

ELEVATOR RIDING DETECTION SYSTEM

FIELD

Embodiments described herein relate generally to an elevator riding detection system which detects a user riding a car of an elevator system.

BACKGROUND

In general, when a car of an elevator arrives a certain floor, its door opens and then closes after a certain period of time, and the car moves. Sometimes, a user of the elevator who enters the car from the floor would hit the door closing since he/she does not know when the door closes.

In order to avoid such a collision between a door and a user during a riding phase, a user is detected by a camera or the like which is attached to the upper side of the car, and the open/close operation of the door is controlled.

A detection area of a user by a camera in a car is different by elevators or by levels, in some case. Thus, in order to optimize the detection area, a service man must input specific values of each elevator and specific values of each level and set the detection area before the elevator is activated. However, if such specific values are difficult to acquire, standard specific values may be set or specific values manually set by a service man may be used. That is, a work load of detection area setting increases and detection performance sometimes becomes insufficient.

SUMMARY

According to an aspect, there is provided an elevator boarding detection system characterized by comprising: image capturing means configured to capture an image of a certain range when a car arrives a floor, the range between the proximity of a door of the car and the floor; detection area setting means configured

to set a detection area in the image captured by the
image capturing means; user detection means configured
to detect a user focusing on a motion of a person
and/or an object within the detection area using a
5 plurality of chronologically consecutive images
captured by the image capturing means; and control
means configured to control an open/close operation of
the door on the basis of a detection result from the
user detection means. The detection area setting means
10 is configured to: detect a sill between the car and the
floor included in the image; detect an area of a jamb
based on corners at a side close to the floor of
corners of the sill, in the image; and set the
detection area not including the area of the jamb in
15 the image.

According to one embodiment, an elevator riding
detection system includes an image capturing means, a
detection area setting means, a user detection means
and control means. The image capturing means captures
20 an image of a certain range when a car arrives a floor,
the range between the proximity of a door of the car

and the floor. The detection area setting means
detects a sill between the car and the floor included
in the image captured by the image capture means in
order to set a detection area on the image on the basis
5 of the sill detected. The user detection means detects
a user on the basis of a motion of a person and/or an
object within the detection area using a plurality of
chronologically consecutive images captured by the
image capturing means. The control means controls an
10 open/close operation of the door on the basis of a
detection result from the user detection means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the structure of an elevator riding
detection system of a first embodiment.

15 FIG. 2 shows an example of an image captured by a
camera of the first embodiment.

FIG. 3 shows an example of a detection area of the
elevator riding detection system of the first
embodiment.

20 FIG. 4 shows a coordinate system in a real space
of the first embodiment.

FIG. 5 is a flowchart showing a flow of a
detection area setting process of the first embodiment.

25 FIG. 6 shows an example of edge detection by a
detection area setting unit of the first embodiment.

FIG. 7 shows an example of detection of a sill
area by the detection area setting unit of the first
embodiment.

30 FIG. 8 shows an example of detection of origin by
the detection area setting unit of the first
embodiment.

FIG. 9 shows an example of detection of jamb by
the detection area setting unit of the first
embodiment.

35 FIG. 10 is a flowchart showing an example of a

detection process of the jamb by the detection area setting unit of the first embodiment.

FIG. 11 shows an example of detection of a front post of a door pocket by the detection area setting unit of the first embodiment.

FIG. 12 is a flowchart of an example of a detection process of the front post of the door pocket by the detection area setting unit of the first embodiment.

FIG. 13 is a flowchart showing a flow of the whole process of an elevator riding detection system of the first embodiment.

FIG. 14 is a flowchart showing an example of a flow of a detection area setting process of a second embodiment.

FIG. 15 shows an example of detection of a sill area by a detection area setting unit of the second embodiment.

DETAILED DESCRIPTION

Hereinafter, embodiments will be described with reference to accompanying drawings. In the flowing description, functions and structural elements which are substantially the same will be referred to by the same reference numbers and some description considered redundant may be omitted.

