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DESCRIPTION

FACE AUTHENTICATION APPARATUS, FACE AUTHENTICATION METHOD,
PROGRAM, AND RECORDING MEDIUM

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TECHNICAL FIELD

[0001] The present invention relates to a face authentication apparatus, a face authentication method, a program, and a recording medium.

BACKGROUND ART

10 [0002] In various fields, personal authentication by face image analysis (hereinafter, referred to as face authentication) is used. In the face authentication, a face image of a registered person is stored in advance as a master face image, a face image of a subject obtained in live as a query face image is collated with the master face image, and the subject of the image is authenticated when the query face image matches the master face image. Such face authentication makes it
15 possible, for example, to negate the need for arranging a security guard or the like for admission management at an entrance, to improve safety, to reduce labor costs, and the like.

SUMMARY OF INVENTION

Technical Problem

[0003] However, on the other hand, since no one is attended, a problem arises in that, for
20 example, a face photograph of a registered person is held over a camera to impersonate during face authentication.

[0004] With the foregoing in mind, it is an object of the present invention to provide a new face authentication system that can easily prevent impersonation using a face photograph.

Solution to Problem

25 [0005] In order to achieve the aforementioned object, the present invention provides a face authentication apparatus, including: a storage unit that stores determination reference information relating to a positional relationship between a face and a part other than the face in a human skeleton; an image acquisition unit that acquires an image of a subject; an extraction unit that extracts face information and skeleton information from the image; a position determination
30 unit that determines whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on the extracted skeleton information in the image is normal or abnormal based on the determination reference information; and an output unit that outputs that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extraction unit and/or when the positional

relationship is determined to be abnormal by the position determination unit.

[0006] The present invention also provides a face authentication method, including the steps of: acquiring an image of a subject; extracting face information and skeleton information from the image; determining whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on the extracted skeleton information in the image is normal or abnormal based on determination reference information, the determination reference information being determination reference information relating to a positional relationship between a face and a part other than the face in a human skeleton; and outputting that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extracting and/or when the positional relationship is determined to be abnormal by the position-determining.

[0007] The present invention also provides a program for a computer to execute the face authentication method according to the present invention.

[0008] The present invention also provides a computer readable recording medium with the program according to the present invention.

Advantageous Effects of Invention

[0009] According to the present invention, by utilizing skeleton information, impersonation using a face photograph can be easily prevented.

BRIEF DESCRIPTION OF DRAWINGS

[0010] [FIG. 1] FIG. 1 is a block diagram showing an example of a face authentication apparatus according to the first example embodiment.

[FIG. 2] FIG. 2 is a block diagram showing an example of a hardware configuration of the face authentication apparatus according to the first example embodiment.

[FIG. 3] FIG. 3 is a flowchart showing an example of a face authentication method of the first example embodiment.

[FIG. 4] FIG. 4 is a schematic view showing states of subjects.

[FIG. 5] FIG. 5 is another schematic view showing a state of a subject.

[FIG. 6] FIG. 6 is another schematic view showing states of subjects.

DESCRIPTION OF EXAMPLE EMBODIMENTS

[0011] Example embodiments of the present invention will be described with reference to the drawings. Note here that the present invention is not limited to the following example embodiments. In the following drawings, identical parts are indicated with identical reference signs. Each example embodiment can be described with reference to the descriptions of other example embodiments, unless otherwise specified, and the configurations of the example

embodiments may be combined, unless otherwise specified.

[0012] First Example Embodiment

An example of the face authentication apparatus and the face authentication method of the present invention will be described with reference to the drawings.

5 [0013] FIG. 1 is a block diagram showing an example of the configuration of a face authentication apparatus according to the present example embodiment. The face authentication apparatus 10 includes a storage unit 11, an image acquisition unit 12, an extraction unit 13, a position determination unit 14, and an output unit 15. The face authentication apparatus 10 includes, for example, a face collation unit 16. The face authentication apparatus 10 is also
10 referred to as a face authentication system, for example.

[0014] The face authentication apparatus 10 may be, for example, a single apparatus including the above-described components, or may be an apparatus to which the components are connectable via a communication network. The communication network is not particularly limited, and a known network can be used, and may be, for example, a wired network or a
15 wireless network. Examples of the communication network include an Internet line, a telephone line, a local area network (LAN), and a wireless fidelity (WiFi). The face authentication apparatus 10 may be, for example, a personal computer (PC) in which the program of the present invention is installed.

[0015] FIG. 2 is a block diagram illustrating a hardware configuration of the face
20 authentication apparatus 10 of FIG. 1. The face authentication apparatus 10 includes, for example, a central processing unit (CPU) 101 as an example of the processor, a memory 102, a bus 103, an input device 104, a display 105, a communication device 106, a storage device 107, a camera 109, and the like.

