

ELEVATOR PASSENGER DETECTION SYSTEM

FIELD

Embodiments described herein relate generally to an elevator passenger detection system.

5

BACKGROUND

When a car door of an elevator opens, a finger or other parts of a user in the car may be pulled into a door pocket. In addition, when a passenger in a hall gets into the car, the passenger may hit an edge of a closing door. A system which aims to prevent such door accidents by detecting passengers in a hall and a car with a camera installed in the car and reflecting the detection on the door open and close control, is known.

In the above-mentioned system, the presence or absence of passengers is detected by a difference in luminance between frames of captured images. For example, however, when a shadow of a passenger enters the captured images due to the lighting environment in the car and the hall, over-detection occurs due to the luminance change caused by the shadow's movement. The term "over-detection" means mistakenly detecting a shadow as a passenger, which is the same as "false detection".

Embodiments described herein aim to provide an elevator passenger detection system capable of correctly detecting a passenger in a car and a hall by suppressing over-detection of a shadow caused by the lighting environment.

SUMMARY

According to one embodiment, an elevator passenger detection system includes: an edge extraction unit extracting information on an edge from a captured image of the camera installed in a car, a motion detection

unit detecting motion of the captured image, based on
an edge change obtained by comparing edges extracted by
the edge extraction unit between images continuously
obtained from the captured image, and a person
5 detection unit detecting the motion as a person, based
on information on the motion detected by the motion
detection unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view showing a configuration of an
10 elevator passenger detection system according to an
embodiment.

FIG. 2 is a view showing a configuration of a
portion around a doorway in a car according to the
embodiment.

15 FIG. 3 is a view illustrating a coordinate system
in a real space according to the embodiment.

FIG. 4 is a view showing an example of an image
captured by a camera according to the embodiment.

FIG. 5 is a view schematically showing a
20 configuration of a ride detection area according to the
embodiment.

FIG. 6 is a view illustrating false detection of a
shadow in a pull-in detection area according to the
embodiment.

25 FIG. 7 is a view showing an example of a captured
image including a person and a shadow according to the
embodiment.

FIG. 8 is a graph showing change in a luminance
value of a person on the captured image of FIG. 7 as
30 viewed in an x-axis direction.

FIG. 9 shows the change in the luminance value of
a person on the captured image of FIG. 7 as viewed in
the x-axis direction.

FIG. 10 is a view illustrating a method of calculating intensity of a mountain-shaped edge according to the embodiment.

5 FIG. 11 is a view showing a specific example of calculation of the intensity of the mountain-shaped edge.

FIG. 12 is a flowchart showing a processing operation of the above passenger detection system.

10 FIG. 13 is a flowchart showing a detection process executed in step S103 of FIG. 12.

DETAILED DESCRIPTION

Embodiments will be described hereinafter with reference to the accompanying drawings.

15 The disclosure is merely an example and is not limited by contents described in the embodiments described below. Modification which is easily conceivable by a person of ordinary skill in the art comes within the scope of the disclosure as a matter of course. In order to make the description clearer, the sizes, shapes and the like of the respective parts may
20 be changed and illustrated schematically in the drawings as compared with those in an accurate representation. Constituent elements corresponding to each other in a plurality of drawings are denoted by
25 like reference numerals and their detailed descriptions may be omitted unless necessary.

FIG. 1 is a view showing a configuration of an elevator passenger detection system according to an embodiment. Descriptions are focused on a car as an
30 example, but the system with a plurality of cars has the same configuration.

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 that covers the upper part of the doorway of the car 11, with a lens portion tilted just below or at a predetermined angle toward a hall 15 side or an inside of the car 11.

5 The camera 12 is, for example, a compact monitoring camera such as an in-vehicle camera, equipped with a wide-angle lens or a fisheye lens, and can continuously capture images of several frames per second (for example, 30 frames/sec). The camera 12 is
10 activated, for example, when the car 11 arrives at the hall 15 on each floor, and captures images of an area around a car door 13 and the hall 15. The camera 12 may be in operation at all times during the operation of the car 11.

15 At this time, a capture range is adjusted such that $L1+L2$ ($L1>L2$). $L1$ refers to a capture range on the hall side, with a predetermined distance from the car door 13 to the hall 15. $L2$ refers to a capture range on the car side, with a predetermined distance
20 from the car door 13 to a back surface of the car. $L1$ and $L2$ refer to ranges in the depth direction, and a range in a width direction (a direction orthogonal to the depth direction) is set to be larger than at least a width of the car 11.