[First embodiment]

FIG. 1 shows the structure of an elevator riding detection system 1 of the present embodiment. Here, the present embodiment will be explained referring to a case where one car is used; however, the present embodiment will be applied to a case where several cars are used.

A camera 12 is mounted in the upper part of an entrance of a car 11. Specifically, the camera 12 is mounted in a plate 11a covering the upper part of the

entrance of the car 11 while the lens of the camera 12 is faced to the floor 15 side. The camera 12 is a small monitoring camera as used in an in-car device, has a wide angle lens, and can consecutively shoot several frames per second (e.g. 30fps). When the car 11 arrives each floor and its door opens, the camera 12 captures the state of the floor 15 and the state of the proximity of a car door 13 in the car 11.

The range of image capturing includes a length L1 and a length L2 ($L1 > L2$). The length L1 is an image capturing range of the floor 15 side, and it is preferably 3 m or the like between the car door 13 and the floor 15. The length L2 is an image capturing range of the car side, and it is preferably 50 cm between the car door 13 and the rear surface of the car. Note that the lengths L1 and L2 extend in the depth. An image capturing range of the width (direction orthogonal to the depth) is at least greater than the horizontal width of the car 11.

Note that, in the floor 15 of each level, a floor door 14 is installed to open/close freely to match the entrance of the car 11. The floor door 14 performs the open/close operation in synchronization with the car door 13 at the arrival of the car 11. A power source (door motor) is mounted in the car 11 side, and the floor door 14 simply opens/closes following the car door 13. In the following description, when the car door 13 is opened, the floor door 14 is opened together, and when the car door 13 is closed, the floor door 14 is closed together.

Each image (video) captured by the camera 12 is analyzed by an image processing device 20 in real time. Note that, in FIG. 1, the image processing device 20 is taken out from the car 11 while the image processing device 20 is actually store in the plate 11a with the

camera 12.

Here, the image processing device 20 includes a storage unit 21 and a user detection unit 22. The storage unit 21 chronologically stores images capture
5 by the camera 12 and includes a buffer area which temporarily stores data required to process the user detection unit 22. The user detection unit 22 focuses on the motion of a person/object closest to the car door 13 in the chronologically consecutive images
10 captured by the camera 12 to detect a user who intends to ride the elevator car. If divided by its functions, the user detection unit 22 includes a detection area setting unit 22a, motion detection unit 22b, position estimation unit 22c, and riding intention estimation
15 unit 22d.

The detection area setting unit 22a sets a detection area in an image captured by the camera 12. The detection area and a detailed setting method of the detection area will be described later.

20 The motion detection unit 22b divides, for example, a detection area into blocks of certain size and detects a motion of a person/object by comparing the brightness of the images. Here, the motion of a person/object refers to a motion of a person, a wheel
25 chair, or the like on the floor 15.

The position estimation unit 22c extracts a block closest to the car door 13 from motion-detected blocks of the images by the motion detection unit 22b and estimates that the block is a foot position of a user.
30 The riding intention estimation unit 22d determines whether or not the user intends to ride the elevator car on the basis of a chronological change of the foot position of the user estimated by the position estimation unit 22c.

35 Note that the above functions (of the detection

area setting unit 22a, motion detection unit 22b, position estimation unit 22c, and riding intention estimation unit 22d) may be provided with the camera 12 or with a car control device 30.

5 The car control device 30 is connected to an elevator control device which is not shown, and transmits/receives various signals such as floor call and car call with the elevator control device. Note that the floor call is a calling signal registered by
10 an operation of a floor call button (which is not shown) mounted in the floor 15 of each level and includes information of registered level and destination direction. The car call is a calling signal registered by an operation of a destination call
15 button (which is not shown) mounted inside the car room of the car 11 and includes information of destination level.

 Furthermore, the car control device 30 includes a door open/close control unit 31. The door open/close
20 control unit 31 controls the door opening/closing of the car door 13 when the car 11 arrives the floor 15. Specifically, the door open/close control unit 31 opens the car door 13 when the car 11 arrives the floor 15 and closes the car door 13 after a certain period of
25 time. Note that, if a person who intends to ride the car 11 is detected by the user detection unit 22 of the image processing device 20 while the car door 13 is opening, the door open/close control unit 31 stops the door closing operation to maintain the car door 13
30 opened.

