

DESCRIPTION

TITLE OF INVENTION

CONGESTION DETERMINATION SYSTEM, CONGESTION
5 DETERMINATION DEVICE, CONGESTION DETERMINATION METHOD, AND
PROGRAM

TECHNICAL FIELD

[0001] The present disclosure relates to a crowding determination system, a crowding
10 determination device, a crowding determination method, and a program.

BACKGROUND ART

[0002] In the related art, there has been a monitoring device for determining an abnormal
situation in a monitored region and alerting an observer. If a crowd is detected from an image
obtained by imaging a predetermined monitored region, the monitoring device calculates a
15 degree of crowding of the crowd and then compares the calculated degree of crowding with a
reference value. If it is determined that the degree of crowding of the crowd is abnormal, the
monitoring device notifies an observer such as an administrator that an abnormality has
occurred (see Patent Literature 1).

CITATION LIST

20 NON-PATENT LITERATURE

[0003] Patent Literature 1: JP3910626B

SUMMARY OF INVENTION

TECHNICAL PROBLEM

25 [0004] If persons are crowded in a region imaged and monitored by the imaging device, the
crowding is a factor that causes a person who continues being a blind spot from the imaging
device, that is, occlusion. For example, if face authentication is performed in a region (for
example, a path), detection accuracy of authentication targets moving in the region may
decrease, or unauthorized passage of an unauthorized passer who misuses a blind spot
30 (occlusion) may occur.

[0005] In the monitoring device of Patent Literature 1, a false alarm (erroneous warning
display) may occur if a crowd whose degree of crowding exceeds a reference value
instantaneously occurs in a predetermined region at a timing when the predetermined region is

imaged. More specifically, for example, if the predetermined region is a path that allows passage in both directions, when small groups (for example, a group of two to three persons) that travel through the path in different directions and are not determined as crowding pass each other, the distance between the persons belonging to each small group is reduced. It is desired to avoid the warning display when individual small groups that should not be subjected to warning display pass each other, but a false alarm (warning display) may occur when a crowd whose degree of crowding exceeds a reference value is formed instantaneously.

[0006] The detection and notification of the abnormality regarding the crowding of persons in a predetermined region lead to dispatch of security guards monitoring the predetermined region or stay (stop of movement) of persons moving in the predetermined region. Therefore, a certain degree of accuracy is required for the detection accuracy of the crowding in the predetermined region. Therefore, it is also desired to accurately detect the crowding status of persons in a predetermined region where a plurality of persons come and go (move in different traveling directions).

[0007] The present disclosure provides a crowding determination system, a crowding determination device, a crowding determination method, and a program capable of detecting a crowding status of persons in a predetermined region with high accuracy.

SOLUTION TO PROBLEM

[0008] An aspect of the present disclosure is a crowding determination system for determining crowding of persons, including: a detection device configured to detect a plurality of persons passing through a path; and a crowding determination device configured to determine crowding of the persons, in which the crowding determination device acquires detection information for identifying at least positions of the plurality of persons detected by the detection device, determines a traveling direction of each of the plurality of persons based on the detection information, and determines that a crowded group in which persons are crowded is generated in the path if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

[0009] An aspect of the present disclosure is a crowding determination device for determining crowding of persons, including: a processor, in which the processor acquires detection information in which a plurality of persons passing through a path are detected, the detection information being for identifying at least positions of the plurality of persons, determines a traveling direction of each of the plurality of persons based on the detection information, and determines that a crowded group in which persons are crowded is generated

in the path if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

[0010] An aspect of the present disclosure is a crowding determination method for determining crowding of persons, including: a step of acquiring detection information in which a plurality of persons passing through a path are detected, the detection information being for identifying at least positions of the plurality of persons; a step of determining a traveling direction of each of the plurality of persons based on the detection information; and a step of determining that a crowded group in which persons are crowded is generated in the path if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

[0011] An aspect of the present disclosure is a program for causing a computer to execute each step of the crowding determination method described above.

ADVANTAGEOUS EFFECTS OF INVENTION

[0012] According to the present disclosure, it is possible to detect a crowding status of persons in a predetermined region with high accuracy.

BRIEF DESCRIPTION OF DRAWINGS

[0013] [FIG. 1] FIG. 1 is a block diagram illustrating a configuration example of a management system according to an embodiment of the present disclosure.

[FIG. 2] FIG. 2 is a diagram illustrating an installation example of a camera and a display installed at a gate.

[FIG. 3] FIG. 3 is a block diagram illustrating a configuration example of a management device.

[FIG. 4] FIG. 4 is a diagram illustrating an example of person registration information.

[FIG. 5] FIG. 5 is a diagram illustrating an example of person detection information.

[FIG. 6] FIG. 6 is a diagram illustrating a determination example of a moving direction of a person.

[FIG. 7] FIG. 7 is a diagram illustrating a crowding state of persons.

[FIG. 8A] FIG. 8A is a diagram illustrating a determination example of crowding of persons.

[FIG. 8B] FIG. 8B is a diagram illustrating a determination example of crowding of persons.

[FIG. 9] FIG. 9 is a diagram illustrating a determination example of crowding of

persons with section overlap and without section overlap.

[FIG. 10] FIG. 10 is a diagram illustrating a display example of information for each person belonging to a crowded group.

5 [FIG. 11A] FIG. 11A is a diagram illustrating a display example when notifying that an unauthorized passer is detected on a terminal screen owned by an observer.

[FIG. 11B] FIG. 11B is a diagram illustrating a display example of the terminal screen while the observer is supporting the unauthorized passer.

[FIG. 12] FIG. 12 is a flowchart illustrating an operation example of the management system.

10

DESCRIPTION OF EMBODIMENTS

[0014] Hereinafter, embodiments will be described in detail with reference to the drawings as appropriate. However, the unnecessarily detailed description may be omitted. For example, the detailed description of well-known matters and the redundant description of substantially the same configuration may be omitted. This is to avoid unnecessary redundancy of the following description and to facilitate understanding of those skilled in the art. It should be noted that 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.

20 [0015] For example, in the embodiments, "unit" or "device" is not limited to a physical configuration that is mechanically implemented by hardware, and also includes those that implement functions of the configuration by software such as a program. Functions of one configuration may be implemented by two or more physical configurations, or functions of two or more configurations may be implemented by, for example, one physical configuration.

25 [0016] FIG. 1 is a block diagram illustrating a configuration example of a management system 5 according to an embodiment of the present disclosure. The management system 5 includes a camera 10, a display 20, and a control PC (personal computer) 30. The camera 10, the display 20, and the control PC 30 are installed, for example, for each gate 50. The number of gates 50 may be one or more. The management system 5 further includes a management device 100 and an authentication server 200.

30

[0017] The camera 10 and the display 20 of each gate 50 are communicably connected to the control PC 30 in a wired or wireless manner. The control PC 30 of each gate 50 is communicably connected to the management device 100 in a wired or wireless manner. The authentication

server 200 is communicably connected to the management device 100 in a wired or wireless manner. The camera 10, the display 20, the control PC 30, the management device 100, and the authentication server 200 may constitute a wired or wireless network and may be communicably connected to each other. The number of cameras 10 and displays 20 installed in each gate 50 may be any number.

[0018] The camera 10 is installed for each gate 50. The camera 10 images various subjects, for example, images a person passing through the corresponding gate 50. The camera 10 captures, for example, an image of the face of a person traveling in a predetermined direction (traveling direction).

10 [0019] The display 20 is installed for each gate 50. The display 20 displays various data and information. For example, the display 20 displays various data and information to a person passing through the corresponding gate 50 or a person positioned around the gate 50.

[0020] The control PC 30 is installed for each gate 50. The control PC 30 controls operations of the camera 10 and the display 20 of the corresponding gate 50. For example, the control PC 30 instructs the camera 10 to perform various settings of the camera 10 and acquires an image captured by the camera 10. For example, the control PC 30 instructs various settings of the display 20 to the display 20, and transmits information to be displayed by the display 20 (for example, warning information, images, and guidance information) to the display 20.

20 [0021] The management device 100 manages devices in the management system 5, manages persons passing through each gate 50 in cooperation with each device, that is, manages persons positioned in a path AL toward the gate 50. The management device 100 may be installed at any position, for example, installed in a management center for managing the gates 50 and the management system 5.

25 [0022] The authentication server 200 acquires an image captured by each camera 10 installed in each gate 50 via the control PC 30 and the management device 100. The authentication server 200 authenticates persons reflected in the acquired image based on the image, and notifies the management device 100 of authentication status information indicating an authentication status. The authentication status information may include an authentication result, information indicating authentication in progress, and the like. The authentication result includes, for example, whether the authentication succeeded (OK) or failed. The authentication server 200 may be installed at any position, for example, installed in a management center for managing the gate 50 and the management system 5. In addition, the "authentication" may be described as "collation". The authentication server 200 includes, for example, a processor, a memory, and

a communication device.