25 In the hall 15 of each floor, a hall door 14 is installed at an entrance of the car 11 so as to freely open and close. The hall door 14 performs open and close operations in association with the car door 13 when the car 11 arrives. A power source (door motor)
30 is located on the car 11 side, and the hall door 14 only opens and closes following the car door 13. In the following description, it is assumed that the hall door 14 is opened when the car door 13 is opened and

that the hall door 14 is closed when the car door 13 is closed.

Each of images (video) sequentially captured by the camera 12 is subjected to analytical processing by an image processing device 20 in real time. The image processing device 20 is extracted from the car 11 for convenience in FIG. 1 but, in reality, the image processing device 20 is accommodated within the modesty panel 11a together with the camera 12.

The image processing device 20 comprises a storage unit 21 and a detection unit 22. The storage unit 21 is composed of, for example, a memory device such as RAM. The storage unit 21 includes a buffer area to sequentially store the images captured by the camera 12 and to temporally store data necessary for the processing of the detection unit 22. In the storage unit 21, images subjected to processing such as a distortion correction, a scaling, and a partial cutting as preprocessing for captured images, may be stored.

The detection unit 22 is composed of, for example, a microprocessor to detect passengers in the car 11 or the hall 15 with the images captured by the camera 12. The detection section 22 is functionally composed of a detection area setting unit 23 and a detection processing unit 24. These may be realized by software or hardware such as integrated circuits (ICs), or by a combination of software and hardware. In addition, the elevator control device 30 may be urged to comprise some or all of the functions of the image processing unit 20.

The detection area setting unit 23 sets at least one or more detection areas for detecting passengers on the captured images obtained from the camera 12. In

this embodiment, a detection area E1 for detecting passengers in the hall 15 and detection areas E2 and E3 for detecting passengers in the car 11 are set. The detection area E1 is used as the ride detection area, and is set from the doorway (car door 13) of the car 11 to the hall 15. The detection area E2 is used as a pull-in detection area and is set at entrance panels 41a and 41b in the car 11. The detection area E3 is used as a pull-in detection area, similarly to the detection area E2, and is set on a floor surface 19 on the doorway side in the car 11 (see FIG. 3).

The detection processing unit 24 includes an edge extraction unit 24a, a motion detection unit 24b, and a person detection unit 24c, and analyzes the captured images obtained from the camera 12 to detect passengers present in the car 11 or the hall 15. The edge extraction unit 24a, the motion detection unit 24b, and the person detection unit 24c will be described in detail later with reference to FIG. 7 to FIG. 11. When a passenger detected by the detection processing unit 24 is present in any of the above-mentioned detection areas E1 to E3, a predetermined response process (door open and close control) is executed.

An elevator control device 30 is composed of a computer equipped with CPU, ROM, RAM, and the like. The elevator control device 30 executes control of the operation of the car 11 and the like. In addition, the elevator control device 30 comprises a door open and close control unit 31 and an alarm unit 32.

The door open and close control unit 31 controls opening and closing of the car door 13 when the car 11 arrives at the hall 15. More specifically, the door open and close control unit 31 opens the car door 13

when the car 11 arrives at the hall 15, and closes the door after a predetermined time elapses. However, if a passenger is detected in the detection area E1 by the detection processing unit 22b during the closing operation of the car door 13, the door open and close control unit 31 prohibits the closing operation of the car door 13, and re-opens the car door 13 in the fully open direction to maintain the door open state.

In addition, if a passenger is detected in the detection area E2 or E3 by the detection processing unit 22b during the opening operation of the car door 13, the door open and close control unit 31 performs the door open and close control to avoid a door accident (an accident of pulling into the door pocket). More specifically, the door open and close control unit 31 temporarily suspends the opening operation of the car door 13, moves the car door 13 in an opposite direction (the door closing direction), or reduces the opening speed of the car door 13.

FIG. 2 is a view showing the configuration of the area around the doorway in the car 11.

The car door 13 is provided to freely open and close, at the doorway of the car 11. In the example shown in FIG. 2, a double car door 13 is shown, and two door panels 13a and 13b, which constitute the car door 13, open and close in opposite directions along a frontage direction (horizontal direction). The "frontage" is the same as the doorway of the car 11.