[0016] The components of the face authentication apparatus 10 are connected to each other via
25 the bus 103 by, for example, respective interfaces (I/F). The I/F can be connected to an external device, for example. The face authentication apparatus 10 can be connected to a communication network by, for example, the communication device 106 connected to the I/F, and can also be connected to the external device via the communication network.

[0017] Examples of the external device include terminals such as a personal computer (PC), a
30 smartphone, a tablet, a mobile phone, and the like. Further, the external device may be, for example, an imaging device (for example, a camera) or the like that takes an image of a subject.

[0018] The CPU 101 is a processor responsible for the entire control of the face authentication apparatus 10, is not limited to the CPU, and may be other processors. In the face authentication apparatus 10, the CPU 101 executes a program of the present invention and other programs, and

reads and writes various pieces of information, for example. Specifically, for example, the CPU 101 functions as the image acquisition unit 12, the extraction unit 13, the position determination unit 14, the output unit 15, and the like, and optionally functions as the face collation unit 16.

[0019] The memory 102 includes, for example, a main memory (main storage device), and the main memory is also referred to as a main storage device. When the CPU 101 performs processing, the memory 102 reads various kinds of programs 108 such as the program of the present invention stored in the storage device 107 to be described below, and the CPU 101 receives data from the memory 102 and executes the program 108. The main memory is, for example, a random access memory (RAM). The memory 102 further includes, for example, a read-only memory (ROM).

[0020] The storage device 107 is also referred to as, for example, a so-called auxiliary storage device relative to the main memory. The storage device 107 stores, as described above, the program 108 including the program of the present invention and the storage unit 11. The storage device 107 includes, for example, a storage medium and a drive for reading from and writing to the storage medium. The storage medium is not particularly limited, and may be, for example, a built-in type or an external type, and examples thereof include a hard disk (HD), a floppy® disk (FD), a CD-ROM, a CD-R, a CD-RW, an MO, a DVD, a flash memory, and a memory card. The drive is not particularly limited. The storage device 107 can be, for example, a hard disk drive (HDD) in which the storage medium and the drive are integrated.

[0021] The face authentication apparatus 10 further includes, for example, an input device 104, a display 105, and a camera 109. Examples of the input device 104 include a touch panel, a keyboard, a mouse, and a scanner. Examples of the display 105 include an LED display and a liquid crystal display. When the face authentication apparatus 10 includes the display 105, the output unit 15 may output the authentication result to the display 105 and the display 105 may display the authentication result, for example. The face authentication apparatus 10 may output the authentication result to the external device or the like via the communication device 106 by the output unit 15, for example.

[0022] In the face authentication apparatus 10, the storage unit 11 contains determination reference information. The determination reference information is reference information relating to the positional relationship between the face and a part other than the face in the human skeleton. When the face authentication apparatus 10 includes the face collation unit 16, the storage unit 11 may further contain registered face information of a registered person, for example.

[0023] As described above, in face authentication impersonation, for example, a subject as a

subject to be taken its image holds the face photograph itself of a registered person or a smartphone, a tablet, or the like displaying the face photograph over a camera, for the purpose of being authenticated. In addition, in face authentication impersonation, for example, a subject as a subject to be taken its image brings the face photograph itself of a registered person or the
5 smartphone, the tablet, or the like displaying the face photograph to the position of the face of the subject so as to be taken by the camera, for the purpose of being authenticated. The inventors of the present invention have found that the positional relationship between the face and a part other than the face is different between the case where the image of the subject himself/herself is taken and the case where the image of the face photograph or the like held over the camera is
10 taken or the case where the image of the subject is taken in the state where the subject holds the face photograph at the position of the face. That is, based on a human skeleton and a human movement, in the case of a subject who is not an impersonator, the head (i.e., face) positions higher than the neck and the arms generally position lower than the shoulder while walking, for example. On the other hand, when a subject who in an impersonator holds the face photograph
15 over the camera, for example, there is no body below the face photograph. Further, when the subject holds the face photograph in his/her hand and brings it to the position of the face, there is the body of the subject below the face photograph but the arm of the subject positions at an unnatural position for the state of walking in order to maintain the face photograph at the position of the face, for example. On the basis of this, the inventors of the present invention have
20 found that it is possible to determine whether there is a possibility of impersonation by extracting face information and skeleton information from a taken image of a subject and determining whether or not the positional relationship between the position of the face information and position of the skeleton information in the image is a positional relationship in normal human movement, and made the present invention. In the present invention, normal or abnormal is
25 merely a judgement used in face authentication impersonation. In other words, "normal" means, for example, a state in which a person who does not impersonate in face authentication is in "natural posture or movement", and "abnormal" means, for example, a state in which a person who impersonate or may impersonate in face authentication is in "unnatural posture or movement".