[0023] FIG. 2 is a diagram illustrating an installation example of the camera 10 and the display 20 installed for each gate 50. In FIG. 2, a first gate 50A and a second gate 50B are provided as the gate 50. In FIG. 2, the first gate 50A and the second gate 50B face each other.
 5 The first gate 50A is, for example, a gate on the IN side (entrance side). The second gate 50B is, for example, a gate on the OUT side (exit side). A range surrounded by the first gate 50A and the second gate 50B is a detection region AR for detecting a person based on a captured image captured by the camera 10, and is at least a part of the path AL where a plurality of persons come and go. In the following description, each device installed on the first gate 50A
 10 side has "A" added at the end of the reference sign, and each device installed on the second gate 50B side has "B" added at the end of the reference sign.

[0024] The camera 10A of the first gate 50A images a person passing through the path AL on the second gate 50B side when viewed from the first gate 50A. The camera 10B of the second gate 50B images a person passing through the path AL on the first gate 50A side when viewed
 15 from the second gate 50B. The display 20A of the first gate 50A is installed such that a person moving from the second gate 50B toward the first gate 50A can be visually recognized. That is, the display surface of the display 20A of the first gate 50A faces the second gate 50B. The display 20B of the second gate 50B is installed such that a person moving from the first gate 50A toward the second gate 50B can be visually recognized. That is, the display surface of the
 20 display 20B of the second gate 50B faces the first gate 50A. In the present embodiment, the traveling direction of each person includes at least a direction from the first gate 50A toward the second gate 50B (first direction) and a direction from the second gate 50B toward the first gate 50A (second direction).

[0025] In the present embodiment, a direction connecting the first gate 50A and the second gate 50B is defined as a Y-axis direction, and a direction perpendicular to the Y-axis direction in a horizontal plane is defined as an X-axis direction. A direction from the first gate 50A toward the second gate 50B is defined as a Y-axis positive direction, and a direction from the second gate 50B toward the first gate 50A is defined as a Y-axis negative direction.

[0026] The first gate 50A and the second gate 50B are simply described as "gate 50" to describe the common content thereof. Similarly, the camera 10A and the camera 10B are simply
 30 described as "camera 10" to describe the common content thereof. Similarly, the display 20A and the display 20B are simply described as "display 20" to describe the common content thereof.

[0027] In FIG. 2, the display 20 is installed at the center of the frame of the gate 50, and the cameras 10 are installed on both sides of the display 20 in the horizontal direction. The gate 50 is installed in a predetermined area, and is installed at the entrance and exit of the area or in the area. Although not illustrated in FIG. 2, the control PC 30 may be arranged at any position relative to the position of the gate 50 for each gate 50.

[0028] The shape of the gate 50 is not limited to the shape illustrated in the installation example of FIG. 2, and may be another shape. For example, the shape of the gate 50 may be a deep tunnel shape, or may be a suspended shape in which the cameras 10 and the display 20 are suspended from a support member installed on a ceiling or above the path AL through which a person moves. Further, the present disclosure is not limited to the form of the gate 50, and may be any form as long as the biometric feature data of a person at a predetermined point or data as the source of the biometric feature data can be acquired. For example, the camera 10 and the display 20 may have a shape in which the camera 10 that images a person passing through the predetermined point is provided on a display 20 that is movable with casters or the like.

[0029] The gate 50 is a gate that allows a plurality of people (for example, multiple people) to pass at the same time. Various persons HM (for example, persons HM1, HM2,...) can pass through the gate 50. For example, an adult, a child (for example, an infant), a person wearing a mask, or a person not wearing a mask may pass through the gate 50. The person passing through the gate 50 is authenticated by the management device 100 and the authentication server 200.

[0030] FIG. 3 is a block diagram illustrating a configuration example of the management device 100.

[0031] The management device 100 includes a processor 110, a memory 120, and a communication device 130. The management device 100 may operate as a server for performing predetermined processing, or may include an operation device or a display device such as a PC and receive an operation from an administrator or perform display for the administrator when performing predetermined processing.

[0032] The processor 110 may include a micro processing unit (MPU), a central processing unit (CPU), a digital signal processor (DSP), or a graphical processing unit (GPU). The processor 110 may be implemented by various integrated circuits (for example, a large scale integration (LSI) or a field programmable gate array (FPGA)). The processor 110 implements various functions by executing a program stored in the memory 120. The processor 110 integrally controls the units of the management device 100 and executes various processing.

[0033] The memory 120 includes a primary storage device (for example, a random access

memory (RAM) or a read only memory (ROM)). The memory 120 may include a secondary storage device (for example, a hard disk drive (HDD), a solid state drive (SSD)), a tertiary storage device (for example, an optical disk or an SD card), or the like. The memory 120 is an external storage medium and may be detachable from the management device 100. The memory 120 stores various data, information, programs, and the like. The memory 120 holds, for example, person registration information I1 and person detection information I2 described later. The person registration information I1 may also be held in the memory of the authentication server 200. The memory 120 may hold, for example, a captured image acquired from the camera 10 via the communication device 130. This captured image can be used, for example, to check unauthorized passage.

[0034] The communication device 130 communicates various data or information according to a wired or wireless communication method. The communication system of the communication device 130 may be a wide area network (WAN), a local area network (LAN), cellular communication for mobile phones (for example, LTE or 5G), power line communication, or the like.

[0035] The communication device 130 can communicate with the camera 10, the display 20, the control PC 30, and other communication devices. For example, the communication device 130 may receive an image captured by the camera 10 from the camera 10. The communication device 130 may transmit display information to be displayed by the display 20 and a display instruction to the display 20. The display 20 may receive the display information and the display instruction from the management device 100 and display the display information according to the display instruction.

[0036] FIG. 4 is a diagram illustrating an example of the person registration information I1. The person registration information I1 includes various information on a person registered in advance. The person registration information I1 includes, for example, identification information (for example, a name or an ID) of a person and a face image of the person. The face image of the person is an example of biometric feature data of the person, and is used for authentication of the person. The person registration information I1 may include an image other than face image of the person.

[0037] FIG. 5 is a diagram illustrating an example of the person detection information I2. For each gate 50, the processor 110 generates person detection information I2 related to detection of each person near the gate 50 (for example, detection in the detection region AR of the path AL). The person detection information I2 includes, for example, a detection time and

a detection position at which each person is detected, and an authentication result. The detection time is a time at which each person is detected based on the captured image, and may be, for example, an imaging time at which the captured image is captured. The detection position is a position in the path AL. The detection position is represented by, for example, an X coordinate indicating a position in the X-axis direction and a Y coordinate indicating a position in the Y-axis direction. The authentication result is an authentication result (success (OK) or failure) obtained from the authentication server 200.

[0038] The detection time and the detection position included in the person detection information I2 may be sequentially acquired as long as the management of the persons passing through the path AL by the management system 5 is continued. Therefore, in the person detection information I2 may accumulate a large number of detection times and a large number of detection positions. The position of the person can be tracked in time series by the large number of detection times and the large number of detection positions of the person.

[0039] Next, a determination example of the traveling direction of the person will be described.

[0040] The processor 110 of the management device 100 determines the traveling direction of the person. The processor 110 sequentially acquires captured images GA captured by the camera 10A from the camera 10A in time series via the communication device 130. The processor 110 sequentially acquires captured images GB captured by the camera 10B from the camera 10B in time series via the communication device 130. The processor 110 may determine the traveling direction of the person based on one or more captured images captured by at least one of the camera 10A and the camera 10B.

[0041] For example, for each person, the processor 110 may determine the traveling direction of the person based on whether the camera 10 that captures the captured image in which the person is first detected is the camera 10A or the camera 10B. For example, if the person HM1 is first detected in a captured image GB captured by the camera 10B, the processor 110 determines that the person HM enters from the first gate 50A (IN side) positioned on the side opposite in the Y-axis direction to the camera 10B that captures the captured image GB and moves toward the second gate 50B (OUT side). That is, the processor 110 determines that the traveling direction of the person HM1 is the direction toward the Y-axis positive direction (first direction).

[0042] For example, if the person HM1 is first detected in a captured image GA, the processor 110 determines that the person HM1 enters from the second gate 50B side (OUT side)

positioned on the side opposite in the Y-axis positive direction to the camera 10A that captures the captured image GA captured by the camera 10A and moves toward the first gate 50A side (IN side). That is, the processor 110 determines that the traveling direction of the person is the direction toward the Y-axis negative direction (second direction).