 FIG. 2 shows an example of an image captured by the camera 12. In this example, the car door 13 is a double door and the image is captured by the camera 12 attached to the center of the car door 13. Note that
35 the mount position of the camera 12 is not limited to

the center of the car door 13. For example, the car door 13 may be a single door, and in such a case, the mount position of the camera 12 is, preferably, attached to the door stopper side.

5 The camera 12 is mounted on the upper part of the entrance of the car 11. When the car 11 opens the door at the floor 15, an image of a certain range in the floor 15 side (length L1) and an image of a certain range in the car 11 side (length L2) are captured.

10 The image captured by the camera 12 includes a left frame A1 of the jamb, right frame A2 of the jamb, sill A3, left front post (left entrance post) A4, and right front post (right entrance post) A5. The sill A3 is an area including both a sill in the floor 15 side and a sill in the car 11 side. The width of the sill A3 is equal to the width of the elevator. The above areas are separate areas in the image.

15 FIG. 3 shows an example of a detection area E of the elevator riding detection system. The detection area E includes a position estimation area E1, riding intention estimation area E2, sill area E3, and front post area E4.

20 The position estimation area E1 is an area which estimates a part of a body of a user approaching the car door 13 from the floor 15, specifically, a foot position of the user.

25 The riding intention estimation area E2 is an area which estimates whether or not the user detected by the position estimation area E1 intends to ride. Note that the riding intention estimation area E2 is included in the position estimation area E1 and is an area which estimates a foot position of a user. That is, in the riding intention estimation area E2, a foot position of a user is estimated and an intention of the user to ride is estimated.

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In a real space, the position estimation area E1 includes a length L3 from the center of the car door 13 to the floor 15. The length L3 is set to, for example, 2 m (length L3 $\leq$ length L1). A width W1 of the position estimation area E1 is set to be greater than a width W0 of the car door 13.

The riding intention estimation area E2 has a length L4 from the center of the car door 13 to the floor 15. The length L4 is set to, for example, 1 m (length L4 $\leq$ length L3). A width W2 of the riding intention estimation area E2 is substantially equal to the width W0 of the car door 13. Note that the width W2 of the riding intention estimation area E2 may be greater than the width W0. The riding intention estimation area E2 may be, as described above, a substantial rectangle in the real space, or may have the same shape as the position estimation area E1 within the range of length L4.

The sill area E3 and the sill A3 of FIG. 2 are, preferably, the same.

The front post area E4 is an area including the left front post A4 and the right front post A5 of FIG. 2.

The sill area E3 and the front post area E4 are, for example, the area where an approach detection is performed (hereinafter referred to as approach detection area). The approach detection is to detect an object approaching the car door 13 or the floor door 14 by image processing with respect to the image captured by the camera 12 or a sensor such as an approach switch. The approach detection is performed by, for example, the motion detection unit 22b of the user detection unit 22.

Note that, between the position estimation area E1 and the riding intention estimation area E2, the

approach detection may be performed in, for example, an area of a certain range close to the sill area E3.

Furthermore, the position estimation area E1 and the riding intention estimation area E2 may include the approach detection area, or may be set as an area excluding the approach detection area.

In the present embodiment, the detection area setting unit 22a sets the detection area E in the image captured by the camera 12. Then, the motion detection unit 22b, position estimation unit 22c, and riding intention estimation unit 22d perform riding detection using the detection area E. The riding detection process will be detailed later with reference to FIG. 11.

FIG. 4 shows a coordinate system in the real space.

An origin O of the coordinate system is set to the car door 13. That is, the origin O corresponds to the center of the side of the rectangle representing the sill A3 in the floor 15 side in the image captured by the camera 12 (cf. FIG. 2).

