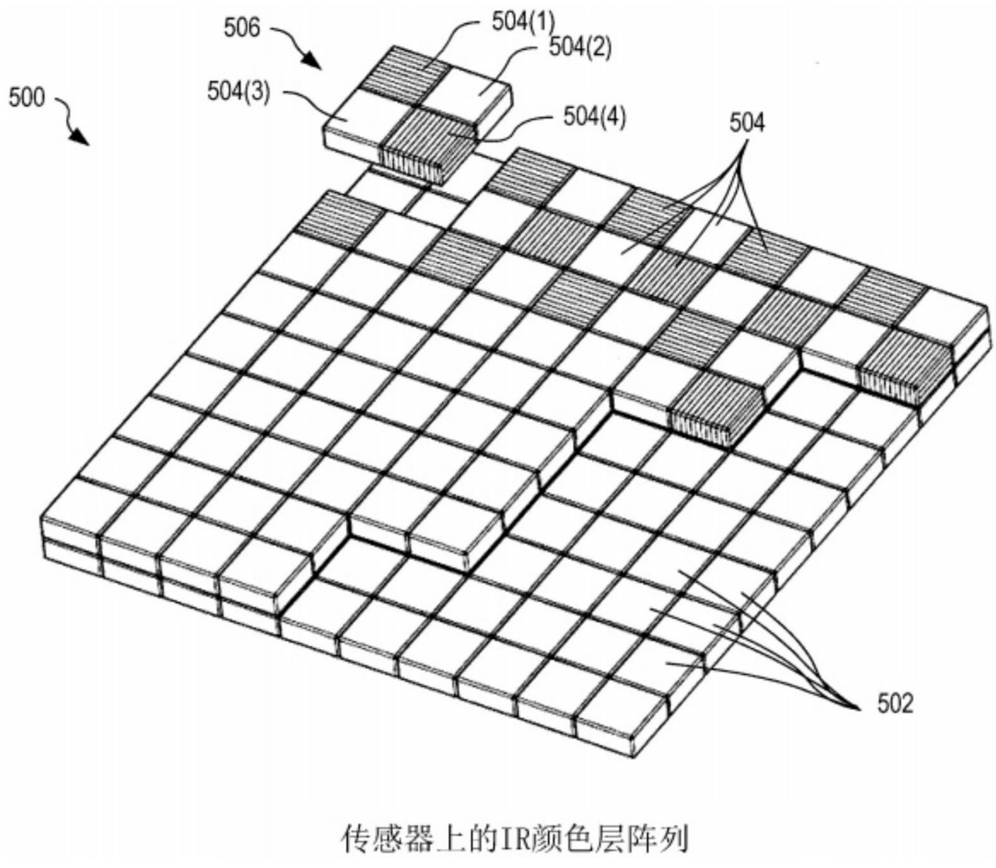

506
504(1)
504(2)
504(3)
504(4)
500
504
502
传感器上的IR颜色层阵列

图5

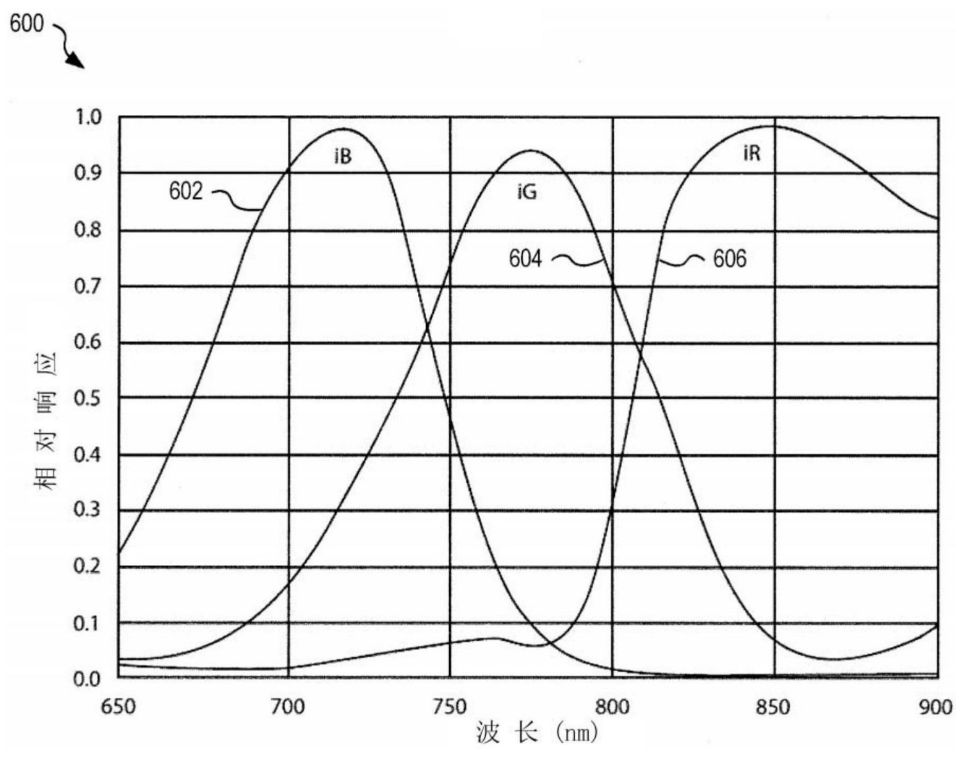

600
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
iB
iG
iR
602
604
606
相对响应
650
700
750
800
850
900
波长 (nm)