5 [0043] For example, the processor 110 may detect the person in the captured image if feature data of an object included in the captured image (for example, the shape of the object) is similar to biometric feature data of a person (for example, a shape of the body or the face or a face image), or may detect the person in the captured image according to another method.

[0044] For each person, the processor 110 may determine the traveling direction of the person based on the moving direction of the person with the elapse of time detected in the sequentially acquired captured images GA or captured images GB. In this case, the moving direction (that is, the traveling direction) of the person in the actual space may be determined based on the movement of the image position of the person in the captured image. For example, if it is detected that the person HM1 is moving from the first gate 50A toward the second gate 15 50B in the sequentially acquired captured images, it is determined that the traveling direction of the person HM1 is a direction toward the Y-axis positive direction (first direction). If it is detected that the person HM1 is moving from the second gate 50B toward the first gate 50A in the sequentially acquired captured images, it is determined that the traveling direction of the person HM1 is a direction toward the Y-axis negative direction (second direction).

20 [0045] For each person, the processor 110 may determine the traveling direction of the person based on a position in the detection region AR at which the person is first detected. FIG. 6 is a diagram illustrating a determination example of a moving direction of a person. For example, if the position of the person HM1 in the actual space corresponding to the detection position of the person HM1 in the captured image GA or the captured image GB is included in the first detection region AR1 closer to the first gate 50A in the detection region AR, the processor 110 determines that the person HM1 enters the detection region AR from the first gate 50A and moves toward the second gate 50B. That is, the processor 110 determines that the traveling direction of the person HM1 is the direction toward the Y-axis positive direction (first direction).

30 [0046] For example, if the position of the person HM1 in the actual space corresponding to the detection position of the person HM1 in the captured image GA or the captured image GB is included in the second detection region AR2 closer to the second gate 50B in the detection region AR, the processor 110 determines that the person HM1 enters the detection region AR

from the second gate 50B and moves toward the first gate 50A. That is, the processor 110 determines that the traveling direction of the person HM1 is the direction toward the Y-axis negative direction (second direction).

[0047] Next, crowding of persons in the path AL will be described.

5 [0048] FIG. 7 is a diagram illustrating a crowding state of persons. In FIG. 7, five persons HM (HM1 to HM5) are present in a predetermined narrow range in the path AL along an XY plane. It is assumed that the five persons HM are moving from the Y-axis negative direction toward the Y-axis positive direction, that is, from the first gate 50A toward the second gate 50B. In this case, the two persons HM1 and HM2 positioned on the side closer to the camera 10B
10 (on the front side of the group) are reflected in the captured image captured by the camera 10B installed at the second gate 50B in front of the five persons HM. The two persons HM4 and HM5 positioned on the side closer to the camera 10A (on the rear side of the group) are reflected in the captured image captured by the camera 10A installed at the first gate 50A behind the five persons HM. On the other hand, the person HM3 surrounded by the persons HM1, HM2, HM4,
15 and HM5 is not imaged by the camera 10A or the camera 10B, and is positioned in a blind spot of both the cameras 10A and 10B. Therefore, the person HM3 is not subjected to detection, authentication, or tracking based on the captured image. In this case, it is not determined whether the person is an authorized person permitted to pass through the second gate 50B (that is, whether the person is a person for whom the person registration information I1 is registered),
20 which may lower the security. In this case, if persons are crowded in a location in the path AL, the management system 5 can perform various processing for dispersing the crowding of persons.

[0049] Next, determination of crowding of persons (crowding determination) will be described.

25 FIGS. 8A and 8B are diagrams illustrating a determination example of crowding of persons. FIG. 9 is a diagram illustrating a determination example of crowding of persons with section overlap and without section overlap. It is assumed that the persons illustrated in FIGS. 8A, 8B, and 9 travel in the same traveling direction.

[0050] The processor 110 of the management device 100 determines that the persons are
30 crowded in the path AL and determines that a crowded group MG in which the persons are crowded is generated if the degree of crowding of the persons traveling in the same traveling direction satisfies a predetermined crowding determination condition. For example, at least one of the following crowding determination conditions A to D may be included, and other

crowding determination conditions may be included. The degree of crowding of persons may be indicated by, for example, the density of persons or the distance between a plurality of persons in a section of a predetermined size.

[0051] The crowding determination condition A is that the number of persons traveling in the same direction in a section DR of any size (for example, a square of 1.2 m) is equal to or greater than a threshold th1 (for example, four) (see a state A in FIG. 8A). For example, if the number of persons traveling in the same direction in the section DR is four or more, it may be determined that the persons are crowded and a crowded group MG is generated. The crowding determination condition A may further include at least one of the crowding determination conditions A1, A2, and A3.

[0052] In the crowding determination condition A1, a plurality of sections DR may be generated by dividing the detection region AR of the path AL between the first gate 50A and the second gate 50B into a grid shape with any size. The crowding determination condition A1 is that the number of persons positioned in the section DR obtained by division is equal to or greater than the threshold th1. In the plurality of sections DR obtained by the division, the adjacent sections DR may or may not overlap each other. The sections DR may be generated by the processor 110 of the management device 100 or may be generated by another device. The processor 110 or another device may freely determine the size and shape of the sections DR.

[0053] In a state B of FIG. 8A and a state C of FIG. 8B, the adjacent sections DR overlap each other. In the state B of FIG. 8A and the state C and a state D of FIG. 8B, the number of persons present in each section DR and traveling in the same traveling direction is three at maximum, which is less than the threshold th1. Therefore, in these states, the processor 110 determines that the persons are not crowded and a crowded group MG is not generated.

[0054] In the crowding determination condition A2, four sections DR are generated, that is, with the position of a predetermined person (for example, a person HMC in FIG. 9) as a base point, a section DR1 formed on the front right side (the X-axis positive direction and the Y-axis positive direction) in the traveling direction of the predetermined person, a section DR2 formed on the front left side (the X-axis negative direction and the Y-axis positive direction) in the traveling direction of the predetermined person, a section DR3 formed on the rear right side (the X-axis positive direction and the Y-axis negative direction) in the traveling direction of the predetermined person, and a section DR4 formed on the rear left side (the X-axis negative direction and the Y-axis negative direction) in the traveling direction of the predetermined

person. The adjacent sections DR among the plurality of sections DR1 to DR4 overlap each other, and a predetermined person is included in any of the sections DR. If persons traveling in the same direction as the direction in which the predetermined person travels are present by a number equal to or greater than the threshold th1 (for example, four) including the predetermined person in any one section DR among the four sections DR, the processor 110 determines that the persons are crowded in the section DR and determines that a crowded group MG is generated.

[0055] In FIG. 9, it is illustrated that the determination result of the crowding is different between the case with section overlap and the case without section overlap. That is, in the case with section overlapping in FIG. 9, since the person HM2 is included in any of the sections DR1 to DR4, the number of persons traveling in the same direction in the section DR3 including the person HMC is four, which is equal to or greater than the threshold th1. Therefore, the processor 110 determines that persons are crowded in the section DR3 and a crowded group MG is generated.

[0056] On the other hand, in the case without section overlap in FIG. 9, the possibility of not being determined as crowding increases depending on the position of the boundary. For example, in the section DR3 in the case of no section overlap, three persons HM1, HM2, and HM5 are positioned near the boundary. In this case, the processor 110 detects the persons HM1, HM2, and HM5 in any of the section DR1 to section DR4, but the positions where the persons HM1, HM2, and HM5 are detected may not be in the section DR3. Therefore, it is determined that the persons are not crowded in the section DR3 and a crowded group MG is not generated. That is, it is determined that persons are not crowded although persons are crowded in the actual state, which is an erroneous determination.

[0057] Therefore, the management device 100 can improve the determination accuracy of the crowding of the persons by generating the plurality of sections DR by dividing the detection region AR with section overlapping and with a predetermined person as the base point.

[0058] In the crowding determination condition A3, the length of the sections DR in the Y-axis direction may be decreased as the walking speeds of the persons in the sections DR are lower, and the length of the sections DR in the Y-axis direction may be increased as the walking speeds of the persons in the sections DR are higher. In this case, the processor 110 may acquire information on the walking speeds of the persons in the sections DR and determine the length of the sections DR in the Y-axis direction based on the walking speeds. In this case, the processor 110 may reduce the length of the sections DR in the Y-axis direction as the walking

speeds of the persons in the sections DR are lower, and increase the length of the sections DR in the Y-axis direction as the walking speeds of the persons in the sections DR are higher. Accordingly, the management device 100 can adjust the size of the sections DR for determining the crowding according to the walking speed.