An X-axis is an axis extending from the origin O in parallel to the car door 13 provided with the entrance of the car 11. An Y-axis is an axis extending from the origin O toward the floor 15 to be orthogonal to the car door 13. An Z-axis is an axis extending from the origin O toward the height direction of the car 11.

The camera 12 is attached to a position of height h which is directly above the origin O. That is, coordinates of the mount position of the camera 12 in the real space are (0, 0, h).

Furthermore, the coordinate system used in the image captured by the camera 12 is, as shown in FIG. 3, a coordinate system in which the upper left end of the

image is set to the origin, the lateral direction of the image is set to X-axis, and the vertical direction of the image is set to Y-axis. The origin O of the coordinate system in the real space is, in the image, the center of the side of the rectangle representing the sill A3 in the floor 15 side. A shift between the axes of the coordinate system in the image and the coordinate system in the real space is represented by, for example, a rotation parameter rotation center of which is set to the origin O. That is, with multiplication of the rotation parameter with respect to each of axes X, Y, and Z of the coordinate system in the image, the coordinate system in the image can be converted into the coordinate system in the real space. Note that the reverse conversion, that is, a conversion of the coordinate system in the real space into the coordinate system in the image can be performed similarly using the rotation parameter.

Furthermore, the camera 12 stores internal parameters at the time of image capture. The internal parameters are, for example, a focal length, lens center, resolution, and distortion coefficient.

In the present embodiment, the detection area setting unit 22a detects the left frame A1 and the right frame A2 of the jamb, sill A3, left front post A4, and right front post A5 of FIG. 2 through the image process of an image n captured by the camera 12, and on the basis of detection results, the detection area E of FIG. 3 (position estimation area E1, riding intention estimation area E2, sill area E3, and front post area E4) is set. Hereinafter, a setting process of the detection area E by the detection area setting unit 22a will be explained specifically with reference to FIGS. 5 to 12.

FIG. 5 is a flowchart showing an example of a flow

of a detection area setting process.

In the present embodiment, the above-mentioned internal parameters of the camera 12 are preliminarily input in the user detection unit 22. Furthermore, the
5 mount position and the rotation parameter of the camera 12 are unknown.

In step S101, the detection area setting unit 22a performs an edge detection with respect to the image captured by the camera 12. In the edge detection,
10 various filters such as Sobel filter and Laplacian filter are used. In the image after the edge detection, many edges indicating the sill, jamb, and front post of the elevator are detected. Note that, if the noise is excessive in the image after the edge
15 detection, a noise canceling treatment is, preferably, performed to the image.

FIG. 6 shows an example of edge detection by the detection area setting unit. As shown in FIG. 6, in the image after the edge detection, noise such as
20 person U may be included.

In step S102 of FIG. 5, the detection area setting unit 22a detects the sill A3. On the floor surface, a quadrangle pattern similar to the sill does not usually appear, and thus, a candidate for the sill can be
25 extracted by searching quadrangular areas from the image after the edge detection. Specifically, the detection area setting unit 22a performs a straight line detection through Hough transformation or the like with respect to the image after the edge detection.
30 The detection area setting unit 22a searches a quadrangular area with respect to the image after the straight line detection process.

The search of quadrangular area may be performed through, for example, template matching. For example,
35 the detection area setting unit 22a preliminarily

stores quadrangular templates images in the storage unit 21. With the template images read from the storage unit 21, the detection area setting unit 22a performs the template matching process with respect to the image after the edge detection and detects the sill A3. If several candidates for the sill A3 are detected, one best matching the sill A3 may be selected on the basis of characteristics such as position, size, and aspect ratio. Note that the template images are, preferably, images representing quadrangles corresponding to average sill shapes. Furthermore, in the template matching process, the detection area setting unit 22a may adjust the shape, size, and the like of the template images on the basis of the preliminarily-set internal parameters of the camera 12.

The search of quadrangular areas may be performed without using a template matching process by, for example, a combination of extraction of a crossing point of two lines detected by Hough transformation, extraction of an angle formed by the two lines, and recognition of a closed area and the number of lines forming the closed area.

