DESCRIPTION

TITLE OF INVENTION: BIOMETRIC INFORMATION IDENTIFICATION METHOD AND BIOMETRIC INFORMATION IDENTIFICATION SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to a biometric information identification method and a biometric information identification system.

BACKGROUND ART

[0002] Patent Literature 1 discloses a method of detecting a zone that may include at least one fingerprint in an image of at least a part of a hand of an individual. In this method, an image of a portion in which at least a part of a hand is illuminated by an optical sensor in a non-contact manner is acquired, and a plurality of zones in which points indicating light intensity levels equal to or higher than a light intensity threshold are continuous are determined in the acquired image. In this method, in order to select a zone having a possibility of indicating a fingerprint of at least one finger among the determined zones, a set of thresholds is selected from the shape identification criterion of the finger and/or the fingerprint standard texture identification criterion and/or the finger standard color identification criterion, and a plurality of zones of the image are stored using each threshold included in the selected set of thresholds.

CITATION LIST

PATENT LITERATURE

[0003] Patent Literature 1: US10248832B2

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] However, in the configuration of Patent Literature 1, it is not identified which finger appears in the finger image. In the fingerprint authentication using the fingerprint acquired in this manner, since the fingerprint at the time of the fingerprint registration and the fingerprint acquired at the time of the fingerprint authentication are different from each other, the fingerprint is not authenticated even though the fingerprint is the fingerprint of the user, and

there is a possibility that the authentication accuracy of the fingerprint authentication decreases.

[0005] The present disclosure has been made in view of the above-described circumstances of the related art, and an object thereof is to provide a biometric information identification method and a biometric information identification system that identify a biometric site corresponding to biometric information used for biometric authentication and improve authentication accuracy of the biometric authentication.

SOLUTION TO PROBLEM

[0006] The present disclosure provides a biometric information identification method performed by at least one computer, the biometric information identification method including: acquiring a captured image in which a plurality of fingers of a subject are captured; detecting each of the plurality of fingers on the basis of the captured image; determining a reference finger serving as an identification criterion of the plurality of fingers among the plurality of fingers on the basis of sizes of detection regions of the plurality of detected fingers to identify the reference finger; and identifying which finger each of the other fingers among the plurality of fingers is on the basis of a position of the reference finger so as to output an identification result of the plurality of fingers.

[0007] The present disclosure provides a biometric information identification system including: a camera; and at least one computer capable of communicating with the camera, in which the camera captures an image of a plurality of fingers of a subject and transmits the image to the computer, and the computer detects each of the plurality of fingers on the basis of the captured image, determines a reference finger serving as an identification criterion of the plurality of fingers among the plurality of fingers on the basis of sizes of detection regions of the plurality of detected fingers, identifies the reference finger, identifies which finger each of the other fingers among the plurality of fingers is on the basis of a position of the reference finger, and outputs an identification result of the plurality of fingers to a monitor.

ADVANTAGEOUS EFFECTS OF INVENTION

[0008] According to the present disclosure, it is possible to identify a biometric site corresponding to biometric information used for biometric authentication and improve the authentication accuracy of biometric authentication.

BRIEF DESCRIPTION OF DRAWINGS

[0009] [FIG. 1] FIG. 1 is a block diagram showing an overall configuration example of a biometric information identification system according to an embodiment.

[FIG. 2] FIG. 2 is a flowchart showing an operation procedure example of the biometric information identification device according to the embodiment.

[FIG. 3] FIG. 3 is a diagram that shows an example of fingertip identification by deep learning.

[FIG. 4] FIG. 4 is a flowchart showing an operation procedure example of the biometric information identification device according to the embodiment.

[FIG. 5] FIG. 5 is a diagram for explaining an example of selecting a bounding box.

[FIG. 6] FIG. 6 is a diagram that shows an example of identifying a finger by selecting a bounding box.

[FIG. 7] FIG. 7 is a diagram that shows an example of fingertip identification in a modification of the embodiment.

DESCRIPTION OF EMBODIMENTS

[0010] Hereinafter, embodiments specifically disclosing configurations and actions of a biometric information identification method and a biometric information identification system according to the present disclosure will be described in detail with reference to the drawings as appropriate. However, unnecessarily detailed description may be omitted. For example, detailed descriptions of already well-known matters and redundant descriptions of substantially the same configurations may be omitted. This is to avoid unnecessary redundancy of the following description and facilitate understanding of those skilled in the art. The accompanying drawings and the following description are provided for those skilled in the art to fully understand the present disclosure, and are not intended to limit the subject matter described in the claims.

[0011] (Embodiment)

An overall configuration example of a biometric information identification system 100 according to an embodiment will be described with reference to FIG. 1. FIG. 1 is a block diagram showing an overall configuration example of a biometric information identification system 100 according to the embodiment.

[0012] The biometric information identification system 100 acquires a captured image (hereinafter, referred to as a “finger image”) in which a finger, which is a part used for biometric authentication (hereinafter, referred to as a “biometric site”), is captured, and detects a plurality of fingers of the user captured in the finger image. The biometric

information identification system 100 identifies which finger each of the plurality of detected fingers is.

