

ELEVATOR SYSTEM

FIELD

Embodiments described herein generally relate to an elevator system.

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BACKGROUND

In the field of elevators, the development of a passenger detection technology using an image captured by a camera with a wide-angle lens has proceeded in recent years. According to this, it is possible to have the advantage of being able to detect a passenger with a higher degree of accuracy than a passenger detection technology using a sensor.

On the other hand, as the camera with the wide-angle lens is used to capture images, the images captured by the camera have distortion. Due to this distortion, there is the disadvantage that the above-described accuracy of passenger detection is reduced. More specifically, due to the distortion of captured images, there is the disadvantage that a passenger normally not supposed to be detected is erroneously detected, and a result of this erroneous detection is reflected in the control of an elevator.

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SUMMARY

According to one embodiment, an elevator system includes a camera, a distortion correction processor, a movement detector, a position estimator and a controller. The camera is configured to capture a hall including around a door of an elevator car. The distortion correction processor is configured to correct distortion of multiple images captured by the camera on the basis of a coordinate conversion table stored in a memory in advance. The movement detector is configured to detect a passenger's movement by comparing brightness of the multiple images corrected by the distortion correction processor block by block.

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The position estimator is configured to extract a block with a movement detected by the movement detector and to estimate a coordinate position from the center of the door in the block as the passenger's position. The controller is configured to reflect the passenger's position estimated by the position estimator in operation control of the elevator car.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing a schematic configuration example of an elevator system according to an embodiment.

FIG. 2 is a diagram for explaining a distortion correction process performed by the elevator system according to the embodiment.

FIG. 3 is a diagram showing a state where an image captured by the elevator system according to the embodiment is divided by the block.

FIG. 4 is a diagram showing an example of a movement detection area set by the elevator system according to the embodiment.

FIG. 5 is a diagram showing an image (an original image) captured by the elevator system according to the embodiment.

FIG. 6 is a diagram showing a case where the movement detection area is set in the original image shown in FIG. 5.

FIG. 7 is a diagram showing a case where a passenger is standing near a door pocket and also a case where the movement detection area is set in a captured image having no distortion.

FIG. 8 is a diagram showing a case where the passenger is standing in the same position as FIG. 7 and also a case where the movement detection area is set in a captured image having distortion.

FIG. 9 is a flowchart showing an example of the

procedure of an initialization process performed by the elevator system according to the embodiment.

FIG. 10 is a flowchart showing an example of the operation of the elevator system according to the embodiment and an example of the operation when a car door is fully closed.

FIG. 11 is a flowchart showing an example of the procedure of a movement detecting process. This movement detecting process is performed by the elevator system according to the embodiment.

FIG. 12 is a flowchart showing an example of the procedure of a position estimating process. This position estimating process is performed by the elevator system according to the embodiment.

FIG. 13 is a flowchart showing an example of the operation of the elevator system according to the embodiment and an example of the operation when the car door is fully open.

FIG. 14 is a flowchart showing an example of the procedure of a boarding-intention estimating process performed by the elevator system according to the embodiment.

FIG. 15 is a diagram showing images before and after distortion correction when the images before and after distortion correction are the same in size.

FIG. 16 is a diagram for explaining another distortion correction process performed by the elevator system according to the embodiment.

FIG. 17 is a diagram showing an example of an image generated in the other distortion correction process performed by the elevator system according to the embodiment.

DETAILED DESCRIPTION

Embodiment will be described below with reference to the figures.

FIG. 1 shows a schematic configuration example of an elevator system according to an embodiment.

Incidentally, here we describe one elevator car as an example; however, the same configuration applies to multiple elevator cars.

In the elevator system shown in FIG. 1, a camera 12 is installed in the upper part of the entrance/exit of an elevator car 11. Specifically, the camera 12 is installed within a modesty panel 11a, which covers the upper part of the entrance/exit of the elevator car 11, with its lens part facing toward a hall 15. The camera 12 is a miniature monitoring camera, and has a wide-angle lens (specifically, a wide-angle lens a view angle of 60° to 130°), and is capable of continuously capturing several frames (for example, 30 frames) of images per second.