FIG. 7 shows an example of detection of a sill area by the detection area setting unit. FIG. 7 shows an area M of FIG. 6 in an enlarged manner. In the example of FIG. 7, as a result of the template matching process performed with respect to the image after the edge detection of FIG. 6 using a template image TI, two candidate areas C1 and C2 are detected, and as a result, the candidate area C2 is recognized as the sill A3.

In step S103 of FIG. 5, the detection area setting unit 22a calculates the mount position and the rotation parameter of the camera.

Firstly, the detection area setting unit 22a

calculates, as shown in FIG. 8, the center of the side of the sill A3 area in the floor 15 side in the image as a position corresponding to the origin O of the coordinate system in the real space. Secondly, the
5 detection area setting unit 22a calculates the height h of the camera 12 in the real space using the position of the origin O in the image and the internal parameters of the camera 12. That is, three-dimensional coordinates (0, 0, h) of the mount position
10 of the camera 12 of the coordinate system in the real space.

Furthermore, the side of the sill A3 including the origin O in the image corresponds to X-axis of the coordinate system in the real space and Y-axis in the
15 real space is in a direction orthogonal to the side. The detection area setting unit 22a compares the axes X and Y of the coordinate system in the image with the axes X and Y of the coordinate system in the real space, and the coordinates of the origin O of the
20 coordinate system in the image and the coordinates (0, 0, h) of the mount position of the camera of the coordinate system in the real space, and calculates the rotation parameter of each of the axes X, Y, and Z. Thus, a correspondence between the coordinate system in
25 the real space and the coordinate system in the image can be clarified. Specifically, for example, a perspective projection conversion process is performed on the basis of the mount position and the rotation parameter of the camera 12, and thus, the positions and
30 lengths of lengths L3 and L4 and widths W1 and W2 in the image, which are used to set the position estimation area E1 and the riding intention estimation area E2, are calculated.

In step S104 of FIG. 5, the detection area setting
35 unit 22a detects the jamb.

Here, FIG. 9 shows an example of detection of the jamb by the detection area setting unit 22a.

Furthermore, FIG. 10 is a flowchart showing an example of a jamb detection process by the detection area

5 setting unit 22a. The jamb is adjacent to the sill and is vertical to the floor surface, and thus, the left frame A1 and the right frame A2 can be detected on the basis of the position of the sill A3.

10 In step S104A of FIG. 10, the detection area setting unit 22a initially detects corners Cn1 and Cn2 of the sill A3 in the floor 15 side. That is, the corners Cn1 and Cn2 are corners of the sill A3 which are closer to the floor 15. The corners Cn1 and Cn2 are detected by, for example, image processing such as
15 corner detection with respect to the sill A3.

In step S104B, the detection area setting unit 22a detects a line segment G1 (line segment G2) extending from the corner Cn1 (corner Cn2) toward the floor 15. The line segment G1 (line segment G2) is a line segment
20 corresponding to an edge of the jamb on the floor surface. Specifically, the detection area setting unit 22a detects, in the image after the edge detection which is obtained in step S102, the line segment G1 (line segment G2) extending from the proximity of the
25 corner Cn1 (corner Cn2) toward the upper side of the image and substantially in parallel to the Y-axis.

In step S104C, the detection area setting unit 22a detects line segments G3 and G4 (line segments G5 and G6) extending vertically from the ends of the line
30 segment G1 (line segment G2). The line segments G3 and G4 (line segments G5 and G6) are line segments corresponding to the edges of the left frame (right frame) of the jamb.

For example, the detection area setting unit 22a
35 uses the image after the edge detection to detect the

line segments G3 and G4 (line segments G5 and G6) extending from the ends of the line segment G1 (line segment G2) toward the ends of the image as the edges of the left frame (right frame) of the jamb. Note
5 that, as another method, the detection area setting unit 22a uses the internal parameter and the rotation parameter of the camera to calculate the inclination of straight lines from the ends of the line segment G1 (line segment G2) which represent a vertical direction
10 in the real space, and detect line segments G3 and G4 (line segments G5 and G6) matching the inclination as the edges of the left frame (right frame) of the jamb.