30 [0024] In usual face authentication, usually, face information is extracted from an acquired image of a subject, and the extracted face information is simply collated with registered face information of a registered person. On the other hand, in the present invention, skeleton information as well as face information is extracted from the image of the subject, and it is possible to determine whether to be non-authenticatable based on the relationship between the

face and a part other than the face in the skeleton in the image, thereby enabling to determine whether to be impersonation. Therefore, in the present invention, the determination reference information may be, for example, a condition under which the positional relationship between the face and a part other than the face in a human skeleton is determined to be a normal state and not impersonation or to be an abnormal state and impersonation, and the specific conditions can be appropriately set. When the determination reference information is "a condition under which the positional relationship can be determined to be a normal state", if the condition is not satisfied, it is determined to be non-authenticatable as an image having an abnormal positional relationship. When the determination reference information is "a condition under which the positional relationship can be determined to be an abnormal state", if the condition is satisfied, it is determined to be non-authenticatable as an image having an abnormal positional relationship. In the present invention, the term "non-authenticatable" may mean uncollatable with registered face information to be described below, for example.

[0025] In the present invention, when the image of the subject is determined to be the image having an abnormal positional relationship, the subject of the image is determined to be non-authenticatable regardless of the collation result between the extracted face information and the registered face information obtained by the face collation unit (determination that the extracted face information and the registered face information are the same person or not the same person), which is to be described below, for example.

[0026] In the positional relationship between the face and a part other than the face, the part other than the face is not particularly limited, and examples thereof include an arm, a hand, a neck, an upper body, and a finger.

[0027] The face authentication apparatus of the present invention can be used for face authentication using a still image as a taken image of a subject, for example, but is preferably used for face authentication using constituent images constituting a moving image taken while the subject is moving. The latter is also referred to as so-called "walk-through face authentication", and the image of the subject is taken while the subject is moving, specifically, the image of the subject is taken while the subject is walking, and face authentication is performed using the image, for example. For this reason, the positional relationship between the face and a part other than the face is preferably set to a positional relationship which can be determined to be normal in a state where a person is walking, for example. The moving image includes a plurality of constituent images taken over time (continuously). In the present invention, when the image of the subject is the moving image, for example, at least one of the plurality of constituent images constituting the moving image may be used, or continuous or

discontinuous two or more of them may be used.

[0028] The face authentication apparatus 10 determines that the image of the impersonator is non-authenticatable based on the determination of the positional relationship using the skeleton information, regardless of whether or not the face information in the image matches the registered face information. Since the so-called face authentication apparatus is usually intended for face authentication in the end, the face authentication apparatus 10 of the present example embodiment preferably further includes a face collation unit 16, and the storage unit 11 preferably further stores registered face information of a registered person, as described above. Examples of the registered face information include a face image of a registered person and information of feature points relating to the face image. The registered face information is stored in association with identification information of a registered person, for example, as registered person information. Examples of the identification information include a name, an identification number, a work place, an affiliation, and a contact address of the registered person.

[0029] In the face authentication apparatus 10, the image acquisition unit 12 acquires an image of a subject. For example, the face authentication apparatus 10 itself may include a camera 109 for taking an image of the subject to acquire the image, or may acquire the image of the subject taken by the external device camera via the input device 104 or the communication device 106. The image of the subject may be, for example, a still image or constituent images constituting the moving image taken over time, as described above.

[0030] In the face authentication apparatus 10, the extraction unit 13 extracts face information and skeleton information from the image of the subject. Extraction of face information from the image and extraction of skeleton information from the image are not particularly limited, and for example, existing image processing techniques can be utilized. Since the extraction method itself is not a key factor in the present invention, the extraction method is not limited in any way, and an image processing technique to be developed after the application of the present application will be also available. For example, Openpose (Wellspring) or the like can be used as an existing program for extracting face information from the image, and Vision Pose® (NEXT-SYSTEM Co.,Ltd.) or the like can be used as an existing program for extracting skeleton information from the image.

