

ELEVATOR BOARDING DETECTION SYSTEM

FIELD

Embodiments described herein relate generally to an elevator boarding detection system of detecting a
5 passenger getting into a car.

BACKGROUND

Generally, when an elevator car arrives at a hall and the door opens, the door closes and the car departs after a predetermined time has elapsed. In this case,
10 a passenger in a hall does not know when the car door closes. For this reason, when the passenger in the hall gets into the car, the passenger may be struck by the door or caught in the door while the door is closing.

15 A technique of detecting the passenger moving from the hall to the car by a camera and reflecting a detection result on the door open/close control to prevent the passenger from colliding with the door or being caught in the door at the riding time, has been
20 developed.

In some situations, however, the passenger cannot be detected accurately from captured images of the camera if, for example, the hall is extremely dark or bright. In such a case, accuracy of detecting the
25 passenger with the camera may be lowered and an operation error may occur at the door. For example, when the hall is extremely bright, a shadow of a person moving across the hall may be reflected on the captured image and erroneously detected as a passenger, and the
30 car may await with the door opening. In contrast, when the hall is extremely dark and the passenger cannot be discriminated from the floor surface, the door may close in a predetermined time even if the passenger willing to get into the car approaches the car.

SUMMARY

According to one embodiment, an elevator boarding detection system includes: a capturing module capable of capturing, when a car arrives at a hall, a
5 predetermined range from a vicinity to a door of the car to a direction of the hall; a passenger detector detecting a passenger by using an image captured by the capturing module; a controller controlling an
10 open/close operation of the door, based on a detection result of the passenger detector; a parameter acquisition module acquiring a parameter of brightness adjustment from the capturing module; and an operation error prevention module determining brightness of the
15 captured image used by the passenger detector, based on the parameter acquired by the parameter acquisition module, and performing processing of preventing an operation error of the passenger detector in accordance with the determination result.

BRIEF DESCRIPTION OF THE DRAWINGS

20 FIG. 1 is a diagram showing a configuration of a boarding detection system of an elevator according to First Embodiment.

FIG. 2 is an illustration showing an example of an image captured by a camera according to the embodiment.

25 FIG. 3 is an illustration showing a state of the captured image divided in units of blocks according to the embodiment.

FIG. 4 is a graph for explanation of a detection area in real space according to the embodiment.

30 FIG. 5 is an illustration for explanation of a coordinate system in the real space according to the embodiment.

FIG. 6 is a flowchart showing passenger detection processing during the door opening in the boarding
35 detection system according to the embodiment.

FIG. 7 is a flowchart showing a passenger detection operation during the door closing in the boarding detection system according to the embodiment.

5 FIG. 8 is an illustration showing an example of an image captured when a hall is extremely dark, according to the embodiment.

FIG. 9 is an illustration showing an example of an image captured when the hall is extremely bright, according to the embodiment.

10 FIG. 10 is a flowchart showing operation error prevention processing in the boarding detection system according to the embodiment.

FIG. 11 is an illustration showing an example of an image captured when a hall is partially extremely bright/dark, according to Second Embodiment.

FIG. 12 is a flowchart showing operation error prevention processing in the boarding detection system according to the embodiment.

DETAILED DESCRIPTION

20 Embodiments will be hereinafter explained with reference to the accompanying drawings.

(First Embodiment)

FIG. 1 is a diagram showing a configuration of a boarding detection system of an elevator according to First Embodiment. One car is explained as an example, but the system configuration is the same even if a plurality of cars are installed.

A camera 12 is installed at an upper part of a doorway of a car 11. More specifically, the camera 12 is installed in a modesty panel 11a covering the upper part of the doorway of the car 11 while a lens portion of the camera 12 is directed toward the hall 15 side. The camera 12 is, for example, a small monitoring camera such as an in-vehicle camera. The camera 12 includes a wide-angle lens, and is capable of

continuously capturing images at the rate of several frames per second (for example, 30 frames/sec). When the car 11 arrives at each floor and the door opens, the camera 12 captures a state of the hall 15 including a state around a car door 13 inside the car 11.

At this time, a capturing range is adjusted to $L1+L2$ ($L1 \gg L2$). $L1$ denotes a capturing range on the hall side and is, for example, 3 m from the car door 13 to the hall 15. $L2$ denotes a capturing range on the car side, and is, for example, 50 cm from the car door 13 to the back surface of the car. Each of $L1$ and $L2$ is the range in the depth direction, and the range in a width direction (i.e., a direction orthogonal to the depth direction) is assumed to be larger than at least the width of the car 11.

A hall door 14 is installed to be freely opened and closed at an arrival position of the car 11, in the hall 15 of each floor. The hall door 14 performs opening and closing operations while engaging with the car door 13 when the car 11 arrives. A power source (door motor) is installed on the car 11 side, and the hall door 14 only opens and closes in accordance with the car door 13. In the following explanations, it is assumed that when the car door 13 is open the hall door 14 is also open, and that when the car door 13 is closed the hall door 14 is also closed.

Each image (video) captured by the camera 12 is analyzed in real time by an image processor 20. The image processor 20 is taken out from the car 11 in FIG. 1 for the sake of convenience but, in reality, the image processor 20 is accommodated within the modesty panel 11a together with the camera 12.

