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Inventor(s)	MAKITA; KOJI

INFORMATION PROCESSING APPARATUS, METHOD OF CONTROLLING THE SAME, AND STORAGE MEDIUM

Abstract

An information processing apparatus includes an acquisition unit that acquires a face image of the target person, a face authentication unit that performs face authentication of the target person by using the face image, an operation instruction unit that issues an instruction to the target person to perform an operation while holding the information processing apparatus, an operation authentication unit that performs operation authentication of the target person based on the operation being performed according to the issued instruction and an actual operation including positional movement of the information processing apparatus, and a determination unit that determines that the authentication of the target person has succeeded when the face authentication has succeeded and the operation authentication has succeeded, and determines that the authentication of the target person has failed when at least one of the face authentication and the operation authentication has failed.

Inventors: **MAKITA; KOJI (Kanagawa, JP)**

Applicant: **CANON KABUSHIKI KAISHA** (Tokyo, JP)

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Background/Summary

BACKGROUND

Field

[0001] The present disclosure relates to an information processing apparatus for performing face authentication, a method of controlling the information processing apparatus, and a storage medium.

Description of the Related Art

[0002] In a face authentication system using a camera mounted on a portable terminal apparatus, a face image previously authenticated and registered and a face image of an authentication target person acquired with the camera are compared to determine whether the authentication target person present in front of the camera at the moment is the person with the registered face image. Such authentication is highly convenient because the authentication is completed only by imaging a face with the camera, and is applicable to, for example, electronic Know Your Customer (eKYC), attendance checking of a class in school and the like, and a roll call at a work site.

[0003] However, since the authentication target person performs the face authentication processing while holding the terminal apparatus by himself/herself, the authentication target person hardly receives attention from those around him/her. Thus, as compared with a face authentication system using a fixed-point camera, there is an issue that spoofing using a face photograph of a different person and the like is easily performable.

[0004] As a method of detecting spoofing, there is a known method in which it is determined whether a face present in front of the camera has a flat shape, and in a case where the face present in front of the camera has a flat shape, it is determined that spoofing using a photograph, a display of another terminal apparatus, or the like is performed. Japanese Patent Application Laid-Open No. 2019-204358 discusses a technique for analyzing whether a face has a flat shape based on a relationship between an angle of the camera and a camera image captured, thereby determining an improper operation such as spoofing.

SUMMARY

[0005] According to an aspect of the present disclosure, an information processing apparatus that performs authentication of a target person includes at least one memory storing instructions, and at least one processor that, upon execution of the stored instructions, causes the information processing apparatus to function as an acquisition unit that acquires a face image of the target person, a face authentication unit that performs face authentication of the target person by using the face image, an operation instruction unit that issues an instruction to the target person to perform an operation while holding the information processing apparatus, an operation authentication unit that performs operation authentication of the target person based on the operation being performed according to the issued instruction and an actual operation of the information processing apparatus, including positional movement of the information processing apparatus, and a determination unit that determines that the authentication of the target person has succeeded when the face authentication has succeeded and the operation authentication has succeeded, and determines that the authentication of the target person has failed when at least one of the face authentication and the operation authentication has failed.

[0006] Further features of the present disclosure will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a diagram illustrating an example of an appearance of an information processing apparatus.

[0008] FIG. **2** is a diagram illustrating an example of an appearance when an authentication target person performs face authentication processing by using the information processing apparatus.

[0009] FIG. **3** is a diagram illustrating an example of a functional configuration of the information processing apparatus.

[0010] FIG. **4** is a flowchart illustrating an example of a processing procedure in a method of controlling the information processing apparatus.

[0011] FIG. **5** is a diagram illustrating processing in step S**101** of FIG. **4**.

[0012] FIG. **6** is a diagram illustrating processing in step S**102** of FIG. **4**.

[0013] FIG. **7** is a diagram illustrating processing in step S**108** of FIG. **4**.

[0014] FIG. **8** is a diagram illustrating processing in step S**109** of FIG. **4**.

[0015] FIG. **9** is a flowchart illustrating an example of a processing procedure in a method of determining whether to display a specific mark on a display in conjunction with a position and orientation of the information processing apparatus in step S**103** of FIG. **4**.

[0016] FIG. **10** is a diagram illustrating processing in step S**201** of FIG. **9**.

[0017] FIG. **11** is a diagram illustrating processing in step S**202** of FIG. **9**.

[0018] FIG. **12** is a diagram illustrating the processing in step S**202** of FIG. **9**.

[0019] FIG. **13** is a diagram illustrating processing in step S**204** of FIG. **9**.

[0020] FIG. **14** is a table illustrating the processing in step S**107** of FIG. **9**.

[0021] FIG. **15** is a diagram illustrating an example of an appearance of an information processing apparatus.

[0022] FIG. **16** is a diagram illustrating an example of an appearance when an authentication target person performs face authentication processing by using the information processing apparatus.

[0023] FIG. **17** is a diagram illustrating processing in step S**102** of FIG. **4**.

DESCRIPTION OF THE EMBODIMENTS

[0024] Some exemplary embodiments of the present disclosure are described below with reference to the drawings. Configurations described in the following exemplary embodiments are merely illustrative, and the present disclosure is not limited to the configurations illustrated in the drawings.

[0025] A first exemplary embodiment is described.

[0026] In the first exemplary embodiment, an information processing apparatus that includes a face authentication function of an authentication target person, an operation authentication function of performing authentication on operation by the authentication target person by using a specific mark, and an authentication determination function of performing authentication determination on the authentication target person based on results of face authentication and operation authentication, is described. The face authentication according to the present exemplary embodiment is not particularly restricted in place and can be performed at any place. Therefore, the face authentication according to the present exemplary embodiment is effective, for example, in a case where identity verification by electronic Know Your Customer (eKYC) is performed at home.

[0027] FIG. **1** is a diagram illustrating an example of an appearance of an information processing apparatus **100**-**1** according to the first exemplary embodiment.

[0028] As the information processing apparatus **100**-**1**, a mobile information terminal apparatus that can be operated by the authentication target person while being held (carried) by the authentication target person is suitably applied.

[0029] An appearance **101** illustrated in FIG. **1** indicates an appearance of an inner surface of the

information processing apparatus **100-1**. An inner surface-side camera **111** that is a first imaging unit and a display **112** that is a display unit are provided on an inner surface side of the information processing apparatus **100-1**. The inner surface-side camera **111** is a camera that images a view in front of the inner surface of the information processing apparatus **100-1** and can image the authentication target person (in particular, the face of the authentication target person in the present exemplary embodiment) who visually checks and the like the display **112** and operates the information processing apparatus **100-1**. The display **112** displays various kinds of images and various kinds of information.

[0030] An appearance **102** illustrated in FIG. **1** indicates an appearance of an outer surface (surface on a side opposite to the inner surface of the information processing apparatus **100-1** indicated by the appearance **101** in FIG. **1**) of the information processing apparatus **100-1**. An outer surface-side camera **114** that is a second imaging unit is provided on an outer surface side of the information processing apparatus **100-1**. The outer surface-side camera **114** is a camera that images a view in front of the outer surface of the information processing apparatus **100-1**. A sensor **113** for measuring a position and orientation of the information processing apparatus **100-1** is provided inside the information processing apparatus **100-1**. The sensor **113** is a sensor that can estimate relative changes from an initial position and orientation, such as an inertial measurement unit.