[0013] In the following description, an example will be described in which each of a plurality of fingers shown in a captured finger image is identified in order to execute fingerprint authentication, but the identification method of a biometric site described in the embodiment may be diverted to other biometric authentication. For example, the identification method of a biometric site described in the embodiment may be used for identification of a finger used for vein authentication.

[0014] The biometric information identification system 100 includes a biometric information identification device P1, a camera 13, and a monitor 14.

[0015] The biometric information identification device P1 includes a communication unit 10, a processor 11, a memory 12, and a biometric information database DB. The biometric information identification device P1 may include a camera 13 or a monitor 14. In such a case, the biometric information identification system 100 may be realized by one device (biometric information identification device P1).

[0016] The communication unit 10 includes a communication interface circuit for transmitting and receiving data. The communication unit 10 is connected to a camera 13 and a monitor 14, which are external devices, so as to be capable of wireless communication or wired communication, and transmits and receives data.

[0017] The processor 11 is configured using, for example, a central processing unit (hereinafter referred to as “CPU”), a graphics processing unit (hereinafter referred to as “GPU”), or a field programmable gate array (hereinafter referred to as “FPGA”), and performs various processes and controls in cooperation with the memory 12. Specifically, the processor 11 refers to a program and data held in the memory 12 and executes the program to realize a function of identifying (specifying) each of a plurality of fingers captured in the finger image.

[0018] After executing the identification of the finger, the processor 11 may generate a finger image obtained by cutting out a region in which the fingerprint is captured, or may extract a feature amount indicating the individuality of the user from the finger image. The processor 11 may execute the registration processing of the biometric information by storing (registering) the identification information of the identified finger and the finger image or the feature amount in the biometric information database DB in association with each other. The processor 11 may execute the fingerprint authentication by collating the identification information and the finger image or the feature amount of the identified finger with the

biometric information registered in advance in the biometric information database DB. The biometric information registration process or the fingerprint authentication may be executed by an external device connected to the biometric information identification device P1 so as to be able to transmit and receive data.

[0019] Here, the biometric information is data from which a feature amount indicating the individuality of the user can be extracted, or a feature amount indicating the individuality of the user itself, and is, for example, a finger image in which a fingerprint that is a biometric site is captured, a fingerprint pattern, a fingerprint feature amount indicating the individuality of the user, or the like.

[0020] The memory 12 includes, for example, a random access memory (hereinafter, referred to as a “RAM”) as a work memory used when each process of the processor 11 is executed, and a read only memory (hereinafter, referred to as a “ROM”) that stores a program and data defining an operation of the processor 11. The RAM temporarily stores data or information generated or acquired by the processor 11. A program that defines the operation of the processor 11 is written in the ROM.

[0021] The camera 13 includes at least a lens (not illustrated) and an image sensor (not illustrated). The image sensor is, for example, a solid-state imaging element of a charge-coupled device (hereinafter referred to as “CCD”) or a complementary metal oxide semiconductor (hereinafter referred to as “CMOS”), converts an optical image formed on an imaging surface into an electric signal, and outputs the electric signal to the processor 11 via the communication unit 10.

[0022] The finger image may be captured in a state where the fingertip is in contact with any surface such as a glass surface, or may be captured in a state where the fingertip is not in contact with any surface.

[0023] The monitor 14 is configured using, for example, a liquid crystal display (hereinafter referred to as “LCD”) or organic electroluminescence (hereinafter referred to as “EL”). The monitor 14 outputs and displays a finger image captured by the camera 13, a fingertip detection result screen generated by the processor 11, or a notification.

[0024] Note that the fingertip detection result screen referred to here is a screen generated including information of an identification result obtained by identifying which finger the detected fingertip is, and will be described later.

[0025] The biometric information database DB is a so-called storage, and is configured using a storage medium such as a flash memory, a hard disk drive (hereinafter referred to as “HDD”), or a solid state drive (hereinafter referred to as “SSD”). The biometric information

database DB stores (registers) identification information identified by the processor 11 and biometric information in association with each other for each user.

[0026] Next, an operation procedure example of the biometric information identification device P1 will be described with reference to FIGS. 2 and 3. FIG. 2 is a flowchart showing an operation procedure example of the biometric information identification device P1 according to the embodiment. FIG. 3 is a diagram that shows an example of fingertip identification example by deep learning.

[0027] In the following description, an example in which the index finger, the middle finger, the ring finger, and the little finger, which are four fingers, are identified from the finger image will be described, but the imaged fingers are not limited thereto. The finger to be imaged may be imaged so as to include at least the little finger and all fingers from the little finger to the finger used for biometric authentication. For example, when the fingertip used for biometric authentication is the middle finger, three fingers from the little finger to the middle finger may be imaged.