The image processor 20 is provided with a storage 21 and a passenger detector 22. The storage 21 includes a buffer area for sequentially storing the

images captured by the camera 12 and temporarily holding data necessary for processing of the passenger detector 22. The passenger detector 22 detects the presence or absence of a passenger having an intention
5 of getting into the car by focusing attention on the motion of a person or object closest to the car door 13, of a plurality of time-series continuous images captured by the camera 12. The passenger detector 22 is functionally composed of a motion detector 22a, a
10 position estimator 22b, and a boarding intention estimator 22c.

The motion detector 22a detects the motion of a person or object by comparing the luminance of the respective images in units of blocks. The "motion of a
15 person or object" refers to the motion of a moving body such as a person or a wheelchair in the hall 15.

The position estimator 22b extracts a block closest to the car door 13 from among blocks representing the motion detected for each of the images
20 by the motion detector 22a. Then, the position estimation module 22b estimates a coordinate position (Y-coordinate shown in FIG. 5) in the hall direction from the center of the car door 13 (i.e., the center of the door width) in the block, as the passenger position
25 (foot position). The boarding intention estimator 22c determines the passenger's intention of getting into the car, based on a time-series change in the position estimated by the position estimator 22b.

The image processor 20 according to the present
30 embodiment comprises not only the above-explained constituent elements, but also a parameter acquisition module 23 and an operation error prevention module 24.

The parameter acquisition module 23 acquires parameters of the brightness adjustment from the camera
35 12. The "parameters of the brightness adjustment"

specifically indicate an exposure time, gain, quantity of aperture, and the like. These parameters are automatically adjusted to optimum values in accordance with the brightness at the capturing time.

5 The operation error prevention module 24 determines the brightness of the captured image used by the passenger detector 22, based on the parameters acquired by the parameter acquisition module 23, and performs processing of preventing an operation error of
10 the passenger detector 22 in response to the determination result. More specifically, the operation error prevention module 24 calculates an index value LU indicating the brightness of the captured image, with at least one of the exposure time, the gain, and the
15 quantity of aperture acquired as the parameters of the brightness adjustment. If the index value LU is higher than a preset upper limit value THa or lower than a lower limit value THb, the operation error prevention module 24 performs processing of preventing the
20 operation error.

 Several or all of the functions (passenger detector 22, parameter acquisition module 23, and operation error prevention module 24) provided in the image processor 20 may be provided in the camera 12 or
25 the car controller 30.

 The car controller 30 is connected to an elevator controller (not shown), and transmits and receives various signals such as a hall call and a car call to and from the elevator controller. The "hall call"
30 corresponds to a signal of a call to be registered by operating a hall call button (not shown) provided in the hall 15 of each floor, and includes information on a registered floor and a destination direction. The "car call" corresponds to a signal of a call to be
35 registered by operating a destination call button (not

shown) provided inside the car 11, and includes information on a destination floor.

5 In addition, the car controller 30 comprises a door open/close controller 31. The door open/close controller 31 controls opening and closing of the car door 13 when the car 11 arrives at the hall 15. More specifically, the door open/close controller 31 opens the car door 13 when the car 11 arrives at the hall 15, and closes the door after a predetermined time elapses. 10 However, if a person having an intention to get into the car is detected by the passenger detector 22 of the image processor 20 while the car door 13 is open, the door open/close controller 31 prohibits the door close operation of the car door 13 and maintains the door-opened state. 15

FIG. 2 is an illustration showing an example of an image captured by the camera 12. In the figure, E1 represents a position estimation area, and yn represents a Y-coordinate of the detected position of the passenger's foot. FIG. 3 is an illustration 20 showing a state of the captured image divided in units of blocks according to the embodiment. A "block" is defined as a piece having a length Wblock on each side, which is obtained by dividing the original image in a lattice shape. 25

The camera 12 is installed at the upper part of the doorway of the car 11. Accordingly, when the door of the car 11 opens at the hall 15, a predetermined range (L1) on the hall side and a predetermined range (L2) inside the car are captured. A detection range 30 can be widened by using the camera 12, and even a passenger located at a place some distance away from the car 11 can be detected. In contrast, however, a person who has just passed through the hall 15 (i.e., a person who does not get into the car 11) may be 35

erroneously detected, and the car door 13 may be opened.

Hence, the present system is configured to divide an image captured by the camera 12 into blocks of a
5 certain size, as shown in FIG. 3, detect a block representing motion of a person or object, and determine whether a passenger having an intention of getting into the car exists or not by tracking the blocks where the motion is represented.

10 In the example of FIG. 3, lateral and longitudinal lengths of one block are the same as each other, but the lateral and longitudinal lengths may be different from each other. In addition, the blocks may be designed to have an equal size throughout the entire
15 image area or may be designed to have unequal sizes by, for example, gradually reducing the longitudinal (Y-direction) length toward the upper part of the image. Thus, the foot position which is to be estimated later can be obtained at a higher resolution, or at an equal
20 resolution in real space. (If the image is divided equally, the resolution becomes lower as the block is farther from the car door 13 in real space).

FIG. 4 is a graph for explanation of a detection area in real space. FIG. 5 is an illustration for
25 explanation of a coordinate system in real space.