图6

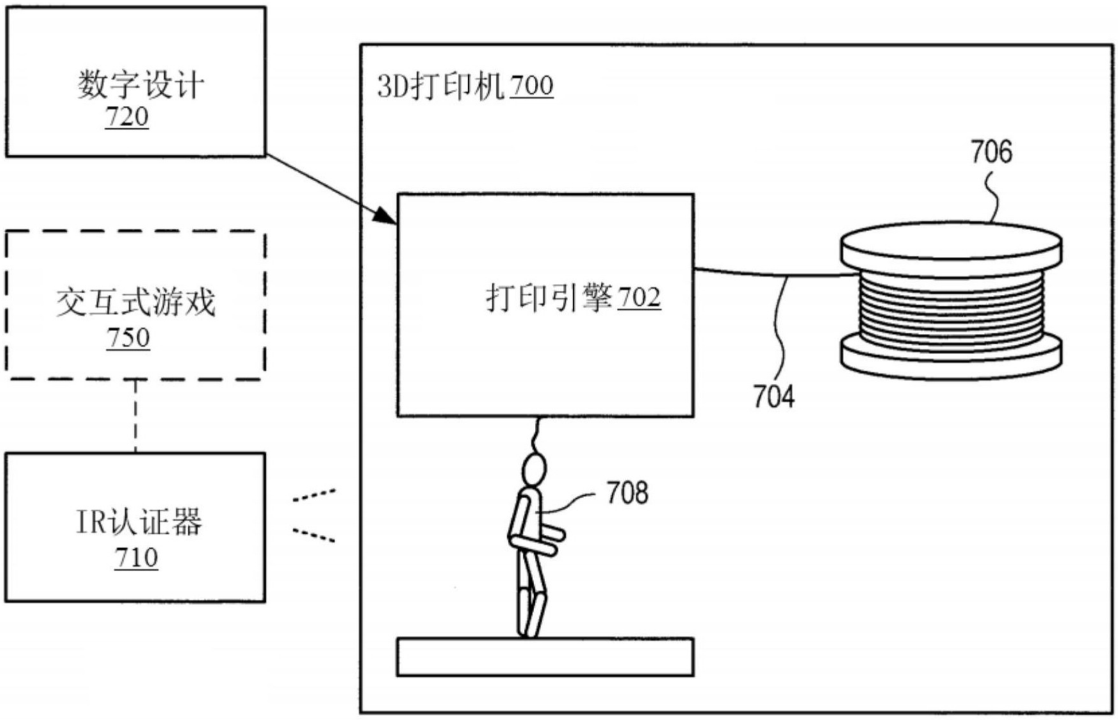