The camera 12 is activated when the traveling speed of the elevator car 11 is less than a predetermined value. Specifically, when the elevator car 11 has started slowing down to stop at a specified floor (for example, a hall call registration floor or a car call registration floor) and then its traveling speed has become less than the predetermined value, the camera 12 is activated and starts capturing. That is, capturing by the camera 12 is continuously performed from when the elevator car 11 starts slowing down to stop at a specified floor and then its traveling speed becomes less than the predetermined value until the elevator car 11 starts speeding up to go from the specified floor to another floor and then its traveling speed becomes equal to or more than the predetermined value, including while the elevator car 11 stops at the specified floor.

A capturing range of the camera 12 is set to L1 +

L2 (L1 >> L2). L1 is a capturing range on the side of the hall 15, and is, for example, 3 m from a car door 13 toward the hall 15. L2 is a capturing range on the side of the elevator car 11, and is, for example, 50 cm from the car door 13 toward the car back side.

Incidentally, L1 and L2 are a range in a depth direction, and their range in a width direction (a direction perpendicular to the depth direction) shall be larger than at least the width of the car door 13 (the door frontage).

In the hall 15 of each floor, a hall door 14 is openably/closably installed at an arrival gate of the elevator car 11. The hall door 14 makes an opening/closing motion in engagement with the car door 13 on the arrival of the elevator car 11.

Incidentally, a power source (a door motor) is located on the side of the elevator car 11, and the hall door 14 only opens/closes following the car door 13. In the following description, when the car door 13 is open, the hall door 14 shall also be open; when the car door 13 is closed, the hall door 14 shall also be closed.

In the elevator car 11, a speaker 16 for announcing (informing) various messages to users is installed. Furthermore, in the elevator car 11, a car operation panel (not shown) including a destination floor button, an open/close button, etc., is installed.

Each image (video) continuously captured by the camera 12 is preprocessed by an image preprocessing apparatus 21 in an image analyzer 20, and then is subjected to analysis processing in real time by an image processing apparatus 22 in the image analyzer 20. Incidentally, in FIG. 1, for the sake of convenience, the image analyzer 20 is shown being taken out from the elevator car 11; however, actually, the image analyzer 20 is housed within the modesty panel 11a together with

the camera 12.

The image preprocessing apparatus 21 includes a resolution reduction processor 23, a storage 24, and a distortion correction processor 25. The resolution
5 reduction processor 23 reduces the resolution of each image (captured image) captured by the camera 12 and generates a low-resolution image. The generated low-resolution image is transmitted to the distortion
10 correction processor 25. Incidentally, as a method of reducing the resolution of a captured image, for example, there is a method of decimating pixels composing a captured image. However, a method of reducing the resolution of a captured image is not limited to this, and the resolution of a captured image
15 can be reduced by any publicly-known method.

By reducing the resolution of the image in this way, the image size (the volume of the image) can be reduced, and analysis processing by the image
20 processing apparatus 22 can be performed at high speed (in real time).

The storage 24 stores therein a coordinate conversion table referenced by the distortion
correction processor 25. The position of each pixel in a captured image can be expressed in $P(x, y)$ by an X-
25 coordinate (a coordinate in a horizontal direction, i.e., a direction horizontal to the car door 13) and a Y-coordinate (a coordinate in a vertical direction, i.e., a direction vertical to the car door 13). The coordinate conversion table shows a correspondence
30 relationship between coordinates $P(x, y)$ before correction and coordinates $P(x', y')$ after correction with respect to each pixel. The coordinate conversion table is created at the time of an initialization process to be described later, and is stored in the
35 storage 24.

The distortion correction processor 25 performs a process of correcting distortion of a captured image by reference to the coordinate conversion table stored in the storage 24. More specifically, the distortion
5 correction processor 25 performs a process of replacing coordinates $P(x, y)$ with coordinates $P(x', y')$ corresponding to the coordinates $P(x, y)$ on the coordinate conversion table with respect to each pixel as shown in FIG. 2 by reference to the coordinate
10 conversion table stored in the storage 24. Incidentally, the corrected capture image (the preprocessed image) is transmitted to the image processing apparatus 22.