5 [0059] Here, a method for deriving the walking speed of the person will be supplemented. For example, the camera 10 can acquire a distance image together with the captured image, that is, can measure the distance between the camera 10 and any position in the imaging range. Therefore, the processor 110 of the management device 100 may sequentially acquire the measurement result of the distance by the camera 10 in time series, and calculate the movement
10 distance of the person per unit time based on the sequentially acquired measurement result of the distance. The movement distance of the person per unit time corresponds to the walking speed of the person passing through the path AL. The processor 110 may derive the walking speed of the person by another method. The processor 110 may derive the walking speed of the person as a statistical value (for example, an average value) of the walking speeds of a plurality
15 of persons passing through the path AL.

[0060] The crowding determination condition B is that a distance between a plurality of persons traveling in the same direction (also referred to as an inter-person distance $d1$) is less than a threshold $th2$ (for example, 0.5 m). That is, if the inter-person distance $d1$ is less than the threshold $th2$, the processor 110 may determine that persons are crowded in the path AL and
20 determine that a crowded group MG is generated.

[0061] The crowding determination condition B may include the number of persons. Specifically, the crowding determination condition B may be that the number of persons whose inter-person distance $d1$ is less than the threshold $th2$ is equal to or greater than a threshold $th3$ (for example, four) in a predetermined region (for example, the section DR) in the path AL. In
25 this case, for example, the management device 100 can avoid determining as crowding if simply the distance between two persons is short.

[0062] In the crowding determination condition C, the inter-person distance $d1$ includes a first inter-person distance $d11$ and a second inter-person distance $d12$ and the threshold $th2$ includes a threshold $th21$ and a threshold $th22$ in the crowding determination condition B. The
30 first inter-person distance $d11$ is the distance along the traveling direction (Y-axis direction) between the plurality of persons traveling in the same direction (see FIG. 8A and the like). The second inter-person distance $d12$ is the distance along the direction perpendicular to the traveling direction (X-axis direction) between the plurality of persons traveling in the same

direction (see FIG. 8A and the like). The threshold th_{21} is compared with the first inter-person distance d_{11} . The threshold th_{22} is compared with the second inter-person distance d_{12} . The threshold th_{22} is smaller than the threshold th_{21} . The crowding determination condition C is that the first inter-person distance d_{11} is less than the threshold th_{21} or the second inter-person distance d_{12} is less than the threshold th_{22} . That is, if the first inter-person distance d_{11} is less than the threshold th_{21} , the processor 110 may determine that persons are crowded in the path AL and determine that a crowded group MG is generated. This is because, if a plurality of persons move toward the gate 50 while being aligned in the horizontal direction (X-axis direction), the plurality of persons tend to be closer to each other than in the vertical direction (Y-axis direction). This is because when a plurality of persons are aligned in the vertical direction, the legs of the walking persons easily come into contact with each other.

[0063] The crowding determination condition C may include the number of persons. Specifically, the crowding determination condition C may be that the number of persons whose inter-person distance d_{11} is less than a threshold th_{12} is equal to or greater than the threshold th_3 in a predetermined region in the path AL. The crowding determination condition C may be that the number of persons whose inter-person distance d_{21} is less than the threshold th_{22} is equal to or greater than the threshold th_3 in a predetermined region in the path AL. In these cases, for example, the management device 100 can avoid determining as crowding if simply the distance between two persons along the X-axis direction or the Y-axis direction is short.

[0064] The processor 110 may acquire walking speeds of a plurality of persons who travel through the path AL in the same traveling direction. The processor 110 may decrease the threshold th_2 in the crowding determination condition B or the crowding determination condition C as the acquired walking speed is lower. Accordingly, if the walking speed is lower, it is likely to be determined that the persons are crowded even if the inter-person distance d_1 is short. If the walking speed is lower, a plurality of persons can move with their bodies being close to each other. Such case where a plurality of persons move with their bodies being close to each other as described above can be appropriately determined as crowding as well. The processor 110 may increase the threshold th_2 in the crowding determination condition B or the crowding determination condition C as the acquired walking speed is higher. Accordingly, if the walking speed is higher, the management device 100 can avoid excessive determination that the persons are crowded if the inter-person distance d_1 is short. Therefore, the management device 100 can hardly follow persons passing in front with a high walking speed without leaving a distance between a plurality of persons, but can appropriately determine as crowding if the

persons are slightly away from each other.

[0065] The processor 110 may decrease the threshold th21 or the threshold th22 in the crowding determination condition C as the acquired walking speed is lower, and increase the threshold th21 or the threshold th22 in the crowding determination condition C as the walking speed is higher. That is, the management device 100 can easily determine as crowding according to the distance of the person in the traveling direction if the walking speed is low, and can hardly determine as crowding according to the distance of the person in the traveling direction if the walking speed is high.

[0066] Here, it is exemplified that the ease of determining as crowding is adjusted according to the speed of the walking speed by changing the thresholds th2, th21, th22, and the like, but the present invention is not limited thereto. For example, the processor 110 may adjust the ease of crowding determination by changing the size of the sections DR or the length of the sides constituting the outer periphery of the sections DR (for example, the sides along the traveling direction of the person).

[0067] For example, the processor 110 may increase the size of the section DR or lengthen one side of the outer periphery of the section DR (for example, a side along the traveling direction of the person) as the walking speed is lower. This case is likely to be determined as crowding. The processor 110 may decrease the size of the section DR or shorten one side of the outer periphery of the section DR (for example, a side along the traveling direction of the person) as the walking speed is higher. This case is unlikely to be determined as crowding.

[0068] Next, an information presentation example based on the determination result of the crowding determination will be described.

[0069] The processor 110 may cause the display 20 to present various information based on the determination result of the crowding determination. The presentation here includes, for example, display by the display 20 and audio output by a speaker, but may be presentation by another method. The speaker may be installed in the gate 50 for each gate 50, for example. Here, as an example, display of information is mainly illustrated. If a plurality of persons are crowded, a group of the plurality of crowded persons is defined as a crowded group MG.

[0070] For example, if it is determined that a plurality of persons are crowded by the crowding determination, the processor 110 may cause the display 20 to display crowding dispersion instruction information MI1, which is information for dispersing the crowding, to a person HMF positioned on the front side of the crowded group MG (in front in the traveling direction). The person HMF is, for example, the person HM1 and the person HM2 in FIG. 7.

The processor 110 may display different pieces of crowding dispersion instruction information MI1 based on whether the person HMF succeeded in authentication or failed in authentication. For example, the crowding dispersion instruction information MI1 may include crowding dispersion instruction information MI11 displayed for the person HMF who succeeds in authentication (person HMF1) and the crowding dispersion instruction information MI12 displayed for the person HMF who does not succeed in authentication (person HMF2).

[0071] The crowding dispersion instruction information MI11 may include, for example, a message such as "Please proceed forward", "Please proceed sideways", "Please move right", or "Please move left". The crowding dispersion instruction information MI1 is for causing the person HMF to move in any direction, which contributes to dispersion of crowding of persons.

[0072] The crowding dispersion instruction information MI12 may include messages such as "Authentication in progress", "Authentication failed", and "Authentication failed. Please show your face clearly". For example, if the authentication of the person HMF based on the captured image is being performed, the processor 110 may cause the display 20 to display a message of "Authentication in progress" as the crowding dispersion instruction information MI12. For example, if the authentication of the person HMF based on the captured image fails, the processor 110 may cause the display 20 to display a message of "Authentication failed" or "Authentication failed. Please show your face clearly" as the crowding dispersion instruction information MI12. Here, the person whose authentication failed is assumed to be, for example, a person who looks at the display 20 or the camera 10 but wears a mask, sunglasses, or the like on the face, and the surface of the face thereof is not sufficiently exposed. In this case, the crowding dispersion instruction information MI12 may include removal instruction information for removing (for example, detaching) a shielding object (for example, a mask or sunglasses) that shields at least a part of the face of the person whose authentication failed with respect to the camera 10. The crowding dispersion instruction information MI12 can prompt a person who is not successfully authenticated to smoothly succeed in authentication, and to cause the person HMF to move in any direction when the person HMF is successfully authenticated, which contributes to dispersion of crowding of persons.

[0073] If it is determined that a plurality of persons are crowded by the crowding determination, the processor 110 may cause the display 20 to display crowding dispersion instruction information MI2, which is information for dispersing crowding, for a person HMB positioned at a position other than the front side (for example, the rear side) of the crowded group. The person HMF is, for example, the person HM4 and the person HM5 in FIG. 7. Since

the person HM3 in FIG. 7 is not detected from the captured image, the processor 110 does not recognize the person HM3 at this time.