[0028] In the following description, an example will be described in which the user's hand is inserted into the angle of view of the camera 13 along the Y-axis direction illustrated in FIG. 3, and an image is captured in a state where a plurality of fingers are arranged side by side along the X-axis direction, but it is needless to say that the arrangement of the fingers at the time of imaging is not limited thereto.

[0029] The processor 11 acquires a finger image IMG1 (see FIG. 3) of the entire hand or a plurality of fingertips including the little finger of the user captured by the camera 13 (St11). Here, the processor 11 may determine whether or not the image is a planar image captured such that each of a plurality of fingertips (ball of the finger), which are biometric sites, and a light receiving surface of an image sensor (not illustrated) of the camera 13 are substantially planar. The processor 11 may acquire the finger image IMG1 only when it is determined that the finger image IMG1 captured by the camera 13 is a planar image.

[0030] The processor 11 executes an image analysis processing using a learning model learned by deep learning in advance, detects an object that seems to be a fingertip from the finger image IMG1 (St12), and generates bounding boxes (for example, bounding boxes FM01, FM02, FM03, FM04, FM05, FM11, FM12, FM13, FM14, FM15, FM16, FM21, FM22, FM23, FM24, and FM25, see FIG. 5) surrounding a region where the object that seems to be a fingertip is detected, respectively. A known technique may be used for detection and identification of a fingertip using learning data by deep learning.

[0031] The processor 11 groups the generated bounding boxes for each class. Here, the class is the type of the finger. The processor 11 calculates each reliability score indicating the probability that the fingertip is captured in the region surrounded by each bounding box. The processor 11 picks up the bounding box having the highest reliability score for each class based on the calculated reliability score in (St13).

[0032] In the example illustrated in FIG. 3, the bounding box FM10 is a bounding box having the maximum reliability score among the bounding boxes grouped into the class “index finger (index)”. The bounding box FM20 is a bounding box having the maximum reliability score among the bounding boxes grouped into the class “middle finger (middle)”. The bounding box FM30 is a bounding box having the maximum reliability score among the bounding boxes detecting the class “ring finger (ring)”. The bounding box FM40 is a bounding box having the maximum reliability score among the bounding boxes detecting the class “little finger (pinky)”.

[0033] The processor 11 determines whether each of the four fingers (index finger, middle finger, ring finger, and little finger) is detected based on the class in which each of the picked-up bounding boxes is grouped (St14).

[0034] In a case where it is determined in the processing of Step St14 that the four fingers are detected (St14, YES), the processor 11 determines whether or not the arrangement order of the detected four fingers is correct based on the classes of the four fingers (St15). Specifically, the processor 11 determines whether the detected arrangement order of the four fingers is “index finger (index), middle finger (middle), ring finger (ring), little finger (pinky)” or “little finger (pinky), ring finger (ring), middle finger (middle), index finger (index)", based on the X coordinate of a predetermined corner (for example, the upper left corner) among the four corners of the bounding box of the detected four fingers, the X coordinate of the center coordinates of the bounding box, or the like.

[0035] In the example illustrated in FIG. 3, the plurality of fingertips, which are biometric sites, are imaged so as to be arranged along the X direction. In such a case, the processor 11 determines whether the detected arrangement order of the four fingers is correct based on the X coordinate of the center coordinate Pt10 of the index finger and the X coordinate of the center coordinate Pt20 of the middle finger, the X coordinate of the center coordinate Pt20 of the middle finger and the X coordinate of the center coordinate Pt30 of the ring finger, and the X coordinate of the center coordinate Pt30 of the ring finger and the X coordinate of the center coordinate Pt40 of the little finger.

[0036] On the other hand, when the processor 11 determines that the four fingers are not detected in the process of step St14 (St14, NO), the processor 11 proceeds to the process of step St18. The processing of step St18 will be described later.

[0037] When the processor 11 determines that the arrangement order of the four fingers is not correct in the process of step St15 (St15, NO), the processor 11 proceeds to the process of step St18. The processing of step St18 will be described later.

[0038] On the other hand, in the processing of step St15, in a case where it is determined that the arrangement order of the four fingers is correct (St15, YES), the processor 11 further determines whether or not the distance between the center coordinates of the bounding boxes corresponding to two adjacent classes (fingers) is equal to or less than the predetermined distance D1 (for example, the predetermined distance D1 = 20 mm or the like) based on the detected center coordinates of the bounding boxes corresponding to each finger (St16).

[0039] The value of the predetermined distance D1 may be a variable. For example, the processor 11 may estimate the size of the hand of the user based on the size of the angle of view of the camera 13, the size of the hand with respect to the size of the angle of view of the camera 13, the size of the bounding box, the distance between the center coordinates of the bounding box corresponding to the fingers (for example, the little finger and the index finger) at both ends, or the like, and determine the value of the predetermined distance D1 based on the estimated size of the hand. As a result, even if the user is a child or a person whose fingers are smaller than those of an adult, the processor 11 can determine whether or not the detected fingers are the same finger and whether or not the detected fingers overlap each other with higher accuracy.