Incidentally, in the present embodiment, as a
15 method of correcting distortion of a captured image, the method of replacing coordinates of each pixel by reference to the coordinate conversion table created at the time of the initialization process is described; however, it is not limited to this, any publicly-known
20 method can be used as a method of correcting distortion of a captured image.

The image processing apparatus 22 includes a storage 26 and a passenger detector 27. The storage 26 has a buffer area for sequentially storing therein
25 preprocessed images (specifically, low-resolution and distortion-corrected images) transmitted from the image preprocessing apparatus 21 and also temporarily storing therein data required for processing by the passenger detector 27.

30 The passenger detector 27 detects the presence or absence of a passenger by focusing on the movement of a person/object closest to the car door 13 in preprocessed images stored in the buffer area in the storage 26. This passenger detector 27 can be
35 functionally separated into a movement detector 27a, a

position estimator 27b, and a boarding-intention estimator 27c.

5 The movement detector 27a divides a preprocessed image into blocks with sides of W_{block} as shown in FIG. 3, and compares the brightness of the image block by block, and detects a block with a movement having a brightness difference of a preset value or more, thereby detecting the movement of a person/object. The term "movement of a person/object" here means the
10 movement of a moving body, such as a person or a wheelchair.

Incidentally, in an example of FIG. 3, the length and width of the blocks are the same; however, the length and width do not necessarily have to be the
15 same. Furthermore, the blocks can be non-uniform in size over the entire area of the image; for example, the more upper the part of the image, the shorter the length (in a Y direction).

Furthermore, in the present embodiment, the
20 movement of a person/object is detected by focusing on the brightness of an image; however, a method of detecting the movement of a person/object is not limited to this, and the movement of a person/object can be detected by using, for example, the lightness or
25 saturation of an image.

The position estimator 27b extracts a block closest to the car door 13 from blocks with a movement detected by the movement detector 27a, and estimates a coordinate position from the center of the car door 13
30 (the center of the door frontage) in the block as a passenger's position (foot position). The boarding-intention estimator 27c estimates the presence or absence of a passenger's intention of boarding on the basis of time-series changes in the position estimated

by the position estimator 27b.

5 An elevator controller 30 performs control of an entire elevator on the basis of the operating state of the elevator car 11 (the car position, the driving direction, the traveling speed, the open/close state, etc.) and the state of occurrence of hall calls and car calls.

10 A car controller 40 includes an open/close controller 41; the open/close controller 41 controls the opening/closing of the car door 13 when the elevator car 11 has arrived at the hall 15 in accordance with an instruction from the elevator controller 30. Furthermore, the car controller 40 performs display control of the car operation panel
15 (not shown) installed in the elevator car 11, control of the speaker 16, or the like in accordance with an instruction from the elevator controller 30.

20 Here we explain a movement detection area set for the passenger detector unit 27 to detect the movement of a user with reference to FIG. 4.

The movement detection area is an area set for each block to detect the movement of a passenger from a captured image. Specifically, as shown in FIG. 4, on a captured image, a position estimation area E1, a
25 boarding-intention estimation area E2, and a caught-in detection area E3 are set as a movement detection area. Incidentally, here we assume that the above-mentioned areas E1 to E3 are set as a movement detection area; however, the movement detection area is not limited to
30 these, and another area can be further set as a movement detection area.

The position estimation area E1 is an area for estimating the position of a part of the body of a passenger coming from the hall 15 toward the car door
35 13, for example, the foot position of the passenger.

This position estimation area E1 has a length of L3 from the center of the car door 13 toward a direction of the hall, and is set to, for example, 2 m ($L3 \leq$ the hall-side capturing range L1). Furthermore, a width W1 of the position estimation area E1 is set to a length equal to or more than a width W0 of the car door 13.

The boarding-intention estimation area E2 is an area for estimating whether or not a passenger detected in the position estimation area E1 has an intention of boarding. This boarding-intention estimation area E2 has a length of L4 from the center of the car door 13 toward the direction of the hall, and is set to, for example, 1 m ($L4 \leq L3$). A width W2 of the boarding-intention estimation area E2 is set to be about the same length as the width W0 of the car door 13. Incidentally, the boarding-intention estimation area E2 is included in the above-described position estimation area E1, and is also an area for estimating the foot position of the passenger. That is, in the boarding-intention estimation area E2, the foot position of the passenger is estimated, and also the passenger's intention of boarding is estimated.