[0074] The crowding dispersion instruction information MI2 may include, for example, a message such as "Please stop", "Please move backwards", "Please proceed sideways", "Please move right", or "Please move left". The crowding dispersion instruction information MI2 is for causing the person HMB to move in a direction other than the forward direction, which contributes to dispersion of crowding of persons. In addition, even if the crowding dispersion instruction information MI2 is a message of "Please stop", for example, by performing a movement instruction message to the person HMF, the distance between the person HMB and the person HMF is increased, which contributes to dispersion of crowding of persons.

[0075] FIG. 10 is a diagram illustrating a display example of information for each person belonging to the crowded group MG.

[0076] In FIG. 10, the processor 110 recognizes four persons HM1, HM2, HM4, and HM5 as the crowded group MG. The persons HM1 and HM2 are persons HMF, and the persons HM4 and HM5 are persons HMB. The persons HM1 and HM2 are successfully authenticated. The persons HM4 and HM5 may be in an unauthenticated state or may have succeeded or failed in authentication. In FIG. 10, the face images, the authentication results, and the crowding dispersion instruction information of the persons HM are displayed for each person. For example, displayed for the persons HM1 and HM2 are the face images, the authentication results (authentication OK), and the crowding dispersion instruction information MI11 (for example, "Please proceed forward"). Displayed for the persons HM4 and HM5 are the face images, the authentication results (authentication failed), and the crowding dispersion instruction information MI2 (for example, "Please stop"). The authentication result may be indicated by, for example, a display mode (for example, a display color or a display pattern) of an authentication result frame WK attached to the outer periphery of the face image.

[0077] The processor 110 may display crowding dispersion instruction information MI3 as information common to all the persons belonging to the crowded group MG. The crowding dispersion instruction information MI3 may include, for example, a message such as "Please keep your distance from other people". The processor 110 may display a group frame WKG indicating a range of persons belonging to the crowded group MG.

[0078] If a crowded group MG other than the crowded group MG formed by the persons HM1, HM2, HM4, and HM5 is present, the processor 110 may similarly display the face images, the authentication results, and the crowding dispersion instruction information MI1 to MI3 of

the persons HM. The processor 110 may also display information on persons other than the crowded group MG, that is, non-crowded persons, together with the information on the persons of the crowded group MG. The information on the non-crowded persons may include, for example, information on face images and authentication results.

5 [0079] FIG. 11A is a diagram illustrating a display example when notifying that an unauthorized passer is detected on a terminal screen owned by an observer.

[0080] In the embodiment of the present disclosure, if a person who continues to move through the path AL in a state where the authentication has failed is detected in the detection region AR, the management device 100 determines the person as an unauthorized passer. If an
10 unauthorized passer is detected, the management device 100 notifies an observer waiting in the vicinity of the gate 50, a security room, or the like that the unauthorized passer is present in the path AL via a tablet terminal such as a smartphone. That is, the management device 100 transmits information on the unauthorized passer to the tablet terminal. The information on the unauthorized passer may include, for example, at least a part of information of the person
15 registration information I1 on the unauthorized passer and at least a part of information of the person detection information I2 on the unauthorized passer. The tablet terminal may display information on the unauthorized passer in screens such as a notification list screen 60. Upon receiving the notification, the observer checks the notification list screen 60 displayed on the tablet terminal, so as to grasp a person who needs to be supported individually. The
20 unauthorized passer is a person who needs to be supported by the observer, and is managed by the management device 100.

[0081] For each unauthorized passer, the notification list screen 60 displays the support status (for example, "waiting for support" or "supporting"), the time when detected, the point when detected (for example, "IN-side gate" or "OUT-side gate"), the traveling direction when
25 detected (for example, "entrance direction" or "exit direction"), the face image, and the like.

[0082] The notification list screen 60 includes a display switching tab 62. The tablet terminal receives pressing on the display switching tab 62 from the observer, and displays a list of unsupported unauthorized passers and a list of supported unauthorized passers. Therefore, the observer can check the list of unsupported unauthorized passers and the list of supported
30 unauthorized passers. If the observer selects an unsupported tab 62A, an unsupported list screen 60A is displayed. If the observer selects the supported tab 62B, an supported list screen 60B is displayed.

[0083] The unsupported list screen 60A may have different display forms of rows for

displaying information related to unauthorized passers between the unauthorized passers whose support status is the status of waiting for support and the unauthorized passers whose support status is the status of supporting. For example, a row of an unauthorized passer in the status of waiting for support may be displayed in red or may be highlighted by blinking. Accordingly, the observer can intuitively and quickly grasp the target to support.

[0084] FIG. 11B is a diagram illustrating a display example of the terminal screen while the observer is supporting the unauthorized passer.

[0085] Upon receiving an operation of selecting a person whose status of the support status is waiting for support from the observer on the notification list screen 60A, the tablet terminal can switch the display to an unauthorized passer support screen 70. At the timing when the display is switched to the unauthorized passer support screen 70, the status of waiting for support of the person selected by the observer is automatically updated to supporting. That is, for example, the tablet terminal may transmit information on a selection operation of a person waiting for support to the management device 100, and the management device 100 may change the status from the status of waiting for support to the status of supporting based on the information on the selection operation and transmit the status information indicating the status of supporting to the tablet terminal.

[0086] The unauthorized passer support screen 70 displays the face image, the point when detected, the elapsed time from the detection, and the like of the person selected by the observer on the notification list screen 60A via the tablet terminal. The tablet terminal may further display information for assisting in finding the unauthorized passer selected by the observer, without being limited to the display content described above.

[0087] The unauthorized passer support screen 70 includes a button 72 for returning to the notification list screen 60. Upon receiving the pressing on the button 72 from the observer, the tablet terminal can switch the screen display from the unauthorized passer support screen 70 to the notification list screen 60. At the timing when the display is switched to the notification list screen 60, the status of supporting of the person selected by the observer may be automatically updated to the status of waiting for support or may be automatically updated to a status of failing in individual support (for example, "support failed"). That is, for example, the tablet terminal may transmit the operation information on the button 72 to the management device 100, and the management device 100 may change the status from the status of supporting to the status of waiting for support or the status of support failed based on the operation information of the button 72 and transmit the status information indicating the status of waiting for support or the

status of support failed to the tablet terminal. If the status is updated to support failed, the management device 100 may store a person failed in individual support as a person requiring caution in the memory 120.

[0088] The unauthorized passer support screen 70 further includes an unregistered person button 74 and a registered person button 76. The observer presses the unregistered person button 74 or the registered person button 76 depending on whether the individually supported person is an unregistered person or a registered person. Whether the person is an unregistered person or a registered person may be, for example, displayed on the tablet terminal based on the person registration information I1 transmitted from the management device 100 to the tablet terminal. Upon receiving the pressing on either the unregistered person button 74 or the registered person button 76 from the observer, the tablet terminal automatically switches the display from the unauthorized passer support screen 70 to the individual support completion screen 80.

[0089] The individual support completion screen 80 includes a close button 82. Upon receiving the pressing on the close button 82 by the observer, the tablet terminal automatically switches the display screen of the tablet terminal from the individual support completion screen 80 to the notification list screen 60. At the timing when the display is switched to the notification list screen 60, the status of the support status of the person selected by the observer is automatically updated from supporting to support complete, and is automatically updated from the state displayed on the unsupported list screen 60A to the state displayed on the supported list screen 60B. In this case, for example, the tablet terminal may transmit the operation information of the close button 82 to the management device 100, and the management device 100 may change the status from the status of supporting to the status of support complete based on the operation information of the close button 82 and transmit the status information indicating the status of support complete to the tablet terminal.

[0090] Next, an operation example of the management system 5 will be described.

FIG. 12 is a flowchart illustrating an operation example of the management system 5.

[0091] First, in the management device 100, the processor 110 sequentially acquires captured images in time series via the communication device 130. The acquired captured images include at least one of the captured image GA captured by the camera 10A and the captured image GB captured by the camera 10B. The processor 110 detects the persons reflected in each acquired captured image by performing any image analysis on the captured images (S11). A plurality of persons may be detected here.