[0031] FIG. **2** is a diagram illustrating an example of an appearance when an authentication target person NT performs face authentication processing by using the information processing apparatus **100-1** according to the first exemplary embodiment. In FIG. **2**, components similar to the components illustrated in FIG. **1** are denoted by the same reference numerals, and detailed descriptions of the components are omitted.

[0032] The authentication target person NT is positioned on the front side of the inner surface of the information processing apparatus **100-1** on which the inner surface-side camera **111** and the display **112** are provided. A mark **201** (a virtual mark in this example) is disposed in a three-dimensional space, and a mark **202** based on the mark **201** is displayed on the display **112** based on the position and orientation of the information processing apparatus **100-1** in the three-dimensional space. The authentication target person NT performs the face authentication processing and operation authentication processing by moving the information processing apparatus **100-1** such that the mark **202** displayed on the display **112** is continuously displayed on the display **112** in conjunction with the position and orientation of the information processing apparatus **100-1** in the three-dimensional space. In this way, the information processing apparatus **100-1** performs authentication of the authentication target person NT.

[0033] FIG. **3** is a diagram illustrating an example of a functional configuration of the information processing apparatus **100-1** according to the first exemplary embodiment. The information processing apparatus **100-1** includes functional components of an image acquisition unit **131**, a position and orientation measurement unit **132**, an operation instruction unit **133**, a face detection unit **134**, a face authentication unit **135**, an operation authentication unit **136**, an authentication determination unit **137**, and an image generation unit **138**. The functional components illustrated in FIG. **3** are all communicably connected and can mutually transmit and receive images and information.

[0034] The image acquisition unit **131** is an acquisition unit that acquires a face image of the authentication target person NT as a camera image captured using the inner surface-side camera **111**.

[0035] The position and orientation measurement unit **132** is a measurement unit that measures the position and orientation of the information processing apparatus **100-1** by using the sensor **113**.

[0036] The operation instruction unit **133** is an operation instruction unit that issues an instruction to the authentication target person NT to perform an operation while holding the information processing apparatus **100-1** during the face authentication processing.

[0037] The face detection unit **134** is a face detection unit that detects the face of the authentication

target person NT from the face image of the authentication target person NT acquired by the image acquisition unit **131**.

[0038] The face authentication unit **135** is a face authentication unit that performs face authentication of the authentication target person NT by determining whether faces of persons previously authenticated and registered include the face that is identical to (that matches) the face of the authentication target person NT detected by the face detection unit **134**. In a case where the faces of persons previously authenticated and registered include the face that is identical to (that matches) the face of the authentication target person NT detected by the face detection unit **134**, the face authentication unit **135** determines that the face authentication of the authentication target person NT has succeeded. In contrast, in a case where the faces of persons previously authenticated and registered do not include the face that is identical to (that matches) the face of the authentication target person NT detected by the face detection unit **134**, the face authentication unit **135** determines that the face authentication of the authentication target person NT has failed.

[0039] The operation authentication unit **136** is an operation authentication unit that performs operation authentication of the authentication target person NT based on the operation according to the instruction issued by the operation instruction unit **133** and an actual operation of the information processing apparatus **100-1**. At this time, the operation authentication unit **136** detects the actual operation of the information processing apparatus **100-1** based on the position and orientation of the information processing apparatus **100-1** measured by the position and orientation measurement unit **132**. More specifically, in a case where the operation according to the instruction issued by the operation instruction unit **133** matches the actual operation of the information processing apparatus **100-1**, the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has succeeded. In contrast, in a case where the operation according to the instruction issued by the operation instruction unit **133** does not match the actual operation of the information processing apparatus **100-1**, the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has failed.

[0040] In a case where the face authentication by the face authentication unit **135** has succeeded and the operation authentication by the operation authentication unit **136** has succeeded, the authentication determination unit **137** determines that authentication of the authentication target person NT has succeeded. In contrast, in a case where at least one of the face authentication by the face authentication unit **135** and the operation authentication by the operation authentication unit **136** has failed, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed. In addition, in a case where the face authentication by the face authentication unit **135** has succeeded but the operation authentication by the operation authentication unit **136** has failed, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed and determines that a spoofing action of spoofing the authentication target person NT has been performed.

[0041] The image generation unit **138** is an image generation unit that generates an image including various kinds of images and various kinds of information obtained by the functional components (**131** to **137**). The image generated by the image generation unit **138** can be displayed on the display **112**. The image displayed on the display **112** includes information indicating a determination result of the authentication determination unit **137**.

[0042] FIG. **4** is a flowchart illustrating an example of a processing procedure in a method of controlling the information processing apparatus **100-1** according to the first exemplary embodiment. Processing for authenticating the authentication target person NT is described below with reference to FIG. **4**. In the following description, an example in which an operation time (time limit) of the authentication processing is set to 10 seconds is described as a specific example; however, the operation time (time limit) of the authentication processing may be appropriately changed and set depending on an environment, a use case, and the like.

[0043] In step S**101** of FIG. **4**, the information processing apparatus **100-1** starts an authentication application in order to perform authentication of the authentication target person NT. FIG. **5** is a diagram illustrating the processing in step S**101** of FIG. **4** according to the first exemplary embodiment. In FIG. **5**, components similar to the components illustrated in FIG. **1** and FIG. **2** are denoted by the same reference numerals, and detailed descriptions of the components are omitted. In FIG. **5**, a button **500** is a button for starting up the authentication application. When the authentication target person NT presses the button **500**, the information processing apparatus **100-1** detects a press thereon and starts the authentication application.

[0044] Subsequently, in step S**102** of FIG. **4**, during the face authentication processing, the operation instruction unit **133** issues an instruction to the authentication target person NT to perform an operation while holding the information processing apparatus **100-1**. More specifically, in the present exemplary embodiment, the operation instruction unit **133** issues the instruction to the authentication target person NT to perform the operation while holding the information processing apparatus **100-1** by displaying an operation instruction on the display **112**. FIG. **6** is a diagram illustrating the processing in step S**102** of FIG. **4** according to the first exemplary embodiment. In FIG. **6**, components similar to the components illustrated in FIG. **1**, FIG. **2**, and FIG. **5** are denoted by the same reference numerals, and detailed descriptions of the components are omitted.

