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Authentication system and authentication method

Abstract

An authentication system includes at least one illumination irradiating a person to be authenticated with invisible light, a first imaging device imaging the person to be authenticated irradiated with the invisible light, and an authentication device communicating with the first imaging device and executes authentication of the person to be authenticated based on a first invisible light image captured by the first imaging device. The illumination and the first imaging device are disposed at positions that are respectively asymmetric with respect to a line-of-sight position of the person to be authenticated guided by a line-of-sight guiding section that guides the line-of-sight position of the person to be authenticated.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is based on and claims priority under 35 USC 119 from Japanese Patent Applications No. 2022-112427 filed on Jul. 13, 2022, No. 2023-015557 filed on Feb. 3, 2023, and No. 2023-026296 filed on Feb. 22, 2023 the contents of which are incorporated herein by reference.

TECHNICAL FIELD

(2) The present disclosure relates to an authentication system and an authentication method.

BACKGROUND ART

(3) JP2021-501401A discloses a device for biometric authentication of objects. The device includes an optical image sensor element that is sensitive to an infrared spectrum with a peak wavelength between 925 nm and 955 nm so as to capture at least one photograph of an object under ambient light conditions with additional infrared conditions, an infrared light source that provides additional

infrared light, and a processing unit that provides an image or image code for biometric authentication obtained from the photograph. The device subtracts a solar photograph from the captured infrared photograph to obtain an image or image code for biometric authentication.
SUMMARY OF INVENTION
(4) In recent years, the use of biometric authentication using a photograph (face image) of a person's face has been increasing in various places indoors and outdoors. However, when taking a photograph in an environment where a person's face is irradiated by sunlight or illumination light, or in an environment where the person's face is backlit, at night, or in rainy weather or in other low-illuminance environments, the device could not pick up the features of the face of the person used for biometric authentication because the face of the person appearing in the photograph is in a white flying state, a backlit state, and the like.
(5) Further, in recent years, there has been a demand for a device capable of realizing biometric authentication using a photograph taken while a person is wearing a mask. In biometric authentication using such a photograph, an eye feature quantity is important because the feature quantity required for biometric authentication is reduced. However, when specular reflection occurs in which light (sunlight, illumination light, and the like) is reflected on glasses, since light (sunlight, illumination light, and the like) is reflected on the glasses, there was a difficulty when the device calculates the feature quantity of the eye required for biometric authentication.
(6) The present disclosure has been devised in view of the conventional circumstances described above, and aims to provide an authentication system and an authentication method capable of obtaining a face image more suitable for biometric authentication by suppressing reflection of illumination light due to specular reflection.
(7) The present disclosure provides an authentication system including at least one illumination that irradiates a person to be authenticated with invisible light; a first imaging device that images the person to be authenticated irradiated with the invisible light; and an authentication device that is capable of communicating with the first imaging device and executes authentication of the person to be authenticated based on a first invisible light image captured by the first imaging device. The illumination and the first imaging device are disposed at positions that are respectively asymmetric with respect to a line-of-sight position of the person to be authenticated guided by a line-of-sight guiding section that guides the line-of-sight position of the person to be authenticated.
(8) Further, the present disclosure provides an authentication method performed by an authentication system including at least one illumination that emits invisible light, a first imaging device that images a person to be authenticated, and an authentication device that is capable of communicating with the first imaging device and executes authentication of the person to be authenticated. The illumination and the first imaging device are disposed at positions that are respectively asymmetric with respect to a line-of-sight position of the person to be authenticated guided by a line-of-sight guiding section that guides the line-of-sight position of the person to be authenticated. The authentication method includes imaging, by the first imaging device, the person to be authenticated irradiated with the invisible light; and authenticating, by the authentication device, the person to be authenticated based on the captured first invisible light image.
(9) According to the present disclosure, it is possible to obtain a face image more suitable for biometric authentication by suppressing reflection of illumination light due to specular reflection.

Description

BRIEF DESCRIPTION OF DRAWINGS
(1) FIG. **1** is a diagram illustrating a use case of a biometric authentication system according to Embodiment 1;
(2) FIG. **2** is a block diagram illustrating an example of an internal configuration of the biometric

authentication system according to Embodiment 1;
(3) FIG. **3** is a sequence diagram illustrating an example of an operation procedure of the biometric authentication system according to Embodiment 1;
(4) FIG. **4** is a block diagram illustrating an example of an internal configuration of a biometric authentication system according to Embodiment 2;
(5) FIG. **5** is a block diagram illustrating an example of an internal configuration of a biometric authentication system according to Modification Example 1 of Embodiment 2;
(6) FIG. **6** is a block diagram illustrating an example of an internal configuration of a biometric authentication system according to Modification Example 2 of Embodiment 2;
(7) FIG. **7** is a sequence diagram showing an example of an operation procedure of the biometric authentication system according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2;
(8) FIG. **8** is a sequence diagram showing an example of the operation procedure of the biometric authentication system according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2;
(9) FIG. **9** is a diagram illustrating a visible light image, an invisible light image, and an invisible light image with and without polarized light;
(10) FIG. **10** is a diagram illustrating Setting Examples 1 and 2 of disposition reference points for cameras and illuminations;
(11) FIG. **11** is a diagram illustrating respective disposition examples of a camera and an illumination when there is one camera;
(12) FIG. **12** is a diagram illustrating respective disposition examples of cameras and an illumination when there are two cameras;
(13) FIG. **13** is a diagram illustrating respective disposition examples of a camera and illuminations when there are two illuminations;
(14) FIG. **14** is a diagram illustrating respective disposition examples of a camera, a light, and a line-of-sight guiding section when there is one camera;
(15) FIG. **15** is a diagram illustrating respective disposition examples of cameras, a light, and a line-of-sight guiding section when there are two cameras;
(16) FIG. **16** is a diagram illustrating respective disposition examples of a camera, illuminations, and a line-of-sight guiding section when there are two illuminations;
(17) FIG. **17** is a diagram illustrating an example of line-of-sight guide and respective disposition examples of a camera and an illumination; and
(18) FIG. **18** is a diagram illustrating an example of line-of-sight guide and respective disposition examples of a camera and an illumination.

DESCRIPTION OF EMBODIMENTS

(19) Hereinafter, embodiments specifically disclosing the configuration and operation of an authentication system and an authentication method according to the present disclosure will be described in detail with reference to drawings as appropriate. However, a detailed description more than necessary may be omitted. For example, a detailed description of a well-known content or a repeated description of the substantially same configuration will be omitted. This is to prevent the following description from being unnecessarily redundant and to facilitate understanding of a person skilled in the art. The accompanying drawings and the following description are provided for those skilled in the art to fully understand the present disclosure, and are not intended to limit the subject matter described in the claims.

Embodiment 1

(20) A biometric authentication system **100** according to Embodiment 1 will be described with reference to FIG. **1**. FIG. **1** is a diagram illustrating a use case of the biometric authentication system **100** according to Embodiment 1. FIG. **2** is a block diagram illustrating an example of an internal configuration of the biometric authentication system **100** according to Embodiment 1.

(21) In FIG. **1**, to make it easy to understand the description of invisible light illumination emitted by an illumination **13** and internally scattered light received and incident on a first camera **22** by being reflected by the inside the face of a user (skin), the drawing of an authentication device P**1** and a face authentication server S**1** is omitted.
(22) The biometric authentication system **100** as an example of an authentication system includes an illumination device LT**1**, a first imaging device C**1**, the authentication device P**1**, and the face authentication server S**1**. The biometric authentication system **100** shown in FIG. **2** is an example and is not limited thereto. For example, the biometric authentication system **100** may include a network. The authentication device P**1** and the face authentication server S**1** may be connected so as to be able to transmit and receive data via a network. Also, a registered face image database DB may be configured separately from the face authentication server S**1**.
(23) The illumination device LT**1** irradiates a user who is a biometric authentication target with invisible light including near-infrared light with a wavelength of 940 nm. The illumination device LT**1** includes a communication section **10**, a control section **11**, an illumination power supply section **12**, the illumination **13**, and a first polarizing plate **14**.
(24) The communication section **10** is connected with the first camera **22** of the first imaging device C**1** in a data-communicable manner and outputs a control command transmitted from the first camera **22** to the control section **11**.
(25) Based on the control command output from the communication section **10**, the control section **11** performs ON/OFF control of the illumination power supply section **12** (that is, control of turning on/off the illumination **13**).
(26) The illumination power supply section **12** is controlled by the control section **11** to turn ON/OFF the power supply to the illumination **13**.
(27) The illumination **13** is implemented by at least one light-emitting diode (LED). The illumination **13** is supplied with power from the illumination power supply section **12** and emits invisible light, which is near-infrared light with a wavelength of 940 nm. The illumination **13** may be a point light source or a surface light source.
(28) A first polarizing plate **14** is disposed perpendicular to a second polarizing plate **20** (that is, crossed Nicols) to polarize the invisible light emitted from the illumination **13** in a first direction. For example, in the example shown in FIG. **1**, the first polarizing plate **14** transmits only the vertical component of the invisible light of the illumination **13**.
(29) The first imaging device C**1** images a region including the face of the user and acquires a first captured image of the user (an example of a first invisible light image) used for biometric authentication. The first imaging device C**1** includes the second polarizing plate **20**, a band-pass filter (BPF) **21**, and the first camera **22**.
(30) The second polarizing plate **20** is disposed perpendicular to the first polarizing plate **14** (for example, crossed Nicols) so that components in the first direction (that is, components of specularly reflected light) out of the specularly reflected light and the internally scattered light reflected by the face of the user and the other light (sunlight, illumination light which is visible light, and the like) are removed, and only the components in the second direction out of the internally scattered light and the other light is transmitted.
(31) The BPF **21** transmits only invisible light (that is, near-infrared light with a wavelength of 940 nm) out of the internally scattered light and other light transmitted through the second polarizing plate **20**. As a result, the BPF **21** can transmit only the invisible light with a wavelength of 940 nm, which is within a sensor sensitivity range within which the Si photodiode (not shown) of the first camera **22** can receive light, and having a large attenuation of sunlight by moisture contained in the air.
(32) The first camera **22** includes at least an image sensor (not shown) and a lens (not shown). The image sensor is a solid-state imaging device including a Si photodiode and, for example, a charged-coupled device (CCD) or a complementary metal oxide semiconductor (CMOS), and converts an

optical image by invisible light (internally scattered light) imaged on the imaging surface into an electric signal. The first camera **22** transmits the converted electric signal (data of the first captured image) to the authentication device P**1**.
(33) The authentication device P**1** is implemented by, for example, a personal computer (PC), a laptop PC, a tablet terminal, a smartphone, or the like, and executes authentication of a user who is a biometric authentication target. The authentication device P**1** includes a communication section **30**, a control section **31**, a memory **32**, and a display section **33**.
(34) The communication section **30** is connected to the first camera **22** of the first imaging device C**1** and the communication section **40** of the face authentication server S**1** in a wireless or wired communicable manner, and transmits and receives data. The communication section **30** acquires data of the first captured image transmitted from the first camera **22** and outputs the data to the control section **31**.
(35) The communication section **30** transmits the face image output from the control section **31** to the face authentication server S**1**. Also, the communication section **30** acquires an authentication score corresponding to the face image transmitted from the face authentication server S**1** and outputs the authentication score to the control section **31**.
(36) Although not shown in FIG. **2**, the communication section **30** may transmit the control command (for example, a control command for starting imaging by the first camera **22** of the first imaging device C**1**, and the like) generated by the control section **31** to the first camera **22**. Based on the control command transmitted from the communication section **30**, the first camera **22** may start exposure (imaging), generate a control command for turning on the illumination **13** of the illumination device LT**1**, and transmit the control command to the communication section **10**.
(37) The control section **31** is configured by using, for example, a central processing unit (CPU) or a field programmable gate array (FPGA), and cooperates with the memory **32** to perform various types of processing and control. Specifically, the control section **31** refers to the program and data stored in the memory **32** and executes the program, thereby implementing the function of the authentication device P**1**.
(38) The control section **31** executes image analysis processing on the first captured image captured by the first camera **22** to detect the face of the user appearing in the first captured image. The control section **31** cuts out a region including the detected face of the user from the first captured image to generate a face image. The control section **31** outputs the generated face image to the communication section **30** and transmits the face image to the face authentication server S**1**.
(39) Based on the positional information of the detected face of the user, the control section **31** generates a frame (frame FB shown in FIG. **10**) indicating the position of the face of the user, and superimposes the frame on the first captured image. The control section **31** outputs the frame-superimposed first captured image to the display section **33** for display.
(40) Further, based on whether or not the authentication score transmitted from the face authentication server S**1** is equal to or greater than a threshold value, the control section **31** determines whether the user appearing in the face image (first captured image) is a registered user registered in advance in the registered face image database DB.
(41) When it is determined that the authentication score is equal to or greater than the threshold value, the control section **31** determines that the user is a registered user registered in advance in the registered face image database DB and that the biometric authentication is “OK” (that is, success). The control section **31** executes a predetermined authentication success operation set in advance (an example of a predetermined operation).
(42) The authentication success operation referred to here is an operation (control) set in advance by the user, administrator, or the like of the biometric authentication system **100** based on the application of the biometric authentication system **100**. Authentication success operations include, for example, operations for unlocking and opening doors, entrance gates, and the like, settlement operations for purchasing goods, and operations for generating and displaying an authentication