In step S104D, the detection area setting unit 22a performs area division using the line segments obtained
15 through the process of step S104C to detect the left frame A1 (right frame A2) of the jamb. The left frame A1 (right frame A2) of the jamb is an area surrounded by the line segments G1, G3, and G4 (line segments G2, G5, and G6) detected in steps S104B and S104C.

20 In step S105 of FIG. 5, the detection area setting unit 22a detects a front post of the door pocket.

Here, FIG. 11 shows an example of detection of the front post of the door pocket by the detection area setting unit 22a. Furthermore, FIG. 12 is a flowchart
25 showing an example of a process of detecting the front post of the door pocket by the detection area setting unit 22a. The front posts of the door pocket are, similarly to the jamb, adjacent to the sill and orthogonal to the floor surface, and thus, the left
30 front post A4 and the right front post A5 of the door pocket can be detected on the basis of the position of the sill A3.

In step S105A of FIG. 12, the detection area setting unit 22a detects the corners Cn3 and Cn4 in the
35 car 11 side of the sill A3. That is, the corners Cn3

and Cn4 are corners of the sill A3 which are closer to the car 11. The corners Cn3 and Cn4 can be detected similarly to the detection of the corners Cn1 and Cn2 of FIG. 9.

5 In step S105B, the detection area setting unit 22a detects a line segment G7 (line segment G8) extending from the corner Cn3 (corner Cn4) toward the car 11. The line segment G7 (line segment G8) is a line segment corresponding to the edge of the front post of the door
10 pocket on the floor surface. Specifically, the detection area setting unit 22a detects, in the image after the edge detection which is obtained in step S102, the line segment G7 (line segment G8) extending from the proximity of the corner Cn3 (corner Cn4)
15 toward the lower side of the image and substantially in parallel to the Y-axis.

 In step S105C, the detection area setting unit 22a detects line segments G9 and G10 (line segments G11 and G12) extending vertically from the ends of the line
20 segment G7 (line segment G8). The line segments G9 and G10 (line segments G11 and G12) are line segments corresponding to the edges of the left front post (right front post) of the door pocket. The detection method of the line segments G9 and G10 (line segments
25 G11 and G12) is similar to the detection method of the line segments G3 and G4 (line segments G5 and G6) of FIG. 9.

 In step S105D, the detection area setting unit 22a performs area division using the line segments obtained
30 through the process of step S105C to detect the left front post A4 (right front post A5) of the door pocket. The left front post A4 (right front post A5) of the door pocket is an area surrounded by the line segments G7, G9, and G10 (line segments G8, G11, and G12)
35 detected in steps S105B and S105C.

In step S106 of FIG. 5, the detection area setting unit 22a sets the detection area E of FIG. 3 on the basis of the left frame A1 of the jamb, right frame A2 of the jamb, sill A3, left front post A4, and right front post A5 obtained through steps S102 to S105.

The position estimation area E1 is, for example, an area defined by the width W1 and the length L3 of the area surrounded by the left frame A1 and the right frame A2 of the jamb and the sill A3.

The front post area E4 is, for example, an area including the detected left front post A4 and right front post A5 together with a substantial rectangle in which the line segment G7 of the left front post A4 and the line segment G8 of the right front post A5 are opposed sides.

The riding intention estimation area E2 is, as described above, set as an area included in the position estimation area E1 of the length L4. Furthermore, the sill area E3 and the sill A3 are, as described above, the same area.

As described above, the detection area setting unit 22a performs image processing with respect to the image captured by the camera 12 to automatically set the detection area E suitable for the image.