[0045] A screen displayed on the display **112** illustrated in FIG. **6** is an example of an image displayed after the button **500** illustrated in FIG. **5** is pressed. An operation instruction content display area **610**, a "Start" button **620**, and a "Back" button **630** are displayed on the display **112** illustrated in FIG. **6**. An operation instruction to "move apparatus to continuously capture specific mark (**611**)" is displayed in the operation instruction content display area **610** illustrated in FIG. **6**. The authentication target person NT can start the authentication processing by pressing the "Start" button **620**. In addition, the authentication target person NT can end the authentication application by pressing the "Back" button **630**. When the authentication target person NT presses the "Start" button **620** to start the face authentication processing, processing in steps S**103**, S**104**, and S**105** illustrated in FIG. **4** described below is performed. In the example illustrated in FIG. **4**, the processing in steps S**103**, S**104**, and S**105** described below is simultaneously started, processed in parallel, and ends after the processing is continuously performed for 10 seconds, which is the operation time (time limit) of the authentication processing. The authentication target person NT can make the authentication processing a success by continuously moving the information processing apparatus **100-1** to continuously capture the specific mark **611** displayed in the operation instruction content display area **610** illustrated in FIG. **6** for 10 seconds, which is the operation time (time limit) of the authentication processing.

[0046] In step S**103** after completion of step S**102** of FIG. **4**, the display **112** displays the specific mark **611** corresponding to the mark **202** based on the position and orientation of the information processing apparatus **100-1** measured by the position and orientation measurement unit **132** and the position of the mark **201**. Depending on the position and orientation of the information processing apparatus **100-1** and the position of the mark **201**, however, the specific mark **611** corresponding to the mark **202** may not be displayed on the display **112**.

[0047] In step S**104** after completion of step S**102** of FIG. **4**, to detect an operation that the authentication target person NT performs while holding the information processing apparatus **100-1**, the position and orientation measurement unit **132** measures the position and orientation of the information processing apparatus **100-1**. In the present exemplary embodiment, the position and orientation measurement unit **132** measures the position and orientation thereof while the authentication target person NT operates the information processing apparatus **100-1** at a rate of 30 times per second by using the sensor **113**, and stores measurement results. In this case, since the operation time (time limit) of the authentication processing is 10 seconds in the present exemplary embodiment, 300 pieces of information indicating the position and orientation of the information

processing apparatus **100-1** are stored in total.

[0048] In step S**105** after completion of step S**102** of FIG. **4**, the face authentication unit **135** performs the face authentication processing using the face image of the authentication target person NT acquired using the inner surface-side camera **111** while the authentication target person NT performs the operation while holding the information processing apparatus **100-1**. In the present exemplary embodiment, the face authentication unit **135** performs the face authentication processing at a rate of two times per second. In this case, since the operation time (time limit) of the authentication processing is 10 seconds in the present exemplary embodiment, the face authentication processing is performed 20 times in total.

[0049] After 10 seconds that is the operation time (time limit) of the authentication processing is elapsed, the processing proceeds to step S**106** of FIG. **4**. In step S**106** of FIG. **4**, the face authentication unit **135** determines whether the face authentication of the authentication target person NT has succeeded based on the result of the face authentication processing in step S**105** of FIG. **4**. In the present exemplary embodiment, in a case where a result indicating that the face of the authentication target person NT is identical to (matches) a face of a person previously authenticated and registered is obtained in 90% or more of the face authentication processing performed in step S**105** of FIG. **4**, namely, 18 or more times, the face authentication unit **135** determines that the face authentication has succeeded. Otherwise, the face authentication unit **135** determines that the face authentication has failed.

[0050] In step S**106** of FIG. **4**, in a case where the face authentication unit **135** determines that the face authentication of the authentication target person NT has succeeded (YES in step S**106**), the processing proceeds to step S**107**. In step S**107** of FIG. **4**, the operation authentication unit **136** determines whether the operation authentication of the authentication target person NT has succeeded based on the operation according to the instruction issued by the operation instruction unit **133** and the actual operation of the information processing apparatus **100-1** based on the position and orientation measured in step S**104**. More specifically, the operation authentication unit **136** analyzes the information indicating the position and orientation of the information processing apparatus **100-1** stored in step S**104** and detects operation contents performed on the information processing apparatus **100-1** by the authentication target person NT during the authentication processing. Then, the operation authentication unit **136** compares the detected operation contents with the operation contents according to the instruction issued in step S**102** and determines whether the operation authentication of the authentication target person NT has succeeded based on whether the operation contents match each other. More specifically, in a case where the operation according to the instruction issued by the operation instruction unit **133** and the actual operation of the information processing apparatus **100-1** match each other, the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has succeeded. In contrast, in a case where the operation according to the instruction issued by the operation instruction unit **133** and the actual operation of the information processing apparatus **100-1** do not match each other, the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has failed.

[0051] In step S**107** of FIG. **4**, in a case where the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has succeeded (YES in step S**107**), the processing proceeds to step S**108** of FIG. **4**. In step S**108** of FIG. **4**, the authentication determination unit **137** determines that the authentication of the authentication target person NT has succeeded. In other words, since it is determined in step S**106** that the face authentication has succeeded and it is determined in step S**107** that the operation authentication has succeeded, the authentication determination unit **137** determines that the authentication of the authentication target person NT has succeeded. In the processing in step S**108** of FIG. **4**, the authentication determination unit **137** performs processing for displaying that the authentication of the authentication target person NT has succeeded on the display **112**. FIG. **7** is a diagram illustrating

the processing in step S**108** of FIG. **4** according to the first exemplary embodiment.
[0052] In FIG. **7**, components similar to the components illustrated in FIG. **1**, FIG. **2**, FIG. **5**, and FIG. **6** are denoted by the same reference numerals, and detailed descriptions of the components are omitted. In FIG. **7**, an authentication success display area **710**, a "Start" button **720**, and a "Back" button **730** are displayed on the display **112**. A registered image **711** corresponding to the authentication target person NT and information **712** indicating that the authentication has succeeded are displayed in the authentication success display area **710** illustrated in FIG. **7**. When the authentication target person NT presses the "Start" button **720** in this state, the processing returns to step S**102** of FIG. **4**. When the authentication target person NT presses the "Back" button **730**, the processing in the flowchart illustrated in FIG. **4** ends.
[0053] In step S**106** of FIG. **4**, in a case where the face authentication unit **135** determines that the face authentication of the authentication target person NT has failed (NO in step S**106**), the processing proceeds to step S**109** of FIG. **4**. Likewise, in step S**107** of FIG. **4**, in a case where the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has failed (NO in step S**107**), the processing proceeds to step S**109** of FIG. **4**. In step S**109** of FIG. **4**, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed. In other words, since it is determined in step S**106** that the face authentication has failed or it is determined in step S**107** that the operation authentication has failed, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed. Note that in a case where it is determined in step S**106** that the face authentication has succeeded but it is determined in step S**107** that the operation authentication has failed, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed and determines that a spoofing action of spoofing the authentication target person NT has been performed. In the processing in step S**109** of FIG. **4**, the authentication determination unit **137** performs processing for displaying that the authentication of the authentication target person NT has failed on the display **112**. FIG. **8** is a diagram illustrating the processing in step S**109** of FIG. **4** according to the first exemplary embodiment. In FIG. **8**, components similar to the components illustrated in FIG. **1**, FIG. **2**, and FIG. **5** to FIG. **7** are denoted by the same reference numerals, and detailed descriptions of the components are omitted. In FIG. **8**, an authentication failure display area **810**, a "Start" button **820**, and a "Back" button **830** are displayed on the display **112**. Information indicating that the authentication has failed is displayed in the authentication failure display area **810** illustrated in FIG. **8**. When the authentication target person NT presses the "Start" button **820** in this state, the processing returns to step S**102** of FIG. **4**. When the authentication target person NT presses the "Back" button **830**, the processing in the flowchart illustrated in FIG. **4** ends.
[0054] In the above description of the flowchart illustrated in FIG. **4**, the processing for measuring the position and orientation of the information processing apparatus **100**-**1** in step S**104** and the face authentication processing in step S**105** are simultaneously started and are processed in parallel. In the present exemplary embodiment, however, the processing is not limited thereto. For example, after the processing for measuring the position and orientation of the information processing apparatus **100**-**1** in step S**104** is performed, the face authentication processing in step S**105** may be performed.
[0055] Next, a method of determining whether to display the specific mark **611** on the display **112** in conjunction with the position and orientation of the information processing apparatus **100**-**1** in a three-dimensional space in step S**103** of FIG. **4** is described. FIG. **9** is a flowchart illustrating an example of a processing procedure in the method of determining whether to display the specific mark **611** on the display **112** in conjunction with the position and orientation of the information processing apparatus **100**-**1** in step S**103** of FIG. **4** according to the first exemplary embodiment.
[0056] First, in step S**201** of FIG. **9**, the information processing apparatus **100**-**1** sets an initial position of a mark disposed in the three-dimensional space. In this example, at a start time of the