result screen for notifying that biometric authentication results are successful.
(43) On the other hand, when it is determined that the authentication score is not equal to or greater than the threshold value, the control section **31** determines that the user is not a registered user registered in advance in the registered face image database DB and that the biometric authentication is “NG” (that is, failure). The control section **31** generates an authentication failure screen (not shown) for notifying the user of biometric authentication failure, and outputs the screen to the display section **33**.
(44) The memory **32** includes, for example, a random access memory (RAM) as a work memory used when executing each processing of the control section **31**, and a read only memory (ROM) for storing programs and data defining the operation of the control section **31**. Data or information generated or acquired by the control section **31** is temporarily stored in the RAM. A program that defines the operation of the control section **31** is written in the ROM.
(45) The display section **33**, which is an example of a monitor, may be configured by using a display device such as a liquid crystal display (LCD) or an organic electroluminescence (EL). The display section **33** displays (outputs) the authentication failure screen output from the control section **31**, and displays (outputs) the first captured image on which the frame FB is superimposed.
(46) The face authentication server S**1** calculates an authentication score indicating the probability that the user appearing in the first captured image transmitted from the authentication device P**1** is one of the users registered in advance in the registered face image database DB. The face authentication server S**1** includes the communication section **40**, the control section **41**, the memory **42**, and the registered face image database DB. The registered face image database DB may be configured separately and may be communicably connected to the face authentication server S**1**.
(47) The communication section **40** is connected to the authentication device P**1** in a wireless or wired communicable manner, and transmits and receives data. The communication section **40** acquires data of the face image (first captured image) transmitted from the authentication device P**1** and outputs the data to the control section **41**. The communication section **40** transmits the authentication score information output from the control section **41** to the authentication device P**1**.
(48) The control section **41** is configured by using, for example, a CPU or FPGA, and cooperates with the memory **42** to perform various types of processing and control. Specifically, the control section **41** refers to the program and data stored in the memory **42** and executes the program, thereby implementing the function of the face authentication server S**1**.
(49) The control section **41** collates the acquired face image with the registered face image of each of a plurality of users registered in advance in the registered face image database DB to calculate (evaluate) an authentication score which is an index of whether a user appearing in the face image and a registered user are the same person or not. The control section **41** outputs information on the calculated authentication score to the communication section **40** and transmits the information to the authentication device P**1**.
(50) The memory **42** includes, for example, a RAM as a work memory used when executing each processing of the control section **41** and a ROM for storing programs and data defining the operation of the control section **41**. Data or information generated or acquired by the control section **41** is temporarily stored in the RAM. A program that defines the operation of the control section **41** is written in the ROM.
(51) The registered face image database DB is a so-called storage, and is configured by using a storage medium such as a flash memory, hard disk drive (HDD), solid state drive (SSD), or the like. The registered face image database DB stores (registers) a registered face image for each user and information about the user (for example, the user's name, date of birth, age, gender, address, telephone number, ID, and the like) in association with each other.
(52) Next, biometric authentication operations performed by the biometric authentication system **100** will be described with reference to FIG. **3**. FIG. **3** is a sequence diagram illustrating an

example of an operation procedure of the biometric authentication system **100** according to Embodiment 1.

(53) The order in which the processing of steps St**11** to St**16** are executed may not be the order shown in FIG. **3**. For example, the processing of steps St**11** and St**12** may be executed after the processing of step St**13**, or the processing of step St**14** may be executed after the processing of step St**16**.

(54) The first imaging device C**1** generates a control command for turning on the illumination **13** at the same time as starting imaging, and transmits the generated control command to the illumination device LT**1** to request to turn on the illumination **13** (St**11**). When the illumination device LT**1** acquires the control command transmitted from the first imaging device C**1**, the illumination power supply section **12** starts supplying power to the illumination **13** to turn on the illumination **13** (St**12**).

(55) The first imaging device C**1** starts exposure of the first camera **22** (St**13**), and ends the exposure after a predetermined exposure time has elapsed (St**14**). After completing the exposure (imaging), the first imaging device C**1** generates a control command for turning off the illumination **13**, and transmits the generated control command to the illumination device LT**1** to request to turn off the illumination **13** (St**15**).

(56) When the illumination device LT**1** acquires the control command transmitted from the first imaging device C**1**, the illumination device LT**1** ends supplying power to the illumination **13** by the illumination power supply section **12** to turn off the illumination **13** (St**16**).

(57) The first imaging device C**1** acquires the captured first captured image (St**17**), and transmits the data of the first captured image to the authentication device P**1** (St**18**).

(58) The authentication device P**1** executes image analysis processing on the first captured image transmitted from the first imaging device C**1** to detect the face of the user. The authentication device P**1** determines whether or not the user's face is detected from the first captured image (St**19**).

(59) When it is determined in the processing of step St**19** that the face of the user has been detected from the first captured image (St**19**, YES), the authentication device P**1** generates a first captured image obtained by superimposing a frame (for example, a frame FB shown in FIG. **10**) surrounding the position (region) of the face detected in the first captured image and outputs (displays) the first captured image to the display section **33** (St**20**). Further, the authentication device P**1** generates a face image obtained by cutting out the detected region of the face of the user from the first captured image, and transmits the face image to the face authentication server S**1** (St**21**).

(60) On the other hand, when it is determined in the processing of step St**19** that the user's face is not detected from the first captured image (St**19**, NO), the authentication device P**1** returns to the processing of step St**11**. Here, the authentication device P**1** may generate a control command for requesting to re-image the user, and transmit the control command to the first imaging device C**1**.

(61) The face authentication server S**1** collates the user's face image transmitted from the authentication device P**1** with the registered face image of each of the plurality of users registered in the registered face image database DB to calculate an authentication score (St**22**). The face authentication server S**1** transmits information on the calculated authentication score to the authentication device P**1** (St**23**).

(62) The authentication device P**1** acquires the authentication score transmitted from the face authentication server S**1** to determine whether or not the authentication score is equal to or greater than the threshold value (St**24**).

(63) When it is determined in the processing of step St**24** that the authentication score transmitted from the face authentication server S**1** is equal to or greater than the threshold value (St**24**, YES), the authentication device P**1** determines that the user is a registered user registered in advance in the registered face image database DB and that the biometric authentication is “OK” (that is, success), and executes a predetermined authentication success operation set in advance (St**25**).

(64) On the other hand, when it is determined in the processing of step St**24** that the authentication

score is not equal to or greater than the threshold value (St**24**, NO), the authentication device P**1** determines that the user is not a registered user registered in advance in the registered face image database DB and that the biometric authentication is "NG" (that is, failure). The authentication device P**1** generates an authentication failure screen (not shown) for notifying the user of biometric authentication failure, and outputs (displays) the screen on the display section **33** (St**26**).

(65) As described above, the biometric authentication system **100** removes light which is specularly reflected by the second polarizing plate **20** disposed in a crossed-Nicols state (for example, sunlight, illumination light which is visible light, and the like) out of the light incident on the first camera **22**, thereby realizing the imaging of the user by the invisible light emitted by the illumination **13** (near-infrared light with a wavelength of 940 nm).

(66) Specifically, the second polarizing plate **20** can remove the components in the first direction out of the light of the illumination **13** which is specularly reflected by the user's glasses (light polarized in the first direction), other light (for example, sunlight, illumination light which is visible light, and the like), or other light which is emitted at a Bluster angle and is specularly reflected by the user's glasses (visible light in the first direction).

(67) As a result, even in an imaging environment where a user is imaged or an environment of the installation environment where the first camera **22** is installed is not suitable for imaging of the first captured image used for biometric authentication (for example, an environment where specular reflection is generated, a low-illuminance environment, and the like), by removing components in the first direction, the biometric authentication system **100** can acquire the first captured image (that is, the first captured image suitable for biometric authentication) from which features necessary for biometric authentication can be extracted.

(68) In addition, even when imaging a user whose face is partially hidden by a mask or the like, the biometric authentication system **100** can acquire the first captured image from which a feature quantity (for example, a feature quantity related to an iris) related to the eyes of the user used for biometric authentication can be calculated from the captured first captured image.

Embodiment 2

(69) The above-described biometric authentication system **100** according to Embodiment 1 shows an example in which one first imaging device C**1** (first camera **22**) captures the first captured image used for biometric authentication. The first captured image captured by the first camera **22** is captured when invisible light illumination (wavelength of 940 nm) emitted to the user is scattered inside the skin of the user and the scattered internally scattered light is received by an image sensor. Therefore, the first captured image becomes a captured image in which the user's blood vessels, whiskers, and the like are reflected. As a result, the user appearing in the first captured image displayed on the display section **33** may differ from the actual appearance of the user.

(70) Therefore, the biometric authentication system **200** according to Embodiment 2 describes an example of imaging a user by each of two imaging devices (first imaging device C**21** and second imaging device C**22**), and capturing a first captured image used for biometric authentication and a second captured image displayed on the display section **33** to be presented to the user.

(71) In the following description, the same symbols are assigned to the same configurations as those of the devices constituting the biometric authentication system **100** according to Embodiment 1, and the description thereof will be omitted.

(72) The biometric authentication system **200** according to Embodiment 2 will be described with reference to FIG. **4**. FIG. **4** is a block diagram illustrating an example of an internal configuration of the biometric authentication system **200** according to Embodiment 2.

(73) The biometric authentication system **200** includes an illumination device LT**1**, two imaging devices (a first imaging device C**21** and a second imaging device C**22**), an authentication device P**1**A, and a face authentication server S**1**.

