

DESCRIPTION
IMAGE PROCESSING APPARATUS, METHOD, SYSTEM, AND
COMPUTER READABLE MEDIUM

5 Technical Field

[0001]

The present disclosure relates to an image processing apparatus, a method,
a system, and a computer readable medium, and in particular to an image
processing apparatus, a method, a system, and a computer readable media that can
10 be used for authentication using an iris(es).

Background Art

[0002]

Biometric authentication using an iris(es) has been known. In such
15 biometric authentication, iris(es) of a subject is photographed by using an image
pick-up apparatus, and feature values are extracted from the pattern of the
photographed iris. In order to authenticate a subject, extracted feature values are
compared with those registered in advance in a database, and a pass/fail is
determined based on a score of matching therebetween. Further, in order to
20 register a subject to be authenticated, extracted feature values are added in the
database.

[0003]

As described in Non-patent Literature 1, an iris, which is a donut-shaped
tissue surrounding a pupil, has a very complex pattern, and is unique to each
25 person. Further, in the photographing of an iris, near-infrared light is applied to
eyes of a subject.

[0004]

As described in Non-patent Literature 2, in the photographing of an
iris(es), an image of the iris is taken with a resolution in which the radius of the
30 iris is expressed by 100 to 140 pixels. Further, the wavelength of the near-
infrared light applied to the eyes of the subject is in a range between 700 nm and
900 nm.

Citation List

Non Patent Literature

[0005]

Non-patent Literature 1: Hosoya, "Identification System by Iris Recognition",
Japanese Society for Medical and Biological Engineering 44(1), pages 33-39,

5 2006

Non-patent Literature 2: Daugman, "How Iris Recognition Works,"
<https://www.cl.cam.ac.uk/~jgd1000/irisrecog.pdf>

Summary of Invention

10 Technical Problem

[0006]

The diameter of an iris is about 1 cm. Therefore, when the radius of an
iris is expressed by 100 pixels, the granularity becomes 50 μm . Since the pattern
of an iris is microscopic as described above, it is difficult to photograph an iris
15 pattern at a level of quality sufficient for authentication and verification under
conditions that distance between the subject and the image pick-up means is large,
a field of view to be photographed is wide, and the subject moves.

[0007]

In light of the above circumstances, an object of the present disclosure is
20 to provide an image processing apparatus, method, system, and computer-readable
medium capable of photographing an iris pattern at a level of quality sufficient
for authentication and verification.

Solution to Problem

25 [0008]

In order to achieve the above-described object, in a first aspect, the
present disclosure provides an image processing system including:

a plurality of iris image pick-up means disposed at mutually different
positions in the same field of view;

30 overall image pick-up means for performing image pick-up over a wider
field of view than the field of view of the iris image pick-up means;

guiding means for guiding a subject;

illumination means for illuminating the subject with light; and

control means for controlling, using an image from the overall image pick-

up means, at least one of reading out an image from the plurality of iris image pick-up means, presenting at least one of an image and a sound through the guiding means, or providing illumination with light from the illumination means, wherein

5 the control means further predicts a period in which the subject will blink next and a period in which the subject will pass through a focusing point of the iris image pick-up means, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, the control means controls at least one of the guiding means or the
10 iris image pick-up means such that the focusing point and a position where the subject will blink next are different.

[0009]

In a second aspect, the present disclosure provides an image processing apparatus including:

15 control means for predicting a period in which a moving subject will blink next and a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, controlling
20 guiding means for guiding the subject such that the subject does not blink at the focusing point.

[0010]

In a third aspect, the present disclosure provides an image processing apparatus including:

25 control means for predicting a period in which a moving subject will blink next and a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, controlling the
30 iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject will blink next.

[0011]

In a fourth aspect, the present disclosure provides an image processing method including:

performing, using an image from overall image pick-up means for performing image pick-up over a wider field of view than a field of view of a plurality of iris image pick-up means disposed at mutually different positions in the same field of view, at least one of reading out an image from the plurality of iris image pick-up means, presenting at least one of an image and a sound through guiding means for guiding a subject, or providing illumination with light from illumination means for illuminating the subject with light.

[0012]

In a fifth aspect, the present disclosure provides an image processing method including:

predicting a period in which a moving subject will blink next;

predicting a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject;

determining whether or not the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point; and

performing, in a case of determining that the periods overlap, at least one of guiding the subject or controlling the iris image pick-up means such that the focusing point and a position where the subject will blink next are different.

[0013]

In a sixth aspect, the present disclosure provides a non-transitory computer readable medium storing a program causing a computer to execute a process including:

performing, using an image from overall image pick-up means for performing image pick-up over a wider field of view than a field of view of a plurality of iris image pick-up means disposed at mutually different positions in the same field of view, at least one of reading out an image from the plurality of iris image pick-up means, presenting at least one of an image and a sound through guiding means for guiding a subject, or providing illumination with light from illumination means for illuminating the subject with light.

[0014]

In a seventh aspect, the present disclosure provides a non-transitory computer readable medium storing a program causing a computer to execute a

process including:

predicting a period in which a moving subject will blink next;

predicting a period in which the subject will pass through a focusing point
of iris image pick-up means for performing image pick-up of an iris of the
5 subject;

determining whether or not the period in which the subject will blink next
overlaps with the period in which the subject will pass through the focusing point;
and

performing, in a case of determining that the periods overlap, at least one
10 of guiding the subject or controlling the iris image pick-up means such that the
focusing point and a position where the subject will blink next are different.

Advantageous Effects of Invention

[0015]

15 An image processing apparatus, a method, a system, and a computer
readable medium according to the present disclosure is capable of photographing
an iris pattern at a level of quality sufficient for authentication and verification.