[0040] In the example illustrated in FIG. 3, after determining that the arrangement order of the detected four fingers is correct, the processor 11 calculates center coordinates Pt10, Pt20, Pt30, and Pt40 of the bounding boxes FM10 to FM40, respectively. The processor 11 determines whether the distance between the two adjacent fingers is equal to or less than the predetermined distance D1 based on the calculated center coordinates Pt10 to Pt40 of each of the bounding boxes FM10 to FM40. As a result, the processor 11 determines whether or not adjacent fingers of the detected four fingers overlap each other and whether or not the positions of the adjacent fingers are too close to each other. In the processing of step St15, when the arrangement order of the four fingers is determined by the coordinate information of the bounding box, the calculation processing of the center coordinates may be executed in step St15.

[0041] In the example illustrated in FIG. 3, the processor 11 determines whether a distance L11 between the center coordinates Pt10 of the index finger and the center coordinates Pt20 of the middle finger, a distance L12 between the center coordinates Pt20 of the middle finger and the center coordinates Pt30 of the ring finger, and a distance L13 between the center coordinates Pt30 of the ring finger and the center coordinates Pt40 of the little finger are each equal to or less than a predetermined distance D1. Accordingly, the processor 11 can more effectively prevent a plurality of fingers imaged in an overlapping manner or a plurality of fingers close to each other from being erroneously detected (erroneously identified) as one finger.

[0042] There is a possibility that the imaging posture of the user's fingers is arbitrary and a plurality of fingers are not aligned in a predetermined direction (for example, the X direction in FIG. 3). In such a case, the processor 11 may further analyze the length of the side of each bounding box, the position of the palm, the direction in which the finger extends, and the like by image analysis to estimate the direction in which the plurality of fingers are arranged on the captured finger image IMG1.

[0043] In the processing of step St16, when it is determined that the distance between the center coordinates of the bounding boxes corresponding to the two adjacent classes (fingers) is not equal to or less than the predetermined distance D1 (St16, NO), the processor 11 determines that the detection result of the finger estimated by deep learning is correct, generates a fingertip detection result screen (see FIG. 3) in which the detection result of the fingertip is superimposed on the finger image IMG1, and outputs the fingertip detection result screen to the monitor 14 (St17). The fingertip detection result illustrated in FIG. 3 is an example including a bounding box (frame line) indicating a region in which each finger is detected and a finger name indicating which finger each detected finger is, but may be only the bounding box (frame line).

[0044] On the other hand, in the processing of step St16, when it is determined that the distance between the center coordinates of the bounding boxes corresponding to the two adjacent classes (fingers) is equal to or less than the predetermined distance D1 (St16, YES), the processor 11 determines that there is a possibility that the detection result of the finger estimated by deep learning is not correct, and proceeds to the processing of step St18. The processing of step St18 will be described later.

[0045] Next, an operation procedure example of the biometric information identification device P1 will be described with reference to FIGS. 4 to 6. FIG. 4 is a flowchart showing an operation procedure example of the biometric information identification device P1 according

to the embodiment. FIG. 5 is a diagram for explaining an example of selecting a bounding box. FIG. 6 is a diagram that shows an example of identifying a finger by selecting a bounding box. FIG. 5 illustrates only the index finger and the middle finger in the finger image IMG1 illustrated in FIG. 3 and does not illustrate the other fingers in order to make the description of the selection example of the bounding box easy to understand.

[0046] The processor 11 refers to the reliability scores of all the generated bounding boxes, and picks up a bounding box having a reliability score equal to or higher than a threshold value as a bounding box candidate (hereinafter, referred to as a “bounding box candidate”) that detects an object (fingertip) to be detected (St18). The threshold here is a threshold set for the reliability score of the bounding box itself.

[0047] In the example illustrated in FIG. 5, the processor 11 determines whether the reliability score of each of the bounding boxes FM01 to FM05, FM11 to FM16, and FM21 to FM25 is equal to or greater than a threshold. The processor 11 picks up each of the bounding boxes FM11 to FM16 and FM21 to FM25 whose reliability scores are determined to be equal to or greater than the threshold as a bounding box candidate. As a result, the biometric information identification device P1 can suppress a decrease in fingertip detection accuracy by excluding a bounding box having a low reliability score and a low likelihood of detecting a fingertip from bounding box candidates.

[0048] The processor 11 calculates the similarity of the center coordinates of the bounding box candidates using the k-means method, and groups each of the picked-up bounding box candidates into four groups based on the calculated similarity in (St19). The number of groups may be set to any number depending on the number of fingers to be detected.

[0049] In the example illustrated in FIG. 5, the processor 11 groups the bounding boxes FM11 to FM16 as an index finger group and groups the bounding boxes FM21 to FM25 as a middle finger group based on the similarity of the center coordinates of each bounding box. In FIG. 5, in order to make the description easy to understand, as an example of the grouping result, the bounding boxes FM11 to FM16 are surrounded by the group GR1 (index finger group) and the bounding boxes FM21 to FM25 are surrounded by the group GR2 (middle finger group) to visualize the bounding boxes belonging to each group.