(74) The first imaging device C**21** images a region including a user's face and acquires a first captured image used for biometric authentication. The first imaging device C**21** includes a second

polarizing plate **50**, a BPF **51**, and a first camera **52**.
(75) The second polarizing plate **50** is disposed perpendicular to the first polarizing plate **14** (for example, crossed Nicols) so that components in the first direction (that is, components of specularly reflected light) out of the specularly reflected light and the internally scattered light reflected by the user's face and the other light (sunlight, illumination light which is visible light, and the like) are removed, and only the components in the second direction out of the internally scattered light and the other light is transmitted.
(76) The BPF **51** transmits only invisible light (that is, near-infrared light with a wavelength of 940 nm) out of the internally scattered light and other light transmitted through the second polarizing plate **50**. As a result, the BPF **51** can transmit only the invisible light with a wavelength of 940 nm, which is within a sensor sensitivity range within which the Si photodiode (not shown) of the first camera **22** can receive light, and having a large attenuation of sunlight by moisture contained in the air.
(77) The first camera **52** includes at least an image sensor (not shown) and a lens (not shown). The image sensor is a solid-state imaging device including a Si photodiode and, for example, a CCD or CMOS, and converts an optical image of invisible light (internally scattered light) formed on an imaging surface into an electric signal. The first camera **52** executes synchronous control with the second camera **62** of the second imaging device C**22**. The first camera **52** transmits the converted electric signal (data of the first captured image) to the authentication device P**1**A.
(78) The second imaging device C**22** images a region including the user's face and acquires a second captured image to be displayed on the display section **33**A. The second imaging device C**22** includes a third polarizing plate **60**, a BPF **61**, and a second camera **62**.
(79) The third polarizing plate **60** is disposed parallel to the first polarizing plate **14** (that is, parallel Nicols), and transmits only the surface-reflected light that is reflected by the surface of the user's face.
(80) The BPF **61** as an example of a filter transmits only invisible light (that is, near-infrared light with a wavelength of 940 nm) out of the surface-reflected light transmitted through the third polarizing plate **60**. As a result, the BPF **61** can transmit only the invisible light with a wavelength of 940 nm, which is within a sensor sensitivity range within which the Si photodiode (not shown) of the second camera **62** can receive light, and having a large attenuation of sunlight by moisture contained in the air.
(81) The second camera **62** includes at least an image sensor (not shown) and a lens (not shown). The image sensor is a solid-state imaging device including a Si photodiode and, for example, a CCD or CMOS, and converts an optical image of invisible light (surface-reflected light) formed on an imaging surface into an electric signal. The second camera **62** executes synchronous control with the first camera **52** of the first imaging device C**21**. The second camera **62** transmits the converted electric signal (data of the second captured image) to the authentication device P**1**A.
(82) The authentication device P**1**A is implemented by, for example, a PC, a laptop PC, a tablet terminal, a smartphone, or the like, and executes authentication of a user who is a biometric authentication target, and displays a second captured image captured by the second camera **62**. The authentication device PIA includes a communication section **30**A, a control section **31**A, a memory **32**, and a display section **33**A.
(83) The communication section **30**A is connected to the first camera **52** of the first imaging device C**21**, the second camera **62** of the second imaging device C**22**, and the communication section **40** of the face authentication server S**1** in a wireless or wired communicable manner, and transmits and receives data.
(84) The communication section **30**A acquires the data of the first captured image transmitted from the first camera **52** and the data of the second captured image transmitted from the second camera **62**, and outputs the data to the control section **31**A. The communication section **30**A also transmits the user's face image generated by the control section **31**A to the face authentication server S**1**. The

communication section **30**A acquires an authentication score corresponding to the face image transmitted from the face authentication server S**1** and outputs the authentication score to the control section **31**A.

(85) The control section **31**A is configured by using, for example, a CPU or FPGA, and cooperates with the memory **32** to perform various types of processing and control. Specifically, the control section **31**A refers to the program and data stored in the memory **32** and executes the program, thereby implementing the function of the authentication device NA.

(86) The control section **31**A executes image analysis processing on the first captured image transmitted from the first camera **52**, and detects the face of the user appearing in the first captured image. The control section **31**A cuts out a region including the detected face of the user from the first captured image to generate a face image. The control section **31**A outputs the generated face image to the communication section **30**A and transmits the face image to the face authentication server S**1**.

(87) In addition, based on the positional information of the disposed first camera **52** and second camera **62**, the control section **31**A converts the positional information of the face of the user on the first captured image into the positional information on the second captured image transmitted from the second camera **62**. Based on the converted positional information, the control section **31**A generates a frame (frame FB shown in FIG. **10**) indicating the region including the face position of the user, and superimposes the frame on the second captured image. The control section **31**A outputs the frame-superimposed second captured image to the display section **33**A for display.

(88) Based on whether or not the authentication score transmitted from the face authentication server S**1** is equal to or greater than a threshold value, the control section **31**A determines whether the user appearing in the face image (first captured image) is a registered user registered in advance in the registered face image database DB.

(89) The display section **33**A, which is an example of a monitor, may be configured by using a display device such as LCD or organic EL. The display section **33**A displays (outputs) the second captured image after superimposing the frame FB output from the control section **31**A, displays (outputs) an authentication failure screen, and/or the like. As described above, the biometric authentication system **200** according to Embodiment 2 and illuminate the user with the invisible light (near-infrared light with a wavelength of 940 nm) of the illumination **13** to capture the second captured image based on the surface-reflected light that is reflected on the surface of the skin of the user. In addition, since the first polarizing plate **14** and the third polarizing plate **60** are in a parallel-Ni cols state, the surface-reflected light received by the second camera **62** becomes invisible light with a wavelength of 940 nm including near-infrared light emitted to the user through the first polarizing plate **14** and other light illuminating the user (sunlight, illumination light of visible light indoors and outdoors, or the like). As a result, the biometric authentication system **200** according to Embodiment 2 is suitable for biometric authentication and can realize acquisition of the first captured image captured by receiving scattered light and display of the second captured image captured by receiving surface-reflected light.

Modification Example 1 of Embodiment 2

(90) The biometric authentication system **200** according to Embodiment 2 has shown an example in which the second imaging device C**22** including the third polarizing plate **60** captures the second captured image to be displayed on the display section **33**A. A biometric authentication system **200**A according to Modification Example 1 of Embodiment 2 describes an example of capturing a second captured image by the second imaging device C**22**A in a configuration where the third polarizing plate **60** is omitted.

(91) In the following description, the same symbols are assigned to the same configurations as those of the devices constituting the biometric authentication system **200** according to Embodiment 2, and the description thereof will be omitted.

(92) The biometric authentication system **200**A according to Modification Example 1 of

Embodiment 2 will be described with reference to FIG. **5**. FIG. **5** is a block diagram illustrating an example of an internal configuration of the biometric authentication system **200**A according to Modification Example 1 of Embodiment 2.
(93) The second imaging device C**22**A images a region including the face of the user and acquires a second captured image to be displayed on the display section **33**A. The second imaging device C**22**A includes a BPF **71** and a second camera **72**.
(94) The BPF **71** as an example of a filter transmits only invisible light (that is, near-infrared light with a wavelength of 940 nm) out of the surface-reflected light that is emitted to the user to be reflected. As a result, the BPF **71** can transmit only the invisible light with a wavelength of 940 nm, which is within a sensor sensitivity range within which the Si photodiode (not shown) of the second camera **72** can receive light, and having a large attenuation of sunlight by moisture contained in the air.
(95) The second camera **72** includes at least an image sensor (not shown) and a lens (not shown). The image sensor is a solid-state imaging device including a Si photodiode and, for example, a CCD or CMOS, and converts an optical image of invisible light (surface-reflected light) formed on an imaging surface into an electric signal. The second camera **72** executes synchronous control with the first camera **52** of the first imaging device C**21**. The second camera **72** transmits the converted electric signal (data of the second captured image) to the authentication device P**1**A.
(96) As described above, the biometric authentication system **200**A according to Modification Example 1 of Embodiment 2 can illuminate the user with the invisible light (near-infrared light with a wavelength of 940 nm) of the illumination **13** and capture the second captured image based on the surface-reflected light that is reflected on the surface of the skin of the user. The surface-reflected light received by the second camera **62** becomes invisible light with a wavelength of 940 nm out of the light including near-infrared light emitted to the user through the first polarizing plate **14** and other light illuminating the user (sunlight, illumination light of visible light indoors and outdoors, or the like). As a result, the biometric authentication system **200**A according to Modification Example 1 of Embodiment 2 is suitable for biometric authentication and can realize acquisition of the first captured image captured by receiving scattered light and display of the second captured image captured by receiving surface-reflected light.
Modification Example 2 of Embodiment 2
(97) The biometric authentication system **200** according to Embodiment 2 has shown an example in which the second imaging device C**22** including the third polarizing plate **60** and the BPF **61** captures the second captured image to be displayed on the display section **33**A. A biometric authentication system **200**B according to Modification Example 2 of Embodiment 2 describes an example of capturing a second captured image by a second imaging device C**22**B in a configuration where the third polarizing plate **60** and the BPF **61** are omitted.
(98) In the following description, the same symbols are assigned to the same configurations as those of the devices constituting the biometric authentication system **200** according to Embodiment 2, and the description thereof will be omitted.
(99) The biometric authentication system **200**B according to Modification Example 2 of Embodiment 2 will be described with reference to FIG. **6**. FIG. **6** is a block diagram illustrating an example of an internal configuration of the biometric authentication system **200**B according to Modification Example 2 of Embodiment 2.
(100) The second imaging device C**22**B images a region including the user's face and acquires a second captured image to be displayed on the display section **33**A. The second imaging device C**22**B includes a second camera **80**.
(101) The second camera **80** includes at least an image sensor (not shown) and a lens (not shown). The image sensor is a solid-state imaging device including a Si photodiode and, for example, a CCD or CMOS, and converts an optical image of visible light (surface-reflected light) formed on an imaging surface into an electric signal. The second camera **80** executes synchronous control

with the first camera **52** of the first imaging device C**21**. The second camera **80** transmits the converted electric signal (data of the second captured image) to the authentication device P**1**A.
(102) As described above, the biometric authentication system **200**B according to Modification Example 2 of Embodiment 2 can capture the second captured image based on the surface-reflected light (visible light) reflected on the surface of the skin of the user. The surface-reflected light received by the second camera **62** becomes visible light including invisible light emitted to the user through the first polarizing plate **14** and other light that illuminates the user (sunlight, illumination light of visible light indoors and outdoors, or the like). As a result, the biometric authentication system **200**B according to Modification Example 2 of Embodiment 2 is suitable for biometric authentication and can realize acquisition of the first captured image captured by receiving scattered light and display of the second captured image captured by receiving surface-reflected light (color image).
(103) Next, biometric authentication operations executed by the biometric authentication systems **200**, **200**A, and **200**B will be described with reference to each of FIGS. **7** and **8**. FIG. **7** is a sequence diagram showing an example of an operation procedure of the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2. FIG. **8** is a sequence diagram showing an example of an operation procedure of the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2.
(104) The order in which the processing of steps St**31** to St**36** are executed may not be the order shown in FIG. **7**. For example, the processing of steps St**31** and St**32** may be executed after the processing of steps St**33**A and St**33**B, or the processing of steps St**34**A and St**34**B may be executed after the processing of step St**36**.
(105) The first imaging device C**21** generates a control command for turning on the illumination **13** at the same time as starting imaging, and transmits the generated control command to the illumination device LT**1** to request to turn on the illumination **13** (St**31**).
(106) When the illumination device LT**1** acquires the control command transmitted from the first imaging device C**21**, the illumination power supply section **12** starts supplying power to the illumination **13** to turn on the illumination **13** (St**32**).
(107) The first imaging device C**21** starts exposure of the first camera **52** (St**33**A), and ends the exposure after a predetermined exposure time has elapsed (St**34**A).
(108) The second imaging devices C**22**, C**22**A, and C**22**B start exposure of the second cameras **62**, **72**, and **80** (St**33**B), and end the exposure after a predetermined exposure time has elapsed (St**34**B). Steps St**33**A and St**33**B and steps St**34**A and St**34**B are each synchronously processed.
(109) After completing the exposure (imaging), the first imaging device C**21** generates a control command for turning off the illumination **13**, and transmits the generated control command to the illumination device LT**1** to request to turn off the illumination **13** (St**35**).
(110) When the illumination device LT**1** acquires the control command transmitted from the first imaging device C**21**, the illumination device LT**1** ends supplying power to the illumination **13** by the illumination power supply section **12** to turn off the illumination **13** (St**36**).
(111) The first imaging device C**21** acquires the first captured image captured by receiving the internally scattered light (St**37**A), and transmits the data of the first captured image to the authentication device P**1**A (St**38**A).
(112) The second imaging devices C**22**, C**22**A, and C**22**B acquire the second captured image captured by receiving the surface-scattered light (St**37**B), and transmit the data of the second captured image to the authentication device P**1**A (St**38**B).
(113) The authentication device P**1**A acquires the first captured image transmitted from the first imaging device C**21** and the second captured images transmitted from the second imaging devices C**22**, C**22**A, and C**22**B. The authentication device P**1**A executes image analysis processing on the acquired first captured image, and determines whether or not the face of the user (that is, person) is

detected from the first captured image (St**39**).