[0031] In the face authentication apparatus 10, the position determination unit 14 determines whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on the extracted skeleton information in the image is normal or abnormal based on the determination reference information. The position of the face based on the extracted face information and the position of the skeleton based on the extracted

skeleton information can be appropriately selected according to, for example, the determination reference information. That is, with reference to the determination reference information, in the case where the position of the face in the human skeleton is specified by, for example, the skeleton of the head (outline of the head), the skeleton of the head may be extracted from the extracted face information, and the position of the skeleton of the head may be set as the position of the face in the extracted face information. Further, with reference to the determination reference information, in the case where a part other than the face in the human skeleton is, for example, an arm (e.g., shoulder to tip of the finger), the skeleton of the arm may be extracted from the extracted skeleton information, and the position of the skeleton of the arm may be set as the position of the skeleton in the extracted skeleton information. The method for determining the position of the face and the position of the skeleton in the image from the extracted face information is not particularly limited, and can be determined, for example, by extracting a feature point of a face and a feature point of a freely selected part (e.g., an arm) of the skeleton, and a general method for image analysis can be utilized.

[0032] In the face authentication apparatus 10, the face collation unit 16 collates the extracted face information with the registered face information to determine whether or not they are of the same person. For example, the face collation unit 16 may perform collation only on face information derived from the image that has not been determined to be non-authenticatable by the position determination unit 14, or may perform collation on face information derived from any image regardless of the determination by the position determination unit 14. That is, the face authentication apparatus 10 according to the present example embodiment may first perform either of the position determination based on the determination reference information and the determination as to whether to be authenticated or non-authenticatable (also referred to as "not authenticated") by the face collation, for example. In other words, when the position determination is performed first, for example, face information and skeleton information are first extracted from the image of the subject, and then, only the image from which both of the face information and the skeleton information are extracted is subjected to the determination whether to be normal or abnormal based on the determination reference information. Further, only the image determined to be normal may be subjected to the face collation to determine whether to be authenticated or not to be authenticated. When the face authentication is performed first, for example, face information and skeleton information are first extracted from the image of the subject, and the image from which the face information is extracted is subjected to the face collation to make a provisional determination as to whether to be authenticated or not to be authenticated. Then, the image that has been provisionally determined to be authenticated may

also be determined whether to be normal or abnormal based on the determination reference information, and in the case of being determined to be abnormal, final determination may be made to be not authenticated, and in the case of being determined to be normal, final determination may be made to be authenticated.

5 [0033] In the face authentication unit 10, the output unit 15 outputs that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extraction unit 13 and/or when the positional relationship is determined not to satisfy the determination reference information by the position determination unit 14. The output unit 15 outputs that the subject of the image is authenticated when the extracted face information and the registered face
10 information are determined to be the same person by the face collation unit 16 and outputs that the subject of the image is non-authenticatable when the extracted face information and the registered face information are determined not to be the same person by the face collation unit 16.

[0034] Next, the face authentication method of the present example embodiment will be
15 described. The face authentication method of the present example embodiment can be performed using, for example, the face authentication apparatus 10 shown in FIGs. 1 and 2. The method, however, is not limited to the use of the face authentication apparatus 10.

[0035] The image-acquiring acquires an image of a subject. This step can be performed by, for example, the image acquisition unit 12 of the face authentication apparatus 10.

20 [0036] The extracting extracts face information and skeleton information from the image. This step can be performed by, for example, the image extraction unit 13 of the face authentication apparatus 10.

[0037] The position-determining determines whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on
25 the extracted skeleton information in the image is normal or abnormal based on the determination reference information. This step can be performed by, for example, the position determination unit 14 of the face authentication apparatus 10, and the determination reference information can be called from the storage unit 11 of the face authentication apparatus 10, for example.

30 [0038] The face-collating collates the extracted face information with registered face information of a registered person. This step can be performed by, for example, the face collation unit 16 of the face authentication apparatus 10.

[0039] The outputting outputs that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extracting and/or when the positional relationship is

determined to be abnormal by the position-determining. The outputting outputs that the subject of the image is authenticated when the positional relationship is determined to be normal by the position-determining and the extracted face information and the registered face information are determined to be the same person by the face-collating, and outputs that the subject of the image is non-authenticatable when the extracted face information and the registered face information are determined not to be the same person by the face-collating. This step can be performed by, for example, the output unit 15 of the face authentication apparatus 10.

[0040] In the face authentication method of the present example embodiment, for example, the face-collating may collate the face image, which is extracted only from the image that has been determined to be normal based on the determination reference information by the position-determining, with the registered face image or may collate the face image, which is extracted from the image regardless of the determination by the position-determining, with the registered face image.

[0041] Next, the face authentication method according to the present example embodiment will be described in more detail with reference to the flowchart of FIG. 3. The flowchart is merely an example, and the present invention is not limited thereto in any way.