Entrance panels 41a and 41b are provided on both sides of the doorway of the car 11 to surround the doorway of the car 11 together with the modesty panel 11a. The "entrance panel" is also referred to as a front return panel, and is generally equipped with a

door pocket for accommodating the car door 13 on the back side. In the example shown in FIG. 2, when the car door 13 is opened, one of the door panels 13a is accommodated in a door pocket 42a provided on a back side of an entrance panel 41a, and the other door panel 13b is accommodated in a door pocket 42b provided on a back side of an entrance panel 41b. An indicator 43, an operating panel 45 on which the destination floor buttons 44 and the like are arranged, and a speaker 46 are installed on one or both of the entrance panels 41a and 41b. In the example shown in FIG. 2, the speaker 46 is installed on the entrance panel 41a, and the indicator 43 and the operation panel 45 are installed on the entrance panel 41b.

The camera 12 is provided in the modesty panel 11a horizontally arranged at the upper part of the doorway of the car 11. The camera 12 is provided in accordance with the closing position of the car door 13 to detect the passengers in the hall 15 until the door closes. More specifically, if the car door 13 is a double door type, the camera 12 is provided in the center of the modesty panel 11a. In addition, for example, a lighting device 48 using LEDs is installed on the ceiling inside the car 11.

As shown in FIG. 3, 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 referred to as an X-axis, a direction from the center of the car door 13 to the hall 15 (the direction perpendicular to the car door 13) is referred to as a Y-axis, and a direction of the height of the car 11 is referred to as a Z-axis.

FIG. 4 is a view showing an example of an image

captured by the camera 12. The upper side is the hall 15 and the lower side is the inside of the car 11. In the figure, 16 denotes a floor surface of the hall 15, and 19 denotes a floor surface of the car 11. E1, E2, and E3 refer to detection areas.

The car door 13 includes two door panels 13a and 13b that move in opposite directions on a car sill 47. Similarly, the hall door 14 include two door panels 14a and 14b that move in opposite directions on a car sill 18. The door panels 14a and 14b of the hall door 14 move in the door opening and closing directions together with the door panels 13a and 13b of the car door 13.

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 in the hall 15, a predetermined range (L1) on the hall side and a predetermined range (L2) inside the car are captured as shown in FIG. 1. Of these, the detection area E1 is set in the predetermined area (L1) on the hall side to detect passengers riding the car 11.

In real space, the detection area E1 has a distance L3 from the center of the doorway (frontage) toward the hall direction ($L3 \leq$ capture range L1 on the hall side). A breadth W1 of the detection area E1 at full opening is set at a distance larger than or equal to a breadth W0 of the doorway (frontage). The detection area E1 includes the sills 18 and 47 and is set except for blind spots of jambs 17a and 17b as represented by hatch lines in FIG. 4. The size of the detection area E1 in the horizontal direction (X-axis direction) may be changed in accordance with the open and close operations of the car door 13. In addition,

the size of the detection area E1 in the vertical direction (Y-axis direction) may also be changed in accordance with the open and close operations of the car door 13.

5 As shown in FIG. 5, the detection area E1 used as the ride detection area consists of a ride intention estimation area E1a, a proximity detection area E1b, and a sill top detection area E1c. The ride intention estimation area E1a is an area for estimating whether
10 or not a passenger is moving toward the car 11 with a ride intention. The proximity detection area E1b is an area for detecting the proximity of a passenger to the doorway of the car 11. The sill top detection area E1c is an area for detecting that the passenger is passing
15 over the sills 18 and 47.

 This system has detection areas E2 and E3 in addition to the detection area E1 for ride detection. The detection areas E2 and E3 are used as pull-in detection areas. The detection area E2 is set with a
20 predetermined width, along inner side surfaces 41a-1 and 41b-1 of the entrance panels 41a and 41b of the car 11. The detection area E2 may be set in accordance with the breadth of the inner side surfaces 41a-1 and 41b-1. The detection area E3 is set with a
25 predetermined width along the car sill 47 of the floor surface 19 of the car 11.

 When a passenger is detected in the detection area E2 or E3 during the open operation of the car door 13, a response operation such as temporarily suspending the
30 open operation of the car door 13, moving the car door 13 in an opposite direction (door closing direction), or reducing the opening speed of the car door 13 is executed. In addition, for example, a warning "Please

move away from the door" is given by a voice announcement.