To detect the motion of a passenger having an intention of getting into the car from the captured image, a passenger detection area is first preset for each block. More specifically, at least a position
30 estimation area E1 and a boarding intention estimation area E2 are preset as the passenger detection areas as shown in FIG. 4.

The position estimation area E1 is an area for estimating a part of a body of the passenger moving
35 from the hall 15 to the car door 13, more specifically,

the passenger's foot position. The intention estimation area E2 is an area for estimating whether the passenger detected in the position estimation area E1 has an intention of getting into the car or not.

5 The boarding intention estimation area E2 is included in the position estimation area E1, and is also an area for estimating the passenger's foot position. That is, not only the passenger's foot position, but the passenger's intention of getting into the car are
10 estimated in the intention estimation area E2.

In real space, the position estimation area E1 has a length L3 from the center of the car door 13 toward the direction of the hall and the length is set to, for example, 2 m ($L3 \leq \text{capturing range } L1$ on the hall side).
15 Width W1 of the position estimation area E1 is set to a length greater than or equal to width W0 of the car door 13. The boarding intention estimation area E2 has a length L4 from the center of the car door 13 toward the direction of the hall, and the length is set to,
20 for example, 1 m ($L4 \leq L3$). Width W2 of the boarding intention estimation area E2 is set to be substantially the same length as the width W0 of the car door 13.

The width W2 of the boarding intention estimation area E2 may be equal to or somewhat greater than the width W0. In addition, the position estimation area E1
25 and the boarding intention estimation area E2 may not be rectangular areas represented by dotted lines in the figure in the real space, but may be trapezoidal areas excluding blind spots on both sides of a three-side
30 frame (jamb) installed on the hall side.

The passenger detection area may be divided into smaller blocks and an approach detection area E3 may be set in front of the car door 13.

The approach detection area E3 is an area where

the passenger's foot position is estimated, and the passenger is considered to have an intention of getting into the car irrespective of whether the passenger's foot position is approaching the car door 13 from the hall 15 or not. The approach detection area E3 has a length L5 from the center of the car door 13 to the direction of the hall, and the length is set to, for example, 30 cm ($L5 \leq L4$). The width of the approach detection area E3 is set to be the same as the width W2 of the intention estimation area E2.

A relationship between each of the passenger detection areas (E1, E2, and E3) and the door open/close control performed by the car controller 30 is as follows.

The position estimation area E1 is an area where even if the passenger is detected in this area, the detection result is not reflected on the door open/close control processing performed by the car controller 30.

The boarding intention estimation area E2 is an area where if the passenger is detected in this area and the passenger has an intention of getting into the car, the detection result is reflected on the door open/close control processing performed by the car controller 30. More specifically, processing such as extending the door open time or the like is performed by the car controller 30.

The approach detection area E3 is an area where the passenger is merely detected in this area, and the detection result is reflected on the door open/close control processing performed by the car controller 30. More specifically, processing such as extending the door open time or the like is performed by the car controller 30.

As shown in FIG. 5, the camera 12 captures an image in which a direction horizontal to the car door 13 provided at the doorway of the car 11 is assumed as the X-axis, a direction from the center of the car door 13 to the hall 15 (i.e., the direction perpendicular to the car door 13) is assumed as the Y-axis, and a direction of the height of the car 11 is assumed as the Z-axis. The motion of the foot position of the passenger who is traveling in the direction from the center of the car door 13 to the hall 15, i.e., the Y-axis direction, is detected by comparing the parts of the position estimation area E1 and the boarding intention estimation area E2 shown in FIG. 4 in units of blocks, in each of the images captured by the camera 12.

Next, the operations of the present system will be described in detail.

(Passenger Detection Processing during the door opening)

FIG. 6 is a flowchart showing passenger detection processing during opening of the door in the present system.

When the car 11 arrives at the hall 15 of an arbitrary floor (Yes in step S11), the car controller 30 opens the door of the car door 13 and awaits the passenger who will get into the car 11 (step S12).

At this time, the predetermined range (L1) on the hall side and the predetermined range (L2) inside the car are captured at a predetermined frame rate (for example, 30 frames/sec), by the camera 12 installed at the upper part of the doorway of the car 11. The image processor 20 acquires images captured by the camera 12 on a time-series basis and performs, while sequentially storing these images in the storage 21 (step S13), the passenger detection processing as described below in

real time (step S14).

The passenger detection processing is performed by the passenger detector 22 provided in the image processor 20. The passenger detection processing is
5 divided into motion detection processing (step S14a), position estimation processing (step S14b), and intention estimation processing (step S14c).

(a) Motion Detection Processing

The motion detection processing is performed by
10 the motion detector 22a which is one of the constituent elements of the passenger detector 22.

The motion detector 22a reads the images stored in the storage 21 one by one and calculates an average luminance value for each block. At this time, the
15 motion detector 22a is assumed to hold the average luminance value of each block calculated when the first image is input as the initial value, in a first buffer area (not shown) in the storage 21. When a second image and the following images are obtained, the motion
20 detector 22a compares the average luminance value of each block of a current image with the average luminance value of each block of a previous image held in the first buffer area. As a result, when a block having a brightness difference greater than or equal to
25 a preset value exists in the current image, the motion detector 22a determines this block as a block representing motion.