[0092] The processor 110 determines whether the persons detected in the plurality of

captured images sequentially acquired in time series are the same person (S12). For example, if the shape or the biometric feature data such as the face image of the persons detected in different captured images is similar (for example, matches), it is determined that the persons reflected in the different captured images are the same person. Without being limited to the
5 above-described method, the processor 110 may determine that persons detected by different cameras 10 are the same person if the position coordinates of the persons detected by the respective cameras 10 are within an error range. The processor 110 can track the movement of the person determined as the same person. Whether the persons are the same person may be determined for a plurality of persons detected in the captured image. That is, if it is determined
10 that four persons detected in a plurality of captured images sequentially acquired in time series are the same persons, the processor 110 can simultaneously track the four persons.

[0093] The processor 110 determines the traveling direction of the person for each person determined as the same person (S13). The method for determining the traveling direction of the person may be any of the methods described above. The processor 110 determines whether one
15 or more persons determined to have the same traveling direction are crowded, that is, performs crowding determination (S14). As described above, the crowding determination method may be any of the above-described methods, and may determine whether any of the above-described crowding determination conditions is satisfied.

[0094] If it is determined that the persons having the same traveling direction are crowded,
20 the processor 110 causes the display 20 installed in the traveling direction of the crowded group MG to display a warning display (display information including the crowding dispersion instruction information MI) to each person belonging to the crowded group (S15). The display information includes, for example, information on each person belonging to the crowded group MG, and may include at least one of the face image, the authentication result, and the crowding
25 dispersion instruction information MI (for example, I1 to I3). In this case, the processor 110 transmits the display information and the display instruction to the display 20. The display 20 receives the display information and the display instruction, and displays the display information according to the display instruction.

[0095] In step S15, the processor 110 may determine the crowding dispersion instruction
30 information MI to be displayed for each person in the crowded group MG based on the relative positions of the persons in consideration of the elapse of time. For example, if the person HM4 changes with the elapse of time from the person HMB to the person HMF, the crowding dispersion instruction information MI for the person HM4 may be changed from the crowding

dispersion instruction information MI2 to the crowding dispersion instruction information MI1. The processor 110 may determine the crowding dispersion instruction information MI to be displayed for each person based on the authentication status (for example, authentication in progress, authentication succeeded, authentication failed) belonging to the crowded group MG.

5 For example, if the person HM1 changes with the elapse of time from a state that the authentication failed to a state that the authentication succeeded, the crowding dispersion instruction information MI for the person HM1 may be changed from the crowding dispersion instruction information MI12 to the crowding dispersion instruction information MI11. That is, the processor 110 may instruct the update of the screen display of the display 20 based on the
10 position, the authentication status, or the like of each person of the crowded group MG via the communication device 130. The display 20 may receive an instruction to update the screen display of the display 20 and update the screen display according to the instruction.

[0096] Alternatively, if it is determined in step S15 that the persons having the same traveling direction are not crowded, the processor 110 causes the display 20 installed in the traveling
15 direction of each person detected from the captured images to display the display information including the face image and the authentication result for each person (S16). The display in this case is a display in a non-crowding case and is a screen display in a normal case.

[0097] When passing through the gate 50 which allows a plurality of persons to pass at the same time, the persons can travel in various directions, and the management system 5 of the
20 present embodiment can determine whether the persons are crowded based on the distance or the density between the persons in the same traveling direction. Therefore, even if a large number of persons traveling in various directions are mixed and accidentally crowded in a narrow area, it can be determined that a crowded group MG is not generated. That is, the management system 5 can determine the crowding of persons with high accuracy. Therefore,
25 the management system 5 can reduce false alarms of the crowding dispersion instruction information MI to be notified if a crowded group MG is generated.

[0098] Further, the management system 5 outputs or presents the crowding dispersion instruction information MI, so that the passing persons can act to disperse the crowding upon checking the crowding dispersion instruction information MI. Accordingly, the management
30 system 5 may be capable of detecting a new person positioned in a blind spot from each camera 10. Therefore, the management system 5 can prevent unauthorized passage of an unauthorized passer who misuses a blind spot (occlusion).

[0099] In the present embodiment, the crowding determination is mainly exemplified in

consideration of the traveling direction, but is not limited thereto. The processor 110 of the management device 100 may output the crowding dispersion instruction information MI by performing crowded determination without considering the traveling direction of each person.

[0100] The management device 100 may be installed in any of the gates 50 and may operate as a gate attached with an authentication device. Alternatively, the management device 100 may not be installed as an independent device, and any device may have a function as the management device 100.

[0101] Further, the management device 100 and the authentication server 200 are exemplified as separate devices, but are not limited thereto. The management device 100 and the authentication server 200 may be an integrated device, and the management device 100 may have the function of the authentication server 200.

[0102] In addition, the management device 100 and the control PCs 30 are exemplified as separate devices, but any one of the control PCs 30 and the management device 100 may be an integrated device, and the control PCs 30 may have the function of the management device 100.

Further, any one of the plurality of control PCs 30 may have the functions of the management device 100, or any two or more of the plurality of control PCs 30 may have the functions of the management device 100 in a dispersed manner. Further, at least one of the camera 10 and the display 20 and the management device 100 may be configured integrally, and at least one of the camera 10 and the display 20 may have the function of the management device 100.

[0103] In the present embodiment, detection, authentication, tracking, and the like of a person are performed based on a captured image captured by the camera 10, but are not limited thereto. Any sensor (detection device) other than the camera 10 may detect a person. For example, the processor 110 may acquire detection information for identifying at least the position of a person from any sensor, and perform detection, authentication, tracking, or the like of the person based on the detection information (for example, the position of the person). The detection information for identifying the position of the person may be the information itself on the position of the person. For example, an infrared sensor, an ultrasonic sensor, a Lidar device, or the like is considered as a sensor for detecting detection information for identifying at least the position of a person. The captured image is included in the detection information for identifying the position of the person.

[0104] The processor 110 may acquire information such as the position, orientation, and angle of view of the camera 10 from the memory 120 or the like, and calculate the imaging range of the camera 10 based on the position, orientation, and angle of view of the camera 10.

The processor 110 may identify the position of the person relative to the camera 10, that is, acquire the position coordinates of the absolute position of the person, based on the position, size, range, or the like of the region in which the person is detected in the captured image captured by the camera 10 and the distance to the person measured by the camera 10.

5 [0105] [Overview of Embodiment]

As described above, the management system 5 (an example of a crowding determination system) according to the present embodiment determines crowding of persons. The management system 5 includes: a detection device (for example, the camera 10) configured to detect a plurality of persons passing through the path AL; and a management device 100 (an
10 example of a crowding determination device) configured to determine crowding of the persons. The management device 100 acquires detection information (for example, captured images) for identifying at least a position of a plurality of persons detected by the detection device, determines a traveling direction of each of the plurality of persons based on the detection information, and determines that a crowded group MG in which persons are crowded is
15 generated in the path AL if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

[0106] The persons can travel in various directions in the path AL, but as a result, the management system 5 can determine whether the persons are crowded depending on whether the predetermined crowding determination condition is satisfied for the persons in the same
20 traveling direction. That is, the management system 5 can determine the crowding status of persons in the predetermined region with high accuracy.

[0107] The management device 100 may determine that the crowded group MG is not generated if the traveling directions of the plurality of persons are different.

[0108] Accordingly, the management device 100 can prevent erroneous determination that
25 the crowded group MG is generated due to, for example, the instantaneous presence at a close position of a person traveling in the opposite direction or a person traveling in an intersecting manner. In this case as well, the management system 5 can eliminate a state in which the persons travel in different directions and the distance between the plurality of persons is short, and can stably perform authentication of each person.

[0109] If it is determined that the crowded group MG is generated, the management device
30 100 may output crowding dispersion instruction information MI, which is information for dispersing crowding of persons, to at least one person among a plurality of persons belonging to the crowded group MG.

[0110] Accordingly, for example, the management device 100 can output the crowding dispersion instruction information MI by any method, and for example, the observer positioned near the gate 50 can check the crowding dispersion instruction information MI, so as to alert the person passing through the path AL to act to disperse the crowding. The output of the crowding dispersion instruction information MI may include, for example, transmission to a mobile terminal carried by the observer.

[0111] The detection device may include a camera 10 (an example of an imaging device) configured to image a plurality of persons passing through the path AL. The detection information may include a captured image captured by the camera 10. Accordingly, the management device 100 can easily obtain various information on the person including the position of the person.

[0112] The management system 5 may include a display 20 (an example of a presentation device) installed at a predetermined position of the path AL and configured to present (for example, display) information. The management device 100 may transmit the crowding dispersion instruction information MI to the display 20. The display 20 may receive and present the crowding dispersion instruction information MI.