(Problem on Detection Process)

5 Usually, the pull-in detection is executed on the assumption that the luminance change of the image in the detection areas E2 and E3, i.e., the pull-in detection areas, is correctly represented by intrusion of a passenger. However, the detection areas E2 and E3 are strongly affected by the lighting environment in
10 the car room since they are set inside the car 11. In other words, as shown in FIG. 6, even when a passenger P1 is boarding at a distance from the car door 13, a shadow S1 of the passenger P1 may enter the detection area E2 or E3 due to the illumination of the lighting
15 device 48. When the shadow S1 enters the detection area E2 or E3, a large change in luminance may occur on the image in accordance with the movement of the shadow S1, and the shadow S1 may be over-detected as the passenger P1.

20 This also occurs in a ride detection process. In other words, the detection area E1, i.e., the ride detection area, is set in the hall 15 around the doorway of the car 11. If a shadow enters the detection area E1 due to the lighting environment of
25 the hall 15, the shadow may be over-detected due to a luminance change on the image.

Therefore, this embodiment is configured such that the detection processing unit 24 of the image processing device 20 shown in FIG. 1 comprises the
30 following functions (edge extraction, motion detection, and person detection) and presence or absence of a passenger is detected by using edge change between images (between frames) continuously obtained as

captured images. The "edge change" refers to a state in which edges extracted from the same position between images are changed. The "edge change" includes an "edge difference" that is the difference in edge intensity. The functions (edge extraction, motion detection, and person detection) provided in the detection processing unit 24 in a case of obtaining the edge difference as an example of edge change will be described below in detail.

10 (a) Edge Extraction

The edge extraction unit 24a extracts information on edges from the images captured by the camera 12. In this case, the edge information may be extracted from a single image or a plurality of images. The "edge" refers to a boundary line where the luminance value of each pixel in the image changes discontinuously. For example, a portion where the luminance value changes characteristically is extracted as the edge by using an edge extraction filter such as a Sobel filter or a Laplacian filter. The edge information includes the direction and intensity of the luminance gradient.

The edge intensity is obtained based on the luminance gradient. The luminance gradient may be obtained, for example, in a range of 3x3 pixels or any other range. In addition, the range for obtaining the luminance gradient may be fixed or may be automatically changed according to the parameter settings or the capture subject.

30 * Combination of Direction and Intensity of Luminance Gradient

The edge extraction unit 24a obtains the direction and the intensity of the luminance gradient for each pixel in the captured image, and extracts the edge

excluding the shadow area, based on the combined information. The directions of the luminance gradient include four directions (horizontal and vertical directions), i.e., upper side → lower side, lower side → upper side, left side → right side, and right side → left side, as well as four directions (diagonal directions), i.e., upper left side → lower right side, lower left side → upper right side, upper right side → lower left side, and lower right side → upper left side. To suppress over-detection of the shadow, the luminance gradient in at least two or more directions is desirably obtained.

An edge for which co-occurrence is established may be extracted. For example, edges with luminance gradient directions to the left and right sides may be extracted with respect to the focused pixel. The edge intensity is calculated based on an average of the luminance values in each selected direction, and the like.

20 * Mountain-shaped Edge

The edge extraction unit 24a extracts edges whose luminance values change in a mountain-shaped pattern as edges excluding the above shadow areas.

FIG. 7 is a view showing an example of a captured image including a person and a shadow. In the figure, 51 denotes a person, more specifically, a passenger in the car 11. In the figure, 52 denotes a shadow generated on the floor surface inside the car 11, and schematically shows a shadow of a hand which the person 51 pushes out to the front side. FIG. 8 is a graph showing a state of the change in luminance values of an image 53 corresponding to the person 51 as viewed in the X-axis direction. FIG. 9 is a graph showing the

change in luminance values of an image 54 corresponding to a shadow 52 as viewed in the X-axis direction.