(114) When it is determined in the processing of step St**39** that the face of the user (person) has been detected from the first captured image (St**39**, YES), the authentication device P**1**A calculates the positional information of the detected face of the user. Based on the positional information of the first camera **52** and the positional information of the second cameras **62**, **72**, and **80**, the authentication device P**1**A converts the positional information of the face of the user on the detected first captured image into the positional information on the second captured image (St**40**).

(115) On the other hand, when it is determined in the processing of step St**39** that the face of the user (person) is not detected from the first captured image (St**39**, NO), the authentication device P**1**A displays the second captured image transmitted from the second imaging devices C**22**, C**22**A, and C**22**B on the display section **33**A (St**41**), and returns to the processing of the step St**31**. The frame FB (see FIG. **10**) may not be superimposed on the second captured image to be displayed on the display section **33**A in step St**41**.

(116) The authentication device P**1**A generates a frame FB (see FIG. **10**) indicating the position of the face of the user based on the converted positional information of the face of the user on the second captured image, and superimposes the frame FB on the second captured image. The authentication device P**1**A displays the second captured image superimposed with the frame FB on the display section **33**A (St**42**).

(117) The authentication device P**1**A generates a face image obtained by cutting out a region including the face of the user from the first captured image based on the detected positional information of the face of the user, and transmits the face image to the face authentication server S**1** (St**43**).

(118) The face authentication server S**1** collates the face image of the user transmitted from the authentication device P**1**A with the registered face image of each of the plurality of users registered in the registered face image database DB to calculate an authentication score (St**44**). The face authentication server S**1** transmits information on the calculated authentication score to the authentication device P**1**A (St**45**).

(119) The authentication device P**1**A acquires the authentication score transmitted from the face authentication server S**1** to determine whether or not the authentication score is equal to or greater than the threshold value (St**46**).

(120) When it is determined in the processing of step St**46** that the authentication score transmitted from the face authentication server S**1** is equal to or greater than the threshold value (St**46**, YES), the authentication device P**1**A determines that the user is a registered user registered in advance in the registered face image database DB and that the biometric authentication is “OK” (that is, success), and executes a predetermined authentication success operation set in advance (St**47**).

(121) On the other hand, when it is determined in the processing of step St**46** that the authentication score is not equal to or greater than the threshold value (St**46**, NO), the authentication device P**1**A determines that the user is not a registered user registered in advance in the registered face image database DB and that the biometric authentication is “NG” (that is, failure). The authentication device P**1**A generates an authentication failure screen (not shown) for notifying the user of biometric authentication failure, and outputs (displays) the screen on the display section **33** (St**48**).

(122) As described above, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can display the second captured image on the display section **33**A to present the second captured image to the user and execute biometric authentication by using the first captured image.

(123) Next, the first captured image captured by the first cameras **22** and **52** will be described with reference to FIG. **9**. FIG. **9** is a diagram illustrating a visible light image, an invisible light image, and an invisible light image with and without polarized light. In FIG. **9**, an example of the first captured image captured by the first cameras **22** and **52** will be described, but the second captured

image (visible light image, invisible light image) captured by the second cameras **62**, **72**, and **80** is also the same.
(124) A captured image IMG**11** is a visible light image, and is a captured image of a backlit user under sunlight outdoors. In the backlit state, the first imaging device C**1** or the first imaging device C**21** cannot capture the face of the user as shown by the captured image IMG**11**, and it is difficult to capture an image suitable for biometric authentication.
(125) In the same imaging environment as the captured image IMG**11**, a captured image IMG**12** is a captured image captured by receiving only the invisible light with a wavelength of 940 nm (near-infrared light) with the image sensors of the first cameras **22** and **52** by using BPFs **21** and **51**. In other words, the first cameras **22** and **52** can image the face of the user even in a backlit state.
(126) A captured image IMG**21** is a captured image captured by receiving only invisible light (near-infrared light) with a wavelength of 940 nm with the image sensors of the first cameras **22** and **52** by using the BPFs **21** and **51**. In the captured image IMG**21**, the user is wearing glasses, and the invisible light illumination with a wavelength of 940 nm emitted by the illumination **13** is reflected on the glasses (region WT**1**).
(127) In such a case, there is a possibility that the biometric authentication systems **100**, **200**, **200**A, and **200**B cannot calculate the feature quantity related to the eyes of the user used for biometric authentication based on the captured image IMG**21** due to the invisible light illumination reflected on the glasses.
(128) The captured image IMG**22** is a captured image that is captured in the same imaging environment as the captured image IMG**21**, and that is obtained by: polarizing the scattered light reflected by the user by further using the second polarizing plates **20** and **50** substantially orthogonal to the first polarizing plate **14** of the illumination **13** (crossed Nicols); and receiving with the image sensors of the first cameras **22** and **52** only the invisible light with a wavelength of 940 nm (near-infrared light) out of the light after polarized by the BPFs **21** and **51**. In the captured image IMG**22**, compared to the captured image IMG**21**, the reflection amount of the invisible light illumination reflected on the glasses wom by the user is suppressed from a region WT**1** to a region WT**2**.
(129) As a result, the biometric authentication systems **100**, **200**, **200**A, and **200**B can calculate the feature quantity related to the eyes of the user, which is used for biometric authentication, based on the captured image IMG**22**.
(130) Next, with reference to FIG. **10**, axes L**1** and L**2** that serve as the reference for disposition of each device will be described in a disposition example of the first camera **22** and the illumination **13** shown in FIG. **11**, a disposition example of the first camera **52**, the second cameras **62**, **72**, and **80**, and the illumination **13** shown in FIG. **12**, and in a disposition example of the first camera **22** and a plurality of illuminations **13** shown in FIG. **13**. FIG. **10** is a diagram illustrating Setting Examples 1 and 2 of disposition reference points Pt**11** and Pt**21** of the camera (specifically, first cameras **22** and **52**, and second cameras **62**, **72**, and **80**) and the illumination **13**. In FIG. **10**, in Setting Example 1, the axis L**1** is indicated by an axis L**11**, the axis L**2** is indicated by an axis L**12**, and a disposition reference point Pt**0** is indicated by the disposition reference point Pt**11**, and in Setting Example 2, the axis L**1** is indicated by an axis L**21**, the axis L**2** is indicated by an axis L**22**, and the disposition reference point Pt**0** is indicated by the disposition reference point Pt**21**.
(131) Each of the axes L**11** and L**12** in Setting Example 1 is set with respect to the image displayable regions in the display sections **33** and **33**A. The axis L**11** bisects the image displayable regions in the display sections **33** and **33**A in the width direction (horizontal direction of the paper surface). The axis L**12** bisects the image displayable regions in the display sections **33** and **33**A in the height direction (vertical direction on the paper surface). The axes L**11** and L**12** are orthogonal to each other at the disposition reference point Pt**11** of the image displayable regions in the display sections **33** and **33**A. The disposition reference point Pt**11** is the intersection of the diagonal lines in the image displayable regions of the display sections **33** and **33**A.

(132) In Setting Example 2, the axis L**21** bisects the frame FB (an example of a first frame and a second frame), which is superimposed on the first captured image or the second captured image and indicates a region in which the face of the user is detected, in the width direction (horizontal direction of the paper surface). The axis L**22** bisects the frame FB in the height direction (vertical direction on the paper surface). The axes L**21** and L**22** are orthogonal to each other at the disposition reference point Pt**21** of the frame FB that indicates the region where the face of the user is detected. The disposition reference point Pt**21** is the intersection of diagonal lines in the frame FB.
(133) With reference to FIG. **11**, the disposition example of the first camera **22** and the illumination **13** in the biometric authentication system **100** according to Embodiment 1 will be described. FIG. **11** is a diagram illustrating respective disposition examples of the camera when there is one camera (specifically, the first camera **22**) and the illumination **13**. The disposition reference point Pt**0** shown in FIG. **11** may be set at either the disposition reference point Pt**11** of Setting Example 1 or the disposition reference point Pt**21** of Setting Example 2 shown in FIG. **10**.
(134) The first camera **22** and the illumination **13** are disposed at positions that are mutually asymmetric with respect to the disposition reference point Pt**0**. In the following, disposition examples 1 to 6 of the first camera **22** and the illumination **13** will be described below, but the disposition examples 1 to 6 shown in FIG. **11** are examples, and it is needless to say that the disposition examples are not limited thereto. Also, the illumination **13** may be a surface light source or a point light source.
(135) For example, the first camera **22** in the disposition example 1 is disposed above the display section **33** (upper side of the paper surface) and on the axis L**1**. The illumination **13** is disposed above the display section **33** (upper side of the paper surface) and on the left side of the first camera **22** on the paper surface.
(136) For example, the illumination **13** in the disposition example 2 is disposed below the display section **33** (lower side of the paper surface) and on the axis L**1**. The first camera **22** is disposed below the display section **33** (on the lower side of the paper surface) and on the left side of the illumination **13** on the paper surface.
(137) For example, the first camera **22** in the disposition example 3 is disposed above the display section **33** (upper side of the paper surface) and on the axis L**1**. The illumination **13** is disposed on the side of the display section **33** (on the right side of the paper surface) and on the axis L**2**.
(138) For example, the first camera **22** in the disposition example 4 is disposed on the side of the display section **33** (left side of the paper surface) and on the axis L**2**. The illumination **13** is disposed on the side of the display section **33** (on the left side of the paper surface) and below the first camera **22** on the paper surface.
(139) For example, the illumination **13** in the disposition example 5 is disposed above the display section **33** (upper side of the paper surface). The first camera **22** is disposed above the illumination **13** (on the upper side of the paper surface), which is a surface light source, and on the axis L**1**.
(140) For example, the illumination **13** in the disposition example 6 is disposed on the side of the display section **33** (right side of the paper surface). The first camera **22** is disposed above the display section **33** (upper side of the paper surface) and on the axis L**1**.
(141) Thereby, the first camera **22** according to Embodiment 1 can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) emitted by the illumination **13**. In other words, even when the user is wearing glasses, the biometric authentication system **100** can further effectively suppress the reflection of invisible light illumination due to the reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **100** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.
(142) Next, with reference to FIG. **12**, the disposition example of the first camera **52**, the second