When the presence or absence of the motion for the current image is determined, the motion detector 22a
30 holds the average luminance value for each block of this image, in the first buffer area, as a luminance value for comparison with the next image. After this, similarly, the motion detector 22a repeats determining the presence or absence of the motion while comparing
35 the luminance values of the respective images captured

by the camera 12 on a time-series basis in units of blocks.

(b) Position estimation processing

5 The position estimation processing is performed by the position estimator 22b which is one of the constituent elements of the passenger detector 22.

10 The position estimator 22b checks a block representing the motion in the current image, based on the detection result of the motion detector 22a. As a result, when blocks representing the motion exist in the position estimation area E1 shown in FIG. 4, the passenger detector 22 extracts a block which is closest to the car door 13, of the blocks representing the motion.

15 As shown in FIG. 1, the camera 12 is installed at the upper part of the doorway of the car 11 to face the hall 15. Accordingly, when the passenger is moving from the hall 15 toward the car door 13, it is highly possible that a part of the passenger's right or left
20 foot will be reflected on the block on the front side, i.e., the block on the car door 13 side of the captured image. Hence, the position estimator 22b obtains the Y-coordinate (i.e., the coordinate from the center of the car door 13 in the direction of the hall 15) of the
25 block representing the motion which is the closest to the car door 13 as data of the passenger's foot position, and holds the data in a second buffer area (not shown) in the storage 21.

30 After this, similarly, the position estimator 22b obtains the Y-coordinate of the block representing the motion which is the closest to the car door 13 for each image, as the data on the passenger's foot position, and holds the data in the second buffer area (not shown) in the storage 21. Such foot position
35 estimation processing is performed in not only the

position estimation area E1, but also the boarding intention estimation area E2.

(c) Boarding intention estimation processing

5 The boarding intention estimation processing is performed by the boarding intention estimator 22c which is one of the constituent elements of the passenger detector 22.

10 The boarding intention estimator 22c urges the data on the passenger's foot position of each of the images held in the second buffer area to be smoothed. For example, a generally known method such as an average value filter or a Kalman filter is used as the smoothing method, and its detailed explanations are omitted.

15 When the data on the foot position is smoothed and data whose variation amount is greater than or equal to a predetermined value exists, the boarding intention estimator 22c excludes such data as an outlier. The predetermined value is determined based on the
20 passenger's normal walking speed and the frame rate of the captured image. In addition, an outlier may be found and excluded before smoothing the data on the foot position.

25 When the passenger is walking from the hall toward the car door 13, the Y-coordinate value of the passenger's foot position is gradually decreased as the time elapses. Motion of a moving body such a wheelchair indicates linear data variation as represented by a dotted line but, motion of a passenger
30 indicates curved data variation represented by a solid line since the passenger's right and left feet are detected alternately. In addition, if some noise enters the detection result, an instantaneous variation in the foot position becomes large. Data on the foot
35 position having such a large variation is excluded as

an outlier.

The boarding intention estimator 22c confirms the motion (data variation) of the foot position in the boarding intention estimation area E2 shown in FIG. 2.

5 As a result, if the boarding intention estimation module 22c successfully confirms the motion (data variation) of the foot position of the passenger moving toward the car door 13 in the Y-axis direction in the boarding intention estimation area E2, the boarding
10 intention estimation module 22c determines that the passenger has an intention of getting into the car.

In contrast, if the boarding intention estimation module 22c cannot confirm the motion of the foot position of the passenger moving toward the car door 13
15 in the Y-axis direction in the boarding intention estimation area E2, the boarding intention estimation module 22c determines that the passenger has no intention of getting into the car. For example, if a person walks across the front side of the car 11 in the
20 X-axis direction, a foot position which does not change in time in the Y-axis direction in the boarding intention estimation area E2 is detected. In such a case, the person is determined to have no intention of getting into the car.

25 Thus, the passenger's intention of getting into the car can be estimated by assuming the block representing the motion which is the closest to the car door 13 as the passenger's foot position and tracking the temporal variation of the foot position in the Y-axis direction.
30

If the passenger having an intention of getting into the car is detected (Yes in step S15), a passenger detection signal is output from the image processor 20 to the car controller 30. The car controller 30
35 prohibits the door close operation of the car door 13

and maintains the door-opened state by receiving the passenger detection signal (step S16).

More specifically, when the car door 13 is in a fully door-opened state, the car controller 30 starts
5 an operation of counting an door-opened time, and closes the door when counting a predetermined time T (for example, one minute). If a passenger having an intention of getting into the car is detected during this time and the passenger detection signal is sent,
10 the car controller 30 stops the counting operation and clears the count value. The door-opened state of the car door 13 is thereby maintained for the above time T.

If a new passenger having an intention of getting into the car is detected during this time, the count
15 value is cleared again and the door-opened state of the car door 13 is maintained for the above time T. However, a situation that the car door 13 cannot be closed continues for a long time if passengers arrive many times during the above time T and, therefore,
20 preferably, an allowance time Tx (for example, three minutes) is preset and the car door 13 is closed compulsorily when the allowance time Tx has elapsed.