[0042] First, an image of a subject is acquired (S101). Then, from the image, extraction of face information (S102) and extraction of skeleton information (S105) are performed. When the face information cannot be extracted from the image (S103, NO), it is determined to be non-authenticatable (face-uncollatable) (S104) because there is no face information to be collated. On the other hand, when the skeleton information cannot be extracted from the image (S106, NO), it is determined that there is a possibility of impersonation and determined to be non-authenticatable (face-uncollatable) (S107).

[0043] When the face information can be extracted from the image (S103, YES) and the skeleton information can be extracted from the image (S106, YES), the positional relationship between the position of the face based on the face information and the position of the skeleton based on the skeleton information in the image is determined to be normal or abnormal based on the determination reference information (S108). When it is determined to be abnormal (NO), it is determined that there is a possibility of impersonation and determined to be non-authenticatable (face-uncollatable) (S109).

[0044] When it is determined to be normal (YES), it is determined that the image of the subject is taken in a normal state and determined to be not impersonation, and the extracted face information is collated with the registered face information (S110). Whether or not the subject and the registered person are the same person is determined based on the collation between the

face information and the registered face information (S111). In the case where the subject and the registered person are the same person (YES), it is determined to be authenticated (S112). In the case where the subject and the registered person are not the same person (NO), it is determined to be non-authenticatable (face-uncollatable) (S113). Then, the determination result of

5 authenticated or non-authenticatable in each step is output (S114), and the process is terminated (END).

[0045] In this flow chart, the collation (S110) is performed when it is determined to be normal in the step (S108, YES). The present invention, however, is not limited thereto. In other words, when the face image can be extracted from the image (S103, YES) and the skeleton information
10 can be extracted from the image (S106, YES), the step (S110) of collating may be performed separately from the step (S108). In this case, even if the subject and the registered person are determined to be the same person in the step (S111, YES), if it is determined to be abnormal in the separately performed step (S108, NO), it is eventually determined to be non-authenticatable (S109).

15 [0046] Second Example Embodiment

In the present example embodiment, determination of the presence or absence of skeleton information in the image and determination of whether to be normal or abnormal based on the determination reference information will be described with reference to specific examples and drawings. The following drawings are merely examples and the present invention is not
20 limited thereto. In each drawing, a square frame is a region of a face extracted from an image, and a branched-line is a skeleton extracted from the image.

[0047] (A) in FIG. 4 is a schematic diagram showing a state in which a subject 20 directs a smartphone 30 displaying the face image of the registered person to a camera 40. When the image of the subject 20 in this state is taken, it can be determined to be non-authenticatable, for
25 example, in the following manner. As the first pattern, it is assumed that both of the face information of the face displayed on the smartphone 30 and the skeleton information of the subject 20 holding the smartphone 30 can be extracted from the acquired image. In the image, however, the face information of the face displayed on the smartphone 30 present at the position of the arm of the subject 20 based on the skeleton information. Since it is impossible for the face
30 to be present on the human arm according to the positional relationship between the face and the arm, it is determined to be abnormal based on the determination reference information that the human face positions above the neck in the skeleton or the determination reference information that the human face is not connected to the arm in the skeleton, and thus it is determined to be face-uncollatable, that is, non-authenticatable as a result.

[0048] As the second pattern, it is assumed that the face information of the face displayed on the smartphone 30 can be extracted from the acquired image and the extracted face information is assumed to be the position of the face in the image. In this case, however, if the extracted face information is the face of the subject 20, since there is no body below the face and the skeleton information is not extracted, it is determined to be abnormal, and thus it is determined to be face-uncollatable, that is, non-authenticatable as a result.

[0049] Further, as the third pattern, it is assumed that the face information of the face displayed on the smartphone 30, the face information of the face of the subject 20 holding the smartphone, and the skeleton information of the subject 20 are extracted. Since one face is normally present in one body, it is determined that the number of pieces of the face information and the number of pieces of the skeleton information are not matched with each other, and it is determined to be face-uncollatable, that is, non-authenticatable as a result. On the other hand, as shown in (B) in FIG. 4, when the image of three subjects 20 (20A, 20B, 20C) is taken, the face information and the skeleton information are extracted for each of them, and the positional relationship between the position of each face and the position of each skeleton is determined to be normal. Thus, the face collation can be continued on the face information of each of the subjects 20A, 20B, and 20C.

[0050] In these example embodiments, for example, even if it is determined to be the same person by face collation, regardless of the determination, it is determined to be non-authenticatable as a result if it is determined to be abnormal based on the determination reference information, so that the risk of impersonation in authentication can be reduced.