authentication processing, the information processing apparatus **100-1** sets the position of the mark such that the mark is positioned 2 m ahead of the information processing apparatus **100-1** in the three-dimensional space based on the information on the position and orientation acquired using the sensor **113**. FIG. **10** is a diagram illustrating processing in step S**201** of FIG. **9** according to the first exemplary embodiment. In FIG. **10**, components similar to the components illustrated in FIG. **1**, FIG. **2**, and FIG. **5** to FIG. **8** are denoted by the same reference numerals, and detailed descriptions of the components are omitted. In FIG. **10**, a point **1000** indicates the position of the information processing apparatus **100-1** at the start time of the authentication processing. A point **1001** indicates a point positioned 2 m ahead of the point **1000** in a depth direction. Therefore, in step S**201** of FIG. **9**, the initial position of the mark is set to the position of the point **1001** in FIG. **10**.

[0057] Subsequently, in step S**202** of FIG. **9**, the information processing apparatus **100-1** draws the mark on the display **112** based on the position and orientation of the information processing apparatus **100-1** measured by the position and orientation measurement unit **132** and the position of the mark. FIG. **11** is a diagram illustrating processing in step S**202** of FIG. **9** according to the first exemplary embodiment. In FIG. **11**, components similar to the components illustrated in FIG. **1**, FIG. **2**, FIG. **5** to FIG. **8**, and FIG. **10** are denoted by the same reference numerals, and detailed descriptions of the components are omitted. For example, in a case where the processing transitions from step S**201** to step S**202** of FIG. **9**, as illustrated in FIG. **11**, the information processing apparatus **100-1** draws a mark **1100** at the position of the point **1000** illustrated in FIG. **10**. In a case where the processing transitions from step S**205** to step S**202** of FIG. **9**, the information processing apparatus **100-1** determines a drawing position of the mark by using the position of the mark updated in step S**204** and the position and orientation updated in step S**205**, and draws the mark **1100**. However, for example, in a case where the position of the point **1001** is out of a visual field of the outer surface-side camera **114** as viewed from the information processing apparatus **100-1**, the mark **1100** is not drawn. FIG. **12** is a diagram illustrating the processing in step S**202** of FIG. **9** according to the first exemplary embodiment. More specifically, FIG. **12** is a diagram illustrating a relationship between the visual field of the outer surface-side camera **114** as viewed from the information processing apparatus **100-1** and the position of the mark set in the three-dimensional space.

[0058] FIG. **12** illustrates an area **1200** within the visual field of the outer surface-side camera **114** as viewed from the information processing apparatus **100-1**, a point **1201** within the area **1200**, and a point **1202** out of the area **1200**. In a case where the position of the mark set in the three-dimensional space is out of the visual field of the outer surface-side camera **114** as viewed from the information processing apparatus **100-1** as in the case of the point **1202** illustrated in FIG. **12**, the mark **1100** is not drawn.

[0059] Subsequently, in step S**203** of FIG. **9**, the information processing apparatus **100-1** determines whether an elapsed time from the start time of the authentication processing is within the time limit. In the present exemplary embodiment, the time limit that is the operation time of the authentication processing is 10 seconds. Therefore, in a case where the elapsed time from the start time of the authentication processing is 10 seconds or less (YES in step S**203**), the processing proceeds to step S**204**.

[0060] Subsequently, in step S**204** of FIG. **9**, the information processing apparatus **100-1** (e.g., the operation instruction unit **133**) updates the position of the mark set in the three-dimensional space. In the present exemplary embodiment, the position of the mark is updated using random numbers r_x, r_y, and r_z according to uniform distribution from −1 m to +1 m. However, the position of the mark may be updated by another method. For example, a straight line or a curved line may be set in the three-dimensional space, and the position of the mark may be updated so as to move on the line at a constant speed. When positional coordinates of the mark before the update are P(x, y, z) and the positional coordinates of the mark after the update are P′ (x′, y′, z′), x′=x+r_x, y′=y+r_y, and

z′=z+r_z are established. FIG. **13** is a diagram illustrating processing in step S**204** of FIG. **9** according to the first exemplary embodiment. More specifically, FIG. **13** is a diagram illustrating an example in a case where the position of the mark is updated from a position (initial position) P before the update to a position P′. In the example illustrated in FIG. **13**, the initial position P of the mark is positioned at the point **1001**, and the position P′ of the mark after the update is positioned at a point **1301**. In the example illustrated in FIG. **13**, the processing for updating the position of the mark from the initial position is described. Similarly, in a second or subsequent update, other random numbers are generated to generate a new position of the mark, and the position of the mark is updated.

[0061] Subsequently, in step S**205** of FIG. **9**, the information processing apparatus **100**-**1** acquires the latest position and orientation of the information processing apparatus **100**-**1** from the sensor **113** and updates the position and orientation of the information processing apparatus **100**-**1**. Then, the processing returns to step S**202**.

[0062] In step S**203** of FIG. **9**, in a case where the elapsed time from the start time of the authentication processing is not within the time limit (NO in step S**203**), more specifically, in a case where the elapsed time exceeds 10 seconds that is the time limit, the processing in the flowchart illustrated in FIG. **9** ends.

[0063] Next, a specific example of the operation authentication processing in step S**107** of FIG. **4** is described. In step S**107** of FIG. **4**, the operation authentication unit **136** performs the operation authentication processing of the authentication target person NT based on the operation according to the instruction issued by the operation instruction unit **133** and the actual operation of the information processing apparatus **100**-**1** based on the position and orientation measured in step S**104**. In the present exemplary embodiment, the operation authentication unit **136** determines whether the position and orientation of the information processing apparatus **100**-**1** is appropriate at each time point during the operation time of the authentication processing. In a case where the position and orientation thereof is appropriate at 90% or more of time points, the operation authentication unit **136** determines that the actual operation matches the operation according to the instruction issued in step S**102**.