Brief Description of Drawings

20 [0016]

Fig. 1 is a block diagram showing an image processing system according
to a first example embodiment of the present disclosure;

Fig. 2 shows a state of iris image pick-up control;

Fig. 3 is a flowchart showing an operational procedure in an image
25 processing system;

Fig. 4 is a flow chart showing an operational procedure in an image
processing system according to a second example embodiment of the present
disclosure;

and

30 Fig. 5 is a block diagram showing an example of a configuration of a
computer apparatus.

Description of Embodiments

[0017]

Prior to giving the description of an example embodiment according to the present disclosure, a problem thereof is quantitatively described. As an example, the below-shown conditions, which are assumed as operational conditions for Automated Border Control systems (ABC systems) and the like, will be described hereinafter. It is assumed that a distance between a subject and image pick-up means (the distance between a subject and a gate) is 2 m, and a horizontal field of view, i.e., a range in the horizontal direction in which both eyes of one subject can be covered, is 0.2m. Further, a vertical field of view, i.e., a range in the vertical direction in which the eyes of a wide range of subjects from a tall subject, typically a male person, to a short subject, typically a female person, can be covered, is 0.4m. Further, it is assumed that the walking speed (the moving speed) of the subject relative to the gate is equal to the average of slow walking speeds of adult people, e.g., is 1 m/s.

[0018]

Under the above operating conditions, assuming that an image sensor with a pixel pitch of 5 μm and a lens with an aperture stop of F2 and a focal length of 200 mm are used, both a high resolution of 32 M pixels and a high frame rate of 100 frames per second (fps) are demanded from the image pick-up means, as described later.

[0019]

With regard to resolution, to secure a 0.2 m horizontal field of view at a position 2 m away from the image pick-up apparatus, the image pick-up apparatus needs 4000 pixels ($0.2 \text{ [m]} \div 50 \text{ [\mu m]} = 4000$) in the horizontal direction. Further, to secure a 0.4 m vertical field of view at a position 2 m away from the image pick-up apparatus, the image pick-up apparatus needs 8000 pixels ($0.4 \text{ [m]} \div 50 \text{ [\mu m]} = 8000$) in the vertical direction. As a result, a resolution of 32 M pixels is demanded from the image pick-up apparatus.

[0020]

On the other hand, in the case where the above lens is used, if the allowable circle of confusion diameter is 0.03 mm, the depth of field that can be secured 2 m away is approximately 1 cm. In the case where the subject has a walking speed of 1 m/s, the time it takes for the subject to pass through the 1 cm subject depth is $1 \text{ [cm]} \div 100 \text{ [cm/s]} = 0.01 \text{ s}$. In this case, to capture the 0.01 s instant when the iris of the walking subject is in focus, a performance of 100 fps

(1 [s] ÷ 100 [fps] = 0.01 s time resolution) is demanded from the image pick-up apparatus.

[0021]

Image pick-up equipment capable of satisfying a high resolution of 32 M pixels and a high frame rate of 100 fps with a single device does not exist as a popular product. Consequently, photographing an iris pattern at a level of quality sufficient for authentication and verification under the operating conditions described above is difficult. This concludes the quantitative description of the problem.

[0022]

Example embodiments according to the present disclosure will be described hereinafter with reference to the drawings. Fig. 1 shows an image processing system according to a first example embodiment of the present disclosure. The image processing system includes an overall imaging device 100, a guiding device 200, an illumination device 300, iris image pick-up devices 401 to 404, and a controller 500. Note that although the number of iris image pick-up devices is four in Fig. 1, the number of iris image pick-up devices is not limited to any particular number. The number of iris image pick-up devices can be set as appropriate according to the field of view to be covered and the resolutions of available iris image pick-up devices.

[0023]

The overall imaging device (overall image pick-up means) 100 photographs a subject with a wide field of view that is wide enough to cover a whole range of subjects from a tall subject to a short subject. The overall imaging device 100 may have a resolution in which a subject can be authenticated by his/her face.

[0024]

The controller (control means) 500 monitors an overall image supplied from the overall imaging device 100, and controls the guiding device (guiding means) 200, the illumination device (illumination means) 300, and the plurality of iris image pick-up devices (iris image pick-up means) 401 to 404. The functions of the controller 500 can be implemented by hardware or by a computer program(s). The controller 500 determines a start of biometric authentication for the subject based on his/her overall image supplied from the overall imaging

device 100, or based on an external input.

[0025]

The control performed by the controller 500 includes guiding control, illumination control, and iris image pick-up control. In the guiding control, the controller 500 supplies guiding control information for guiding the subject to the guiding device 200. The guiding device 200 guides the subject based on the guiding control information. The guiding device 200 includes, for example, a display and/or a speaker(s). For example, the guiding device 200 presents an image(s) and a sound(s) for indicating the start of biometric authentication through the display and/or the speaker, respectively. Further, the guiding device 200 presents images and sounds for inducing the subject to turn his/her eyes to the iris image pick-up devices through the display and/or the speaker, respectively.

[0026]

In the illumination control, the controller 500 supplies, to the illumination device 300, illumination control information for applying illumination light to the subject. The illumination device 300 applies light (e.g., near-infrared light) to the subject based on the illumination control information. The illumination device 300 includes LEDs (Light Emitting Diodes) as a light source, and a synchronization signal generator. The amount of light applied from the illumination device 300 to the subject is determined by the value of the current supplied to the LEDs, the lighting time of the LEDs, and the lighting cycle thereof, and the illumination control information includes the numerical values thereof. When the LEDs are not continuously kept in the on-state, the lighting cycle of the LEDs is synchronized with the frame rates of the plurality of iris image pick-up devices 401 to 404.

[0027]

In the iris image pick-up control, the controller 500 determines, based on the overall image supplied from the overall imaging device 100, one of the plurality of iris image pick-up devices 401 to 404 that can suitably photograph an area of the subject including his/her eyes. Further, the controller 500 determines the vertical position of a region of interest that is read out at a high speed in the determined iris image pick-up device.