When the counting operation for the above time T is ended (step S17), the car controller 30 closes the
25 car door 13 and urges the car 11 to depart for a destination floor (step S18).

In a case where the approach detection area E3 shown in FIG. 4 is set, if the boarding intention estimator 22c confirms the passenger's foot position in
30 the approach detection area E3, the boarding intention estimator 22c assumes that the passenger has an intention of getting into the car irrespective of whether the passenger's foot position is approaching the car door 13 from the hall 15 or not.

35 By thus analyzing an image of the hall 15 captured

by the camera 12 installed at the upper part of the doorway of the car 11, for example, a passenger moving toward the car door 13 from a place some distance away from the car 11 can be detected and the detection can
5 be reflected on the door open/close operation.

In particular, by focusing attention to the passenger's foot position in the captured image and tracking the variation in time of the foot position in the direction from the car door 13 to the hall 15
10 (i.e., the Y-axis direction), for example, a person who has just passed near the car can be prevented without a detection error. The only passenger having an intention of getting into the car can be detected correctly and the detection result can be reflected on
15 the door open/close operation. In this case, the door-opened state is maintained while the passenger having an intention of getting into the car is detected. Therefore, when the passenger is getting into the car 11, a situation in which the door close operation is
20 started and the passenger is struck by the door can be avoided.

(Passenger Detection Processing during the door closing)

In the flowchart shown in FIG. 6, a situation in which the car door 13 of the car 11 is open in the hall
25 15 is assumed but, even when the car door 13 is closed (or is closing), presence or absence of a passenger having an intention of getting into the car is detected by using the images captured by the camera 12. When a
30 passenger having an intention of getting into the car is detected, the door close operation of the car door 13 is suspended by the door open/close controller 31 of the car controller 30 and the door open operation is performed again.

FIG. 7 is a flowchart showing a passenger

detection operation during the door closing in the present system.

When a predetermined time elapses in a state in which the car door 13 of the car 11 is fully open, the door close operation is started by the door open/close controller 31 (step S21). At this time, the image capturing operation of the camera 12 is continuously performed. The image processor 20 acquires images captured by the camera 12 on a time-series basis and performs, while sequentially storing these images in the storage 21 (step S22), the passenger detection processing in real time (step S23).

The passenger detection processing is performed by the passenger detector 22 provided in the image processor 20. The passenger detection processing is divided into motion detection processing (step S23a), position estimation processing (step S23b), and boarding intention estimation processing (step S23c). Since these processing steps are similar to steps S14a, S14b, and S14c of FIG. 6, their detailed descriptions are omitted.

If the passenger having an intention of getting into the car is detected (Yes in step S24), a passenger detection signal is output from the image processor 20 to the car controller 30. When the car controller 30 receives the passenger detection signal during the door closing, the car controller 30 suspends the door close operation of the car door 13 and performs the door open operation again (i.e., reopening the door) (step S25).

After that, the same processing steps as the above are repeated. However, if a passenger having an intention of getting into the car is continuously detected during the door closing, reopening is repeated and departure of the car 11 is delayed. Accordingly, if the above-mentioned allowance time T_x (for example,

three minutes) has passed even in a case where a passenger having an intention of getting into the car is detected, the door should preferably close without reopening.

5 If the approach detection area shown in FIG. 4 is set, the following processing is performed.

 If the boarding intention estimator 22c confirms the passenger's foot position in the approach detection area E3, the boarding intention estimator 22c assumes
10 that the passenger has an intention of getting into the car irrespective of whether the passenger's foot position is approaching the car door 13 from the hall
15 or not.

 Thus, presence or absence of a passenger having an
15 intention of getting into the car is detected even when the door is closing, and the detection result can be reflected on the door open/close operation.
Accordingly, a situation in which the passenger who is getting into the car 11 is struck by the door when the
20 door is closing, can be avoided.

 (Passenger Detection Operation during door fully closing or opening: caught-by-door pocket detection)

 When the car door 13 is fully closed or the car door 13 is opening, the passenger detection area is set
25 on the car 11 side. Though not illustrated in the figure, the passenger detection area on the car 11 side has a predetermined length (L6) from the center of the car door 13 toward the direction of the car 15 and the length is set to, for example, 30 cm ($L6 \leq$ capturing
30 range L2 on the car 11 side). The width of the car door 13 is substantially the same as the width W0.

 The passenger detection area on the car 11 side is used as a "caught-by-door pocket detection area" and, if the passenger is detected in this area, the

detection result is reflected on the door open/close control processing performed by the car controller 30. More specifically, processing such as prohibiting an operation of opening the car door 13 by the car
5 controller 30, reducing a speed of opening the car door 13, and notifying a passenger of a message that the passenger should step back from the car door 13, and the like, is performed.

(Operation error prevention processing)

10 Since the present system is configured to detect a passenger with the images captured by the camera 12, a passenger detection accuracy depends on the states of the captured images. For example, if the hall 15 is extremely dark as shown in FIG. 8 or if the hall 15 is
15 extremely bright such that a passenger's shadow and the like are vividly reflected on the image as shown in FIG. 9, the passenger cannot be detected correctly from the captured image and an operation error will occur. The same situation will also occur if the inside of the
20 car 11 is extremely dark or extremely bright. Thus, in the present system, an operation error is prevented by temporarily suspending the detection processing (sensing), prohibiting output of the detection result, or reducing the sensitivity of the detection processing
25 if the image captured by the camera 12 is extremely dark or extremely bright.