The caught-in detection area E3 is an area for detecting a passenger who is near the car door 13 in the elevator car 11 and is likely to get his/her hand or arm caught in a door pocket. This caught-in detection area E3 is set to be along a car-side sill groove (a car-side sill), and has a length of L5 from the center of the car door 13 toward a direction of the car back side, and is set to, for example, 10 cm. Furthermore, a width W3 of the caught-in detection area E3 is set to be about the same length as the width W0 of the car door 13.

Subsequently, distortion produced in a captured

image is explained.

In the present embodiment, it is necessary to capture a range wider than at least the width W_0 of the car door 13 as described above, so it is preferable that the camera 12 is a camera with a wide-angle lens. However, because of the characteristics of a wide-angle lens, the periphery of an image captured by the camera 12 is largely distorted. This state is shown in FIG. 5.

FIG. 5 shows an original image captured by the camera 12. Incidentally, here we assume that the car door 13 is a slide type door that opens in one direction from the right to left in the figure, and the camera 12 is installed within the modesty panel 11a on the right side in the figure. In this case, as shown in FIG. 5, the car side sill located in the periphery, especially, a portion on the left side in the figure (the door pocket side) away from the right side in the figure (the doorstep side), which is the installation position of the camera 12, is largely curved and distorted.

According to this, the following disadvantage may arise.

FIG. 6 shows a case where the above-described movement detection area (the caught-in detection area E3) is set in the original image shown in FIG. 5. The movement detection area is set with respect to each block as described above. That is, the movement detection area is always set in the same position on a captured image. Accordingly, if an image has distortion just like the captured image shown in FIG. 5, there arises the disadvantage that, as shown in FIG. 6, the caught-in detection area E3 cannot be set in a suitable position, i.e., to be along the car side sill. According to this disadvantage, the following

disadvantage may further arise.

FIGS. 7 and 8 are a captured image of a passenger standing in the same position; FIG. 7 shows a case where a captured image has no distortion, and FIG. 8 shows a case where a captured image has distortion. As shown in FIG. 7, in the image having no distortion, the caught-in detection area E3 is set to be along the car side sill, and therefore, a passenger standing in a position P1 is not detected as a passenger who is likely to get his/her hand or arm caught in a door pocket from the caught-in detection area E3. On the other hand, as shown in FIG. 8, in the image having distortion, the caught-in detection area E3 cannot be set to be along the car side sill, and therefore, the passenger standing in the position P1 is detected as a passenger who is likely to get his/her hand or arm caught in a door pocket from the caught-in detection area E3 in spite of the fact that the passenger stands in the same position as FIG. 7. That is, erroneous detection caused by distortion of the image occurs.

Therefore, in the present embodiment, the distortion correction processor 25 in the image preprocessing apparatus 21 is configured to correct distortion of a captured image. In the following description, first, the initialization process performed when the image analyzer 20 is installed together with the camera 12 is described with reference to a flowchart in FIG. 9, and then an example of the operation of the elevator system according to the present embodiment is described with reference to a flowchart in FIG. 10.

FIG. 9 is a flowchart showing an example of the procedure of the initialization process performed when the image analyzer 20 is installed together with the camera 12.

First, the image analyzer 20 sets a movement detection area, specifically, the position estimation area E1, the boarding-intention estimation area E2, and the caught-in detection area E3 with respect to each
5 block (step S1).

Then, the image analyzer 20 checks whether or not a distortion correction process is enabled (step S2). Incidentally, whether the distortion correction process is enabled or disabled shall be able to be
10 appropriately selected by a user (an administrator).

If the distortion correction process is not enabled, i.e., is disabled (NO in step S2), the distortion correction process is not performed in the image analyzer 20, so the initialization process is
15 terminated. On the other hand, if the distortion correction process is enabled (YES in step S2), the image analyzer 20 creates a coordinate conversion table referenced at the time of the distortion correction process (step S3), and stores the coordinate conversion
20 table in the storage 24 (step S4), and then the initialization process is terminated.