[0028]

Fig. 2 shows a state of the iris image pick-up control. Details of the iris image pick-up control will be described with reference to Fig. 2. In this example, it is assumed that a general-purpose camera having 12M pixels (4,000 horizontal pixels and 3,000 vertical pixels) and a frame rate of 60 fps is used for each of the iris image pick-up devices 401 to 404. Such cameras have been becoming widespread as industrial cameras. In the case where the photographing is performed with a granularity of 50 μm , with which a subject can be authenticated by his/her iris, the horizontal and vertical fields of view of each of the iris image pick-up devices are 0.2 m ($4,000 \times 50 [\mu\text{m}] = 0.2 [\text{m}]$) and 0.15 m ($3,000 \times 50 [\mu\text{m}] = 0.15 [\text{m}]$), respectively.

[0029]

The plurality of iris image pick-up devices 401 to 404 are arranged so that they are stacked on top of each other in the vertical direction. Note that the plurality of iris image pick-up devices 401 to 404 are arranged so that the image areas of iris image pick-up devices adjacent to each other partially overlap each other. For example, the iris image pick-up devices 401 to 404 are arranged so that the image areas of iris image pick-up devices adjacent to each other overlap each other by 2.5 cm. In such a case, at the focusing point 2m away from the four iris image pick-up devices, they can secure a field of view of 0.2 m in the horizontal direction and 0.45 m ($((0.15-0.025)+(0.15-0.025-0.025)+(0.15-0.025-0.025)+(0.15-0.025))$ m) in the vertical direction. That is, it is possible to secure the required field of view of 0.2 m in the horizontal direction and 0.4 m in the vertical direction. Note that it can be understood, by the drawings and the above description, that the iris image pick-up devices have the same fields of view as each other and are placed in positions different from each other.

[0030]

In the case where the frame rate of each of the iris image pick-up devices is 60 fps, they cannot meet the required frame rate of 100 fps when they are used as they are. Note that an industrial camera or the like has a region-of-interest mode. In the region-of-interest mode, only a partial area that is defined as a region of interest is read out instead of reading out the entire area of the screen. It is possible to increase the frame rate by using such a region-of-interest mode.

[0031]

The controller 500 sets a region of interest in any given iris image pick-up

device and reads out the image in the region of interest from that iris image pick-up device. In the example shown in Fig. 2, a partial area of 4,000 pixels in the horizontal direction and 1,500 pixels in the vertical direction, which corresponds to a half of the entire area of the screen, is defined as the region of interest. In this case, since the number of pixels in each frame is a half of the number of pixels in the entire area, it is possible to increase the frame rate to 120 fps, which is twice the frame rate of 60 fps in the case where the entire area of the screen is read out. However, the horizontal and vertical fields of view of the partial area become 0.2 m and 0.75 m, respectively. Note that both eyes of a human being are aligned in the horizontal direction. Therefore, in the region-of-interest, it is preferred to reduce the number of pixels in the vertical direction, instead of reducing that in the horizontal direction, so that both eyes can be photographed. [0032]

Under the condition that the area of eyes is not photographed in the above-described range where the image areas of iris image pick-up devices adjacent to each other overlap each other, the iris image pick-up device that photographs the area of eyes is only one of the four iris image pick-up devices 401 to 404. Further, the condition under which the image can be read out at the frame rate of 120 fps is a partial area in that iris image pick-up device. The controller 500 infers one of the iris image pick-up devices 401 to 404 that can suitably photograph the area of eyes, and estimates the vertical position of the region of interest in which the image is read out at a high speed in that iris image pick-up device. [0033]

The above-described inference/estimation can be carried out by a method described below. The overall imaging device 100 has a resolution in which a subject can be authenticated by his/her face, and the controller 500 derives the positions of the eyes of the subject in the overall image taken by the overall imaging device 100. The controller 500 derives the iris image pick-up device corresponding to the positions of the eyes of the subject in the overall image and the positions of the eyes present in that imaging device by using camera parameters and the positional relation of the overall imaging device 100 and each of the iris image pick-up devices. By using the region-of-interest mode, it is possible, by using a general-purpose camera, to achieve a field of view wider than

0.2 m in the horizontal direction and 0.4 m in the vertical direction, and a temporal resolution higher than 100 fps.

[0034]

Note that when the vertical position is changed in the above-described region-of-interest mode, a delay occurs before the start of the photographing. Therefore, in the above-described inference/estimation, an image that is obtained by photographing the subject at a position that is more distant than the position 2 meters away, i.e., more distant than the focusing point of the iris image pick-up device, e.g., by photographing the subject at a position 3 meters away may be used. The resolution in which a subject present at a position 3 meters away can be authenticated by his/her face can be achieved by a camera having about 2M pixels, so that cameras having specifications lower than those of the iris image pick-up cameras can be used for the overall imaging device 100.

[0035]

The controller 500 supplies iris image pick-up information to each of the iris image pick-up devices 401 to 404 based on the above-described iris image pick-up control. The controller 500 supplies iris image pick-up information including the vertical position of the region of interest to the iris image pick-up device that photographs the area of the eyes of the subject. The controller 500 may supply optional iris image pick-up information to the other iris image pick-up devices. The controller 500 may supply iris image pick-up information including information about the stop of the supply of the iris image to the other iris image pick-up devices, for example, in order to reduce the total amount of the data of the iris image.

[0036]

Each of the iris image pick-up devices 401 to 404 supplies the iris image to the controller 500 based on the iris image pick-up information supplied from the controller 500. Note that each of the iris image pick-up devices 401 to 404 outputs the image in the region of interest that is set by the controller 500 by using the iris image pick-up information (i.e., the iris image) to the controller 500. Each of the iris image pick-up devices 401 to 404 may lossy-compress the iris image in the region of interest and output the compressed iris image to the controller 500. For example, each of the iris image pick-up devices 401 to 404 compresses the iris image in the region of interest by using quantization (pixel-

by-pixel compression), predictive coding and quantization (compression on a basis of a plurality of pairs of pixels), or a combination of transform coding and quantization (compression on a basis of a plurality of pairs of pixels). The controller 500 performs the authentication and the registration described in the background section by using the iris images supplied from the iris image pick-up devices 401 to 404. The controller 500 returns to the next process when there is a next subject or when the authentication or the registration has failed.