[0064] In the present exemplary embodiment, in step S**102** of FIG. **4**, the operation instruction to "move apparatus to continuously capture specific mark (**611**)" is issued as displayed in the operation instruction content display area **610** illustrated in FIG. **6**. Thus, in a case where the specific mark (**611**) is displayed on the display **112** at each time point during the operation time of the authentication processing, the operation authentication unit **136** determines that the position and orientation of the information processing apparatus **100**-**1** is appropriate. It is possible to determine whether the mark is displayed on the display **112** from the position of the mark in the three-dimensional space and the position and orientation of the information processing apparatus **100**-**1** in a manner similar to the processing in step S**202** of FIG. **9**. FIG. **14** is a table illustrating the processing in step S**107** of FIG. **4** according to the first exemplary embodiment. FIG. **14** illustrates each time point (T**0** to Tn), the position and orientation (R**0** to Rn) of the information processing apparatus, whether the mark is displayed on the display (YES/NO), and whether the position and orientation of the information processing apparatus is appropriate (YES/NO) during the authentication processing. As illustrated in FIG. **14**, the operation authentication unit **136** analyzes whether the mark is displayed on the display **112** at each time point (T**0** to Tn) during the authentication processing. In a case where the mark is displayed on the display **112**, the operation authentication unit **136** determines that the position and orientation of the information processing apparatus **100**-**1** is appropriate. Then, the operation authentication unit **136** calculates a percentage of the position and orientation of the information processing apparatus **100**-**1** determined to be appropriate. In a case where the calculated percentage is 90% or more, the operation authentication unit **136** determines that the actual operation matches the operation according to the instruction issued in step S**102**.

[0065] In the information processing apparatus **100-1** according to the first exemplary embodiment described above, the face authentication unit **135** performs the face authentication of the authentication target person NT, and the operation authentication unit **136** performs the operation authentication of the authentication target person NT. In the case where the face authentication by the face authentication unit **135** has succeeded and the operation authentication by the operation authentication unit **136** has succeeded, the authentication determination unit **137** determines that the authentication of the authentication target person NT has succeeded.
[0066] In contrast, in the case where the face authentication by the face authentication unit **135** has failed or the operation authentication by the operation authentication unit **136** has failed, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed.
[0067] According to the configuration, it is possible to perform high-accuracy authentication of the authentication target person while simplifying preparation of the authentication.
[0068] In addition, in the case where the face authentication by the face authentication unit **135** has succeeded but the operation authentication by the operation authentication unit **136** has failed, the authentication determination unit **137** determines that the authentication of the authentication target person NT has failed and determines that a spoofing action of spoofing the authentication target person NT has been performed.
[0069] According to the configuration, it is possible to reduce a risk of spoofing.
[0070] A second exemplary embodiment is described. In the following description of the second exemplary embodiment, a description of a matter common to the above-described first exemplary embodiment is omitted, and a matter different from the above-described first exemplary embodiment is described.
[0071] In the above-described first exemplary embodiment, the operation instruction (in step S**102** of FIG. **4**) during the face authentication processing is to move the apparatus such that the specific mark based on a virtual mark is continuously displayed on the display. In the above-described first exemplary embodiment, the position of the mark is set to a position near the initial position of the apparatus. Thus, it is possible to make the face authentication a success at any place, and a place where the authentication target person NT has performed the face authentication cannot be specified. For example, in a case where the face authentication is used to check attendance at a class in school, there is a case where the authentication can succeed even though the authentication target person NT is not actually present in a classroom but is present in another building or the like. Thus, in the second exemplary embodiment, a configuration of issuing an operation instruction requiring the authentication target person NT to be present in a specific place is described. The second exemplary embodiment is particularly effective in a case where a place of the authentication is important such as the above-described case of checking attendance at a class in school.
[0072] FIG. **15** is a diagram illustrating an example of an appearance of an information processing apparatus **100-2** according to the second exemplary embodiment. As the information processing apparatus **100-2**, a mobile information terminal apparatus that can be operated by the authentication target person while being held (carried) by the authentication target person is suitably applied.
[0073] An appearance **103** illustrated in FIG. **15** indicates an appearance of an inner surface of the information processing apparatus **100-2**. An inner surface-side camera **121** that is a first imaging unit and a display **122** that is a display unit are provided on an inner surface side of the information processing apparatus **100-2**. The inner surface-side camera **121** is a camera that images a view in front of the inner surface of the information processing apparatus **100-2** and can image the authentication target person (in particular, the face of the authentication target person in the present exemplary embodiment) who visually checks and the like the display **112** and operates the information processing apparatus **100-2**. The display **122** displays various kinds of images and various kinds of information.
[0074] An appearance **104** illustrated in FIG. **15** indicates an appearance of an outer surface

(surface on a side opposite to the inner surface of the information processing apparatus **100-2** indicated by the appearance **103** in FIG. **15**) of the information processing apparatus **100-2**. An outer surface-side camera **125** that is a second imaging unit is provided on an outer surface side of the information processing apparatus **100-2**.

[0075] The outer surface-side camera **125** is a camera that images a view in front of the outer surface of the information processing apparatus **100-2**.

[0076] A sensor **123** for measuring an absolute orientation of the information processing apparatus **100-2** and a sensor **124** for measuring an absolute position thereof are provided inside the information processing apparatus **100-2**. The sensor **123** is a sensor that can estimate the absolute orientation, for example, an inertial measurement unit including a magnetic sensor. For example, in a case where the information processing apparatus **100-2** is assumed to be used outdoors, the sensor **124** may be implemented by a global navigation satellite system (GNSS) or the like. For example, in a case where the information processing apparatus **100-2** is assumed to be used indoors, the sensor **124** may be a sensor that estimates a position based on radio wave intensity of Wi-Fi, a sensor using ultra-wideband (UWB) positioning, or the like.

[0077] A functional configuration of the information processing apparatus **100-2** according to the second exemplary embodiment is similar to the functional configuration of the information processing apparatus **100-1** according to the first exemplary embodiment illustrated in FIG. **3**.

[0078] FIG. **16** is a diagram illustrating an example of an appearance when the authentication target person NT performs face authentication processing by using the information processing apparatus **100-2** according to the second exemplary embodiment. In FIG. **16**, components similar to the components illustrated in FIG. **15** are denoted by the same reference numerals, and detailed descriptions of the components are omitted.

[0079] The authentication target person NT is positioned on the front side of the inner surface of the information processing apparatus **100-2** on which the inner surface-side camera **121** and the display **122** are provided. A current position **1600** of the information processing apparatus **100-2** is displayed on the display **122** illustrated in FIG. **16**. The authentication target person NT performs the face authentication processing and the operation authentication processing by moving to a designated position while holding the information processing apparatus **100-2**. As described above, the information processing apparatus **100-2** also performs the authentication of the authentication target person NT.