cameras **62**, **72**, and **80**, and the illumination **13** in the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 will be described. FIG. **12** is a diagram illustrating respective disposition examples of the cameras when there are two cameras (specifically, the first camera **52** and each of the second cameras **62**, **72**, and **80**) and the illumination **13**.
(143) The disposition reference point Pt**0** shown in FIG. **12** may be set at either the disposition reference point Pt**11** of Setting Example 1 or the disposition reference point Pt**21** of Setting Example 2 shown in FIG. **10**. Also, the disposition of the first camera **52** and the disposition of each second camera **62**, **72**, and **80** may be reversed.
(144) The first camera **52** or each second camera **62**, **72**, and **80**, and the illumination **13** are disposed at positions that are mutually asymmetric with respect to the disposition reference point Pt**0**. In the following, the disposition examples 1 to 6 of the first camera **52**, each second camera **62**, **72**, and **80**, and the illumination **13** will be described below, but the disposition examples 1 to 6 shown in FIG. **12** are examples, and it is needless to say that the disposition examples are not limited thereto. Also, the illumination **13** may be a surface light source or a point light source.
(145) For example, the first camera **52**, each second cameras **62**, **72**, and **80**, and the illumination **13** in the disposition example 1 are disposed side by side above the display section **33**A (upper side of the paper surface). The second cameras **62**, **72**, and **80** are disposed on the axis L**1**. The first camera **52** is disposed to the left of the second cameras **62**, **72**, and **80** on the paper surface. The illumination **13** is disposed to the left of the first camera **52** on the paper surface.
(146) For example, the first camera **52**, each second camera **62**, **72**, and **80**, and the illumination **13** in the disposition example 2 are disposed side by side below the display section **33**A (lower side of the paper surface). The illumination **13** is disposed on the axis L**1**. The first camera **52** is disposed to the left of the illumination **13** on the paper surface. Each second camera **62**, **72**, and **80** is disposed to the right of the illumination **13** on the paper surface.
(147) For example, the first camera **52** and each second camera **62**, **72**, and **80** in the disposition example 3 are disposed side by side above the display section **33**A (upper side of the paper surface), and the illumination **13** is disposed on the side of the display section **33**A (right side of the paper surface). The first camera **52** is disposed on the axis L**1**. Each second camera **62**, **72**, and **80** is disposed to the right of the first camera **52** on the paper surface. The illumination **13** is disposed on the axis L**2**.
(148) For example, the first camera **52**, each second camera **62**, **72**, and **80**, and the illumination **13** in the disposition example 4 are disposed side by side on the side of the display section **33**A (left side of the paper surface). The first camera **52** is disposed on the axis L**2**. Each second camera **62**, **72**, and **80** is disposed below the first camera **52** on the paper surface. The illumination **13** is disposed below each second camera **62**, **72**, and **80** on the paper surface.
(149) For example, the illumination **13** in the disposition example 5 is disposed above the display section **33**A (upper side of the paper surface). The first camera **52** is disposed above the illumination **13** (upper side of the paper surface), which is a surface light source, and on the left side of the paper surface with respect to the axis L**1**. Each second camera **62**, **72**, and is disposed above the illumination **13** (upper side of the paper surface), which is a surface light source, and on the right side of the paper surface with respect to the axis L**1**.
(150) For example, the illumination **13** in the disposition example 6 is disposed on the side of the display section **33**A (right side of the paper surface). The first camera **52** is disposed above the display section **33**A (upper side of the paper surface) and on the axis L**1**. Each second camera **62**, **72**, and **80** is disposed above the display section **33**A (upper side of the paper surface) and to the right of the first camera **52** on the paper surface.
(151) As a result, the first camera **22** and each of the second cameras **62**, **72**, and **80** in Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can suppress the reception of the specularly reflected light in which the invisible light emitted by the illumination **13** is specularly

reflected. In other words, even when the user is wearing glasses, the biometric authentication system **200**, **200**A, and **200**B can further effectively suppress the reflection of invisible light illumination due to the reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication systems **200**, **200**A, and **200**B can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.
(152) Next, with reference to FIG. **13**, respective disposition examples of the first camera **22** and the two illuminations **13**A and **13**B in the biometric authentication system **100** according to Embodiment 1 will be described. FIG. **13** is a diagram illustrating respective disposition examples of the camera (the first camera **22**) and the illuminations **13**A and **13**B when there are two of the illuminations **13**A and **13**B. The disposition reference point Pt**0** shown in FIG. **13** may be set at either the disposition reference point Pt**11** of Setting Example 1 or the disposition reference point Pt**21** of Setting Example 2 shown in FIG. **10**. In addition, in the description of FIG. **13**, in order to make the description easier to understand, one illumination **13** is given the code "**13**A" and the other illumination **13** is given the code "**13**B" to describe the disposition of each of the two illuminations **13**.
(153) The first camera **22** and the two illuminations **13**A and **13**B are each disposed at positions that are mutually asymmetric with respect to the disposition reference point Pt**0**. In the following, respective disposition examples 1 to 6 of the first camera **22** and the two illuminations **13**A and **13**B will be described below, but the disposition examples 1 to 6 shown in FIG. **13** are examples, and it is needless to say that the disposition examples are not limited thereto. In addition, each of the two illuminations **13**A and **13**B may be a surface light source, a point light source, one illumination may be a surface light source, and the other illumination may be a surface light source.
(154) For example, each of the illuminations **13**A and **13**B and the first camera **22** in the disposition example 1 are disposed side by side above the display section **33** (upper side of the paper surface). The illumination **13**A is disposed on the axis L**1**. The first camera **22** is disposed to the left of the illumination **13**A on the paper surface. The illumination **13**B is disposed on the left side of the first camera **22** on the paper surface.
(155) For example, the illuminations **13**A and **13**B, and the first camera **22** in the disposition example 2 are disposed side by side above the display section **33** (upper side of the paper surface). The first camera **22** is disposed on the axis L**1**. The illumination **13**A is disposed on the left side of the first camera **22** on the paper surface. The illumination **13**B is disposed on the left side of the illumination **13**A on the paper surface.
(156) For example, the illuminations **13**A and **13**B, and the first camera **22** in the disposition example 3 are disposed side by side on the side of the display section **33** (left side of the paper surface). The illumination **13**A is disposed on the axis L**2**. The first camera **22** is disposed below the illumination **13**A on the paper surface. The illumination **13**B is disposed below the first camera **22** on the paper surface.
(157) For example, each of the illuminations **13**A and **13**B and the first camera **22** in the disposition example 4 are disposed side by side above the display section **33** (upper side of the paper surface). The illumination **13**A is disposed on the axis L**1**. The illumination **13**B is disposed to the left of the illumination **13**A (on the left side of the paper surface). The first camera **22** is disposed to the left of the illumination **13**B (on the left side of the paper surface).
(158) For example, each of the illuminations **13**A and **13**B and the first camera **22** in the disposition example 5 are disposed side by side above the display section **33** (upper side of the paper surface). The first camera **22** is disposed on the axis L**1**. The illumination **13**A is disposed to the right of the first camera **22** (on the right side of the paper surface). The illumination **13**B is disposed to the left of the first camera **22** (on the left side of the paper surface).
(159) For example, the illumination **13**B in the disposition example 6 is disposed above the display section **33** (upper side of the paper surface) and on the axis L**1**. The first camera **22** is disposed

above the display section **33** (upper side of the paper surface) and to the right of the illumination **13**B (right side of the paper surface). The illumination **13**A is disposed on the side of the display section **33** (right side of the paper surface) and on the axis L**2**.

(160) Thereby, the first camera **22** according to Embodiment 1 can suppress the reception of specularly reflected light in which the invisible light emitted by each of the two illuminations **13**A and **13**B is specularly reflected. Therefore, even when the user is wearing glasses, the biometric authentication system **100** can further effectively suppress the reflection of invisible light illumination due to the reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **100** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.

(161) As described above, the biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiments 1 and 2, and Modification Examples 1 and 2 of Embodiment 2 (an example of an authentication system) includes at least one illumination **13** that irradiates a user (an example of a person to be authenticated) with invisible light, the first imaging devices C**1** and C**21** that image the user irradiated with the invisible light, and the authentication devices P**1** and PIA that are capable of communicating with the first imaging devices C**1** and C**21** and execute authentication of the user based on the first captured images (examples of the first invisible light images) captured by the first imaging devices C**1** and C**21**. The illumination **13** emits invisible light polarized in the first direction by the first polarizing plate **14**. The first imaging devices C**1** and C**21** receive invisible light polarized in a second direction substantially orthogonal to the first direction by the second polarizing plates **20** and **50** to image the user.

(162) As a result, the biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiments 1 and 2, and Modification Examples 1 and 2 of Embodiment 2 can more effectively suppress the reflection of invisible light illumination on the first captured image such as the captured image IMG**22** shown in FIG. **9** by polarizing the invisible light with a wavelength of 940 nm by the second polarizing plates **20** and **50**. That is, the biometric authentication systems **100**, **200**, **200**A, and **200**B can more effectively suppress the reflection of invisible light on the first captured image used for calculating the feature quantity of the biological information of a user, and can acquire the first captured image more suitable for biometric authentication (that is, the feature quantity of the user used for biometric authentication can be calculated).

(163) Further, as described above, in the biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiments 1 and 2, and Modification Examples 1 and 2 of Embodiment 2, the invisible light is near-infrared light with a wavelength of 940 nm. As a result, the biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiments 1 and 2, and Modification Examples 1 and 2 of Embodiment 2 can acquire the first captured image from which a feature quantity of a user used for biometric authentication can be calculated when imaging outdoors or even when the user's face is in a backlit state by capturing the first captured image at a wavelength of 940 nm having a large attenuation amount of energy of sunlight due to moisture in air.

(164) Further, as described above, the authentication device P**1** in the biometric authentication system **100** according to Embodiment 1 detects the face of the user appearing in the first captured image, generates the frame FB (an example of the first frame) showing the position of the face of the user appearing in the first captured image based on the positional information of the face of the user on the detected first captured image, superimposes the frame FB on the first captured image, and displays the first captured image superimposed with the frame FB on the display section **33** (an example of a monitor). Thereby, the biometric authentication system **100** according to Embodiment 1 can present the user with the first captured image used for biometric authentication.

(165) In addition, as described above, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 include the

second imaging devices C**22**, C**22**A, and C**22**B that are capable of communicating with the authentication device P**1**A and receive the surface-reflected light of the user irradiated with invisible light for imaging. The second imaging devices C**22**, C**22**A, and C**22**B transmit the second captured images of the user to the authentication devices P**1** and P**1**A. The authentication device P**1**A displays the second captured images on display section **33**A. As a result, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can present the second captured image captured by receiving surface-reflected light at approximately the same timing as the first captured image used for biometric authentication to the user. The second captured image captured by receiving surface-reflected light more effectively suppress the reflection of blood vessels, whiskers, and the like, compared with the first captured image captured by receiving the internally scattered light scattered inside the skin, and can reduce the difference between the user appearing in the second captured image and the actual appearance of the user.

(166) Further, as described above, the authentication device PIA in the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 detects the face of the user appearing in the first captured image, generates the frame FB (an example of the second frame) showing the position of the face of the user appearing in the second captured image based on the positional information of the face of the user on the detected first captured image, superimposes the frame FB on the second captured image, and displays the second captured image superimposed with the frame FB on the display section **33**A. As a result, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can show a region in which the face of the user is detected in the second captured image with the frame FB.

(167) Moreover, as described above, in the biometric authentication systems **200** and **200**A according to Embodiment 2, and Modification Example 1 of Embodiment 2, the second captured image is an invisible light image. The second imaging devices C**22** and C**22**A receive light through the BPFs **61** and **71** (an example of filters) that transmit invisible light out of the surface-reflected light that is reflected on the surface of the skin of the user to image the user. As a result, since the biometric authentication systems **200** and **200**A according to Embodiment 2, and Modification Example 1 of Embodiment 2 can capture the second captured image with a more clear face of a user even when the face of the user is in a backlit state to acquire the second captured image by receiving invisible light (near-infrared light with a wavelength of 940 nm) out of surface-reflected light since the reflection of the blood vessels, whiskers, and the like of a user appearing in the second captured image is suppressed and the amount of attenuation of energy of sunlight is increased by moisture in the air.

(168) Moreover, as described above, in the biometric authentication system **200** according to Embodiment 2, the second captured image is an invisible light image. The second imaging device C**22** polarizes the surface-reflected light that is reflected by the user in a third direction substantially parallel to the first direction by the third polarizing plate **60**, and receives the invisible light after polarization to image the user. As a result, since the biometric authentication system **200** according to Embodiment 2 can capture the second captured image with a more clear face of a user even when the face of the user is in a backlit state to acquire the second captured image by receiving invisible light (near-infrared light with a wavelength of 940 nm) out of surface-reflected light since the reflection of the blood vessels, whiskers, and the like of a user appearing in the second captured image is suppressed and the amount of attenuation of energy of sunlight is increased by moisture in the air.