[0037]

Next, an operational procedure will be described. Fig. 3 shows an operational procedure in the image processing system. The controller 500 performs guiding control and thereby guides a subject by using the guiding device 200 (step S1001). The controller 500 performs the illumination control and thereby applies infrared light to the subject by using the illumination device 300 (step S1002). The controller 500 performs the above-described iris image pick-up control and thereby acquires an image(s) of an iris(es) (an iris image(s)) by using the plurality of iris image pick-up devices 401 to 404 (step S1003). The iris image(s) acquired in the step S1003 is used for the authentication or registration of the iris. In the step S1003, the controller 500 does not need to obtain the iris image from each of the iris image pick-up devices 401 to 404 for a given subject as described above. The controller 500 obtains the iris image from the iris image pick-up device that has photographed the area of the eyes of the subject.

[0038]

The controller 500 performs iris-based authentication by using the iris image acquired in the step S1003, or registers the iris image (step S1004). The controller 500 determines whether or not there is a next subject, or whether or not re-authentication or re-registration should be performed (step S1005). When it is determined that there is a next subject, or re-authentication or re-registration should be performed, the process returns to the step S1001 and the process is performed starting from the guiding control.

[0039]

Note that when the overall imaging device 100 according to this example embodiment has a resolution in which a subject can be authenticated by his/her face, and holds feature values for authenticating the subject by his/her face in a

database but does not hold feature values for authenticating the subject by his/her iris in the database, the apparatus according to the present disclosure can also be used for a use in which the apparatus identifies a subject based on face-based authentication and registers extracted feature values of the iris(es) of the subject in the database. Further, the apparatus according to the present disclosure can also be used for a use in which the apparatus estimates information about the height of a subject based on information about the positions of the eyes obtained by the iris image pick-up control, or information about the positions of the eyes that is obtained when an iris image obtained by the iris image pick-up device is authenticated or registered, and registers the estimated information in the database. Further, the apparatus according to the present disclosure can be used, by using the estimated information about height, to determine or calibrate the vertical position of one of iris image pick-up devices that can suitably photograph the area of eyes and the region of interest in which the image is read out at a high speed in that iris image pick-up device.

[0040]

In this example embodiment, a high resolution supporting the demanded $0.2\text{ m} \times 0.4\text{ m}$ field of view and a high frame rate performance corresponding to a time resolution of 0.01 s can be achieved with a combination of general-purpose cameras. As a result, it is easy to photograph an iris pattern at a level of quality sufficient for authentication and verification under conditions such as when there is a long distance between the subject and the image pick-up means, a wide field of view to be photographed, and the subject moves.

[0041]

Next, a second example embodiment of the present disclosure will be described. The configuration of an image processing system according to the example embodiment may be similar to the configuration of the image processing system in the first example embodiment illustrated in Fig. 1. In the present example embodiment, the controller 500 respectively predicts the next blink occurrence period of the subject and the period in which the subject will pass through the focusing point (2 m away) of the iris image pick-up devices. The controller 500 controls the guiding device 200 such that blinking does not occur at the focusing point when these periods overlap. In the present example embodiment, the controller 500 also functions as an image processing apparatus

(control apparatus) that performs an image processing method (control method) related to blinking. Otherwise, the configuration may be similar to the first example embodiment.

[0042]

5 Since blinking is a physiological phenomenon that is difficult to control even with the subject's own effort, there is a possibility that blinking may occur at the focusing point of the iris image pick-up devices 401 to 404. Humans blink an average of 20 times per minute (interval time 3 s) with each blink lasting 0.2 s (duration 0.2 s), and the time ratio of the eyes being open is 93.3%. Calculated
10 simply, the retry probability for authentication and registration due to blinking is 6.6%, and approximately 7 out of 100 people will have to retry authentication or registration.

[0043]

The controller 500 can acquire information about whether or not the
15 subject's eyes are closed by analyzing the eye region of the overall image from the overall image pick-up device 100. In addition, the controller 500 can also acquire distance information about the distance to the subject by using an overall image pick-up device 100 that includes a distance measurement function such as time of flight (ToF). The controller 500 can acquire not only position
20 information about the subject but also information about the walking speed of the subject by analyzing the distance information in a time series.

[0044]

Next, for the description hereinafter, the information about whether or not the subject's eyes are closed, the position information about the subject, the
25 walking speed of the subject, the blink interval time, the blink duration, information about the focusing point, and information about an in-focus range are defined as follows.

[0045]

Let $b(t)$ be the information about whether or not the subject's eyes are
30 closed at a time t . Here, let $b(t) = 1$ denote that the subject's eyes are closed. Also, let $b(t) = 0$ denote that the subject's eyes are open. That is, $b(t) = 1$ corresponds to blinking, and $b(t) = 0$ corresponds to not blinking.

[0046]

Let $d(t)$ [m] be the position information about the subject, namely the

distance from the overall image pick-up device 100 to the subject, at the time t .

Let v [m/s] be the average walking speed of the subject. Let b_i_t [s] be the

blink interval time. Let b_p_t [s] be the blink duration. Let df [m] be the

information about the focusing point, namely the distance from the iris image

5 pick-up devices 401 to 404 to the focusing point. Let dof [m] be the information about the in-focus range. This completes the definition of each piece of information.

[0047]

The controller 500 can predict the next blink occurrence period of the

10 subject as follows (hereinafter also referred to as next blink period prediction).