As shown in FIG. 8, the image 53 corresponding to the person 51 includes a large number of edges whose
5 luminance values change discontinuously due to the fingers of the hand, wrinkles on clothes, and the like of the person 51. In contrast, as shown in FIG. 9, the change in luminance values inside the image 54 corresponding to the shadow 52 is flat, and luminance
10 values change at the boundaries, but the direction of the luminance gradient is unidirectional. Therefore, to suppress the over-detection of the shadow 52, it is effective to extract edges that have a combination of luminance gradients in two or more directions and their
15 intensities and whose luminance values change continuously in a mountain-shaped pattern (hereinafter referred to as "mountain-shaped edges"). By focusing on such mountain-shaped edges to execute the edge extraction, edges other than shadow areas can be
20 efficiently extracted from the captured image, and a detection process unaffected by shadow motion can be realized by using the edge change, i.e., edge difference.

A method of calculating the intensity of the
25 mountain-shaped edges will be described with reference to FIG. 10 and FIG. 11.

For example, a pixel located at the center of a range of 3×3 pixels is referred to as a focused pixel, and the luminance differences in four directions, i.e.,
30 upper, lower, left, and right directions, are obtained for the focused pixel. A value obtained by averaging these luminance differences is calculated as the intensity of the mountain-shaped edge.

It is assumed that the luminance value of the focused pixel is "191" in 256 shades. The intensity of the mountain-shaped edge is obtained by the following calculation if the luminance value of the pixel located on the upper side of the focused pixel is "0 (black)", the luminance value of the pixel located on the right side of the focused pixel is "64", the luminance value of the pixel located on the lower side of the focus pixel is "127", and the luminance value of the pixel on the left side the focus pixel is "255 (white)".

$$\{(191-0)+(191-64)+(191-127)+0\}/4=95.5$$

The luminance value of the pixel located on the left side of the focused pixel is calculated as "0" since the luminance value is larger than that of the focused pixel. The edge intensity at the position of the pixel is obtained as "96 (obtained by normalizing 95.5 to an integer)" by the above expression.

(b) Motion Detection

The motion detection unit 24b compares the edges extracted by the edge extraction unit 24a in the images continuously obtained as the captured images to obtain the edge difference, and detects the motion based on the edge difference. The "motion" refers to an area where an object having some movement is captured on a captured image.

The "edge difference" specifically refers to the difference in edge intensity. It is assumed that in the example shown in FIG. 11, the edge intensity of the focused pixel in the first image is calculated to be "96". If the edge intensity of the same focused pixel in the next image is "10", the difference in edge intensity is $96-10=86$. For example, if the threshold is set to "40", then "86" is larger than or equal to

the threshold value, and the part of the focused pixel is therefore determined to have motion.

The edge intensity may be binarized and then the difference may be calculated as an alternative method.

5 For example, if the threshold value is set to "40", the edge intensity "96" is binarized to "255", and the edge intensity "40" is binarized to "0". The difference between both the edge intensities is $255 - 0 = 255$, which is not "0", and the image is
10 determined to have motion.

 In the example in FIG. 7, 55 in the figure denotes pixels (motion pixels) determined to have motion. There are a large number of motion pixels 55 on the hand and clothes, in the image 53 of the person 51, but
15 no motion pixels 55 are present in the image 54 of the shadow 52. As described below, whether the motion is a person or not can be determined from the distribution of the motion pixels 55.

* Edge Difference and Luminance Difference

20 The motion detection may be executed by using both the edge difference and the luminance difference. In this case, the motion detection unit 24b obtains the luminance difference (difference in luminance values) in the images continuously obtained as the captured
25 images, apart from the edge difference, and detects the motion based on the luminance difference and the edge difference. Examples of the method for integrating the result of edge difference and the result of luminance difference include the logical operations (such as
30 AND/OR operations) and parameter changes as explained below, and the like.

 AND operation: When the motion pixels on an image are detected by both the edge difference and the

luminance difference, it is determined that the motion exists within a predetermined range including the motion pixels.

5 OR operation: The luminance difference is used for an area with a number of edges (an area which may be a shadow with little possibility), and the edge difference is used for an area with few edges (an area which may be a shadow with high possibility). The "area with a number of edges" refers to an area where
10 the number of edges (number of pixels) extracted by the edge extraction unit 24a is larger than or equal to a specified number of pixels, which is defined as the criterion for determining shadows. The "area with few edges" refers to an area where the number of edges
15 (number of pixels) extracted by the edge extraction unit 24a is smaller than the specified number of pixels, which is defined as the criterion for determining shadows.