[0080] A method of controlling the information processing apparatus **100-2** according to the second exemplary embodiment is basically similar to the processing in the flowchart illustrating the example of the processing procedure in the method of controlling the information processing apparatus **100-1** according to the first exemplary embodiment illustrated in FIG. **4**. In the following description, differences from the processing in the above-described first exemplary embodiment are described with reference to FIG. **4**.

[0081] In step S**101** of FIG. **4**, the information processing apparatus **100-2** starts the authentication application in a manner similar to the above-described first exemplary embodiment.

[0082] Subsequently, in step S**102** of FIG. **4**, during the face authentication processing, the operation instruction unit **133** issues an instruction to the authentication target person NT to perform an operation while holding the information processing apparatus **100-2** in a manner similar to the above-described first exemplary embodiment. More specifically, also in the present exemplary embodiment, the operation instruction unit **133** issues the instruction to the authentication target person NT to perform the operation while holding the information processing apparatus **100-2** by displaying an operation instruction on the display **122** in a manner similar to the above-described first exemplary embodiment. FIG. **17** is a diagram illustrating processing in step S**102** of FIG. **4** according to the second exemplary embodiment. In FIG. **17**, components similar to the components illustrated in FIG. **15** and FIG. **16** are denoted by the same reference numerals, and detailed descriptions of the components are omitted. A screen displayed on the

display **122** illustrated in FIG. **17** is an example of an image displayed after the button **500** illustrated in FIG. **5** is pressed. An operation instruction content display area **1710**, a "Start" button **1720**, and a "Back" button **1730** are displayed on the display **122** illustrated in FIG. **17**. An operation instruction to "move to specific destination (**1711**)" from a current position **1712** of the information processing apparatus **100**-**2** is displayed in the operation instruction content display area **1710** illustrated in FIG. **17**. The destination **1711** is set in such a manner that, for example, a plurality of destination candidates is registered in advance in the information processing apparatus **100**-**2** and a nearest destination is selected based on the current position **1712** of the information processing apparatus **100**-**2**. More specifically, for example, in a case of a system for checking attendance in a classroom, the destination is set in such a manner that the destination candidates are set to four corners of the classroom and the nearest corner thereof is selected as the destination **1711** based on the current position **1712** of the information processing apparatus **100**-**2**.

[0083] Subsequently, in step S**103** of FIG. **4**, the display **122** displays the current position **1712** of the information processing apparatus **100**-**2** and the destination **1711** as illustrated in the operation instruction content display area **1710** in FIG. **17** based on the position and orientation of the information processing apparatus **100**-**2**. At this time, the authentication target person NT moves to the destination **1711** while holding the information processing apparatus **100**-**2** and viewing the display **122**.

[0084] In the second exemplary embodiment, in steps S**104** to S**106** of FIG. **4**, processing similar to the processing in the above-described first exemplary embodiment is performed.

[0085] Subsequently, in step S**107** of FIG. **4**, the operation authentication unit **136** determines whether the operation authentication of the authentication target person NT has succeeded based on the operation according to the instruction issued by the operation instruction unit **133** and the actual operation of the information processing apparatus **100**-**2** based on the position and orientation measured in step S**104**. More specifically, in a case where a distance between the current position **1712** of the information processing apparatus **100**-**2** and the destination **1711** is greater than or equal to a threshold, the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has failed. Otherwise, the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has succeeded.

[0086] In step S**107** of FIG. **4**, in a case where the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has succeeded (YES in step S**107**), the processing proceeds to step S**108** of FIG. **4**. In step S**107** of FIG. **4**, in a case where the operation authentication unit **136** determines that the operation authentication of the authentication target person NT has failed (NO in step S**107**), the processing proceeds to step S**109** of FIG. **4**. In the second exemplary embodiment, in steps S**108** and S**109** of FIG. **4**, processing similar to the processing in the above-described first exemplary embodiment is performed.

[0087] According to the second exemplary embodiment, as in the above-described first exemplary embodiment, it is possible to perform high-accuracy authentication of the authentication target person while simplifying preparation of the authentication. Further, according to the second exemplary embodiment, it is possible to further reduce a risk of spoofing.

MODIFICATIONS OF ABOVE-DESCRIBED EXEMPLARY EMBODIMENTS

[0088] Modifications of the above-described exemplary embodiments are described.

First Modification

[0089] In the above-described first exemplary embodiment, in the case where the information processing apparatus **100**-**1** is moved such that the mark **611** illustrated in FIG. **6** is continuously displayed on the display **112**, only the mark **611** is displayed on the display **112**. Thus, if the mark **611** disappears from the display **112** once, it is difficult to find the mark again. Thus, in a first modification, for example, virtual reality (VR) may be used in addition to the mark, and a combined image obtained by combining a virtual environment and the mark may be displayed on

the display **112**. Further, in the first modification, for example, augmented reality (AR) may be used in addition to the mark, and a combined image obtained by combining a real environment captured by the outer surface-side camera **114** and the mark may be displayed on the display **112**. As in the first modification, when the mark and the virtual environment or the real environment are simultaneously displayed on the display **112**, even if the mark disappears from the display **112** once, it is easier to intuitively grasp a lost position of the mark. Therefore, the mark can be easily found again. In the first modification, in a case of using VR, for example, a result obtained by rendering a computer graphics (CG) model of a wide-area environment by using the current position and orientation of the information processing apparatus **100**-**1** is desirably displayed on the display **112**. Further, in the case of using VR, only the virtual environment may be displayed on the display **112** by using a part of the virtual environment as a substitute for the mark. In the first modification, in a case of using AR, for example, a view in front of the outer surface of the information processing apparatus **100**-**1** is desirably imaged by the outer surface-side camera **114**, the mark and the view are preferably combined to generate a combined image, and the combined image is preferably displayed on the display **112**.

Second Modification

[0090] In the above-described first exemplary embodiment, the place where the face authentication processing has been performed cannot be specified. To implement a method in which the authentication can succeed only at an assumed place, the position of the mark and the position and orientation of the information processing apparatus **100**-**1** with a certain coordinate system as a reference are desirably used without depending on the initial position and orientation of the information processing apparatus **100**-**1**. A second modification can be realized by, for example, the following procedure.

[0091] As advance preparation, first, an environment is established where the position and orientation of the information processing apparatus **100**-**1** can be measured in real time with one coordinate system as a reference using a motion capture system using an environment-installation camera. Next, with the above-described coordinate system as the reference, an initial position of the mark and positions of the mark at respective time points after a start of the authentication processing are set in advance. Then, during the authentication processing, the processing in the above-described first exemplary embodiment is desirably performed using the position and orientation of the information processing apparatus **100**-**1** and the position of the mark with the above-described coordinate system as a reference.

Third Modification

[0092] In the above-described second modification, the authentication processing is performed using the virtual mark not existing in a real environment, which is similar to the above-described first exemplary embodiment. In a third modification, as a substitute for the virtual mark disposed in the three-dimensional space, an object (hereinafter, referred to as a “real mark”) existing in the three-dimensional space, such as a robot travelling on the ground and a drone flying in the air, is used. In the third modification, to display the real mark on the display **112**, it is necessary to capture an image of the real environment by the outer surface-side camera **114**.