The controller 500 searches for the last time t_{blast} at which $b(t) = 1$ in a period

$(t_c - b_i_t \leq t \leq t_c)$ going back b_i_t seconds from the current time t_c . The

controller 500 treats the value obtained by adding b_i_t and subtracting b_p_t

from t_{blast} as the next blink occurrence start time t_{bnext} ($= t_{blast} + b_i_t -$

15 b_p_t). The controller 500 predicts the time from the next blink occurrence start time t_{bnext} until $t_{bnext} + b_p_t$ ($t_{bnext} \leq t \leq t_{bnext} + b_p_t$) as the next blink occurrence period.

[0048]

The controller 500 can predict the period in which the subject will pass

20 through the focusing point as follows (hereinafter also referred to as focusing point pass-through period prediction). The controller 500 calculates a time t_a at

which the subject at the distance $d(t)$ at the time t will reach the focusing point.

The time t_a can be calculated by subtracting the distance df from the distance

$d(t)$, dividing the result by the walking speed v , and adding the resulting time to

25 the time t . In other words, $t_a = t + (d(t) - df) \div v$. The controller 500 predicts

the period from the time t_a until the time obtained by adding the time during

which the subject will pass through the in-focus range to the time t_a ($t_a \leq t \leq t_a +$

$(dof \div v)$) as the period in which the subject will pass through the focusing point.

[0049]

30 The controller 500 determines whether or not the next blink occurrence

period of the subject derived as above overlaps with the period in which the

subject will pass through the focusing point. In the case where the next blink

occurrence period and the period in which the subject will pass through the

focusing point overlap, the controller 500 uses the guiding device 200 to guide

the subject such that blinking does not occur at the focusing point (hereinafter also referred to as blink avoidance guiding control).

[0050]

In the blink avoidance guiding control, the controller 500 controls the
5 guiding device 200 to delay the time at which the subject will reach the focusing
point, for example. In this case, the controller 500 causes the guiding device
200 to use the display or speaker to present information such as an image or
sound for causing the subject to "slow down" or "stand still". By causing the
subject to follow the guidance and lower the walking speed or temporarily stand
10 still, the time at which the subject will reach the focusing point can be delayed,
and the probability of successfully avoiding blinking at the focusing point can be
increased.

[0051]

In the blink avoidance guiding control, the controller 500 may also control
15 the guiding device 200 to hasten the time at which the subject will reach the
focusing point. In this case, the controller 500 causes the guiding device 200 to
use the display or speaker to present information such as an image or sound for
causing the subject to "speed up". By causing the subject to follow the guidance
and raise the walking speed, the time at which the subject will reach the focusing
20 point can be hastened, and the probability of successfully avoiding blinking at the
focusing point can be increased.

[0052]

In the blink avoidance guiding control, the controller 500 may also control
the guiding device 200 to cause the subject to blink. For example, in the case
25 where $b(t)$ cannot be stored for a long time, the controller 500 may cause the
display or speaker to present information such as an image or sound for asking the
subject to "please blink" in the period until a time obtained by subtracting the
blink duration from the time t_a . In this case, by causing the subject to blink
once before passing through the focusing point, it is possible to keep blinking
30 from occurring in the period in which the subject passes through the focusing
point. Furthermore, in the case where the iris image pick-up means includes a
function of moving the focusing point, the controller 500 may also move the
focusing point such that the subject is in focus outside the next blink occurrence
period. The function of moving the focusing point can be achieved by driving a

means for controlling the point of focus, such as a liquid lens provided in the iris image pick-up device, for example.

[0053]

Next, an operational procedure will be described. Fig. 4 illustrates an operational procedure in the image processing system. The controller 500 performs the next blink period prediction described above (step S2001). In additionally, the controller 500, the controller 500 performs the focusing point pass-through period prediction described above (step S2002). The controller 500 determines whether or not the next blink period predicted in step S2001 and the focusing point pass-through period predicted in step S2002 overlap (step S2003). In the case where the controller 500 determines that the periods overlap in step S2003, the controller 500 performs the blink avoidance guiding control described above, and guides the subject using the guiding device 200 (step S2004).

[0054]

The controller 500 performs the guiding control described in the first example embodiment, and guides the subject using the guiding device 200 (step S2005). The controller 500 performs the illumination control and irradiates the subject with infrared light using the illumination device 300 (step S2006). The controller 500 performs the iris image pick-up control and acquires an image of the iris (iris image) picked up using the plurality of iris image pick-up devices 401 to 404 (step S2007). In step S2007, as described in the first example embodiment, the controller 500 does not need to obtain iris images for a certain subject from all of the iris image pick-up devices 401 to 404. The controller 500 acquires an iris image from each iris image pick-up device performing image pick-up of the eye region of the subject.

[0055]

The controller 500 performs iris authentication using the iris image(s) acquired in step S2007, or registers the iris image(s) (step S2008). The controller 500 determines whether or not there is a next subject, or whether or not re-authentication or re-registration should be performed (step S2009). In the case of determining that there is a next subject or that re-authentication or re-registration should be performed, the process returns to step S2001, and the process is performed from the next blink period prediction. Steps S2005 to S2009 may be similar to steps S1001 to S1005 in Fig. 3.

[0056]

In the present example embodiment, the controller 500 predicts the next blink period of the subject. Further, the controller 500 predicts the period in which the subject will pass through the focusing point of the iris image pick-up devices. In the case where the next blink period and the period in which the subject will pass through the focusing point overlap, the controller 500 performs the blink avoidance guiding control, and uses the guiding device 200 to guide the subject. With this arrangement, the probability of successfully avoiding blinking by the subject at the focusing position can be increased, and the retry rate of authentication and registration caused by blinking can be lowered.

[0057]

Note that although an example in which a partial area of 4,000 pixels in the horizontal direction and 1,500 pixels in the vertical direction is defined as the region of interest in Fig. 2, the present disclosure is not limited to this example.