[0113] As a result, the person passing through the path AL can check the crowding dispersion instruction information MI displayed on the display 20, and can act to disperse the crowding of persons. The presentation device may be a device other than the display 20, and for example, the crowding dispersion instruction information MI may be audibly output as voice data such as public announcement by a speaker installed at a predetermined position of the path AL (for example, the gate 50). In this case, even if it is difficult to visually recognize the display 20 due to crowding or the like, a person passing through the path AL can recognize the crowding state or the crowding dispersion instruction information MI.

[0114] The management system 5 may include an authentication server 200 configured to authenticate a person. The authentication server 200 may acquire the captured image, authenticate a person passing through the path AL based on first biometric feature data (for example, a face image) registered in advance and second biometric feature data (for example, a face image) of the person obtained from the captured image, and transmit an authentication status of the person to the management device 100. The management device 100 may acquire, and transmit to the display 20, an authentication status of each of the plurality of persons belonging to the crowded group MG from the authentication server 200. The display 20 may acquire the authentication status of each of the plurality of persons belonging to the crowded

group MG, and present the crowding dispersion instruction information MI and the authentication status of each of the plurality of persons belonging to the crowded group MG.

[0115] Accordingly, the management system 5 can simultaneously present, for example, both whether the person passing through the path AL is a pre-registered person and the crowding dispersion instruction information MI. Therefore, each person passing through the path AL can act while grasping the method for dispersing the crowding of persons and checking the authentication status of the person.

[0116] The management device 100 may transmit, to the display 20, the crowding dispersion instruction information MI for a person HMF1 (an example of a first person) whose authentication status by the authentication server 200 indicates authentication success among persons HMF positioned in front in the traveling direction (for example, the Y-axis positive direction) in the crowded group MG, the crowding dispersion instruction information MI including forward instruction information instructing the person HMF1 to move forward. The display 20 may present the forward instruction information included in the crowding dispersion instruction information MI.

[0117] Accordingly, the management system 5 can present a message such as "Please proceed forward" to the person on the front side of the crowded group. In this case as well, the management system 5 causes a successfully authenticated person to move forward, thereby avoiding a decrease in security. Further, the management system 5 can disperse the persons included in the crowded group MG by causing the person HMF1 to move forward, and may be capable of detecting, for example, a person who is positioned in the area where the crowded group MG is positioned but is not detected.

[0118] The management device 100 may transmit, to the display 20, the crowding dispersion instruction information MI for a person HMF2 (an example of a second person) whose authentication status by the authentication server 200 does not indicate authentication success among persons positioned in front in the traveling direction in the crowded group MG, the crowding dispersion instruction information MI including removal instruction information for removing a shielding object (for example, a mask or sunglasses) that shields at least a part of a face of the second person from the camera 10. The display 20 may present the removal instruction information included in the crowding dispersion instruction information MI.

[0119] This enables the management system 5 to present a message such as "Please show your face clearly". In this case as well, the management system 5 can increase the possibility of authentication success of a person who failed in authentication due to crowding, for example,

by authenticating again.

[0120] The management device 100 may transmit, to the display 20, the crowding dispersion instruction information MI for a person HMB (an example of a third person) who is a person not positioned in front in the traveling direction in the crowded group MG, the crowding
5 dispersion instruction information MI including non-forward instruction information for instructing the person HMB to move in a direction other than forward or to stop. The display 20 may present the non-forward instruction information included in the crowding dispersion instruction information MI.

[0121] This enables the management system 5 to present a message such as "Please stop". In
10 this case as well, the management system 5 can instruct the person HMB who may not be successfully authenticated not to move forward, thereby maintaining the security. In addition, for example, if an instruction to move in a lateral direction (X-axis direction) other than the forward direction is given, the management system 5 may also be capable of dispersing the crowding and detecting, for example, a person who is positioned in the area where the crowded
15 group MG is positioned but is not detected.

[0122] The crowding determination condition may be that if the inside of the path AL is divided into a plurality of sections DR having a predetermined size, the number of persons present in any of the sections DR and traveling in the same direction is equal to or greater than the threshold th1 (an example of a first threshold).

20 [0123] Accordingly, if a plurality of persons traveling in the same direction are positioned in the section DR having a predetermined size in a state of high density, the management system 5 can determine that the crowded group MG is generated and is in the crowding state.

[0124] The section DR may be formed with a position of a fourth person in the path AL as a base point with the adjacent sections DR partially overlapping. The adjacent sections DR may
25 each include the position of the fourth person. The crowding determination condition may be that the number of persons traveling in the same direction as the fourth person present in any section DR is equal to or greater than the threshold th1 including the fourth person.

[0125] Accordingly, the management system 5 can prevent, for example, the fourth person as the base point from being positioned on the boundary of the plurality of sections DR.
30 Therefore, the management system 5 can determine whether the surroundings of the fourth person are in the crowding state with high accuracy.

[0126] The crowding determination condition may be that an inter-person distance d1 between the plurality of persons traveling through the path AL in the same traveling direction

is less than the threshold th2 (an example of a second threshold).

[0127] Accordingly, if a plurality of persons traveling in the same direction are too close, the management system 5 can determine that the crowded group MG is generated and is in the crowding state.

5 [0128] The inter-person distance d1 may include: a first inter-person distance d11 that is a distance between the plurality of persons in the traveling direction (for example, the Y-axis direction); and a second inter-person distance d12 that is a distance between the plurality of persons in a direction (for example, the X-axis direction) perpendicular to the traveling direction on a horizontal plane (for example, the XY plane) of the path AL. The threshold th2 may include
10 the threshold th21 (an example of a third threshold) and the threshold th22 (an example of a fourth threshold) smaller than the threshold th21. The crowding determination condition may be that the first inter-person distance d11 is less than the threshold th21 or the second inter-person distance d12 is less than the threshold th22.

[0129] As a result, if the plurality of persons traveling in the same direction are at a short
15 distance along the traveling direction, the management system 5 can make it more difficult to determine that the persons are crowding than a case where the persons are at a short distance along the direction perpendicular to the traveling direction. In the direction along the traveling direction, for example, persons aligned on the front and rear are more likely to come into physical contact when walking speed. Therefore, the management system 5 sets the threshold
20 th21 to a length in consideration of walking speed, so as to detect the persons with higher probability, and to prevent the determination of crowding at a high frequency while preventing a decrease in security.

[0130] The management device 100 may acquire walking speeds of a plurality of persons who travel through the path AL in the same traveling direction. The management device 100
25 may decrease the threshold th2 as the walking speed is lower, and increase the threshold th2 as the walking speed is higher.

[0131] If the walking speed is high, for example, the inter-person distance between the front and rear persons tends to be longer than in a case where the walking speed is low. Regarding this, the management device 100 sets the threshold th2 to a length in consideration of walking
30 speed, so as to detect the persons with higher probability, and to prevent the determination of crowding at a high frequency while preventing a decrease in security.

[0132] The management device 100 may acquire walking speeds of a plurality of persons who travel through the path AL in the same traveling direction. The management device 100

may decrease the threshold th21 or the threshold th22 as the walking speed is lower, and increase the threshold th21 or the threshold th22 as the walking speed is higher.

[0133] Thereby, the management device 100 sets the threshold th21 or the threshold th22 to a length in consideration of walking speed, so as to detect the persons with higher probability, and to prevent the determination of crowding at a high frequency while preventing a decrease in security.

[0134] The management device 100 may acquire walking speeds of a plurality of persons who travel through the path AL in the same traveling direction. The management device 100 may increase a size of the section DR or increase a length of one side of an outer periphery of the section DR as the walking speed decreases. The management device 100 may decrease the size of the section DR or decrease the length of one side of the outer periphery of the section DR as the walking speed increases.

[0135] As a result, the management device 100 can easily increase the number of detected persons detected in the section DR by increasing the size of the section DR to be subjected to the crowding determination or increasing the length of one side such as the traveling direction of the section DR in consideration of the walking speed. In addition, the management device 100 can easily decrease the number of detected persons detected in the section DR by decreasing the size of the section DR to be subjected to the crowding determination or decreasing the length of one side such as the traveling direction of the section DR in consideration of the walking speed. As a result, the management device 100 can prevent the determination of crowding with a high frequency while preventing a decrease in security.

[0136] The management device 100 of the present embodiment is for determining crowding of persons. The management device 100 includes a processor 110. The processor 110 acquires a captured image in which a plurality of persons passing through the path AL are captured, and determines a traveling direction of each of the plurality of persons based on the captured image. The processor 110 determines that a crowded group in which persons are crowded is generated in the path AL if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

[0137] The persons can travel in various directions in the path AL, but as a result, the management device 100 can determine whether the persons are crowded depending on whether the predetermined crowding determination condition is satisfied for the persons in the same traveling direction. That is, the management device 100 can determine the crowding status of persons in the predetermined region with high accuracy.