FIG. 10 is a flowchart showing operation error prevention processing in the present system. The operation error prevention processing is performed
30 after acquisition of the captured image in step S13, in the flowchart of FIG. 6, and after acquisition of the captured image in step S22, in the flowchart of FIG. 7.

First, as a precondition, the camera 12 is assumed to comprise a function of automatically adjusting at
35 least one of the exposure time, the gain, and the

quantity of aperture as a function of capturing an image in predetermined brightness. A device outside the camera may be equipped with the automatic adjustment function.

5 * Quantity of aperture: generally called "aperture". The quantity of aperture is smaller as the aperture value is larger. The aperture is represented as "quantity of aperture" and, a more quantity of light is taken in, i.e., the image is reflected more brightly
10 as the value is larger. In addition, as the value of the quantity of aperture is doubled, the quantity of light taken is assumed to be doubled to simplify explanations.

 In general, since the quantity of light taken is
15 reduced to 1/2 every time the "aperture" value is multiplied by 1.4, the quantity of aperture $=1/\text{aperture}^2$ is used when the value is obtained actually. No unit represents the quantity of aperture (no unit represents the aperture either, but the
20 aperture is called an F value for convenience). The range is, for example, from 1/4 to 1/64 (aperture ranges from 2 to 8).

 * Exposure time: also called a shutter speed. The unit is the second. The range is, for example, from
25 1/1000 to 1/30.

 * Gain: represents a multiple of the input signal. No unit represents the gain (magnification). The range is, for example, from 1 to 30.

 The brightness of the image captured by the camera
30 12 is quantified here. This is called "brightness index value". The brightness of the captured image has the following relationship of proportion as the principle of camera.

Luminance value $\propto$ (physical) quantity of light $\times$
quantity of aperture $\times$ exposure time $\times$ gain

If the quantity of light is regarded as
brightness, a brightness index value can be obtained in
5 the following expression (1).

Brightness index value = luminance value /
(quantity of aperture $\times$ exposure time $\times$ gain) ... (1)

The parameter acquisition module 23 provided in
the image processor 20 acquires automatically adjusted
10 values of the exposure time, the gain, and the quantity
of aperture, as parameters of the brightness adjustment
from the camera 12 (step S31).

The operation error prevention module 24
calculates an index value LU indicating the brightness
15 of the captured image used by the passenger detector
22, based on the parameters acquired by the parameter
acquisition module 23 (step S32). The "brightness of
captured image" specifically indicates the brightness
of the capturing range represented as L1+L2 in FIG. 1.

20 In the present embodiment, it is assumed that the
camera 12 can automatically adjust the exposure time
and the gain, and the quantity of aperture is fixed.
In addition, if the luminance value of the expression
(1) is set to be constant, the operation error
25 prevention module 24 obtains the brightness index value
LU in the following manner.

$$LU = 1 / (\text{exposure time} \times \text{gain})$$

The operation error prevention module 24 compares
the brightness index value LU with the preset upper
30 limit value THa and lower limit value THb of brightness
(step S33). THa>THb and, for example, THa=300 and
THb=3.

If $LU > THa$ or $LU < THb$, i.e., if the captured image
is extremely bright or dark as a whole (Yes in step

S33), the operation error prevention module 24 determines that the passenger cannot be detected correctly from the captured image, and performs specific processing of preventing the operation error of the passenger detector 22 (step S34). More specifically, the operation error prevention module 24 performs any one of temporarily suspending the detection processing of the passenger detector 22, prohibiting the output of the detection result, and reducing the sensitivity of the detection processing.

"Temporarily suspending the detection processing" is not to perform the passenger detection (sensing). In other words, the passenger detection processing (steps S14 to S15 in FIG. 6 / steps S23 to S24 in FIG. 7) is not performed as regards the captured image. In this case, since the detection result is not reflected on the door open/close control, the general door open/close control is performed.

"Prohibiting the output of the detection result" is to perform the passenger detection but to prohibit the detection result from being output to the car controller 30 as an invalidated detection result. In this case, too, since the detection result is not reflected on the door open/close control, the general door open/close control is performed.

"Reducing the sensitivity of the detection processing" is to reduce the accuracy of passenger detection. More specifically, in the motion detection processing explained in step S14a in FIG. 6, a detection rate of the block representing motion is lowered by increasing threshold values of luminance differences obtained from comparison among luminance values of the captured images continuous in time, in units of blocks, as compared with a threshold value at a general time.

In the case where $LU > THa$ or $LU < THb$, the sensitivity of detection processing of the captured image may be lowered step by step in accordance with the value of LU at this time (i.e., the sensitivity to the captured image is lowered as the value of LU is farther from THa or THb).

Thus, according to the First Embodiment, an operation error of the passenger detection in a case where the captured image is extremely bright or extremely dark can be prevented in the system of detecting the passenger with the image captured by the camera 12. The passenger's motion can be thereby reflected on the door open/close control only when the passenger can be detected correctly.

(Modified Example)

The brightness index value LU may be calculated in the following manner as a modified example of the First Embodiment.