Incidentally, here, the image analyzer 20 first sets the movement detection area, and then performs the determination of whether distortion correction is
25 necessary or not and the creation and storage of the coordinate conversion table; however, the order of processes is not limited to this, and the image analyzer 20 can perform the determination of whether distortion correction is necessary or not and the
30 creation and storage of the coordinate conversion table and then set the movement detection area.

FIG. 10 is a flowchart showing an example of the operation of the elevator system according to the present embodiment. Incidentally, here, there is
35 described the operation of the elevator system when the

car door 13 is in a fully closed state.

When the traveling speed of the elevator car 11 has become less than a predetermined value (YES in step S11), the camera 12 is activated and starts capturing.

5 On the other hand, when the traveling speed of the elevator car 11 is equal to or more than the predetermined value (NO in step S11), the camera 12 is not activated in terms of energy saving, and the process in step S11 is again performed while the camera
10 12 is kept in a sleep state.

When the camera 12 has been activated and started capturing, the image analyzer 20 acquires an image captured by the camera 12 in time series (step S12). Then, the image analyzer 20 determines whether or not
15 the captured image is normal on the basis of whether or not a difference between the maximum brightness value and the minimum brightness value of the captured image is equal to or more than a predetermined value (step S13).

20 If it has been determined that a difference between the maximum brightness value and the minimum brightness value of the captured image is less than the predetermined value and the captured image is not normal (NO in step S13), the captured image is not used
25 in a passenger detection process to be described later, and the image analyzer 20 performs the process in step S12 again to acquire the next captured image.

On the other hand, if it has been determined that a difference between the maximum brightness value and
30 the minimum brightness value of the captured image is equal to or more than the predetermined value and the captured image is normal (YES in step S13), the resolution reduction processor 23 in the image preprocessing apparatus 21 composing the image analyzer
35 20 reduces the resolution of the captured image and

generates a low-resolution captured image (step S14).
Incidentally, the generated low-resolution captured
image is sequentially transmitted to the distortion
correction processor 25 in the image preprocessing
5 apparatus 21.

Then, when having received an input of the low-
resolution captured image transmitted from the
resolution reduction processor 23, the distortion
correction processor 25 checks whether or not the
10 distortion correction process is enabled (step S15).
If distortion correction processing is not enabled,
i.e., is disabled (NO in step S15), the distortion
correction processor 25 sequentially transmits the
captured image preprocessed in step S14 as it is to the
15 image processing apparatus 22 without performing the
distortion correction process, the elevator system goes
on to a process in step S17 described below.

On the other hand, if the distortion correction
process is enabled (YES in step S15), the distortion
20 correction processor 25 corrects distortion of the low-
resolution captured image of which the input has been
received, by reference to the coordinate conversion
table stored in the storage 24, thereby generating a
distortion-corrected captured image. Specifically, the
25 distortion correction processor 25 replaces coordinates
 $P(x, y)$ with coordinates $P(x', y')$ corresponding to the
coordinates $P(x, y)$ on the coordinate conversion table
with respect to each pixel of the captured image,
thereby correcting distortion of the captured image
30 (step S16). Incidentally, the captured image
preprocessed in steps S14 to S16 is sequentially
transmitted to the image processing apparatus 22.

When having received an input of the preprocessed
captured image transmitted from the image preprocessing
35 apparatus 21, the image processing apparatus 22

sequentially stores the captured image in the storage 26, and performs a passenger detection process in real time (step S17).

5 The passenger detection process is performed by the passenger detector 27 in the image processing apparatus 22; the passenger detection process performed when the car door 13 is in the fully closed state is composed of a movement detecting process (step S17a) and a position estimating process (step S17b).

10 In the following description, the movement detecting process is described with reference to a flowchart in FIG. 11, and the position estimating process is described with reference to a flowchart in FIG. 12.

15 (a) Movement Detecting Process

FIG. 11 is a flowchart showing an example of the procedure of the above-mentioned movement detecting process in step S17a. This movement detecting process is performed by the movement detector 27a which is one of components of the passenger detector 27. Here we described on the assumption that the brightness of an image is used to detect the movement of a person/object.