[0051] (C) in FIG. 4 is a schematic diagram showing a state in which the subject 20 holds the smartphone 30 displaying the face image of the registered person at the position of his/her face. When the image of the subject 20 in this state is taken, both of the face information and the skeleton information can be extracted from the acquired image. In the image, however, with reference to the position of the face based on the extracted face information, the position of the arm based on the extracted skeleton information (particularly, the position of the tip of finger from the elbow) positions higher than the shoulder. (D) in FIG. 4 shows the outline of a normal state of a person during walking. As shown in (D) in FIG. 4, in a normal state of a person during walking, the arms position lower than the shoulder (lower than the dotted line in (D) in FIG. 4). Therefore, for example, when the reference value (threshold) of the height of the arm during walking is set to the height of the shoulder, since the arm positions higher than the shoulder in (C) in FIG. 4 (higher than the dotted line in (C) in FIG. 4), i.e., the position of the arm exceeds the height of the reference value, it is determined to be non-authenticatable as being abnormal. In

this case, even if it is determined to be the same person by face collation, regardless of the determination, it is determined to be non-authenticatable as being abnormal, so that the risk of impersonation in authentication can be reduced.

[0052] On the other hand, in the case of (D) in FIG. 4, since the arm positions lower than the shoulder in the image (lower than the dotted line in (D) in FIG. 4), i.e., the position of the arm does not exceed the height of the reference value, it is determined to be normal. Thus, the face collation can be continued on the face information of the subject 20.

[0053] FIG. 5 is a schematic diagram showing a state in which the subject brings the face image of the registered person displayed on the smartphone 30 closer to the camera 40 in closeup. When the image of the subject in this state is taken, since only the face is included in the image, face information can be extracted, whereas skeleton information cannot be extracted. Thus, it is determined that there is a possibility of impersonation and determined to be non-authenticatable. In this case, even if it is determined to be the same person by face collation, regardless of the determination, it is determined to be non-authenticatable, so that the risk of impersonation in authentication can be reduced.

[0054] The image of the subject may be constituent images constituting the moving image as described above, and it is preferable to perform the extracting, the position-determining, and the like on any two or more of a plurality of constituent images taken over time (continuously).

When the determination as described above is performed on one of the plurality of time-series images, there may be a case where the determination reference information is satisfied and it is determined to be the same person by face collation, despite impersonation. This is the case, for example, where the subject brings the face image of the registered person to the position of his/her face in a natural posture for only one moment of taking an image. However, even in such a case, if the same extraction, determination, and the like are performed on a plurality of constituent images, it is possible to more accurately determine that an image of the subject bringing the face image of the registered person to the position of his/her face in an unnatural posture for the purpose of impersonation is included. On the other hand, when the determination as described above is performed on one of the plurality of time-series images, there may be a case where it is determined to be non-authenticatable as being abnormal despite the fact that the subject moves normally in fact. However, even in such a case, if the same extraction, determination, and the like are performed on a plurality of time-series images, it is possible to more accurately determine that the subject is moving normally and not impersonation but normal. Therefore, in order to eliminate the image of impersonation with higher accuracy, it is preferable to use the time-series images.

[0055] Hereinafter, a specific example of using a plurality of constituent images will be described with reference to the drawings. FIG.6 is merely an example, and the present invention is not limited thereto.

[0056] (A) and (B) in FIG. 6 are constituent images constituting a moving image, and the arrow indicates the time axis. That is, (A) in FIG. 6 is a constituent image (A) of time T_n , and (B) in FIG. 6 is a constituent image (B) of time T_{n+m} . As shown in (A) in FIG. 6, when face information and skeleton information are extracted from the constituent image (A), two pieces of face information and one piece of skeleton information are extracted, and thus the constituent image (A) is determined to be non-authenticatable as being abnormal based on the above-described pattern. However, in fact, although a subject 20A and a subject 20B are walking, the subject 20B is in a condition in which only the image of the face is taken but the body is not. On the other hand, in the constituent image (B) taken after the time T_{n+m} from the constituent image (A), the body of the subject 20B who has moved also appears. Therefore, when the face information and the skeleton information are extracted from the constituent image (B), two pieces of face information and two pieces of skeleton information are extracted, and the positional relationship between the position of the face and the position of the skeleton is normal in one set of the face information and skeleton information and the positional relationship between the position of the face and the position of the skeleton is normal in the other set of the face information and skeleton information. Therefore, the constituent image (B) can be determined to be normal, and face collation can be performed for each of the subject 20A and the subject 20B.