Note that the detection area setting unit 22a, preferably, performs a detection area setting process while the car door 13 and the floor door 14 are fully opened such that the camera 12 can capture the image of the entire range of the detection area E. However, the detection area setting unit 22a may perform the setting process of the front post area E4 of the detection area E while the car door 13 and the floor door 14 are completely closed. The image captured by the camera 12 while the doors are completely closed has less noise such as a person/object from the floor 15 side or

light, and is suitable for the detection area setting process. In that case, the detection area setting unit 22a initially performs the edge detection with respect to the image captured by the camera 12 while the doors
5 are completely closed. The detection area setting unit 22a detects the end side of the sill A3 in the car 11 side (elevator width) from the image after the edge detection in order to detect the corners Cn3 and Cn4 of the both ends of the end side. The detection of the
10 end side may be performed by, for example, searching straight lines which are substantially parallel to the X-axis of the coordinate system in the image, or may be performed by a template matching process. The detection area setting unit 22a sets the front post
15 area E4 through steps S105B to S105D of FIG. 12 on the basis of the corners Cn3 and Cn4.

FIG. 13 is a flowchart showing a flow of the entire processes of the elevator riding detection system 1.

20 Note that, in the present embodiment, in consideration of a case where the jambs of different specs are used in levels, a detection area E is set in each level.

When the car 11 arrives a floor 15 of an optional
25 level (Yes in step S11), the car control device 30 opens the car door 13 and waits for a user to ride the car 11 (step S12).

A certain range (length L1) in the floor side and a certain range (length L2) in the car are captured by
30 the camera 12 provided with the upper part of the entrance of the car 11 in a certain frame rate (for example, 30fps). The image processing device 20 chronologically acquires images captured by the camera 12 and stores the images in the storage unit 21 (step
35 S13).

Then, if a detection area E of a level where the car 11 arrives is not set yet (No in step S14), the detection area setting unit 22a of the user detection unit 22 performs the detection area setting process (step S15). The detection area setting process is not detailed here as being already explained with reference to FIGS. 5 to 12.

Furthermore, the detection area setting unit 22a may store the detection area E of each level set in step S15 in the storage unit 21. Thus, the detection area setting unit 22a can omit the calculation of the detection area E at each time when the car arrives each level. Specifically, the detection area setting unit 22a initially searches the storage unit 21 when arriving each level and determines whether or not the detection area E of the level is stored. If the detection area E of the level is stored, the detection area setting unit 22a reads the detection area E from the storage unit 21 and uses the detection area E in step S15, and thus, the calculation of detection area E can be skipped.

Then, the user detection unit 22 of the image processing device 20 performs the flowing user detection process in real time (step S16). The user detection process can be divided into a detection process performed by the motion detection unit 22b (step S16-1), position estimation process performed by the position estimation unit 22c (step S16-2), and riding intention estimation process performed by the riding intention estimation unit 22d (step S16-3).

Initially, the motion detection unit 22a determines whether or not a person/object moves in the detection area E in order to detect a user who intends to ride the car from the captured images.

Specifically, the motion detection unit 22b divides an

image of the current frame and an image of one-previous frame stored in the storage unit 21 into blocks of a certain size and compares the blocks by calculating an average brightness value. If a result shows a block
5 which has a brightness value above the average, the motion detection unit 22b determines that the block is a motion-detected block. Hereinafter, in a similar manner, the motion detection unit 22b repeats the motion detection by comparing the brightness values of
10 the images using the blocks in the chronological order.

Furthermore, if a motion-detected block is detected in the approach detection area such as sill area E3 and front post area E4, the motion detection unit 22b transmits a user detection signal to the car
15 control device 30. In that case, the process proceeds to step S17. Note that the approach detection with respect to the sill area E3 and the front post area E4 is effective to detect a person/object exiting the car 11 to the floor 15.

20 Then, the position estimation unit 22c extracts the block closest to the car door 13 out of the motion-detected blocks in the current image on the basis of the detection result of the motion detection unit 22b. Then, the motion detection unit 22b acquires the
25 coordinate Y of the block as data of the foot position of the user and stores the data in the storage unit 21.

Hereinafter, in a similar manner, the position estimation unit 22c acquires the data of the foot position of the user and stores the data in the storage
30 unit 21. Note that the estimation process of the front position is performed not only in the position estimation area E1 but also in the riding intention estimation area E2.