The shape of the region of interest is not limited to the rectangle, and the number of region of interest s is not limited to one. The controller 500 may, for example, derive the positions of the right eye and left eye of the subject from the overall image (the overlooked image) taken by the overall imaging device 100, and set a region of interest corresponding to the position of the right eye and a region of interest corresponding to the position of the left eye in the iris image pick-up device. In such a case, the iris image pick-up device supplies iris images of the right and left eyes to the controller 500. The shape of the region of interest may be rectangular or may be elliptic. The controller 500 may derive the positions of the right and left eyes of the subject based on the iris image taken by the iris image pick-up device instead of based on the overlooked image. For example, the controller 500 may temporarily define the partial area shown in Fig. 2 as the region of interest, and derive the positions of the right and left eyes from the images in the region of interest. In such a case, the controller 500 may set, based on the derived positions of the right and left eyes, each of a partial area corresponding to the position of the right eye and a partial area corresponding to the position of the left eye as a region of interest in the iris image pick-up device.

[0058]

In each of above-described example embodiments, the controller 500 can be formed as a computer apparatus. Fig. 5 shows an example of a configuration

of an information processing apparatus (a computer apparatus) that can be used for the controller 500. An information processing apparatus 600 includes a control unit (CPU: Central Processing Unit) 610, a storage unit 620, a ROM (Read Only Memory) 630, a RAM (Random Access Memory) 640, a communication interface (IF: Interface) 650, and a user interface 660.

[0059]

The communication interface 650 is an interface for connecting the information processing apparatus 600 to a communication network through wired communication means, wireless communication means, or the like. The user interface 660 includes, for example, a display unit such as a display. Further, the user interface 660 includes an input unit such as a keyboard, a mouse, and a touch panel.

[0060]

The storage unit 620 is an auxiliary storage device that can hold various types of data. The storage unit 620 does not necessarily have to be a part of the information processing unit 600, and may be an external storage device or a cloud storage connected to the information processing unit 600 through a network. The ROM 630 is a non-volatile storage device. For example, a semiconductor storage device such as a flash memory having relatively small capacity is used for the ROM 630. Programs executed by the CPU 610 can be stored in the storage unit 620 or the ROM 630.

[0061]

The aforementioned program can be stored and provided to the information processing apparatus 600 by using any type of non-transitory computer readable media. Non-transitory computer readable media include any type of tangible storage media. Examples of non-transitory computer readable media include magnetic storage media such as floppy disks, magnetic tapes, and hard disk drives, optical magnetic storage media such as magneto-optical disks, optical disk media such as CD (Compact Disc) and DVD (Digital Versatile Disk), and semiconductor memories such as mask ROM, PROM (Programmable ROM), EPROM (Erasable PROM), flash ROM, and RAM. Further, the program may be provided to a computer using any type of transitory computer readable media. Examples of transitory computer readable media include electric signals, optical signals, and electromagnetic waves. Transitory computer readable media can

provide the program to a computer via a wired communication line such as electric wires and optical fibers or a radio communication line.

[0062]

5 The RAM 640 is a volatile storage device. As the RAM 640, various types of semiconductor memory apparatuses such as a DRAM (Dynamic Random Access Memory) or an SRAM (Static Random Access Memory) can be used. The RAM 640 can be used as an internal buffer for temporarily storing data and the like. The CPU 610 expands (i.e., loads) a program stored in the storage unit 620 or the ROM 630 in the RAM 640, and executes the expanded (i.e., loaded)
10 program. By executing the program, the CPU 610 performs various types of control including, for example, guiding control, illumination control, and iris image pick-up control. Further, by the CPU 610 executing the program, various types of processing including an image processing method related to blinking are executed.

15 [0063]

Although example embodiments according to the present disclosure have been described above in detail, the present disclosure is not limited to the above-described example embodiments, and the present disclosure also includes those that are obtained by making changes or modifications to the above-described
20 example embodiments without departing from the spirit of the present disclosure.

[0064]

For example, the whole or part of the example embodiments disclosed above can be described as, but not limited to, the following supplementary notes.

[0065]

25 (Supplementary note 1)

An image processing system comprising:

a plurality of iris image pick-up means disposed at mutually different positions in the same field of view;

30 overall image pick-up means for performing image pick-up over a wider field of view than the field of view of the iris image pick-up means;

guiding means for guiding a subject;

illumination means for illuminating the subject with light; and

control means for controlling, using an image from the overall image pick-up means, at least one of reading out an image from the plurality of iris image

pick-up means, presenting at least one of an image and a sound through the guiding means, or providing illumination with light from the illumination means, wherein

the control means further predicts a period in which the subject will blink next and a period in which the subject will pass through a focusing point of the iris image pick-up means, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, the control means controls at least one of the guiding means or the iris image pick-up means such that the focusing point and a position where the subject will blink next are different.

[0066]

(Supplementary note 2)

The image processing system according to Supplementary note 1, wherein the control means performs readout of an image from the plurality of iris image pick-up means, and

in the readout of an image from the plurality of iris image pick-up means, the control means specifies an iris image pick-up means capable of performing image pick-up of an eye of the subject from among the plurality of iris image pick-up means on the basis of an image acquired by the overall image pick-up means, sets a region of interest including the position of the eye of the subject in the specified iris image pick-up means, and acquires an image of the observation target region from the specified iris image pick-up means.

[0067]

(Supplementary note 3)

The image processing system according to Supplementary note 1 or 2, wherein

the control means controls the guiding means such that the subject does not blink at the focusing point in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

[0068]

(Supplementary note 4)

The image processing system according to Supplementary note 1 or 2, wherein

the control means controls the iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject will blink next in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

[0069]

(Supplementary note 5)

The image processing system according to Supplementary note 3 or 4, wherein

the control means predicts the period in which the subject will blink next on a basis of a last time the subject blinked, a blink interval time, and a blink duration.