25 The movement detector 27a reads out preprocessed captured images stored in the storage 26 one by one, and divides each captured image in a reticular pattern, and calculates an average brightness value of each of blocks obtained (step A1). At this time, the movement detector 27a stores, as an initial value, the average brightness value of each block calculated from the first image in the buffer area (not shown) in the storage 26 in time series (step A2).

30 When the second or subsequent image has read out, the movement detector 27a compares the average brightness value of each block of the current image

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with the average brightness value of each block of the last image stored in the buffer area (step A3). As a result, if there is a block having a brightness difference of a preset value or more in the current
5 image, the movement detector 27a determines the block as a block with a movement (step A4).

When having determined the presence or absence of a movement in the current image, the movement detector 27a stores the average brightness value of each block
10 of the image as an average brightness value for comparison with the next image in the buffer area (step A5).

Thereafter, the movement detector 27a repeats the determination of the presence or absence of a movement
15 by comparing the brightness value of a preprocessed captured image stored in the storage 26 block by block in time series likewise.

(b) Position Estimating Process

FIG. 12 is a flowchart showing an example of the procedure of the above-mentioned position estimating
20 process in step S17b. This position estimating process is performed by the position estimator 27b which is one of components of the passenger detector 27.

The position estimator 27b checks a block with a
25 movement in the current image on the basis of a result of detection by movement detector 27a (step B1). As a result, if there are blocks with a movement in the movement detection area (the caught-in detection area E3), the position estimator 27b extracts a block
30 closest to the car door 13 out of the blocks with a movement (step B2).

After that, the position estimator 27b finds a Y-coordinate (a Y-coordinate in a direction of the back side from the center of the car door 13) of the block
35 with a movement closest to the car door 13 as data of a

passenger's position, and stores the found y-coordinate of the block in the buffer area (not shown) in the storage 26 (step B3).

5 Thereafter, the position estimator 27b finds a Y-coordinate of a block with a movement closest to the car door 13 with respect to each image as data of the passenger's position, and stores the found Y-coordinate of the block in the buffer area likewise.
10 Incidentally, the data indicating the passenger's position is transmitted to the elevator controller 30.

 To return to the explanation of FIG. 10 again, the elevator controller 30 checks whether or not data indicating the passenger's position has been transmitted from the image analyzer 20 (step S18).
15 Incidentally, if data indicating the passenger's position has not been transmitted from the image analyzer 20, i.e., there is no input of the data (NO in step S18), the elevator system goes on to a process in step S20 described below.

20 On the other hand, if data indicating the passenger's position has been transmitted from the image analyzer 20, i.e., there is an input of the data (YES in step S18), the elevator controller 30 outputs an alert instruction signal instructing to alert the
25 passenger in the elevator car 11 to the car controller 40, and also registers a low-speed open instruction signal instructing to open the car door 13 at low speed in a memory (not shown). When having received an input of the alert instruction signal from the elevator
30 controller 30, the car controller 40 alerts by outputting a message and a beep sound or the like prompting the user to move away from the car door 13 from the speaker 16 in accordance with the alert instruction signal (step S19).

35 Then, the elevator control device 30 determines

whether or not the elevator car 11 has arrived at a specified floor on the basis of the presence or absence of a landing signal indicating that the elevator car 11 has landed at the specified floor (step S20).

5 Incidentally, if it has been determined that the elevator car 11 has not arrived at the specified floor, i.e., is still traveling (NO in step S20), the elevator system returns to the above-described process in step S12, and performs the same process again.

10 On the other hand, if it has been determined that the elevator car 11 has arrived at the specified floor (YES in step S20), the elevator controller 30 checks whether or not a low-speed open instruction signal has been registered in the memory (not shown) (step S21).

15 If a low-speed open instruction signal has been registered in the memory (not shown) (YES in step S21), the elevator controller 30 outputs the low-speed open instruction signal to the car controller 40. The open/close controller 41 in the car controller 40 opens
20 the car door 13 at slower speed than normal speed in accordance with the low-speed open instruction signal from the elevator controller 30 (step S22), and terminates the process here.