(169) Moreover, as described above, in the biometric authentication system **200**B according to Modification Example 2 of Embodiment 2, the second captured image is a visible light image. The second imaging device C**22**B receives the surface-reflected light that is reflected by the user and images the user. Thereby, the biometric authentication system **200**B according to Modification

Example 2 of Embodiment 2 can capture a visible light (color) image as the second captured image to be presented to the user.

(170) As described above, the authentication device P**1** in the biometric authentication system **100** according to Embodiment 1 includes the display section **33** that displays the first captured image. The illumination **13** and the first imaging device C**1** are disposed at positions that are respectively asymmetric with respect to the center position (for example, the disposition reference point Pt**11** shown in FIG. **10**) of the display region for displaying the first captured image of the display section **33**. As a result, the biometric authentication system **100** according to Embodiment 1 can prevent the reception of the specularly reflected light (light of invisible light illumination) in which the invisible light illumination by the illumination **13** is specularly reflected by the face of the user, thereby more effectively suppressing the reflection of the invisible light illumination on the captured first captured image.

(171) As described above, the illumination **13** and the first imaging device C**1** in the biometric authentication system **100** according to Embodiment 1 are disposed at positions (for example, the disposition reference point Pt**21** shown in FIG. **10**) that are respectively asymmetric with respect to the center position of the frame FB superimposed on the first captured image. As a result, the biometric authentication system **100** according to Embodiment 1 can prevent the reception of the specularly reflected light (light of invisible light illumination) in which the invisible light illumination by the illumination **13** is specularly reflected by the face of the user, thereby more effectively suppressing the reflection of the invisible light illumination on the captured first captured image.

(172) Further, as described above, the illumination **13**, the first imaging device C**21**, and the second imaging devices C**22**, C**22**A, and C**22**B in the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 are disposed at positions that are respectively asymmetric with the center position (for example, the disposition reference point Pt**11** shown in FIG. **10**) of the display region for displaying the second captured image of the display section **33**A. As a result, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can prevent the reception of the specularly reflected light (light of invisible light illumination) in which the invisible light illumination by the illumination **13** is specularly reflected by the face of the user, thereby more effectively suppressing the reflection of the invisible light illumination on the captured first captured image and the second captured image.

(173) Further, as described above, the illumination **13**, the first imaging device C**21**, and the second imaging devices C**22**, C**22**A, and C**22**B in the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 are disposed at positions that are respectively asymmetric with respect to the center position (for example, the disposition reference point Pt**21** shown in FIG. **10**) of the frame FB superimposed on the second captured image. As a result, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can prevent the reception of the specularly reflected light (light of invisible light illumination) in which the invisible light illumination by the illumination **13** is specularly reflected by the face of the user, thereby more effectively suppressing the reflection of the invisible light illumination on the captured first captured image and the second captured image.

(174) Further, as described above, in the biometric authentication system **100** according to Embodiment 1, when the user is authenticated, the authentication device P**1** executes an authentication success operation set in advance (an example of a predetermined operation), and when the user is not authenticated, displays the first captured image on the display section **33**. Thereby, the biometric authentication system **100** according to Embodiment 1 can notify the user of the success or failure of the biometric authentication based on the authentication result of the user based on the first captured image.

(175) Further, as described above, in the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2, when the user is authenticated, the authentication device P**1**A executes a predetermined operation set in advance, and when the user is not authenticated, displays the second captured image on the display section **33**A. As a result, the biometric authentication systems **200**, **200**A, and **200**B according to Embodiment 2, and Modification Examples 1 and 2 of Embodiment 2 can notify the user of the success or failure of biometric authentication based on the authentication result of the user based on the first captured image.

Embodiment 3

(176) The biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiment 1 to Modification Examples 2 of Embodiment 2 show an example of determining the respective disposition of the cameras (the first cameras **22** and **52** or the second cameras **62**, **72**, and **80**) and the illumination **13** using the user appearing on the display sections **33** and **33**A or the display sections **33** and **33**A as a disposition reference point. A biometric authentication system **300** according to Embodiment 3 describes an example of determining the respective dispositions of the camera (the first cameras **22** and **52** or the second cameras **62**, **72**, and **80**) and the illumination **13** without using the user appearing on the display sections **33** and **33**A or the display sections **33** and **33**A as a disposition reference point.

(177) The biometric authentication system **300** according to Embodiment 3 includes a configuration in which the display sections **33** and **33**A are omitted from the respective authentication devices P**1** and P**1**A of the biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiment 1 to Modification Example 2 of Embodiment 2 but which new line-of-sight guiding sections In**0**, Int**1**, In**12**, In**21**, In**31**, In**32**, and In**33** are included. In the following description, the biometric authentication system **300** according to Embodiment 3 will be described by using the same symbols for the same configurations as those of the devices constituting the biometric authentication systems **100**, **200**, **200**A, and **200**B according to Embodiment 1 to Modification Example 2 of Embodiment 2.

(178) The line-of-sight guiding sections In**0**, In**11**, In**12**, In**21**, In**31**, In**32**, and In**33** guide the user's line of sight to a predetermined line-of-sight direction or line-of-sight position. In Embodiment 3, the position of the user's line of sight indicates the midpoint of a line segment connecting the right eye and left eye of the user. In addition, the direction of the user's line of sight indicates the direction in which the user's line of sight is directed, starting from the midpoint of a line segment connecting the right eye and the left eye of the user.

(179) The line-of-sight guiding section In**0** guides the user's line of sight by directing the user's line of sight to the line-of-sight guiding section In**0** itself. The line-of-sight guiding section In**0** may be, for example, a mark, a character, and a LED (visible light illumination) provided in the housings of the illumination **13**, the first cameras **22** and **52**, or the second cameras **62**, **72**, and **80**, an opening portion of the lens peripheral edge of the first cameras **22** and **52** or the second cameras **62**, **72**, and **80**, a projection projected by a projector, or the like, and a mirror for reflecting the user's own face instead of the display sections **33** and **33***a*.

(180) Also, the line-of-sight guiding sections In**11**, In**12**, In**21**, In**31**, In**32**, and In**33** guide the user's own position (standing position, passage position, and the like) to guide the user's line of sight to a predetermined position (for example, the user's traveling direction, the front of the user, and the like). The line-of-sight guiding sections In**11**, In**12**, In**21**, In**31**, In**32**, and In**33** may be, for example, regions or marks indicating the user's standing position, gates, passages, walls, or the like that guide the user's direction of travel.

(181) Here, axes L**3** and L**4** that serve as the reference for disposition of each device will be described in a disposition example of the first camera **22** and the illumination **13** shown in FIG. **14**, a disposition example of the first camera **52**, the second cameras **62**, **72**, and **80**, and the illumination **13** shown in FIG. **15**, and in a disposition example of the first camera **22** and a

plurality of illuminations **13** shown in FIG. **16**.
(182) Each of the axes L**3** and L**4** shown in FIGS. **14** to **16** is set with respect to the line-of-sight guiding section In**0**. The axis L**3** and axis L**4** are orthogonal to each other at the line-of-sight guiding section In**0**. The axis L**3** is an axis that indicates a horizontal direction (horizontal direction on the paper surface) that passes through the line-of-sight guiding section In**0**. The axis L**4** is an axis that indicates a vertical direction (vertical direction on the paper surface) passing through the line-of-sight guiding section In**0**.
(183) With reference to FIG. **14**, the disposition example of the first camera **22** and the illumination **13** in the biometric authentication system **300** according to Embodiment 3 will be described. FIG. **14** is a diagram illustrating respective disposition examples of the camera (specifically, the first camera **22**), the illumination **13**, and the line-of-sight guiding section In**0** when there is only one camera. In addition, the biometric authentication system **300** shown in FIG. **14** shows an example in which the first camera **22**, the illumination **13**, and the line-of-sight guiding section In**0** are integrally configured, but some or all may be configured separately.
(184) The first camera **22** and the illumination **13** are disposed at positions that are mutually asymmetric with respect to the line-of-sight guiding section In**0**, which is the line-of-sight position of the user. In the following, the disposition examples 1 to 7 of the first camera **22**, the illumination **13**, and the line-of-sight guiding section In**0** will be described below, but the disposition examples 1 to 7 shown in FIG. **14** are examples, and it is needless to say that the disposition examples are not limited thereto. Also, the illumination **13** may be a surface light source or a point light source.
(185) For example, the first camera **22**, the illumination **13**, and the line-of-sight guiding section In**0** in the disposition example 1 are disposed on a straight line (axis L**4**). The illumination **13** is disposed on the left side of the line-of-sight guiding section In**0** (left side of the paper surface). The first camera **22** is disposed on the right side of the line-of-sight guiding section In**0** (right side of the paper surface). Here, a distance D**11**<a distance D**12**.
(186) For example, the first camera **22**, the illumination **13**, and the line-of-sight guiding section In**0** in the disposition example 2 are disposed on a straight line (axis L**4**), respectively. The illumination **13** is disposed on the left side of the line-of-sight guiding section In**0** (left side of the paper surface). The first camera **22** is disposed on the left side of the illumination **13** (left side of the paper surface).
(187) The disposition examples 1 and 2 describe an example in which the first camera **22**, the illumination **13**, and the line-of-sight guiding section In**0** are each disposed on a straight line (axis L**4**), but each may be disposed on the axis L**3** under similar conditions.
(188) For example, the first camera **22** in the disposition example 3 is disposed above the line-of-sight guiding section In**0** (upper side of the paper surface) and on the axis L**3**. The illumination **13** is disposed on the right side of the first camera **22** (right side of the paper surface).
(189) For example, the illumination **13** in the disposition example 4 is a surface light source, and is disposed over the upper side of the line-of-sight guiding section In**0** and the first camera **22** (upper side of the paper surface). The first camera **22** is disposed on the right side (the right side of the paper surface) of the line-of-sight guiding section In**0** and on the axis L**4**.
(190) For example, the first camera **22** in the disposition example 5 is disposed at the lower left of the line-of-sight guiding section In**0** (lower left of the paper surface). The illumination **13** is disposed at the lower right (at the lower right on the paper surface) of the line-of-sight guiding section In**0**.
(191) For example, the first camera **22** in the disposition example 6 is disposed at the upper left (upper left of the paper surface) of the line-of-sight guiding section In**0**. The illumination **13** is disposed at the lower left of the line-of-sight guiding section In**0** (lower left on the paper surface). The first camera **22** and the illumination **13** are disposed at positions that are line-symmetric with respect to each other with respect to the axis L**4**.
(192) For example, the first camera **22** in the disposition example 7 is disposed below the line-of-

sight guiding section In**0** (lower side of the paper surface) and on the axis L**3**. The illumination **13** is a rectangular illumination, and is disposed below the line-of-sight guiding section In**0** (lower side of the paper surface) and on the axis L**3** so as to surround the first camera **22**.

(193) Thereby, the first camera **22** according to Embodiment 3 can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) emitted by the illumination **13**. In other words, even when the user is wearing glasses, the biometric authentication system **300** can further effectively suppress the reflection of invisible light illumination due to the light reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **300** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.

(194) Next, with reference to FIG. **15**, a disposition example of the first camera **52**, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** in the biometric authentication system **300** according to Embodiment 3 will be described. FIG. **15** is a diagram illustrating respective disposition examples of the cameras (specifically, the first camera **52** and the second cameras **62**, **72**, and **80**, respectively), the illumination **13**, and the line-of-sight guiding section In**0** when there are two cameras. In addition, the biometric authentication system **300** shown in FIG. **15** shows an example in which the first camera **52**, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** are integrally configured, but some or all may be configured separately.