图7

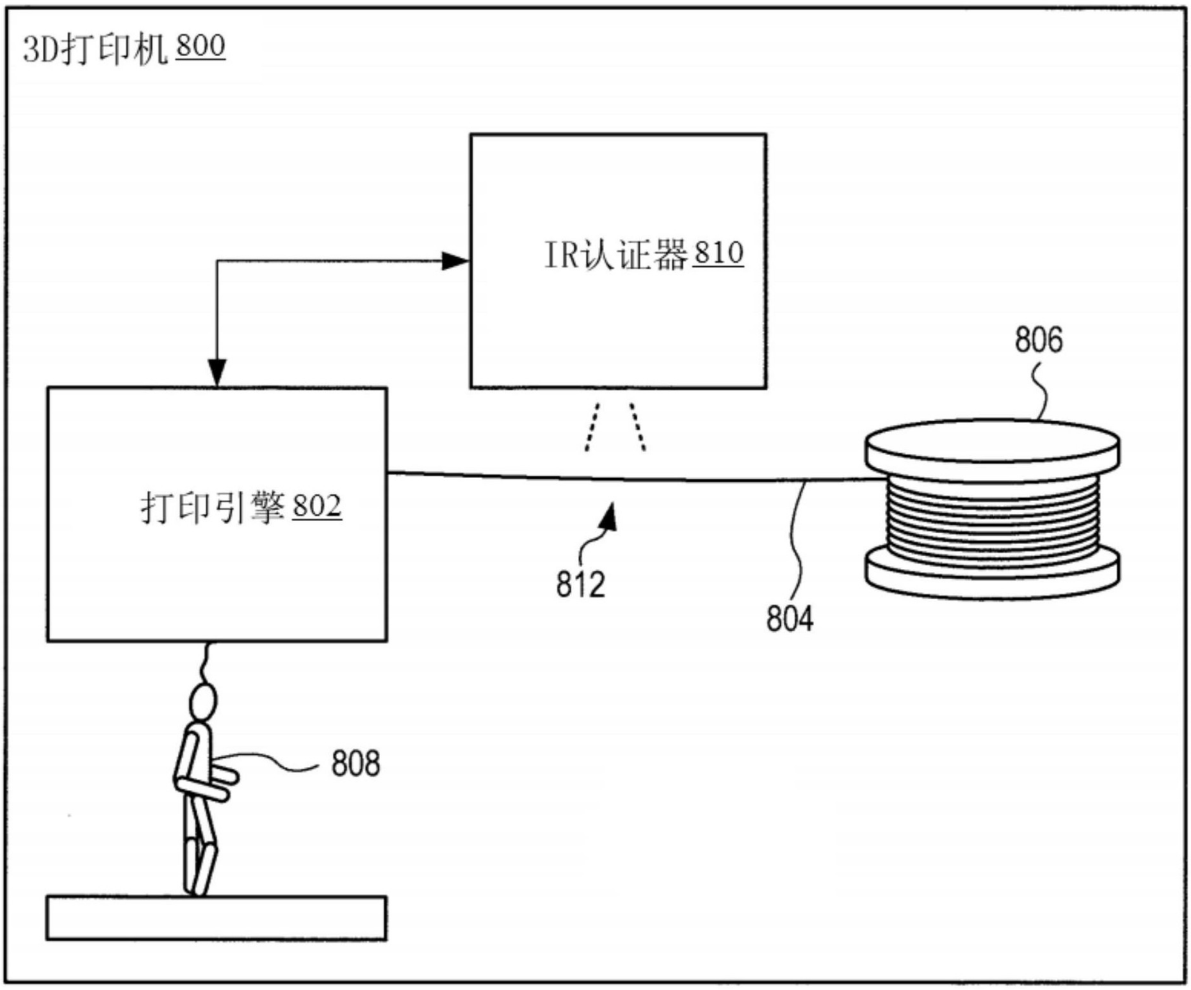


图8