[0070]

(Supplementary note 6)

The image processing system according to any one of Supplementary notes 3 to 5, wherein

the control means predicts the period in which the subject will pass through the focusing point on a basis of a position and a movement speed of the subject.

[0071]

(Supplementary note 7)

An image processing apparatus comprising:

control means for predicting a period in which a moving subject will blink next and a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, controlling guiding means for guiding the subject such that the subject does not blink at the focusing point.

[0072]

(Supplementary note 8)

The image processing apparatus according to Supplementary note 7, wherein

the control means predicts the period in which the subject will blink next

on a basis of a last time the subject blinked, a blink interval time, and a blink duration.

[0073]

(Supplementary note 9)

5 The image processing apparatus according to Supplementary note 7 or 8, wherein

 the control means predicts the period in which the subject will pass through the focusing point on a basis of a position and a movement speed of the subject.

10 [0074]

(Supplementary note 10)

 The image processing apparatus according to any one of Supplementary notes 7 to 9, wherein

 the control means controls the guiding means to delay a time at which the
15 subject will reach the focusing point in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

[0075]

(Supplementary note 11)

20 The image processing apparatus according to any one of Supplementary notes 7 to 9, wherein

 the control means controls the guiding means to hasten a time at which the subject will reach the focusing point in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass
25 through the focusing point.

[0076]

(Supplementary note 12)

 The image processing apparatus according to any one of Supplementary notes 7 to 9, wherein

30 the control means controls the guiding means to cause the subject to blink in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

[0077]

(Supplementary note 13)

An image processing apparatus comprising:

control means for predicting a period in which a moving subject will blink next and a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject, and
5 in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, controlling the iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject will blink next.

[0078]

10 (Supplementary note 14)

The image processing apparatus according to Supplementary note 13, wherein

the control means predicts the period in which the subject will blink next on a basis of a last time the subject blinked, a blink interval time, and a blink
15 duration.

[0079]

(Supplementary note 15)

The image processing apparatus according to Supplementary note 13 or 14, wherein

20 the control means predicts the period in which the subject will pass through the focusing point on a basis of a position and a movement speed of the subject.

[0080]

(Supplementary note 16)

25 An image processing method comprising:

performing, using an image from overall image pick-up means for performing image pick-up over a wider field of view than a field of view of a plurality of iris image pick-up means disposed at mutually different positions in the same field of view, at least one of reading out an image from the plurality of
30 iris image pick-up means, presenting at least one of an image and a sound through guiding means for guiding a subject, or providing illumination with light from illumination means for illuminating the subject with light.

[0081]

(Supplementary note 17)

An image processing method comprising:

predicting a period in which a moving subject will blink next;

predicting a period in which the subject will pass through a focusing point
 of iris image pick-up means for performing image pick-up of an iris of the
 5 subject;

determining whether or not the period in which the subject will blink next
 overlaps with the period in which the subject will pass through the focusing point;
 and

performing, in a case of determining that the periods overlap, at least one
 10 of guiding the subject or controlling the iris image pick-up means such that the
 focusing point and a position where the subject will blink next are different.
 [0082]

(Supplementary note 18)

The image processing method according to Supplementary note 17,
 15 wherein

the subject is guided to blink next at a different position such that the
 subject does not blink at the focusing point in a case of determining that the
 period in which the subject will blink next overlaps with the period in which the
 subject will pass through the focusing point.

20 [0083]

(Supplementary note 19)

The image processing method according to Supplementary note 17 or 18,
 wherein

the iris image pick-up means is controlled such that the focusing point is a
 25 position other than the position of the subject in the period in which the subject
 will blink next in a case of determining that the period in which the subject will
 blink next overlaps with the period in which the subject will pass through the
 focusing point.

[0084]

30 (Supplementary note 20)

A non-transitory computer readable medium storing a program causing a
 computer to execute a process comprising:

performing, using an image from overall image pick-up means for
 performing image pick-up over a wider field of view than a field of view of a

plurality of iris image pick-up means disposed at mutually different positions in the same field of view, at least one of reading out an image from the plurality of iris image pick-up means, presenting at least one of an image and a sound through guiding means for guiding a subject, or providing illumination with light from illumination means for illuminating the subject with light.

[0085]

(Supplementary note 21)

A non-transitory computer readable medium storing a program causing a computer to execute a process comprising:

predicting a period in which a moving subject will blink next;

predicting a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject;

determining whether or not the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point; and

performing, in a case of determining that the periods overlap, at least one of guiding the subject or controlling the iris image pick-up means such that the focusing point and a position where the subject will blink next are different.

[0086]

(Supplementary note 22)

The non-transitory computer readable medium according to Supplementary note 21, wherein the program causes the computer to execute a process comprising:

guiding the subject such that the subject does not blink at the focusing point in a case of determining that the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

[0087]

(Supplementary note 23)

The non-transitory computer readable medium according to Supplementary note 21 or 22, wherein the program causes the computer to execute a process comprising:

controlling the iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject

will blink next in a case of determining that the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

[0088]

5 This application is based upon and claims the benefit of priority from Japanese patent application No. 2019-026941, filed on February 18, 2019, the disclosure of which is incorporated herein in its entirety by reference.

Reference Signs List

10 [0089]

100 OVERALL IMAGING DEVICE

200 GUID DEVICE

300 ILLUMINATION DEVICE

401-404 IRIS IMAGE PICK-UP DEVICE

15 500 CONTROLLER

600 INFORMATION PROCESSING APPARATUS

CLAIMS

1. An image processing system comprising:

a plurality of iris image pick-up means disposed at mutually different

5 positions in the same field of view;

overall image pick-up means for performing image pick-up over a wider field of view than the field of view of the iris image pick-up means;

guiding means for guiding a subject;

illumination means for illuminating the subject with light; and

10 control means for controlling, using an image from the overall image pick-up means, at least one of reading out an image from the plurality of iris image pick-up means, presenting at least one of an image and a sound through the guiding means, or providing illumination with light from the illumination means, wherein

15 the control means further predicts a period in which the subject will blink next and a period in which the subject will pass through a focusing point of the iris image pick-up means, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, the control means controls at least one of the guiding means or the
20 iris image pick-up means such that the focusing point and a position where the subject will blink next are different.