(195) The first camera **52** or the second cameras **62**, **72**, and **80**, and the illumination **13** are disposed at positions that are mutually asymmetric with respect to the line-of-sight guiding section In**0**, which is the line-of-sight position of the user. More specifically, each of the first camera **52** and the second cameras **62** and **72** is disposed at a position that is symmetric with respect to the illumination **13** that emits invisible light. Further, when the line-of-sight guiding section In**0** is a visible light illumination, the second camera **80** is disposed at a position that is mutually asymmetric with respect to the line-of-sight guiding section In**0** that emits visible light. In addition, the disposition examples 1 to 4 of the first camera **52**, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** will be described below, but the disposition examples 1 to 4 shown in FIG. **15** are examples, and it is needless to say that the disposition examples are not limited thereto. Also, the illumination **13** may be a surface light source or a point light source.

(196) For example, the first camera **52**, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** in the disposition example 1 are each disposed on a straight line (axis L**4**). The first camera **52** is disposed on the left side of the line-of-sight guiding section In**0** (left side of the paper surface). The second cameras **62**, **72**, and **80** are disposed on the right side of the line-of-sight guiding section In**0** (right side of the paper surface). The illumination **13** is disposed on the right side of the second cameras **62**, **72**, and **80** (right side of the paper surface). Here, the first camera **52** and the second cameras **62**, **72**, and **80** are disposed at positions that are line-symmetric to each other with respect to the axis L**3**.

(197) For example, the first camera **52**, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** in the disposition example 2 are each disposed on a straight line (axis L**4**). Each of the first camera **52**, the second cameras **62**, **72**, and **80**, and the illumination **13** is disposed on the left side of the line-of-sight guiding section In**0** (left side of the paper surface).

(198) In addition, the disposition examples 1 and 2 describe an example in which the first camera **52**, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** are each disposed on a straight line (axis L**4**), but each may be disposed on the axis L**3** under similar conditions.

(199) For example, the illumination **13** in the disposition example 3 is disposed on the right side of

the line-of-sight guiding section In**0** (right side of the paper surface) and on the axis L**4**. The first camera **52** is disposed above the line-of-sight guiding section In**0** (upper side of the paper surface) and on the axis L**4**. The second cameras **62**, **72**, and **80** are disposed above the illumination **13** (upper side of the paper surface), to the right side of the first camera **52** (right side of the paper surface), and at positions adjacent to each of the illumination **13** and the first camera **52**.
(200) For example, the first camera **52**, the second cameras **62**, **72**, and **80**, and the illumination **13** in the disposition example 4 are each disposed side by side in the direction along the axis L**3** on the right side of the line-of-sight guiding section In**0** (right side of the paper surface). The illumination **13** is disposed at the lower right (at the lower right on the paper surface) of the line-of-sight guiding section In**0**. The first camera **52** and the second cameras **62**, **72**, and **80** are each disposed side by side along the axis L**3** above the illumination **13** (upper side of the paper surface).
(201) Thereby, the first camera **52** according to Embodiment 3 can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) emitted by the illumination **13**. In other words, even when the user is wearing glasses, the biometric authentication system **300** can further effectively suppress the reflection of invisible light illumination due to the light reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **300** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.
(202) Next, with reference to FIG. **16**, respective disposition examples of the first camera **22**, the two illuminations **13**A and **13**B, and the line-of-sight guiding section In**0** in the biometric authentication system **300** according to Embodiment 3 will be described. FIG. **16** is a diagram illustrating respective disposition examples of the camera (specifically, the first camera **22**), the illuminations **13**A and **13**B, and the line-of-sight guiding section In**0** when there are two illuminations. In addition, the biometric authentication system **300** shown in FIG. **16** shows an example in which the first camera **22**, the illuminations **13**A and **13**B, and the line-of-sight guiding section In**0** are integrally configured, but some or all may be configured separately. In addition, in the description of FIG. **16**, in order to make the description easier to understand, one illumination **13** is given the code "**13**A" and the other illumination **13** is given the code "**13**B" to describe the disposition of each of the two illuminations **13**.
(203) The first camera **22**, and the illuminations **13**A and **13**B are disposed at positions that are mutually asymmetric with respect to the line-of-sight guiding section In**0**, which is the line-of-sight position of the user. More specifically, the first camera **22** is disposed at a position that is mutually asymmetric with respect to the illuminations **13**A and **13**B that emit invisible light. In addition, the disposition examples 1 to 4 of the first camera **22**, the illuminations **13**A and **13**B, and the line-of-sight guiding section In**0** will be described below, but the disposition examples 1 to 4 shown in FIG. **16** are examples, and it is needless to say that the disposition examples are not limited thereto. Also, the illuminations **13**A and **13**B may be surface light sources or point light sources.
(204) For example, the first camera **22** and the illuminations **13**A and **13**B in the disposition example 1 are disposed on a straight line (axis L**4**). The first camera **22** is disposed on the right side of the line-of-sight guiding section In**0** (right side of the paper surface). The illuminations **13**A and **13**B are each disposed at the same distance from the axis L**3** on the right side (the right side of the paper surface) and the left side (the left side of the paper surface) of the line-of-sight guiding section In**0**. Here, the illuminations **13**A and **13**B are each disposed at positions farther than a distance D**31** from the axis L**3**.
(205) For example, the first camera **22** and the illuminations **13**A and **13**B in the disposition example 2 are disposed on a straight line (axis L**4**). The illuminations **13**A and **13**B, and the first camera **22** are each disposed on the left side of the line-of-sight guiding section In**0** (left side of the paper surface).
(206) In addition, the disposition examples 1 and 2 describe an example in which the first camera

52, the second cameras **62**, **72**, and **80**, the illumination **13**, and the line-of-sight guiding section In**0** are each disposed on a straight line (axis L**4**), but each may be disposed on the axis L**3** under similar conditions.
(207) For example, the first camera **22** in the disposition example 3 is disposed on the right side of the line-of-sight guiding section In**0** (right side of the paper surface) and on the axis L**4**. The illumination **13**A is disposed above the line-of-sight guiding section In**0** (upper side of the paper surface) and on the axis L**4**. In addition, the illumination **13**B is disposed above the first camera **22** (upper side of the paper surface), to the right side of the illumination **13**A (right side of the paper surface), and at positions adjacent to each of the illumination **13**A and the first camera **22**.
(208) For example, the first camera **22**, and the illuminations **13**A and **13**B in the disposition example 4 are each disposed side by side in the direction along the axis L**3** on the right side of the line-of-sight guiding section In**0** (right side of the paper surface). The first camera **22** is disposed on the right side (the right side of the paper surface) of the line-of-sight guiding section In**0** and on the axis L**4**. The illuminations **13**A and **13**B are disposed at positions that are line-symmetric with respect to the axis L**3** with the first camera **22** disposed on the axis L**4** interposed therebetween.
(209) Thereby, the first camera **22** according to Embodiment 3 can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) respectively emitted by the illuminations **13**A and **13**B. In other words, even when the user is wearing glasses, the biometric authentication system **300** can further effectively suppress the reflection of invisible light illumination due to the light reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **300** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.
(210) Next, with reference to FIG. **17**, a disposition example of the first camera **22**, the illumination **13**, and the line-of-sight guiding sections In**11**, In**12**, and In**21** in the biometric authentication system **300** according to Embodiment 3 will be described. FIG. **17** is a diagram illustrating an example of line-of-sight guide, and respective disposition examples of the camera (specifically, the first camera **22**) and the illumination **13**.
(211) For example, each of the line-of-sight guiding sections In**11** and In**12** in disposition example 1 forms a movement line of the user along the extending direction of each of the line-of-sight guiding sections In**11** and In**12**. A line-of-sight direction Pt**3** of the user passing between the line-of-sight guiding sections In**11** and In**12** is a direction along the respective extending directions of the line-of-sight guiding sections In**11** and In**12**. In other words, the user's line-of-sight direction is guided by the line-of-sight guiding sections In**11** and In**12** in a direction along the respective extending directions of the line-of-sight guiding sections In**11** and In**12**.
(212) When such line-of-sight guiding sections In**11** and In**12** are provided respectively, the first camera **22** and the illumination **13** are disposed above the line-of-sight guiding section In**12** and in front of the user in the traveling direction. In addition, the first camera **22** and the illumination **13** are disposed at positions that are mutually asymmetric with respect to a line-of-sight position Pt**32** of the user obtained by projecting a midpoint of a line segment connecting the right eye and the left eye of the user on a horizontal plane orthogonal to the respective extending directions of the line-of-sight guiding sections In**11** and In**12** (that is, line-of-sight direction Pt**3**).
(213) For example, the line-of-sight guiding section In**21** in the disposition example 2 is a circular mark provided on the floor surface, and indicates the standing position of the user. A line-of-sight position Pt**4** of the user standing upright on the line-of-sight guiding section In**21** is guided to the central portion of the line-of-sight guiding section In**21** in a direction perpendicular to the floor surface on which the line-of-sight guiding section In**21** is provided.
(214) When such the line-of-sight guiding section In**21** is provided, the first camera **22** and the illumination **13** are disposed at positions that mutually asymmetric with respect to the line-of-sight position Pt**4** of the user, respectively. The first camera **22** and the illumination **13** shown in FIG. **17**

are disposed on the front side of the user's face, at a position higher than a horizontal axis L**6** corresponding to the height of the user's line-of-sight position Pt**4**, and on the left side of a vertical axis L**5** perpendicular to the standing position (floor surface) indicated by the line-of-sight guiding section In**21** (left side of the paper surface).
(215) Here, the user's line-of-sight position Pt**4** depends on the user's own height. Therefore, the first camera **22** and the illumination **13** may be provided at a position higher or lower than the possible line-of-sight height of the user (that is, height of eye indicated by the horizontal axis L**6**).
(216) In addition, the user's standing position guided by the line-of-sight guiding section In**21** may differ depending on the user. Therefore, the first camera **22** and the illumination **13** are located within the region indicated by the line-of-sight guiding section In**21**, and may be disposed biased to either one side of the right side or the left side with respect to the standing position to which the user can be guided (that is, the position of the midpoint of a line segment connecting the right eye and the left eye indicated by the vertical axis L**5**).
(217) As a result, in the biometric authentication system **300** according to Embodiment 3, even when the line-of-sight position changes for each user based on the height of the user, the standing position of the user, and the like, the first camera **22** and the illumination **13** can be disposed at positions that are mutually asymmetric with respect to the line-of-sight positions of the user that can be guided by the line-of-sight guiding sections Int**1**, In**12**, and In**21**. Therefore, the first camera **22** can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) that is emitted by the illumination **13**. In other words, even when the user is wearing glasses, the biometric authentication system **300** can further effectively suppress the reflection of invisible light illumination due to the light reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **300** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.
(218) Next, with reference to FIG. **18**, a disposition example of the first camera **22**, the illumination **13**, and the line-of-sight guiding sections In**31** to In**33** in the biometric authentication system **300** according to Embodiment 3 will be described. FIG. **18** is a diagram illustrating an example of line-of-sight guide, and respective disposition examples of the camera (specifically, the first camera **22**) and the illumination **13**.
(219) For example, each of the line-of-sight guiding sections In**31** to In**33** shown in FIG. **18** forms the user's movement line or standing position between the line-of-sight guiding section In**31** and the line-of-sight guiding section In**32** and between the line-of-sight guiding section In**32** and the line-of-sight guiding section In**33**. In such a case, the user is guided between the line-of-sight guiding section In**31** and the line-of-sight guiding section In**32**, or between the line-of-sight guiding section In**32** and the line-of-sight guiding section In**33**.
(220) When each of such the line-of-sight guiding sections In**31** to In**33** is provided, the first camera **22** and the illumination **13** are located in front of the faces of users US**1** and US**2**, respectively, and provided between a horizontal axis L**61** indicating the height of the eye of the user US**1** having the maximum height (that is, the line-of-sight position Pt**51**) who can be a biometric authentication target by the biometric authentication system **300** and a horizontal axis L**62** indicating the height of the eye of the user US**2** having the minimum height (that is, the line-of-sight position pt**52**) who can be a biometric authentication target by the biometric authentication system **300**, and between a vertical axis L**51** and a vertical axis L**52** indicating respective standing positions of the users US**1** and US**2** who are respectively guided between the line-of-sight guiding section In**31** and the line-of-sight guiding section In**32** and between the line-of-sight guiding section In**32** and the line-of-sight guiding section In**33**.
(221) As a result, in the biometric authentication system **300** according to Embodiment 3, even when the line-of-sight position changes for each user based on the height of the user, the standing position of the user, and the like, the first camera **22** and the illumination **13** can be disposed at

positions that are mutually asymmetric with respect to the line-of-sight positions Pt**51** and Pt**52** of the user that can be guided by the line-of-sight guiding sections In**31** to In**33**. Therefore, the first camera **22** can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) that is emitted by the illumination **13**. In other words, even when the user is wearing glasses, the biometric authentication system **300** can further effectively suppress the reflection of invisible light illumination due to the light reception of the specularly reflected light which is specularly reflected by the glasses (region WT**2**, see FIG. **9**). Therefore, the biometric authentication system **300** can calculate the feature quantity of the eyes of the user required for biometric authentication processing from the first captured image.