[0093] To determine whether the real mark is within the visual field of the outer surface-side camera **114** of the information processing apparatus **100**-**1**, a position of the real mark and the position and orientation of the information processing apparatus **100**-**1** with a certain coordinate system as a reference are necessary, as described in the second modification. Thus, for example, in a manner similar to the second modification, the position of the real mark and the position and orientation of the information processing apparatus **100**-**1** are desirably measured and used in real time by using a motion capture system using an environment-installation camera. In a case where the real mark is an apparatus mounted with a camera, simultaneous localization and mapping (SLAM) with an image is desirably used. In other words, in the case where the real mark is an apparatus mounted with a camera, an environment map may be generated in advance using the

SLAM with an image, and the position of the real mark and the position and orientation of the information processing apparatus **100-1** may be measured and used with a coordinate system of the map as a reference. Further, the position of the real mark is desirably measured using an image captured with the camera mounted on the real mark, and the position and orientation of the information processing apparatus **100-1** is desirably measured using an image captured by the outer surface-side camera **114** of the information processing apparatus **100-1**.

[0094] Further, as a substitute for the real mark which varies in position, a still object may be used as the real mark. In a case of the still object, the position of the real mark with the above-described coordinate system as a reference is desirably measured in advance and used. The measurement is preferably performed using, for example, a total station.

[0095] In the third modification, for example, the outer surface-side camera **114** images the real mark disposed in the three-dimensional space, and the display **112** displays the real mark imaged by the outer surface-side camera **114**. Then, the operation instruction unit **133** can be configured to issue an instruction, for example, to the authentication target person NT to perform an operation on the information processing apparatus **100-1** such that the real mark is continuously displayed on the display **112**.

Fourth Modification

[0096] In the above-described third modification, the method using the still object as the real mark is described. In the case of the still object, however, an operation of moving the information processing apparatus **100-1** so as to capture the real mark is easily performable, and accordingly, there is a possibility that spoofing will be successful. Therefore, a plurality of real marks may be prepared to increase difficulty of the operation of moving the real mark within the visual field of the outer surface-side camera **114** of the information processing apparatus **100-1**.

[0097] For example, as advance preparation, the plurality of real marks may be discretely set on an indoor wall surface. When a track record that five or more real marks have entered the visual field of the outer surface-side camera **114** within 10 seconds during the authentication processing, it may be determined that spoofing is not performed. In this case, the operation instruction unit **133** can be configured to issue an instruction, for example, to the authentication target person NT to perform an operation on the information processing apparatus **100-1** such that each of the plurality of real marks is displayed on the display **112** one or more times within a predetermined time.

[0098] For example, restriction may be set to an order of the real marks that enter the visual field of the outer surface-side camera **114**, and only when the real marks enter the visual field of the outer surface-side camera **114** in a specific order, it may be determined that spoofing is not performed. In this case, the operation instruction unit **133** can issue an instruction, for example, to the authentication target person NT to perform an operation on the information processing apparatus **100-1** such that the plurality of real marks is displayed on the display **112** in a predetermined order.

Fifth Modification

[0099] In the above-described second exemplary embodiment, the example in which the operation instruction to “move to specific destination (**1711**)” from the current position **1712** of the information processing apparatus **100-2** is issued during the authentication processing is described. The present disclosure is not limited to such a configuration. For example, the operation instruction unit **133** may issue an operation instruction to cause the information processing apparatus **100-2** to “pass through specific area”. In this case, for example, in the information processing apparatus **100-2**, as advance preparation, a three-dimensional area in a specific space is set as the specific area. The operation authentication unit **136** analyzes the position and orientation of the information processing apparatus **100-2** stored in step S**104** of FIG. **4** and performs the operation authentication based on whether the information processing apparatus **100-2** has entered, from an outside of the specific area, the specific area once, and then has exited the specific area.

[0100] In addition, in the above-described second exemplary embodiment, the position and orientation measurement unit **132** measures the absolute position and orientation of the information

processing apparatus **100**-**2** with one coordinate system as a reference; however, the present disclosure is not limited to such a configuration. For example, the position and orientation measurement unit **132** may measure a relative position and orientation of the information processing apparatus **100**-**2** in a manner similar to the above-described first exemplary embodiment. The destination or the specific area is desirably automatically set to a position near an initial value that is the position and orientation of the information processing apparatus **100**-**2** at the time of starting the authentication processing.

Sixth Modification

[0101] In the second exemplary embodiment and the fifth modification described above, it is necessary for the authentication target person NT to move from the initial position while holding the information processing apparatus **100**-**2**. Thus, in a case where moving means of the authentication target person NT is assumed to be walking, a fact that the authentication target person NT is walking while moving may be added to information for making a determination of the operation authentication processing in order to enhance reliability of the operation authentication processing. For example, in step S**107** of FIG. **4**, the operation authentication unit **136** performs determination on whether the authentication target person NT is walking by analyzing data such as an acceleration and an angular velocity acquired from the sensor **123** that is a detection unit. In a case where it is detected that the authentication target person NT is not walking in a predetermined section, the operation authentication unit **136** determines that the operation authentication has failed, and the processing proceeds to step S**109** of FIG. **4**. As the above-described predetermined section, a section from the initial position of the authentication target person NT holding the information processing apparatus **100**-**2** to the destination, or a section in a predetermined area through which the authentication target person NT holding the information processing apparatus **100**-**2** passes is suitably applied.

Seventh Modification

[0102] In the first exemplary embodiment, the second exemplary embodiment, and the fifth modification described above, the operation instructions to “move apparatus to continuously capture specific mark”, to “move to specific destination”, and to “pass through specific area” are described as examples. However, in the present disclosure, another operation instruction may be issued. As the operation instruction, for example, an operation instruction to “walk straight ahead” or to “walk around a circle” may be issued. In this case, for example, in step S**107** of FIG. **4**, data on the acceleration and the angular velocity acquired from the sensor **123** and data on the position and orientation of an information processing apparatus **100** measured in step S**104** are analyzed by pedestrian dead reckoning (PDR).

[0103] Then, the operation authentication in step S**107** of FIG. **4** may be performed by determining whether the authentication target person NT has walked straight ahead or whether a track of the authentication target person NT walking has a closed loop.

Eighth Modification

[0104] In the first exemplary embodiment and the second exemplary embodiment described above, the face authentication processing is repeatedly performed in step S**105** of FIG. **4**. In addition, in step S**106** of FIG. **4**, success/failure of the face authentication is determined based on a result of the face authentication processed in step S**105**.

[0105] However, in a case where information processing performance of the information processing apparatus **100** is low, it may be difficult to perform the face authentication processing in step S**105** of FIG. **4**. Thus, alternatively, only storage of the face image may be performed in step S**105** of FIG. **4**, and in step S**106**, the face authentication processing may be performed using the face image stored in step S**105**. For example, processing similar to the processing in step S**106** in the above-described first exemplary embodiment is desirably performed using results obtained by performing the face authentication processing on all stored face images. To further reduce a calculation amount, results obtained by performing the face authentication processing on some face

images selected from the stored face images may be used.