 Parameter change: For the area with a number of
20 edges (the area which may be a shadow with little possibility), the parameter of luminance difference is made easier to detect (i.e., the threshold value of the luminance difference is made lower than the standard value) and, for the area with few edges (the area which
25 may be a shadow with high possibility), the parameter of the luminance difference is made difficult to detect (i.e., the threshold value of the luminance difference is made higher than the standard value).

(c) Person Detection

30 The person detection unit 24c detects the above motion as a person, based on the information of the motion detected by the motion detection unit 24b. The "person" specifically refers to a passenger in the car

11 or the hall 15. The "motion information" includes at least one of the distribution of the motion pixels, the size of the motion, and the motion detection count.

5 The "distribution of the motion pixels" indicates the state of distribution of the motion pixels within a predetermined range. For example, if there are forty (i.e., approximately 10%) or more motion pixels in the range of 20×20 pixels, it is determined that the motion pixels indicate the motion of a person. The "motion
10 size" indicates the size of an aggregate of continuous motion pixels. For example, if forty or more motion pixels exist as a continuous aggregate, it is determined that the motion pixels indicate the motion of a person. The "motion detection count" indicates
15 the number of times at which the motion is detected in each image. For example, if the motion is detected a certain number of times at the same location in the image, it is determined that the motion indicates the movement of a person.

20 * Information on Edges and Motion

The person detection may be executed by using both the information on the edges and the information on the motion. In this case, the person detection unit 24c changes the criterion for person detection, using one
25 of the distribution of the motion pixels, the motion size, and the motion detection count, which are obtained as the information on motion, based on the information of edges, to execute the person detection.

More specifically, the person detection unit 24c
30 makes the distribution of motion pixels or the motion size smaller, in the area with a number of edges (the area which may be a shadow with little possibility) than that in the area with few edges, to execute the

person detection. Alternatively, the motion detection count in the area with a number of edges (the area which may be a shadow with little possibility) among the captured images, may be made smaller than that in the area with few edges and, for example, the area which is detected as the motion even once may be determined as a person.

This system detects a person (passenger) in the captured image, using the detection processing unit 24 having the above configuration and, if the person exists in one of the detection areas E1 to E3 shown in FIG. 3, executes the predetermined corresponding process (door open and close control). The processing operation of this system will be described below using an example of the pull-in detection.

FIG. 12 is a flowchart showing the processing operation of this system. The processing shown in this flowchart is executed by the image processing device 20 and elevator control device 30 shown in FIG. 1.

First, a detection area setting process is executed by the detection area setting unit 23 of the detection unit 22 provided in the image processing device 20 as an initial setting (step S100). This detection area setting process is executed in a manner described below when, for example, the camera 12 is installed or the installation position of the camera 12 is adjusted.

In other words, the detection area setting unit 22a sets the detection area E1 having the distance L3 from the doorway to the hall 15, in a state in which the car door 13 is fully opened. As shown in FIG. 4, the detection area E1 includes the sills 18 and 47 and is set except for the blind spots of the jambs 17a and

17b. In the state in which the car door 13 is fully opened, the size of the detection area E1 in the horizontal direction (X-axis direction) is denoted by W1 and has a distance larger than or equal to the horizontal width W0 of the doorway (frontage). In addition, the detection area setting unit 22a sets the detection area E2 having a predetermined width along the inner side surfaces 41a-1 and 41b-1 of the entrance panels 41a and 41b of the car 11, and sets the detection area E3 having a predetermined width along the sill 47 of the floor surface 19 of the car 11.

During the normal operation, when the car 11 arrives at the hall 15 on any floor (Yes in step S101), the elevator control device 30 starts the opening operation of the car door 13 (step S102). In accordance with this opening operation, 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. Capturing using the camera 12 may be continuously executed in a state in which the door of the car 11 is closed.

The image processing device 20 obtains the images captured by the camera 12 on a time-series basis, and executes the following detection process (a pull-in detection process) in real time while sequentially storing these images in the storage unit 21 (step S103). Distortion correction, enlargement and reduction, cutting a part of the image, and the like may be executed as pretreatment for the captured images.

FIG. 13 shows the detection process executed in step S103. This detection process is executed by the

detection processing unit 24 of the image processing device 20. Extracting the mountain-shaped edges from the captured images is assumed below.