[0138] Although various embodiments are described above with reference to the drawings, it is needless to say that the present disclosure is not limited to such examples. It is apparent that those skilled in the art can conceive of various modifications or alterations within the scope described in the claims, and it is understood that such modifications and alterations naturally
 5 fall within the technical scope of the present disclosure. In addition, the constituent elements in the above embodiments may be freely combined without departing from the scope of the disclose.

[0139] The operations, procedures, steps, and stages of each processing performed by a device, system, program, and method illustrated in the claims, embodiments, or diagrams can
 10 be performed in any order as long as the order is not indicated by "prior to", "before", or the like and as long as the output from previous processing is not used in later processing. Even if the operation flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessarily mean that the process must be performed in this order.

[0140] The present application is based on a Japanese patent application filed on March 24, 2023 (Japanese Patent Application No. 2023-048589), and the contents thereof are incorporated
 15 herein by reference.

INDUSTRIAL APPLICABILITY

[0141] The present disclosure is useful for a crowding determination system, a crowding
 20 determination device, a crowding determination method, a program, and the like capable of detecting a crowding status of persons in a predetermined region with high accuracy.

REFERENCE SIGNS LIST

[0142] 5 management system
 10, 10A, 10B camera
 25 20, 20A, 20B display
 30 control PC
 50 gate
 50A first gate
 50B second gate
 30 100 management device
 110 processor
 120 memory
 130 communication device

200 authentication server

AL path

HM, HM1, HM2, HM3, HM4, HM5, HMB, HMF person

MG crowded group

5

MI1, MI11, MI12, MI2, MI3 crowding dispersion instruction information

CLAIMS

[Claim 1]

A crowding determination system for determining crowding of persons, the crowding
5 determination system comprising:

a detection device configured to detect a plurality of persons passing through a path;

and

a crowding determination device configured to determine crowding of the persons,

wherein

10 the crowding determination device

acquires detection information for identifying at least positions of the
plurality of persons detected by the detection device,

determines a traveling direction of each of the plurality of persons based on
the detection information, and

15 determines that a crowded group in which persons are crowded is generated
in the path if a degree of crowding of persons traveling in the same traveling direction satisfies
a predetermined crowding determination condition.

[Claim 2]

20 The crowding determination system according to claim 1, wherein

the crowding determination device determines that the crowded group is not
generated when the traveling directions of the plurality of persons are different.

[Claim 3]

25 The crowding determination system according to claim 1 or 2, wherein

when it is determined that the crowded group is generated, the crowding
determination device outputs crowding dispersion instruction information, which is information
for dispersing crowding of persons, to at least one person among a plurality of persons
belonging to the crowded group.

30 [Claim 4]

The crowding determination system according to claim 3, wherein

the detection device includes an imaging device configured to image the plurality of

persons passing through the path, and

the detection information includes a captured image captured by the imaging device.

[Claim 5]

5 The crowding determination system according to claim 4, further comprising:
 a presentation device installed at a predetermined position of the path and configured
to present information, wherein
 the crowding determination device transmits the crowding dispersion instruction
information to the presentation device, and
10 the presentation device receives and presents the crowding dispersion instruction
information.

[Claim 6]

 The crowding determination system according to claim 5, further comprising:
15 an authentication server configured to authenticate a person, wherein
 the authentication server
 acquires the captured image,
 authenticates a person passing through the path based on first biometric
feature data registered in advance and second biometric feature data of a person obtained from
20 the captured image, and
 transmits an authentication status of the person to the crowding
determination device,
 the crowding determination device
 acquires, and transmits to the presentation device, an authentication status
25 of each of the plurality of persons belonging to the crowded group from the authentication
server, and
 the presentation device
 acquires the authentication status of each of the plurality of persons
belonging to the crowded group, and
30 presents the crowding dispersion instruction information and the
authentication status of each of the plurality of persons belonging to the crowded group.

[Claim 7]

The crowding determination system according to claim 6, wherein
the crowding determination device

transmits, to the presentation device, the crowding dispersion instruction
information for a first person whose authentication status by the authentication server indicates
5 authentication success among persons positioned in front in the traveling direction in the
crowded group, the crowding dispersion instruction information including forward instruction
information instructing the first person to move forward, and

the presentation device

presents the forward instruction information included in the crowding
10 dispersion instruction information.

[Claim 8]

The crowding determination system according to claim 6, wherein
the crowding determination device

15 transmits, to the presentation device, the crowding dispersion instruction
information for a second person whose authentication status by the authentication server does
not indicate authentication success among persons positioned in front in the traveling direction
in the crowded group, the crowding dispersion instruction information including removal
instruction information for removing a shielding object that shields at least a part of a face of
20 the second person from the imaging device, and

the presentation device

presents the removal instruction information included in the crowding
dispersion instruction information.

25 [Claim 9]

The crowding determination system according to claim 6, wherein
the crowding determination device

transmits, to the presentation device, the crowding dispersion instruction
information for a third person who is a person not positioned in front in the traveling direction
30 in the crowded group, the crowding dispersion instruction information including non-forward
instruction information for instructing the third person to move in a direction other than forward
or to stop, and

the presentation device

presents the non-forward instruction information included in the crowding dispersion instruction information.

[Claim 10]

5 The crowding determination system according to claim 1 or 2, wherein
the crowding determination condition is that
when the inside of the path is divided into a plurality of sections in a grid
pattern having a predetermined size, the number of persons present in any of the sections and
traveling in the same direction is equal to or greater than a first threshold.

10

[Claim 11]

 The crowding determination system according to claim 10, wherein
the section is formed with a position of a fourth person in the path as a base point
with adjacent sections partially overlapping,
15 the adjacent sections each include the position of the fourth person, and
the crowding determination condition is that
the number of persons traveling in the same direction as the fourth person
present in any section is equal to or greater than the first threshold including the fourth person.

20 [Claim 12]

 The crowding determination system according to claim 1 or 2, wherein
the crowding determination condition is that
an inter-person distance between the plurality of persons traveling in the
same traveling direction through the path is less than a second threshold.

25

[Claim 13]

 The crowding determination system according to claim 10, wherein
the crowding determination condition is that
an inter-person distance between the plurality of persons traveling in the
30 same traveling direction through the path is less than a second threshold.

[Claim 14]

 The crowding determination system according to claim 12, wherein

the inter-person distance includes:

a first inter-person distance that is a distance between the plurality of persons in the traveling direction, and

5 a second inter-person distance that is a distance between the plurality of persons in a direction perpendicular to the traveling direction on a horizontal plane of the path,

the second threshold includes a third threshold and a fourth threshold smaller than the third threshold, and

the crowding determination condition is that the first inter-person distance is less than the third threshold or the second inter-person distance is less than the fourth threshold.

10

[Claim 15]

The crowding determination system according to claim 12, wherein the crowding determination device

15 acquires walking speeds of the plurality of persons traveling in the same traveling direction in the path,

decreases the second threshold as the walking speed is lower, and

increases the second threshold as the walking speed is higher.

[Claim 16]

20 The crowding determination system according to claim 14, wherein the crowding determination device

acquires walking speeds of the plurality of persons traveling in the same traveling direction in the path,

25 decreases the third threshold or the fourth threshold as the walking speed is lower, and

increases the third threshold or the fourth threshold as the walking speed is higher.

[Claim 17]

30 The crowding determination system according to claim 10, wherein the crowding determination device

acquires walking speeds of the plurality of persons traveling in the same traveling direction in the path,

increases a size of the section or increases a length of one side of an outer periphery of the section as the walking speed is lower, and

decreases the size of the section or decreases the length of one side of the outer periphery of the section as the walking speed is higher.

5

[Claim 18]

A crowding determination device for determining crowding of persons, comprising:

a processor, wherein

the processor

10

acquires detection information in which a plurality of persons passing through a path are detected, the detection information being for identifying at least positions of the plurality of persons,

determines a traveling direction of each of the plurality of persons based on the detection information, and

15

determines that a crowded group in which persons are crowded is generated in the path if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

[Claim 19]

20

A crowding determination method for determining crowding of persons, comprising:

a step of acquiring detection information in which a plurality of persons passing through a path are detected, the detection information being for identifying at least positions of the plurality of persons;

a step of determining a traveling direction of each of the plurality of persons based on the detection information; and

25

a step of determining that a crowded group in which persons are crowded is generated in the path if a degree of crowding of persons traveling in the same traveling direction satisfies a predetermined crowding determination condition.

30 [Claim 20]

A program for causing a computer to execute each step of the crowding determination method according to claim 19.