Other Embodiments

[0106] Embodiment(s) of the present disclosure can also be realized by a computer of a system or apparatus that reads out and executes computer executable instructions (e.g., one or more programs) recorded on a storage medium (which may also be referred to more fully as a 'non-transitory computer-readable storage medium') to perform the functions of one or more of the above-described embodiment(s) and/or that includes one or more circuits (e.g., application specific integrated circuit (ASIC)) for performing the functions of one or more of the above-described embodiment(s), and by a method performed by the computer of the system or apparatus by, for example, reading out and executing the computer executable instructions from the storage medium to perform the functions of one or more of the above-described embodiment(s) and/or controlling the one or more circuits to perform the functions of one or more of the above-described embodiment(s). The computer may comprise one or more processors (e.g., central processing unit (CPU), micro processing unit (MPU)) and may include a network of separate computers or separate processors to read out and execute the computer executable instructions. The computer executable instructions may be provided to the computer, for example, from a network or the storage medium. The storage medium may include, for example, one or more of a hard disk, a random-access memory (RAM), a read only memory (ROM), a storage of distributed computing systems, an optical disk (such as a compact disc (CD), digital versatile disc (DVD), or Blu-ray Disc (BD)™), a flash memory device, a memory card, and the like.

[0107] While the present disclosure has been described with reference to exemplary embodiments, it is to be understood that the disclosure is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0108] This application claims the benefit of Japanese Patent Application No. 2024-018130, filed Feb. 8, 2024, which is hereby incorporated by reference herein in its entirety.

Claims

1. An information processing apparatus that performs authentication of a target person, the information processing apparatus comprising: at least one memory storing instructions; and at least one processor that, upon execution of the stored instructions, causes the information processing apparatus to function as: an acquisition unit that acquires a face image of the target person; a face authentication unit that performs face authentication of the target person by using the face image; an operation instruction unit that issues an instruction to the target person to perform an operation while holding the information processing apparatus; an operation authentication unit that performs operation authentication of the target person based on the operation being performed according to the issued instruction and an actual operation of the information processing apparatus, including positional movement of the information processing apparatus; and a determination unit that determines that the authentication of the target person has succeeded when the face authentication has succeeded and the operation authentication has succeeded, and determines that the authentication of the target person has failed when at least one of the face authentication and the operation authentication has failed.

2. The information processing apparatus according to claim 1, wherein, it is determined that a spoofing action of spoofing the target person has been performed when the face authentication has succeeded but the operation authentication has failed.

3. The information processing apparatus according to claim 1, wherein it is determined that the operation authentication has succeeded when the operation according to the issued instruction and the actual operation of the information processing apparatus match each other.

4. The information processing apparatus according to claim 1, wherein execution of the stored

instructions further configures the at least one processor to function as a measurement unit that measures a position and orientation of the information processing apparatus, and wherein the actual operation of the information processing apparatus is detected based on the measured position and orientation of the information processing apparatus.

5. The information processing apparatus according to claim 4, wherein measurement of the position and orientation of the information processing apparatus and the face authentication are processed in parallel.

6. The information processing apparatus according to claim 4, wherein, after the measurement of the position and orientation of the information processing apparatus is performed, the face authentication is performed.

7. The information processing apparatus according to claim 4, wherein a relative position and orientation of the information processing apparatus is measured with an initial position and orientation of the information processing apparatus as a reference.

8. The information processing apparatus according to claim 4, wherein an absolute position and orientation of the information processing apparatus is measured with one coordinate system as a reference.

9. The information processing apparatus according to claim 1, wherein execution of the stored instructions further configures the at least one processor to function as a display unit that causes display of a mark based on a position and orientation of the information processing apparatus, and wherein an instruction is issued to the target person to perform the operation on the information processing apparatus to cause the mark to be continuously displayed on the display unit.

10. The information processing apparatus according to claim 9, wherein the mark is a mark based on a virtual mark or a real mark disposed in a three-dimensional space.

11. The information processing apparatus according to claim 9, further comprising a camera, wherein the mark is a mark based on a real mark disposed in a three-dimensional space, wherein the camera images the real mark, wherein the real mark imaged by the camera is caused to be displayed on the display unit, and wherein an instruction is issued to the target person to perform the operation on the information processing apparatus to cause the real mark to be continuously displayed on the display unit.

12. The information processing apparatus according to claim 11, wherein a plurality of real marks is provided, and wherein the operation instruction unit issues an instruction to the target person to perform the operation on the information processing apparatus to cause each of the plurality of real marks to be displayed on the display unit one or more times within a predetermined time.

13. The information processing apparatus according to claim 11, wherein a plurality of real marks is provided, and wherein the operation instruction unit issues an instruction to the target person to perform the operation on the information processing apparatus to cause the plurality of real marks to be displayed on the display unit in a predetermined order.

14. The information processing apparatus according to claim 9, wherein the display unit causes display of a combined image obtained by combining a virtual environment and the mark by using virtual reality (VR).

15. The information processing apparatus according to claim 9, further comprising a camera that images a real environment, wherein the display unit causes display of a combined image obtained by combining the real environment imaged by the camera and the mark by using augmented reality (AR).

16. The information processing apparatus according to claim 1, wherein execution of the stored instructions further configures the at least one processor to function as a display unit that causes display of a current position of the information processing apparatus and a destination on the display unit, wherein the operation instruction unit issues an instruction to the target person to perform the operation to move the information processing apparatus to the destination.

17. The information processing apparatus according to claim 1, wherein the operation instruction

unit issues the instruction to the target person to perform the operation to cause the information processing apparatus to pass through a specific area.

18. The information processing apparatus according to claim 1, wherein execution of the stored instructions further configures the at least one processor to function as a detection unit that detects whether the target person holding the information processing apparatus is walking, and wherein the operation authentication unit determines that the operation authentication has failed when it is detected that the target person is not walking.

19. A method of controlling an information processing apparatus that performs authentication of an target person, the method comprising: acquiring a face image of the target person; performing face authentication of the target person by using the face image; issuing an instruction to the target person to perform an operation while holding the information processing apparatus; performing operation authentication of the target person based on the operation being performed according to the issued instruction and an actual operation of the information processing apparatus, including positional movement of the information processing apparatus; and determining that the authentication of the target person has succeeded when the face authentication has succeeded and the operation authentication has succeeded, and determining that the authentication of the target person has failed when at least one of the face authentication and the operation authentication has failed.

20. A non-transitory computer-readable storage medium storing computer-executable instructions for causing a computer to execute a method comprising: acquiring a face image of the target person; performing face authentication of the target person by using the face image; issuing an instruction to the target person to perform an operation while holding the information processing apparatus; performing operation authentication of the target person based on the operation being performed according to the issued instruction and an actual operation of the information processing apparatus, including positional movement of the information processing apparatus; and determining that the authentication of the target person has succeeded when the face authentication has succeeded and the operation authentication has succeeded, and determining that the authentication of the target person has failed when at least one of the face authentication and the operation authentication has failed.