2. The image processing system according to Claim 1, wherein

the control means performs readout of an image from the plurality of iris
25 image pick-up means, and

in the readout of an image from the plurality of iris image pick-up means, the control means specifies an iris image pick-up means capable of performing image pick-up of an eye of the subject from among the plurality of iris image pick-up means on the basis of an image acquired by the overall image pick-up
30 means, sets a region of interest including the position of the eye of the subject in the specified iris image pick-up means, and acquires an image of the observation target region from the specified iris image pick-up means.

3. The image processing system according to Claim 1 or 2, wherein

the control means controls the guiding means such that the subject does not blink at the focusing point in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

5

4. The image processing system according to Claim 1 or 2, wherein the control means controls the iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject will blink next in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

10

5. The image processing system according to Claim 3 or 4, wherein the control means predicts the period in which the subject will blink next on a basis of a last time the subject blinked, a blink interval time, and a blink duration.

15

6. The image processing system according to any one of Claims 3 to 5, wherein

20

the control means predicts the period in which the subject will pass through the focusing point on a basis of a position and a movement speed of the subject.

7. An image processing apparatus comprising:

25

control means for predicting a period in which a moving subject will blink next and a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, controlling guiding means for guiding the subject such that the subject does not blink at the focusing point.

30

8. The image processing apparatus according to Claim 7, wherein the control means predicts the period in which the subject will blink next

on a basis of a last time the subject blinked, a blink interval time, and a blink duration.

9. The image processing apparatus according to Claim 7 or 8, wherein
5 the control means predicts the period in which the subject will pass through the focusing point on a basis of a position and a movement speed of the subject.

10. The image processing apparatus according to any one of Claims 7 to 9,
10 wherein
the control means controls the guiding means to delay a time at which the subject will reach the focusing point in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

11. The image processing apparatus according to any one of Claims 7 to 9,
15 wherein
the control means controls the guiding means to hasten a time at which the subject will reach the focusing point in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

12. The image processing apparatus according to any one of Claims 7 to 9,
20 wherein
the control means controls the guiding means to cause the subject to blink in the case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

13. An image processing apparatus comprising:
30 control means for predicting a period in which a moving subject will blink next and a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject, and in a case where the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point, controlling the

iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject will blink next.

14. The image processing apparatus according to Claim 13, wherein
5 the control means predicts the period in which the subject will blink next on a basis of a last time the subject blinked, a blink interval time, and a blink duration.

15. The image processing apparatus according to Claim 13 or 14, wherein
10 the control means predicts the period in which the subject will pass through the focusing point on a basis of a position and a movement speed of the subject.

16. An image processing method comprising:
15 performing, using an image from overall image pick-up means for performing image pick-up over a wider field of view than a field of view of a plurality of iris image pick-up means disposed at mutually different positions in the same field of view, at least one of reading out an image from the plurality of iris image pick-up means, presenting at least one of an image and a sound through
20 guiding means for guiding a subject, or providing illumination with light from illumination means for illuminating the subject with light.

17. An image processing method comprising:
predicting a period in which a moving subject will blink next;
25 predicting a period in which the subject will pass through a focusing point of iris image pick-up means for performing image pick-up of an iris of the subject;

determining whether or not the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point;
30 and

performing, in a case of determining that the periods overlap, at least one of guiding the subject or controlling the iris image pick-up means such that the focusing point and a position where the subject will blink next are different.

18. The image processing method according to Claim 17, wherein
the subject is guided to blink next at a different position such that the
subject does not blink at the focusing point in a case of determining that the
period in which the subject will blink next overlaps with the period in which the
5 subject will pass through the focusing point.

19. The image processing method according to Claim 17 or 18, wherein
the iris image pick-up means is controlled such that the focusing point is a
position other than the position of the subject in the period in which the subject
10 will blink next in a case of determining that the period in which the subject will
blink next overlaps with the period in which the subject will pass through the
focusing point.

20. A non-transitory computer readable medium storing a program causing
15 a computer to execute a process comprising:

performing, using an image from overall image pick-up means for
performing image pick-up over a wider field of view than a field of view of a
plurality of iris image pick-up means disposed at mutually different positions in
the same field of view, at least one of reading out an image from the plurality of
20 iris image pick-up means, presenting at least one of an image and a sound through
guiding means for guiding a subject, or providing illumination with light from
illumination means for illuminating the subject with light.

21. A non-transitory computer readable medium storing a program causing
25 a computer to execute a process comprising:

predicting a period in which a moving subject will blink next;

predicting a period in which the subject will pass through a focusing point
of iris image pick-up means for performing image pick-up of an iris of the
subject;

30 determining whether or not the period in which the subject will blink next
overlaps with the period in which the subject will pass through the focusing point;
and

performing, in a case of determining that the periods overlap, at least one
of guiding the subject or controlling the iris image pick-up means such that the

focusing point and a position where the subject will blink next are different.

22. The non-transitory computer readable medium according to Claim 21, wherein the program causes the computer to execute a process comprising:

5 guiding the subject such that the subject does not blink at the focusing point in a case of determining that the period in which the subject will blink next overlaps with the period in which the subject will pass through the focusing point.

23. The non-transitory computer readable medium according to Claim 21 or 22, wherein the program causes the computer to execute a process comprising:

10 controlling the iris image pick-up means such that the focusing point is a position other than the position of the subject in the period in which the subject will blink next in a case of determining that the period in which the subject will blink next overlaps with the period in which the subject will pass through the
15 focusing point.