5 First, the detection processing unit 24 obtains each image (original image) from the memory unit 21 on a time-series basis (step S201) and creates an image consisting only of the mountain-shaped edges for each of these images (step S202). More specifically, the detection processing unit 24 extracts the edges which
10 have a combination of the direction and the intensity of the luminance gradient in two or more directions and whose luminance values change in a mountain-shaped pattern, as the mountain-shaped edges, and creates an image consisting only of the mountain-shaped edges
15 (hereinafter referred to as a mountain-shaped edge image).

Subsequently, the detection processing unit 24 executes differential binarization of the mountain-shaped edge image (step S203). As described with
20 reference to FIG. 11, the detection processing unit 24 obtains the luminance gradient for each pixel of the mountain-shaped edge image, and binarizes the difference obtained by comparing the intensity of the luminance gradient at the same pixel position in the
25 next image, with a preset threshold value TH1. The threshold value TH1 is set to an optimum value depending on the lighting environment inside the car 11 and in the hall 15.

In addition, the detection processing unit 24 also
30 executes differential binarization of the original image, which is the captured image (step S204). More specifically, the detection processing unit 24 obtains the luminance difference by comparing the luminance

values of the respective pixels in the image at the same pixel position of the next image, and binarizes the luminance difference with a preset threshold value TH2. The threshold value TH2 is set to an optimum value depending on the lighting environment in the car 11 and the hall 15, as well as the threshold value TH1.

The detection processing unit 24 integrates the value obtained by binarizing the edge difference of each pixel, which is obtained from the mountain-shaped edge images, and the value obtained by binarizing the luminance difference of each pixel, which is obtained from the original image (step S205), and detects the presence or absence of the motion from the result of the integration process (step S206). Examples of the method of integrating the edge difference and the luminance difference include the logical operation (AND/OR operation, and the like) and parameter changes as described above, and the like.

Thus, when the motion (motion pixel) is detected, the detection processing unit 24 detects a person based on the information on the motion (step S207). More specifically, the detection processing unit 24 determines whether or not the motion is that of a person, based on at least one of the distribution of motion pixels, the motion size, and the motion detection count, which are obtained as the information on the motion. For example, in the case of executing the person detection, based on the distribution of the motion pixels, if approximately 10% or more of the motion pixels exist within a predetermined pixel range, the person detection unit 24c determines the range including the motion pixels as the motion of the person. In this embodiment, the "person" refers to a

passenger in the car 11 or the hall 15, and the movement of the passenger's clothes, hands, and the like are represented as the motion pixels in the captured image (see FIG. 7).

5 In the example in FIG. 13, the edge difference and the luminance difference are used together, but the motion detection process may be executed using the only edge difference and a person (passenger) may be detected based on the distribution of the motion pixels and the like obtained as the detection result. In this
10 case, the processes in steps S204 and S205 in FIG. 13 are unnecessary.

 The description returns FIG. 12 and, when a passenger is detected by the above detection process
15 during the opening operation, the detection processing unit 24 determines whether or not the passenger is in the detection area E2 or E3, which is set as the pull-in detection area inside the car 11 (step S104). If the passenger is in the detection area E2 or E3 (Yes in
20 step S104), a pull-in detection signal is output from the detection processing unit 24 to the elevator control device 30. As a result, the elevator control device 30 temporarily suspends the opening operation of the car door 13 via the door open and close control
25 unit 31 and restarts the opening operation at its suspend position after several seconds, as the responsive process associated with the pull-in detection area (step S105).

 As the response process, the opening speed of the
30 car door 13 may be made slower than usual, or the opening operation may be restarted after slightly moving the car door 13 in the opposite direction (door closing direction). In addition, audio announcement

may be made through the speaker 46 in the car 11 by activating the alarm unit 32 of the elevator control unit 30, to call attention to the passenger to move away from the door 13 or to sound the alarm (step
5 S106). The above process is repeated while a passenger is detected in the detection area E2 or E3. As a result, for example, when a passenger is near the car door 13, it is possible to prevent the passenger from being pulled into the door pocket 42a or 42b.

10 (Ride detection process)

In the example in FIG. 12, the pull-in detection process has been described as an example, but the ride detection process is also executed in the same manner.