[0050] The processor 11 selects a bounding box having the highest reliability score among the grouped bounding box candidates for each class (finger) (St20).

[0051] In the example illustrated in FIG. 5, the processor 11 selects the bounding box FM12 having the highest reliability score among the bounding box candidates belonging to

the group GR1. The processor 11 selects the bounding box FM23 having the highest reliability score among the bounding box candidates belonging to the group GR2.

[0052] The processor 11 determines the bounding box (for example, the bounding box FM44 illustrated in FIG. 6) having the smallest area (size) among the selected four bounding boxes as the bounding box of the little finger in (St21).

[0053] In the example illustrated in FIG. 6, the processor 11 determines the bounding box FM44 having the smallest area (size) of the bounding box among the bounding boxes FM12, FM23, FM35, and FM44 selected in each class as the bounding box of the little finger.

[0054] The processor 11 determines classes (fingers) corresponding to the other three selected bounding boxes with reference to the bounding box of the little finger in (St22).

[0055] In the example illustrated in FIG. 6, the processor 11 determines the class of the other three bounding boxes FM12 as the index finger, the class of the bounding box FM23 as the middle finger, and the class of the bounding box FM35 as the ring finger in order of proximity to the bounding box FM44 with reference to the bounding box FM44 of the little finger (pinky).

[0056] The processor 11 determines whether the distance between the center coordinates of the bounding boxes corresponding to two adjacent classes (fingers) is equal to or less than the predetermined distance D2 in (St23). Here, the predetermined distance D2 may be the same as the predetermined distance D1. Similarly to the predetermined distance D1, the value of the predetermined distance D2 may be a variable.

[0057] In the example illustrated in FIG. 6, the processor 11 calculates center coordinates Pt12, Pt23, Pt35, and Pt44 of the bounding boxes FM12, FM23, FM35, and FM44, respectively. Based on the calculated center coordinates Pt12, Pt23, Pt35, and Pt44 of each of the bounding boxes FM12, FM23, FM35, and FM44, the processor 11 determines whether the distance between the two adjacent fingers is equal to or greater than the predetermined distance D2, that is, whether the adjacent fingers overlap each other, and whether the positions of the adjacent fingers are too close to each other.

[0058] In the example illustrated in FIG. 6, the processor 11 determines whether a distance L21 between the center coordinates Pt12 of the index finger and the center coordinates Pt23 of the middle finger, a distance L22 between the center coordinates Pt23 of the middle finger and the center coordinates Pt35 of the ring finger, and a distance L23 between the center coordinates Pt35 of the ring finger and the center coordinates Pt44 of the little finger are each equal to or less than a predetermined distance D2. Accordingly, the processor 11 can

determine whether there are a plurality of fingers imaged in an overlapping manner or whether the same finger is detected in a plurality of different bounding boxes.

[0059] There is a possibility that the imaging posture of the user's fingers is arbitrary and a plurality of fingers are not aligned in a predetermined direction (for example, the X direction in FIG. 6). In such a case, the processor 11 may further analyze the length of the side of each bounding box, the position of the palm, the direction in which the finger extends, and the like by image analysis to estimate the direction in which the plurality of fingers are arranged on the captured finger image IMG1.

[0060] In the processing of step St23, when it is determined that the distance between the center coordinates of the bounding boxes corresponding to the two adjacent classes (fingers) is equal to or less than the predetermined distance D2 (St23, YES), the processor 11 determines that the distance between the fingers is small and the adjacent fingers overlap each other. Therefore, the processor 11 determines that the fingertip cannot be detected, generates a notification indicating that the fingertip cannot be detected, and outputs the notification to the monitor 14 (St25).

[0061] On the other hand, in the processing of step St23, when it is determined that the distance between the center coordinates of the bounding boxes corresponding to the two adjacent classes (fingers) is not equal to or less than the predetermined distance D2 (St23, NO), the processor 11 determines that the distance between the two adjacent fingers is sufficiently large and the adjacent fingers do not overlap.

[0062] The processor 11 further determines whether the value of the X coordinate of the center coordinates of the bounding box of the little finger is minimum or maximum in (St24). That is, the processor 11 determines whether the position of the little finger is located at the end portion in the arrangement of the four fingers.

[0063] In the present embodiment, an example in which it is determined whether or not the value of the X coordinate of the center coordinates of the bounding box is the minimum or the maximum is shown, but it is needless to say that the value used in the determination processing of step St24 is not limited thereto. The value used in the determination processing of step St24 may be set to any value based on the direction in which the plurality of fingertips are arranged on the finger image IMG1, and may be the value of the Y coordinate of the center coordinates when the hand of the user is inserted in the X-axis direction. In addition, in the determination processing of step St24, it may be determined whether or not the distance between any vertex along the direction in which the fingertips are arranged among the four corners of the finger image IMG1 or any side forming an intersection in the direction in which

the fingertips are arranged among the four sides of the finger image IMG1 having a rectangular shape and the center coordinates of the bounding box of the little finger is the minimum or the maximum based on the direction in which the plurality of fingertips are arranged on the finger image IMG1.