 On the other hand, if a low-speed open instruction
25 signal has not been registered in the memory (not shown) (NO in step S21), the elevator controller 30 outputs a normal open instruction signal instructing to open the car door 13 at normal speed to the car
 controller 40. The open/close controller 41 in the car
30 controller 40 opens the car door 13 at normal speed in accordance with the normal open instruction signal from the elevator controller 30 (step S23), and terminates the process here.

 Subsequently, there is described the operation of
35 the elevator system when the car door 13 is in a fully

open state with reference to a flowchart in FIG. 13.

When the car door 13 has been fully open (step in S31), the image analyzer 20 performs the same processes as the above-described processes in steps S12 to S16
5 (steps S32 to S36).

After that, when having received an input of a preprocessed captured image transmitted from the image preprocessing apparatus 21, the image processing apparatus 22 sequentially stores the captured image in
10 the storage 26, and performs a passenger detection process in real time (step S37).

The passenger detection process performed when the car door 13 is in the fully open state is composed of a movement detecting process (step S37a), a position
15 estimating process (step S37b), and a boarding-intention estimating process (step S37c).
Incidentally, the movement detecting process and the position estimating process are the same as the already-described steps S17a and S17b, so detailed
20 description is omitted here. However, in step S37b, not the position estimating process with the caught-in detection area E3 described in step S17b but a position estimating process with the boarding-intention estimation area E2 is performed.

25 Here, the boarding-intention estimating process is described with reference to a flowchart in FIG. 14.

(c) Boarding-intention Estimating Process

FIG. 14 is a flowchart showing an example of the procedure of the above-mentioned boarding-intention
30 estimating process in step S37c. This boarding-intention estimating process is performed by the boarding-intention estimator 27c which is one of components of the passenger detector 27.

The boarding-intention estimating unit 27c smooths
35 data of a passenger's position in each image stored in

the buffer area in the storage 26 (step C1).

Incidentally, as a method of smoothing, for example, a commonly-known method, such as the mean filter or the Kalman filter, shall be used, and its detailed description is omitted here.

When the above-described position data has been smoothed, if there is data of which the amount of change is equal to or more than a predetermined value (YES in step C2), the boarding-intention estimator 27c excludes the data as an outlier (step C3).

Incidentally, the above-mentioned predetermined value is determined by passenger's typical walking speed and the frame rate of captured images. Furthermore, before smoothing the above-described position data, an outlier can be found and excluded.

Then, the boarding-intention estimator 27c checks a change in the passenger's position in the boarding-intention estimation area E2 (step C4). As a result, if the boarding-intention estimator 27c can confirm a change in the passenger's position heading to the car door 13 in the boarding-intention estimation area E2 (YES in step C5), the boarding-intention estimator 27c determines that the passenger has an intention of boarding (step C6).

On the other hand, if the boarding-intention estimator 27c cannot confirm a change in the passenger's position heading to the car door 13 in the boarding-intention estimation area E2 (NO in step C5), the boarding-intention estimator 27c determines that the passenger has no intention of boarding (step C7). For example, if a person cuts across the front of the elevator car 11, the person is not heading to the car door 13, so the position of the person does not change temporally, and, in such a case, it is determined that the person has no intention of boarding.

In this way, the presence or absence of a passenger's intention of boarding can be estimated by regarding a block with a movement closest to the car door 13 as the passenger's position and tracking temporal changes in the position to a direction of the car door 13.

To return to the explanation of FIG. 13 again, when a passenger having an intention of boarding has been detected (YES in step S38), a passenger detection signal is output from the image analyzer 20 to the elevator controller 30. The elevator controller 30 receives this passenger detection signal, thereby prohibiting a closing motion of the car door 13 and keeps the car door 13 in the open state (step S39).

Specifically, when the car door 13 has gone into the fully open state, the elevator controller 30 starts an operation to count an open time, and, when having counted a predetermined time T (for example, 1 minute), closes the car door 13. If a passenger having an intention of boarding has been detected during this time, and a passenger detection signal has been transmitted, the elevator controller 30 stops the counting operation and clears the count value. Accordingly, for the above-described time T, the car door 13 is kept in the open state.