(222) As described above, the biometric authentication system **300** (an example of an authentication system) according to Embodiment 3 includes at least one illumination **13** that irradiates a user (an example of a person to be authenticated) with invisible light, the first imaging devices C**1** and C**21** that capture images of the user irradiated with the invisible light, the authentication devices P**1** and P**1**A that are capable of communicating with the first imaging devices C**1** and C**21** and execute authentication of the user based on the first invisible light image captured by the first imaging devices C**1** and C**21** (an example of the first invisible light image), and the line-of-sight guiding sections In**0**, In**11**, In**12**, In**21**, In**31**, In**32**, and In**33** that guide the line-of-sight position of the user. The illumination **13** and the first imaging devices C**1** and C**21** are disposition at positions that are respectively asymmetric with respect to the line-of-sight position (for example, the position of the line-of-sight guiding section In**0** equal to the line-of-sight position, and the line-of-sight positions Pt**32**, Pt**4**, Pt**51**, Pt**52**, and the like) of the person to be authenticated guided by the line-of-sight guiding sections In**0**, In**11**, In**12**, In**21**, In**31**, In**32**, and In**33**.

(223) Thereby, the biometric authentication system **300** according to Embodiment 3 can suppress the reception of specularly reflected invisible light (near-infrared light with a wavelength of 940 nm) emitted by the illumination **13**. In other words, even when the user is wearing glasses, the biometric authentication system **300** can more effectively suppress the reflection (region WT**2**, see FIG. **9**) of invisible light illumination due to the light reception of the specularly reflected light which is reflected by the glasses, and acquire the first captured image suitable (that is, the feature quantity of the user used for biometric authentication can be calculated) for biometric authentication.

(224) Also, the line-of-sight guiding section In**0** in the biometric authentication system **300** according to Embodiment 3 is provided in an illumination or the first imaging device. As a result, the biometric authentication system **300** according to Embodiment 3 can respectively dispose the illumination **13** and the first imaging devices C**1** and C**21** at positions that are respectively asymmetric with respect to the line-of-sight guiding section In**0** by guiding the user's line-of-sight position to the line-of-sight guiding section In**0**.

(225) Also, the line-of-sight guiding section In**0** in the biometric authentication system **300** according to Embodiment 3 is a mark that can be visually recognized by the user. As a result, the biometric authentication system **300** according to Embodiment 3 can respectively dispose the illumination **13** and the first imaging devices C**1** and C**21** at positions that are respectively asymmetric with respect to the line-of-sight guiding section In**0** by guiding the user's line-of-sight position to the line-of-sight guiding section In**0** that is visually recognizable.

(226) In addition, the line-of-sight guiding sections Int**1**, In**12**, In**31**, In**32**, and In**33** in the biometric authentication system **300** according to Embodiment 3 guide the user in a predetermined direction (for example, the line-of-sight direction Pt**31** shown in FIG. **17**). As a result, the biometric authentication system **300** according to Embodiment 3 can guide the user's line-of-sight direction in a predetermined direction by guiding the user in a predetermined direction and respectively dispose the illumination **13** and the first imaging devices C**1** and C**21** at positions that are respectively asymmetric with respect to the line-of-sight guiding sections Int**1**, In**12**, In**31**, In**32**, and In**33**.

(227) In addition, the line-of-sight guiding sections In**21**, In**31**, In**32**, and In**33** in the biometric

authentication system **300** according to Embodiment 3 guide the user to a position at which authentication is performed. As a result, the biometric authentication system **300** according to Embodiment 3 can guide the user's line-of-sight position to a position that is respectively asymmetric with respect to the respective illumination **13** and the first imaging devices C**1** and C**21** by guiding the user to be authenticated.
(228) Also, the invisible light in the biometric authentication system **300** according to Embodiment 3 is near-infrared light with a wavelength of 940 nm. As a result, the biometric authentication system **300** according to Embodiment 3 can acquire the first captured image from which a feature quantity of a user used for biometric authentication can be calculated when imaging outdoors or even when the user's face is in a backlit state by capturing the first captured image at a wavelength of 940 nm having a large attenuation amount of energy of sunlight due to moisture in air.
(229) Also, the illumination **13** in the biometric authentication system **300** according to Embodiment 3 polarizes invisible light in the first direction by the first polarizing plate **14** and irradiates the invisible light. The first imaging devices C**1** and C**21** receive invisible light polarized in a second direction substantially orthogonal to the first direction by the second polarizing plates **20** and **50** to image the user. As a result, the biometric authentication system **300** according to Embodiment 3 can more effectively suppress the reflection of the invisible light illumination on the first captured image such as the captured image IMG**22** shown in FIG. **9** by polarizing the invisible light with a wavelength of 940 nm by the second polarizing plates **20** and **50**. That is, the biometric authentication systems **300** can more effectively suppress the reflection of invisible light on the first captured image used for calculating the feature quantity of the biological information of a user, and can acquire the first captured image more suitable for biometric authentication (that is, the feature quantity of the user used for biometric authentication can be calculated).
(230) As described above, various forms of embodiments have been described with reference to the accompanying drawings, but the present disclosure is not limited to such examples. It is obvious for a person skilled in the art to conceive of various modifications, alterations, replacements, additions, deletions, and equivalents within the category disclosed in the claims, and it is understood that they are also included in the technical scope of the present disclosure. Further, the constitutional elements of the various embodiments described above may be arbitrarily combined without departing from the spirit of the invention.
INDUSTRIAL APPLICABILITY
(231) The present disclosure is useful as presentation of an authentication system and an authentication method capable of suppressing reflection of illumination light due to specular reflection and acquiring a face image more suitable for biometric authentication.

Claims

1. An authentication system, comprising: at least one illumination that irradiates a person to be authenticated with invisible light; a first imaging device that images the person to be authenticated and irradiated with the invisible light; an authentication device that is capable of communicating with the first imaging device, and executes authentication of the person to be authenticated based on a first invisible light image captured by the first imaging device; and a second imaging device that is capable of communicating with the authentication device, and receives surface-reflected light of the person to be authenticated and irradiated with the invisible light, wherein the illumination and the first imaging device are disposed at positions that are respectively asymmetric with respect to a line-of-sight position of the person to be authenticated, the line-of-sight position of the person to be authenticated being guided by a monitor that guides the line-of-sight position of the person to be authenticated, the monitor displays the first invisible light image, the second imaging device transmits a second captured image obtained by imaging the person to be authenticated to the authentication device, the authentication device outputs the second captured

image to the monitor for display, the second captured image is a second invisible light image, the illumination emits the invisible light polarized in a first direction by a first polarizing plate, and the second imaging device polarizes the surface-reflected light that is reflected by the person to be authenticated in a second direction substantially parallel to the first direction by a second polarizing plate, and receives the polarized invisible light to image the person to be authenticated.

2. The authentication system according to claim 1, wherein the monitor is provided in the illumination or the first imaging device.

3. The authentication system according to claim 1, wherein the first imaging device receives the invisible light polarized in a third direction substantially orthogonal to the first direction by a third polarizing plate to image the person to be authenticated.

4. The authentication system according to claim 1, wherein the illumination and the first imaging device are disposed at the positions that are respectively asymmetric with respect to a center position of a display region for displaying the first invisible light image by the monitor.

5. The authentication system according to claim 1, wherein the authentication device detects a face, of the person to be authenticated, appearing in the first invisible light image, generates a first frame indicating a position of the face, of the person to be authenticated, appearing in the first invisible light image based on positional information of the detected face of the person to be authenticated on the first invisible light image, superimposes the first frame on the first invisible light image, and outputs the first invisible light image superimposed with the first frame to the monitor for display.

6. The authentication system according to claim 5, wherein the illumination and the first imaging device are disposed at the positions that are respectively asymmetric with respect to a center position of the first frame superimposed on the first invisible light image.

7. The authentication system according to claim 1, wherein when the person to be authenticated is authenticated, the authentication device executes a predetermined operation set in advance, and when the person to be authenticated is not authenticated, the authentication device outputs the first invisible light image to the monitor for display.

8. The authentication system according to claim 1, wherein the illumination, the first imaging device, and the second imaging device are disposed at positions that are respectively asymmetric with respect to a center position of a display region for displaying the second captured image by the monitor.

9. The authentication system according to claim 1, wherein the authentication device detects a face, of the person to be authenticated, appearing in the first invisible light image, generates a second frame indicating a position of the face, of the person to be authenticated, appearing in the second captured image based on positional information of the detected face of the person to be authenticated on the first invisible light image, superimposes the second frame on the second captured image, and outputs the second captured image superimposed with the second frame to the monitor for display.

10. The authentication system according to claim 9, wherein the illumination, the first imaging device, and the second imaging device are disposed at positions that are respectively asymmetric with respect to a center position of the second frame superimposed on the second captured image.

11. The authentication system according to claim 1, wherein the second imaging device includes a filter that transmits invisible light out of surface-reflected light that is reflected by the person to be authenticated, and receives the invisible light through the filter with an image sensor to image the person to be authenticated.

12. The authentication system according to claim 1, wherein when the person to be authenticated is authenticated, the authentication device executes a predetermined operation set in advance, and when the person to be authenticated is not authenticated, the authentication device displays the second captured image on the monitor.

13. The authentication system according to claim 1, wherein the invisible light is near-infrared light with a wavelength of 940 nm.

14. An authentication method performed by an authentication system, the authentication system including: at least one illumination that irradiates a person to be authenticated with invisible light; a first imaging device that images the person to be authenticated, which is irradiated with the invisible light; an authentication device that is capable of communicating with the first imaging device, and executes authentication of the person to be authenticated based on a first invisible light image captured by the first imaging device; and a second imaging device that is capable of communicating with the authentication device, and receives surface-reflected light of the person to be authenticated and irradiated with the invisible light, wherein the illumination and the first imaging device are disposed at positions that are respectively asymmetric with respect to a line-of-sight position of the person to be authenticated, the line-of-sight position of the person to be authenticated being guided by a monitor that guides the line-of-sight position of the person to be authenticated, the authentication method comprising: imaging, by the first imaging device, the person to be authenticated and irradiated with the invisible light; imaging, by the second imaging device, the person to be authenticated; and authenticating, by the authentication device, the person to be authenticated based on the captured first invisible light image and the received surface-reflected light, wherein the monitor displays the first invisible light image, the second imaging device transmits a second captured image obtained by the imaging of the person to be authenticated to the authentication device, the authentication device outputs the second captured image to the monitor for display, the second captured image is a second invisible light image, the illumination emits the invisible light polarized in a first direction by a first polarizing plate, and the second imaging device polarizes the surface-reflected light that is reflected by the person to be authenticated in a second direction substantially parallel to the first direction by a second polarizing plate, and receives the polarized invisible light to image the person to be authenticated.