In other words, when the car 11 starts closing the
15 door at any floor, the detection process described with reference to FIG. 13 is executed. As described above, when a passenger is detected based on the edge difference and the luminance difference of the captured image, it is determined whether or not the passenger is
20 in the detection area E1, which is set as the ride detection area in the hall 15. When it is detected that the passenger is in the detection area E1 and is moving toward the door 13 of the car 11, the ride detection signal is output from the detection
25 processing unit 24 to the elevator control device 30. As a result, the elevator control device 30 temporarily suspends the closing operation of the car door 13 via the door open and close control unit 31, moves the car door 13 in an opposite direction (the door closing
30 direction), or makes the opening speed of the car door 13 slower than usual, as the responsive process associated with the ride detection area.

Thus, according to this embodiment, the

over-detection of the shadow that has entered the captured image can be suppressed and the passenger can be detected by using the edge difference. In particular, if the mountain-shaped edges whose
5 luminance values change in a mountain-shaped pattern are used as extraction targets, by considering the difference in luminance characteristics between the person and the shadow, the passenger can be correctly detected by eliminating the influence of the shadow,
10 and the responsive processing corresponding to the detection results can be realized.

In the above embodiment, detecting a passenger from the entire captured image has been assumed, but a passenger may be detected in each detection area that
15 is set in advance on the captured image. For example, if the door is in the opening operation, the system focuses on the images in the detection areas E2 and E3 shown in FIG. 4, and detects a passenger in the detection area E2 or E3 by the edge difference of the
20 images. In addition, if the door is in the closing operation, the system focuses on the image in the detection area E1 shown in FIG. 4, and detects the passenger in the detection area E1 by the edge difference of the image.

25 In addition, in the above embodiment, the edge difference (difference in edge intensity) has been described as an example of the edge change, but the edge change may be determined using, for example, a rectangle such as normalized correlation. In short,
30 any method may be employed irrespective of the edge difference if it can detect the state in which the edge changes between images.

According to at least one of the embodiments

described above, an elevator passenger detection system capable of suppressing over-detection of shadows caused by the lighting environment and correctly detecting passengers in the car or the hall can be provided.

5 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;
10 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
15 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 passenger detection system
equipped with a camera installed in a car to capture a
predetermined range including an inside of the car, the
5 system comprising:

an edge extraction unit extracting information on
an edge from a captured image of the camera;

a motion detection unit detecting motion of the
captured image, based on an edge change obtained by
10 comparing edges extracted by the edge extraction unit
between images continuously obtained from the captured
image; and

a person detection unit detecting the motion as a
person, based on information on the motion detected by
15 the motion detection unit.

2. The elevator passenger detection system of
claim 1, wherein

the edge extraction unit extracts an edge
including a combination of a direction and an intensity
20 of luminance gradient in two or more directions, which
is obtained from each pixel of the captured image.

3. The elevator passenger detection system of
claim 2, wherein

the edge extraction unit extracts an edge whose
25 luminance value changes in a mountain-shaped pattern.

4. The elevator passenger detection system of
claim 1, wherein

the motion detection unit detects the motion from
the captured image, based on the luminance difference
30 between the images and the edge change between the
images.

5. The elevator passenger detection system of
claim 4, wherein

the motion detection unit easily detects a parameter of the luminance difference in an area including a large number of edges in the captured image, and hardly detects the parameter of the luminance difference in an area including a small number of edges in the captured image.

6. The elevator passenger detection system of claim 4, wherein

the motion detection unit uses the luminance difference in an area including a large number of edges in the captured image, and uses the edge difference in an area including a small number of edges in the captured image.

7. The elevator passenger detection system of claim 1, wherein

the person detection unit detects the motion as a person, based on at least one of a motion pixel distribution, a motion size, and a motion detection count which are obtained as the information on the motion.

8. The elevator passenger detection system of claim 7, wherein

the person detection unit detects the motion as a person, based on the information on the motion and the information on the edge.

9. The elevator passenger detection system of claim 8, wherein

the person detection unit lowers a determination criterion on the motion pixel distribution or the motion size, in the area including a large number of edges in the captured image.

10. The elevator passenger detection system of claim 8, wherein

the person detection unit lowers a determination criterion on the motion detection count, in the area including a large number of edges in the captured image.

5 11. The elevator passenger detection system of claim 1, further comprising:

 a control unit, when the person is detected in a detection area preset in the captured image, executing a responsive process associated with the detection
10 area.

 12. The elevator passenger detection system of claim 11, wherein

 the detection area is set near a door in the car,
 and

15 the control unit controls door open and close operations to prevent the person from being caught by the door during the operation of opening the door of the car.