[0064] In the processing of step St24, when it is determined that the value of the X coordinate of the center coordinates of the bounding box of the little finger is the minimum or the maximum (St24, YES), the processor 11 determines that the detection and identification of the fingertip are completed, generates a fingertip detection result screen IMG2 (see FIG. 6) in which the detection result of the fingertip is superimposed on the finger image IMG1, and outputs the fingertip detection result screen IMG2 to the monitor 14 (St26). The fingertip detection result illustrated in FIG. 6 is an example including a bounding box (frame line) indicating a region in which each finger is detected and a finger name indicating which finger each detected finger is, but may be only the bounding box (frame line).

[0065] On the other hand, in the processing of step St24, in a case where it is determined that the value of the X coordinate of the center coordinates of the bounding box of the little finger is not the minimum or the maximum (St24, NO), the processor 11 determines that the fingertip cannot be detected and identified, generates a notification indicating that the fingertip cannot be detected, and outputs the notification to the monitor 14 (St25).

[0066] As described above, the biometric information identification device P1 according to the embodiment is a conventional fingertip detection and identification method, and generates a bounding box surrounding a region of an object that appears to be a fingertip in the finger image IMG1 by image analysis processing using a learning model generated by deep learning, so that the biometric information identification device P1 can identify (specify) which finger each finger detected using the generated bounding box is.

[0067] In addition, even in a case where the predetermined number of fingers are not detected in the conventional image analysis processing and the detected finger arrangement is not correct (in a case of “NO” in step St14 and step St15 illustrated in FIG. 2 or in a case of “YES” in step St16), the biometric information identification device P1 can identify (specify) which finger each detected finger is by specifying the bounding box in which each finger is detected among the plurality of generated bounding boxes by executing the processing of step St18 to step St24.

[0068] As described above, the biometric information identification device P1 according to the embodiment can more accurately identify which finger each of the plurality of fingertips captured in the finger image is. Accordingly, the biometric information identification device

P1 can identify (specify) the biometric information used for the biometric authentication, and can improve the authentication accuracy of the biometric authentication.

[0069] (Modification of Embodiment)

In the embodiment, an example in which each of the other fingers (the ring finger, the middle finger, and the index finger) is identified using the little finger as the reference finger has been described. In the following modification of the embodiment, an example of identifying each of other fingers (ring finger, middle finger, and index finger) with a thumb as a reference finger will be described.

[0070] Since the biometric information identification device according to the modification of the embodiment has the same configuration as the biometric information identification device P1 according to the embodiment, the description thereof will be omitted.

[0071] With reference to FIG. 7, a fingertip identification processing executed by biometric information identification device P1 according to the modification of the embodiment will be described. FIG. 7 is a diagram that shows an example of fingertip identification in the modification of the embodiment.

[0072] In the following description, an example in which five fingers are identified from the finger image will be described, but the imaged fingers are not limited thereto. The finger to be imaged may be imaged so as to include at least the thumb (reference finger) and all fingers from the thumb to the finger used for biometric authentication. For example, when the fingertip used for biometric authentication is the middle finger, three fingers from the thumb to the middle finger may be imaged.

[0073] The processor 11 in the biometric information identification device P1 executes the processing of step St11 to step St13 illustrated in FIG. 2, detects the five fingers captured in the finger image IMG3 (St14), and determines whether or not the arrangement order of the detected five fingers is correct (St15).

[0074] The biometric information identification device P1 executes the processing of step St16 shown in FIG. 2, outputs the detection result of the fingertip (St17) when it is determined that the detection result of the fingertip using deep learning is correct (St16, NO), and executes the processing of step St18 to step St20 shown in FIG. 4 when it is determined that the detection result of the fingertip using deep learning is likely to be incorrect (St16, YES).

[0075] The processor 11 determines the bounding box having the largest area as the bounding box of the thumb (reference finger) (St21A). After determining the bounding box of the thumb as the reference finger, the processor 11 executes the processing of steps St22 to

St23 and determines whether the center coordinates of the bounding box of the thumb (reference finger) are the minimum or the maximum (St24).

[0076] When it is determined that the center coordinates of the bounding box of the thumb (reference finger) are the minimum or the maximum (St24, YES), the processor 11 outputs the detection result of the fingertip determined in step St22 (St26), and when it is determined that the center coordinates of the bounding box of the thumb (reference finger) are not the minimum or the maximum (St24, NO), the processor 11 determines that the fingertip cannot be detected and identified, generates a notification indicating that the fingertip cannot be detected, and outputs the notification to the monitor 14 (St25).

[0077] As described above, even when the reference finger is set to the thumb, the biometric information identification device P1 according to the embodiment can more accurately identify which finger each of the plurality of fingertips captured in the finger image is. Accordingly, the biometric information identification device P1 can identify (specify) the biometric information used for the biometric authentication, and can improve the authentication accuracy of the biometric authentication.