Incidentally, if a new passenger having an intention of boarding has been detected during this, the count value is again cleared, and the car door 13 is kept in the open state for the above-described time T. However, if passengers keep coming in the above-described time T, the state in which the car door 13 cannot be closed is continued forever; therefore, it is preferable that an allowed time T_x (for example, 3 minutes) is set, and, when this allowed time T_x has passed, the car door 13 is closed forcibly.

When having completed the operation to count the above-described time T (YES in step S40), the elevator controller 30 closes the car door 13 through the open/close controller 41 in the car controller 40 (step S41), and terminates the process here.

According to the embodiment described above, the elevator system includes the distortion correction processor 25 capable of correcting distortion of a captured image; therefore, it is possible to prevent the reduction in the accuracy of passenger detection due to distortion of an image. Specifically, it is possible to prevent erroneous detection of a passenger's movement normally not supposed to be able to be detected like those described in FIGS. 7 and 8.

Incidentally, in the present embodiment, a captured image before distortion correction and a captured image after distortion correction are the same in size, and the distortion correction process is performed on the captured image; however, in this case, the following disadvantage may arise.

FIG. 15 is a diagram for explaining the disadvantage that arises when images before and after distortion correction are the same in size; FIG. 15(a) shows a captured image before distortion correction, and FIG. 15(b) shows a captured image after distortion correction. As shown in FIG. 15(b), in the captured image after distortion correction, due to the effect of the correction of distortion, the edge part seen on the captured image before distortion correction shown in FIG. 15(a) (the periphery of the captured image before distortion correction) is partially vanished (missing). Accordingly, there is the disadvantage that even if a passenger stands in the place which is vanished in the captured image after distortion correction, the movement of the passenger cannot be detected.

To dissolve this disadvantage, the distortion correction processor 25 performs a process of reducing a captured image after distortion correction to be smaller than a captured image before distortion correction as shown in FIG. 16. Specifically, the distortion correction processor 25 generates a distortion-corrected captured image by reducing a captured image before distortion correction to 0.85 times from its size. At this time, the distortion correction processor 25 reduces the movement detection area as well. According to this, as shown in FIG. 17, even in the captured image after distortion correction, the edge part is not vanished (missing), so it is possible to dissolve the above-described disadvantage. Especially, in most of elevators, a car operation panel is installed on the side of a door pocket, and a passenger is highly likely to stand near the car operation panel; therefore, by preventing the above-described missing of an image, a passenger can be prevented from being gotten his/her hand or arm caught in a door pocket with a high degree of accuracy.

Incidentally, when the size of captured images is changed at the time of the distortion correction process, the image analyzer 20 creates the coordinate conversion table taking account of reducing the size of a captured image after distortion correction to 0.85 times from its original size at the time of the initialization process. Furthermore, at this time, the size of the movement detection area is also changed likewise. Incidentally, here, the reducing power of the captured image is described as 0.85; however, the reducing power is not limited to this, and shall be able to be appropriately changed.

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
5 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
10 of the inventions.

WHAT IS CLAIMED IS:

1. An elevator system comprising:

a camera configured to capture a hall including around a door of an elevator car;

5 a distortion correction processor configured to correct distortion of multiple images captured by the camera on the basis of a coordinate conversion table stored in a memory in advance;

10 a movement detector configured to detect a passenger's movement by comparing brightness of the multiple images corrected by the distortion correction processor block by block;

15 a position estimator configured to extract a block with a movement detected by the movement detector and to estimate a coordinate position from the center of the door in the block as the passenger's position; and

a controller configured to reflect the passenger's position estimated by the position estimator in operation control of the elevator car.

20 2. The elevator system of Claim 1, wherein the distortion correction processor is configured to correct distortion of multiple images captured by the camera so that size of the images after correction is smaller than size of the images before correction.

25 3. The elevator system of Claim 1, wherein when the passenger's position estimated by the position estimator is included in an area where a part of the passenger's body is likely to be caught in the door, the controller is configured to alert the passenger and
30 to open the door at a lower speed than normal.

35 4. The elevator system of Claim 1, further comprising a boarding-intention estimator configured to estimate the presence or absence of the passenger's intention of boarding on the basis of time-series changes in the passenger's position estimated by the

position estimator,

wherein the controller is configured to control an
opening/closing motion of the door on the basis of a
result of estimation by the boarding-intention
estimator.

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