(1) When the average luminance value is used

It is assumed that the exposure time and the gain can be acquired from the camera 12. The operation error prevention module 24 obtains the average luminance value of the whole captured image or the area to be used for detection and obtains the brightness index value LU in the following manner.

$$LU = \text{average luminance value} / (\text{exposure time} \times \text{gain})$$

(2) Method using three elements, i.e., exposure time, gain, and quantity of aperture

It is assumed that the exposure time, the gain, and the quantity of aperture can be acquired from the camera 12. The operation error prevention module 24 obtains the brightness index value LU in the following manner using these values.

$$LU = 1 / (\text{exposure time} \times \text{gain} \times \text{quantity of aperture})$$

(3) Combination of values to be used

5 The operation error prevention module 24 obtains the brightness index value LU in the following manner, using a combination of the exposure time, the gain, the quantity of aperture, and the average luminance.

* When the exposure time, the gain, the quantity of aperture, and the average luminance are used

10
$$LU = \text{average luminance value} / (\text{exposure time} \times \text{gain} \times \text{quantity of aperture})$$

* If exposure time is used (i.e., the gain and the quantity of aperture are fixed)

$$LU = 1 / \text{exposure time}$$

15 * If the gain is used (i.e., the exposure time and the quantity of aperture are fixed)

$$LU = 1 / \text{gain}$$

20 When the brightness index value LU is obtained in the manner as explained above, an operation error of the passenger detection in a case where the captured image is extremely bright or extremely dark can also be prevented similarly to the First Embodiment.

(Second Embodiment)

Next, Second Embodiment will be explained.

25 In the above-explained First Embodiment, the operation error prevention processing is performed based on the brightness of the whole captured image of the camera 12. In the Second Embodiment, an extremely bright part or extremely dark part in a captured image is detected and the operation error prevention
30 processing is performed for this part.

As shown in FIG. 11, a partially bright place or dark place may appear due to illumination light, natural light, and the like. As explained with

reference to FIG. 3, in the present system, the image captured by the camera 12 is divided into blocks each having a predetermined size, the block representing the motion of a person or an object is detected, and it is
5 determined whether the person or the object is a passenger having an intention of riding into the car or not, by tracking the block representing the motion. Then, a brightness index value LU_i (i is the block number) is calculated for each block, and the operation
10 error preventing processing is performed for a part in which the value is higher than the upper limit value TH_a or a part in which the value is lower than the lower limit value TH_b .

The specific processing operation will be
15 explained below.

FIG. 12 is a flowchart showing the operation error prevention processing according to the Second Embodiment. The operation error prevention processing is performed after acquisition of the captured image in
20 step S13, in the flowchart of FIG. 6, and after acquisition of the captured image in step S22, in the flowchart of FIG. 7.

The camera 12 is assumed to comprise a function of automatically adjusting at least one of the exposure
25 time, the gain, and the quantity of aperture as a function of capturing an image in predetermined brightness, similarly to the above-explained First Embodiment. A device outside the camera may be equipped with the automatic adjustment function.

30 A parameter acquisition module 23 provided in an image processor 20 acquires automatically adjusted values of the exposure time, the gain, and the quantity of aperture from the camera 12, as parameters of the brightness adjustment (step S41).

35 In the Second Embodiment, an operation error

prevention module 24 divides the captured images used by the passenger detector 22 into blocks each having a predetermined size (step S42), and performs the following processing for each of the blocks.

5 Processing in steps S43 to S46 surrounded by a dotted line in the flowchart is performed in each block.

First, the operation error prevention module 24 obtains the luminance value of each block (step S43). In this case, the operation error prevention module 24
10 obtains a value obtained by averaging the luminance values of respective pixels belonging to the block, in each block, as the luminance value of the block.

Next, the operation error prevention module 24 obtains the brightness index value L_{Ui} in units of
15 blocks, in the following manner using the luminance value obtained for each block (step S44).

$$L_{Ui} = \text{luminance value of block } i / (\text{exposure time} \times \text{gain})$$

It is assumed that the camera 12 can automatically
20 adjust the exposure time and the gain and that the quantity of aperture is fixed. In this example, i denotes the block number.

The operation error prevention module 24 compares the brightness index value L_{Ui} in units of blocks with
25 the preset upper limit value TH_a and lower limit value TH_b of brightness (step S44). $TH_a > TH_b$ and, for example, $TH_a = 300$ and $TH_b = 3$.

If $L_{Ui} > TH_a$ or $L_{Ui} < TH_b$, i.e., if the part
30 corresponding to the block of the capturing range is extremely bright or dark (Yes in step S45), the operation error prevention module 24 determines that the passenger cannot be detected correctly from the captured image, and performs specific processing of preventing the operation error of the passenger

detector 22 (step S46). More specifically, the operation error prevention module 24 performs any one of temporarily suspending the detection processing of the passenger detector 22 for the block, prohibiting
5 the output of the detection result for the block, and reducing the sensitivity of the detection processing for the block.