[0078] (Supplementary Notes)

The following technique is disclosed by the description of each of the above embodiments.

[0079] (Technique 1)

A biometric information identification method performed by at least one computer (biometric information identification device P1), the biometric information identification method including:

acquiring a captured image (finger image) in which a plurality of fingers of a subject are captured;

detecting each of the plurality of fingers on the basis of the captured image (finger image);

determining a reference finger (little finger or thumb) serving as an identification criterion of the plurality of fingers among the plurality of fingers on the basis of sizes of detection regions (for example, bounding box FM12, FM23, FM35, or FM44) of the plurality of detected fingers so as to identify the reference finger; and

identifying which finger each of the other fingers among the plurality of fingers is on the basis of a position of the reference finger to output an identification result of the plurality of fingers. With this configuration, by using the little finger or the thumb as a

reference, the biometric information identification device P1 can more accurately identify which finger each of the plurality of fingertips captured in the finger image is.

According to this configuration, the biometric information identification device P1 can identify (specify) the biometric information used for the biometric authentication, and can improve the authentication accuracy of the biometric authentication.

[0080] (Technique 2)

The biometric information identification method according to (Technique 1), in which

each of the other fingers is identified based on a distance between the reference finger and the other finger.

According to this configuration, the biometric information identification device P1 can more accurately identify which finger each of the plurality of fingertips appearing in the finger image is based on the distance to the little finger or the thumb. Accordingly, the biometric information identification device P1 can identify (specify) the biometric information used for the biometric authentication, and can improve the authentication accuracy of the biometric authentication.

[0081] (Technique 3)

The biometric information identification method according to (Technique 1) or (Technique 2), in which

a finger having the smallest size of the detection region among the detection regions of the plurality of fingers is identified as a little finger.

According to this configuration, the biometric information identification device P1 can identify the little finger among the plurality of fingers captured in the finger image with higher accuracy. Accordingly, the biometric information identification device P1 can improve the identification accuracy of each of the plurality of fingertips based on the little finger.

[0082] (Technique 4)

The biometric information identification method according to (Technique 1) or (Technique 2), in which

a finger having the largest size of the detection region among the detection regions of the plurality of fingers is identified as a thumb.

According to this configuration, the biometric information identification device P1 can identify the thumb among the plurality of fingers captured in the finger image with higher accuracy. Accordingly, the biometric information identification device P1 can improve the identification accuracy of each of the plurality of fingertips based on the thumb.

[0083] (Technique 5)

The biometric information identification method according to any one of (Technique 1) to (Technique 4), in which

distances (for example, distances L21 to L23) between two of the detection regions corresponding to two of the fingers adjacent to each other are calculated based on the identification result of the plurality of fingers, and

when it is determined that all the calculated distances (for example, distances L21 to L23) are equal to or greater than a predetermined distance D2, the identification result of the plurality of fingers is output.

According to this configuration, the biometric information identification device P1 determines that one finger is detected for one bounding box based on the positions of the plurality of detected fingers. Accordingly, the biometric information identification device P1 can identify (specify) the biometric information used for the biometric authentication, and can improve the authentication accuracy of the biometric authentication.

[0084] (Technique 6)

The biometric information identification method according to (Technique 5), in which

when it is determined that at least one of the distances (for example, the distances L21 to L23) is not equal to or greater than the predetermined distance D2, a notification indicating that the plurality of fingers cannot be identified is generated and output.

According to this configuration, the biometric information identification device P1 suppresses erroneous detection or erroneous identification of a finger due to the presence or absence of overlapping of two adjacent fingers, suppresses erroneous detection or erroneous identification of a finger due to the positions of adjacent fingers being too close, or determines that there is a possibility that the same finger is detected in a plurality of different bounding boxes. Accordingly, the biometric information identification device P1 can more effectively suppress a decrease in finger identification accuracy and authentication accuracy of fingerprint authentication by determining that the finger cannot be identified.

[0085] (Technique 7)

The biometric information identification method according to any one of (Technique 1) to (Technique 6), in which

in a case where it is determined that the reference finger is located at an end portion of an arrangement of the plurality of fingers based on positions (that is, center coordinates of

a bounding box) of the detection regions of the plurality of fingers, an identification result of the plurality of fingers is output.

With this configuration, the biometric information identification device P1 can identify the little finger among the plurality of fingers captured in the finger image with higher accuracy. Accordingly, the biometric information identification device P1 can improve the identification accuracy of each of the plurality of fingertips based on the little finger.

[0086] (Technique 8)

The biometric information identification method according to (Technique 7), in which

when it is determined that the reference finger is not located at the end portion of the arrangement, a notification indicating that the plurality of fingers cannot be identified is generated and output. According to this configuration, when it is determined that the reference finger is not the little finger, the biometric information identification device P1 can more effectively suppress a decrease in finger identification accuracy and authentication accuracy of fingerprint authentication by determining that the finger cannot be identified.