[0057] When the number of pieces of face information and the number of pieces of skeleton information extracted from the constituent image (A) are not matched as shown in (A) in FIG. 6, it is also possible to determine whether or not the constituent image (A) is abnormal by utilizing the distance between eyes in the extracted face information, for example. That is, although two pieces of face information and one piece of skeleton information are extracted from (A) in FIG. 6, as described above, the image of the subject 20A and the subject 20B is taken and there is no impersonation in fact. On the other hand, in the case of (A) in FIG. 4, as described above, two pieces of face information and one piece of skeleton information are extracted, and the smartphone 30 of the subject 20 is used for impersonation. When the smartphone 30 is held over the camera 40 as shown in (A) in FIG. 4, not only the skeleton information is not extracted, but also the distance between eyes in the face displayed on the smartphone 30 is relatively small in the constituent image (A). On the other hand, as shown in (A) in FIG. 6, when the image of the subject 20B is taken instead of the face displayed on the smartphone 30, the distance between the

eyes in the face is relatively large in the constituent image (A). Therefore, in the case where a reference value (threshold) of the distance between eyes in the constituent image is provided, and when the skeleton information is not extracted and the distance between eyes in the extracted face information is smaller than the threshold, it can be determined to be abnormal as in the case shown in (A) in FIG. 4 without performing extraction or the like on other constituent images. On the other hand, when the skeleton information is not extracted and the distance between eyes in the extracted face information is equal to or larger than the threshold value, extraction or the like of skeleton information may be performed on the constituent images taken before or after as described above to determine whether to be abnormal or normal.

[0058] Third Example Embodiment

The program of the present example embodiment is a program for a computer to execute the face authentication method of each example embodiment. The program of the present example embodiment may be recorded on, for example, a computer readable recording medium. The recording medium is not particularly limited, and may be, for example, a storage medium as described above.

[0059] While the present invention has been described above with reference to illustrative example embodiments, the present invention is by no means limited thereto. Various changes and variations that may become apparent to those skilled in the art may be made in the configuration and specifics of the present invention without departing from the scope of the present invention.

[0060] This application claims priority from Japanese Patent Application No. 2019-009726 filed on January 23, 2019. The entire subject matter of the Japanese Patent Applications is incorporated herein by reference.

[0061] (Supplementary Notes)

Some or all of the above example embodiments and examples may be described as in the following Supplementary Notes, but are not limited thereto.

(Supplementary Note 1)

A face authentication apparatus, including:

- a storage unit that stores determination reference information relating to a positional relationship between a face and a part other than the face in a human skeleton;

- an image acquisition unit that acquires an image of a subject;

- an extraction unit that extracts face information and skeleton information from the image;

- a position determination unit that determines whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on

the extracted skeleton information in the image is normal or abnormal based on the determination reference information; and

an output unit that outputs that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extraction unit and/or when the positional relationship is determined to be abnormal by the position determination unit.

(Supplementary Note 2)

The face authentication apparatus according to Supplementary Note 1, further including:

a face collation unit, wherein

the storage unit further stores registered face information of a registered person,

the face collation unit collates the extracted face information with the registered face information, and

the output unit outputs that the subject of the image is authenticated when the extracted face information and the registered face information are determined to be the same person by the face collation unit and outputs that the subject of the image is non-authenticatable when the extracted face information and the registered face information are determined not to be the same person by the face collation unit.

(Supplementary Note 3)

The face authentication apparatus according to Supplementary Note 1 or 2, wherein

the determination reference information is information relating to a positional relationship between a face and an arm.

(Supplementary Note 4)

The face authentication apparatus according to any one of Supplementary Notes 1 to 3, wherein

the image of the subject includes a plurality of time-series images taken over time.

(Supplementary Note 5)

The face authentication apparatus according to Supplementary Note 4, wherein

the output unit outputs that the subject of the image is non-authenticatable when the plurality of time-series images taken in a predetermined time includes an image from which the skeleton information is not extracted by the extraction unit and/or when the plurality of time-series images taken in a predetermined time includes an image showing the positional relationship that has been determined not to satisfy the determination reference information by the position determination unit.

(Supplementary Note 6)

A face authentication method, including the steps of:

acquiring an image of a subject;

extracting face information and skeleton information from the image;

determining whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on the extracted skeleton information in the image is normal or abnormal based on determination reference information, the determination reference information being determination reference information relating to a positional relationship between a face and a part other than the face in a human skeleton; and

outputting that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extracting and/or when the positional relationship is determined to be abnormal by the position-determining.

(Supplementary Note 7)

The face authentication method according to Supplementary Note 6, further including the step of:

collating the extracted face information with registered face information of a registered person, wherein

the outputting outputs that the subject of the image is authenticated when the extracted face information and the registered face information are determined to be the same person by the face-collating and outputs that the subject of the image is non-authenticatable when the extracted face information and the registered face information are determined not to be the same person by the face-collating.