"Temporarily suspending the detection processing of the block" is to perform no passenger detection
10 (sensing) for the extremely bright part or extremely dark part in the captured image. In other words, the passenger detection processing (steps S14 to S15 in FIG. 6 / steps S23 to S25 in FIG. 7) is not performed for the extremely bright part or extremely dark art in
15 the captured image. In this case, if the passenger is detected at the other part, the detection result is output to the car controller 30 and reflected on the door open/close control.

"Prohibiting the output of the detection result
20 for the block" is to perform the passenger detection for the extremely bright part or extremely dark part in the captured image but to prohibit the detection result from being output to the car controller 30 as an invalidated detection result. In this case, if the
25 passenger is detected at the other part in the captured image, the detection result is output to the car controller 30 and reflected on the door open/close control.

"Reducing the sensitivity of the detection
30 processing" is to reduce the accuracy of passenger detection. More specifically, in the motion detection processing explained in step S14a in FIG. 6, a detection rate of the block representing motion to the extremely bright part or extremely dark part is lowered
35 by raising threshold values of luminance differences

obtained from comparison among luminance values of the captured images continuous in time, in units of blocks, as compared with a threshold value at a general time.

In the case where $L_{Ui} > THa$ or $L_{Ui} < THb$, the sensitivity of detection processing of the block may be lowered step by step in accordance with the value of L_{Ui} at this time (i.e., the sensitivity to the block is lowered as the value of L_{Ui} is farther from THa or THb).

Thus, according to the Second Embodiment, an operation error of passenger detection for the extremely bright part or extremely dark part in the capturing range in the hall 15 or the car 11 can be prevented, and the passenger's motion can be reflected on the door open/close control only when the passenger can be detected correctly at the other part. Thus, for example, if the hall 15 side is entirely dark and the inside of the car 11 is moderately bright, operations of performing sensing at the hall 15 and not performing sensing inside the car 11 can be selectively performed.

(Modified Example)

The brightness index value L_{Ui} in units of blocks may be calculated in the following manner as a modified example of the Second Embodiment.

(1) Method using three elements, i.e., exposure time, gain, and quantity of aperture

It is assumed that the exposure time, the gain, and the quantity of aperture can be acquired from the camera 12. The operation error prevention module 24 obtains the brightness index value L_{Ui} in units of blocks, in the following manner using these values.

$$L_{Ui} = \text{luminance value of block } i / (\text{exposure time} \times \text{gain} \times \text{quantity of aperture})$$

(2) Combination of values to be used

The operation error prevention module 24 obtains the brightness index value LU in the following manner using a combination of the exposure time, the gain, and the quantity of aperture.

* If exposure time is used (i.e., the gain and the quantity of aperture are fixed)

$$LU_i = \text{luminance value of block } i / \text{exposure time}$$

* If the gain is used (i.e., the exposure time and the quantity of aperture are fixed)

$$LU_i = \text{luminance value of block } i / \text{gain}$$

When the brightness index value LU_i in units of blocks is obtained in the manner as explained above, an operation error of the passenger detection in a case where the captured image is extremely bright or extremely dark can also be prevented similarly to the First Embodiment.

At least one of the above-explained embodiments can provide an elevator boarding detection system in which when the passenger is detected by using the image captured by the camera, an operation error of passenger detection can be prevented by the capturing environment, and the passenger's motion can be reflected on the door open/close control only when the passenger can be detected correctly.

While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or

modifications as would fall within the scope and spirit of the inventions.

WHAT IS CLAIMED IS:

1. An elevator boarding detection system comprising:

5 a capturing module capable of capturing, when a car arrives at a hall, a predetermined range from a vicinity to a door of the car to a direction of the hall;

a passenger detector detecting a passenger by using an image captured by the capturing module;

10 a controller controlling an open/close operation of the door, based on a detection result of the passenger detector;

15 a parameter acquisition module acquiring a parameter of brightness adjustment from the capturing module; and

an operation error prevention module determining brightness of the captured image used by the passenger detector, based on the parameter acquired by the parameter acquisition module, and performing processing of preventing an operation error of the passenger detector in accordance with the determination result.

20 2. The elevator boarding detection system of Claim 1, wherein

25 the parameter includes at least any one of an exposure time, a gain, and a quantity of aperture.

3. The elevator boarding detection system of Claim 2, wherein

30 the operation error prevention module calculates an index value indicating brightness of the captured image with at least one of the exposure time, the gain, and the quantity of aperture, and performs processing of preventing an operation error of the passenger detector if the index value is higher than a preset upper limit value or lower than a preset lower limit value.

35

4. The elevator boarding detection system of Claim 2, wherein

5 the operation error prevention module divides the captured image in units of blocks, calculates an index value indicating brightness in units of blocks with at least one of the exposure time, the gain, and the quantity of aperture, and performs processing of preventing an operation error of the passenger detector for the block if the index value is higher than a
10 preset upper limit value or lower than a preset lower limit value.

5. The elevator boarding detection system of Claim 1, wherein

15 the operation error prevention module temporarily suspends detection processing as processing of preventing an operation error of the passenger detector.

6. The elevator boarding detection system of Claim 1, wherein

20 the operation error prevention module prohibits output of a detection result to the controller as processing of preventing an operation error of the passenger detector.

25 7. The elevator boarding detection system of Claim 1, wherein

 the operation error prevention module reduces sensitivity detection processing as processing of preventing an operation error of the passenger detector.