[0087] (Technique 9)

A biometric information identification system 100 including:

a camera 13; and

at least one computer (biometric information identification device P1) capable of communicating with the camera 13, in which

the camera 13 captures an image of a plurality of fingers of a subject and transmits the image to the computer (biometric information identification device P1), and

the computer (biometric information identification device P1):

detects each of the plurality of fingers on the basis of the captured image (finger image);

determines a reference finger (little finger) serving as an identification criterion of the plurality of fingers among the plurality of fingers on the basis of sizes of detection regions (for example, bounding boxes FM12, FM23, FM35, and FM44) of the plurality of detected fingers, identifies the reference finger; and

identifies which finger each of the other fingers among the plurality of fingers is on the basis of a position of the reference finger, and outputs an identification result of the plurality of fingers to a monitor.

With this configuration, by using the little finger as a reference, the biometric information identification system 100 can more accurately identify which finger each of the

plurality of fingertips captured in the finger image is. Accordingly, the biometric information identification device P1 can identify (specify) the biometric information used for the biometric authentication, and can improve the authentication accuracy of the biometric authentication.

[0088] Although various embodiments have been described above with reference to the accompanying drawings, the present disclosure is not limited thereto. It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the technical scope of the appended claims or the equivalents thereof. In addition, the components in the various embodiments described above may be arbitrarily combined without departing from the gist of the invention.

[0089] The present application is based on the Japanese patent application filed on March 15, 2024 (JP2024-041366), the contents of which are incorporated herein by reference.

INDUSTRIAL APPLICABILITY

[0090] The present disclosure provides a biometric information identification method and a biometric information identification system that identify a biometric site corresponding to biometric information used for biometric authentication and improve authentication accuracy of the biometric authentication.

REFERENCE SIGNS LIST

[0091] 10 communication unit
11 processor
12 memory
13 camera
14 monitor
100 biometric information identification system
D1, D2 predetermined distance
DB biometric information database
FM01, FM02, FM03, FM04, FM05, FM1, FM2, FM3, FM4, FM5, FM10, FM11, FM12, FM13, FM14, FM15, FM16, FM20, FM21, FM22, FM23, FM24, FM25, FM30, FM35, FM40, FM44 bounding box
IMG1 finger image
IMG2 fingertip detection result screen

L11, L12, L13, L21, L22, L23 distance

P1 biometric information identification device

Pt10, Pt12, Pt20, Pt23, Pt30, Pt34, Pt35, Pt40, Pt44 center coordinate

CLAIMS

[Claim 1]

A biometric information identification method performed by at least one computer, the biometric information identification method comprising:

acquiring a captured image in which a plurality of fingers of a subject are captured;

detecting each of the plurality of fingers on the basis of the captured image;

determining a reference finger serving as an identification criterion of the plurality of fingers among the plurality of fingers on the basis of sizes of detection regions of the plurality of detected fingers to identify the reference finger; and

identifying which finger each of the other fingers among the plurality of fingers is on the basis of a position of the reference finger so as to output an identification result of the plurality of fingers.

[Claim 2]

The biometric information identification method according to claim 1, wherein

each of the other fingers is identified based on a distance between the reference finger and the other finger.

[Claim 3]

The biometric information identification method according to claim 1, wherein

a finger having the smallest size of the detection region among the detection regions of the plurality of fingers is identified as a little finger.

[Claim 4]

The biometric information identification method according to claim 1, wherein

a finger having the largest size of the detection region among the detection regions of the plurality of fingers is identified as a thumb.

[Claim 5]

The biometric information identification method according to claim 1, wherein

distances between two of the detection regions corresponding to two of the fingers adjacent to each other are calculated based on the identification result of the plurality of

fingers, and when it is determined that all the calculated distances are equal to or greater than a predetermined distance, the identification result of the plurality of fingers is output.

[Claim 6]

The biometric information identification method according to claim 5, wherein

when it is determined that at least one of the distances is not equal to or greater than the predetermined distance, a notification indicating that the plurality of fingers cannot be identified is generated and output.

[Claim 7]

The biometric information identification method according to claim 1, wherein

in a case where it is determined that the reference finger is located at an end portion of an arrangement of the plurality of fingers based on positions of the detection regions of the plurality of fingers, an identification result of the plurality of fingers is output.

[Claim 8]

The biometric information identification method according to claim 7, wherein

when it is determined that the reference finger is not located at the end portion of the arrangement, a notification indicating that the plurality of fingers cannot be identified is generated and output.

[Claim 9]

A biometric information identification system comprising:

a camera; and

at least one computer configured to communicate with the camera, wherein

the camera captures an image of a plurality of fingers of a subject and transmits the image to the computer, and

the computer:

detects each of the plurality of fingers on the basis of the captured image;

determines a reference finger serving as an identification criterion of the plurality of fingers among the plurality of fingers on the basis of sizes of detection regions of the plurality of detected fingers, identifies the reference finger; and

identifies which finger each of the other fingers among the plurality of fingers is on

the basis of a position of the reference finger, and outputs an identification result of the plurality of fingers to a monitor.