(Supplementary Note 8)

The face authentication method according to Supplementary Note 6 or 7, wherein

the determination reference information is information relating to a positional relationship between a face and an arm.

(Supplementary Note 9)

The face authentication method according to any one of Supplementary Notes 6 to 8, wherein

the image of the subject includes a plurality of time-series images taken over time.

(Supplementary Note 10)

The face authentication method according to Supplementary Note 9, wherein

the outputting outputs that the subject of the image is non-authenticatable when the plurality of time-series images taken in a predetermined time includes an image from which the skeleton information is not extracted by the extracting and/or when the plurality of time-series images taken in a predetermined time includes an image showing the positional relationship that has been determined not to satisfy the determination reference information by the position-determining.

(Supplementary Note 11)

A program for a computer to execute the face authentication method according to any one of Supplementary Notes 6 to 10.

(Supplementary Note 12)

- 5 A computer readable recording medium with the program according to Supplementary Note 11.

Industrial Applicability

[0062] According to the present invention, by utilizing skeleton information, impersonation using a face photograph can be easily prevented.

Reference Signs List

- 10 [0063]
- 10: face authentication apparatus
 - 11: storage unit
 - 12: image acquisition unit
 - 13: extraction unit
 - 15 14: position determination unit
 - 15: output unit
 - 16: face collation unit

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CLAIMS

1. A face authentication apparatus, comprising:
 - a storage unit that stores determination reference information relating to a positional
 - 5 relationship between a face and a part other than the face in a human skeleton;
 - an image acquisition unit that acquires an image of a subject;
 - an extraction unit that extracts face information and skeleton information from the image;
 - a position determination unit that determines whether a positional relationship between
 - 10 a position of a face based on the extracted face information and a position of a skeleton based on the extracted skeleton information in the image is normal or abnormal based on the determination reference information; and
 - an output unit that outputs that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extraction unit and/or when the positional
 - 15 relationship is determined to be abnormal by the position determination unit.
2. The face authentication apparatus according to claim 1, further comprising:
 - a face collation unit, wherein
 - the storage unit further stores registered face information of a registered person,
 - 20 the face collation unit collates the extracted face information with the registered face information, and
 - the output unit outputs that the subject of the image is authenticated when the extracted face information and the registered face information are determined to be the same person by the face collation unit and outputs that the subject of the image is non-authenticatable when the
 - 25 extracted face information and the registered face information are determined not to be the same person by the face collation unit.
3. The face authentication apparatus according to claim 1 or 2, wherein
 - the determination reference information is information relating to a positional
 - 30 relationship between a face and an arm.
4. The face authentication apparatus according to any one of claims 1 to 3, wherein
 - the image of the subject includes a plurality of time-series images taken over time.

5. The face authentication apparatus according to claim 4, wherein
the output unit outputs that the subject of the image is non-authenticatable when the plurality of time-series images taken in a predetermined time includes an image from which the skeleton information is not extracted by the extraction unit and/or when the plurality of time-series images taken in a predetermined time includes an image showing the positional relationship that has been determined not to satisfy the determination reference information by the position determination unit.

6. A face authentication method, comprising the steps of:

acquiring an image of a subject;

extracting face information and skeleton information from the image;

determining whether a positional relationship between a position of a face based on the extracted face information and a position of a skeleton based on the extracted skeleton information in the image is normal or abnormal based on determination reference information, the determination reference information being determination reference information relating to a positional relationship between a face and a part other than the face in a human skeleton; and outputting that the subject of the image is non-authenticatable when the skeleton information is not extracted by the extracting and/or when the positional relationship is determined to be abnormal by the position-determining.

7. The face authentication method according to claim 6, further comprising the step of:

collating the extracted face information with registered face information of a registered person, wherein

the outputting outputs that the subject of the image is authenticated when the extracted face information and the registered face information are determined to be the same person by the face-collating and outputs that the subject of the image is non-authenticatable when the extracted face information and the registered face information are determined not to be the same person by the face-collating.

8. The face authentication method according to claim 6 or 7, wherein

the determination reference information is information relating to a positional relationship between a face and an arm.

9. The face authentication method according to any one of claims 6 to 8, wherein

the image of the subject includes a plurality of time-series images taken over time.

10. The face authentication method according to claim 9, wherein

the outputting outputs that the subject of the image is non-authenticatable when the

5 plurality of time-series images taken in a predetermined time includes an image from which the skeleton information is not extracted by the extracting and/or when the plurality of time-series images taken in a predetermined time includes an image showing the positional relationship that has been determined not to satisfy the determination reference information by the position-determining.

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11. A program for a computer to execute the face authentication method according to any one of claims 6 to 10.

12. A computer readable recording medium with the program according to claim 11.

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