Furthermore, the riding intention estimation unit
35 22d performs smoothing of the data of the foot position

of the user obtained from the above-described position estimation process. Note that, as a smoothing method, a well-known method using, for example, a smoothing filter or a Kalman filter will be used and detailed description thereof is thus omitted.

In a smoothed data sequence of the foot position, if there are data showing a change amount is more than a certain value, the riding intention estimation unit 22d excludes the data as an outlier. Note that the above-mentioned certain value is determined on the basis of an average walking speed of users and frame rate of captured images. Furthermore, the riding intention estimation unit 22d may find and exclude an outlier before smoothing the data of the foot position. A result of the riding intention estimation unit 22d shows a user with riding intention, the image processing device 20 outputs a user detection signal to the car control device 30.

As a result of the above-mentioned user detection process (step S16), if the car control device 30 receives a user detection signal (Yes in step S17), the door open/close control unit 31 stops the door closing operation of the car door 13 and maintains the door opening state (step S18).

Specifically, if the car door 13 is fully opened, the car control device 30 initiates a door opening period counting operation and performs door closing after a certain period of time T (unit: minute, for example one minute) is counted. If a user with riding intention is detected during the period of time T and a user detection signal is received, the car control device 30 stops the counting operation and resets the count value. Thus, the door opening state of the car door 13 is maintained during the certain period of time T. Note that, if another user detection signal is

received, the count value is reset again and the door opening state of the car door 13 is maintained for another certain period of time T. The count value may be reset at each time when a user detection signal is received or at every T minutes.

Here, if user detection signals are received again and again within T minutes, the car door 13 cannot be closed for a very long time. Thus, an acceptance time Tx (unit: minute, for example, three minutes), and the car door 13 is, preferably, forcedly closed after the acceptance time Tx.

Aster the counting operation of the certain period of time T ends (step S19), the car control device 30 closes the car door 13 and starts the car 11 to a target level (step S20).

As can be understood from the above, in the present embodiment, images of the floor 15 captured by the camera 12 provided with the upper part of the entrance of the car 11 are analyzed to detect, for example, a user coming toward the car door 13 from a place slightly distant from the car 11, or a user going out of the car 11 toward the floor, and such a result of the analysis can be reflected upon the door open/close operation.

In the present embodiment described as above, while the elevator is in the operation, the elevator riding detection system 1 automatically detects the left frame A1 and right frame A2 of the jamb, sill A3, left front post A4, and right front post A5 by image processing. Furthermore, the elevator riding detection system 1 automatically sets the detection area E (position estimation area E1, riding intention estimation area E2, sill area E3, and front post area E4) on the basis of the detection result. Thus, a suitable detection area E can be set regardless of

specs of an elevator such as elevator width and door pocket size or specs of a jamb of each level where the elevator stops, and therefore, highly stable elevator riding detection system can be presented.

5 Furthermore, since the detection area E can be set automatically, factory check work and elevator setting work can be reduced.

 In the elevator riding detection system 1 of the present embodiment, internal parameters of the camera
10 12 are preliminarily applied to the elevator riding detection system 1, and the mount position and the rotation parameter of the camera 12 can be automatically calculated by image processing. Thus, for example, a service man who attaches the camera 12
15 does not need to fine tuning of the mount position of the camera 12, and thus, a work load of the service man can be reduced.

 Note that the detection area setting unit 22a may calculate a position of the origin O in the image by
20 perspective projection conversion processing on the basis of coordinates of the mount position and the rotation parameter of the camera 12, and on the basis of the calculated origin O, may adjust a position of origin O calculated preliminarily on the basis of the
25 area of the sill A3.

 In the present embodiment, the lengths L3 and L4 and the widths W1 and W2 used for setting the position estimation area E1 and the riding intention estimation area E2 may be automatically set to correspond to
30 environments of the floor 15 of each level. For example, the detection area setting unit 22a may automatically detect a depth and a width of the floor 15 of each level from the images captured by the camera 12 and adjust the lengths L3 and L4 and the widths W1
35 and W2 on the basis of the detected depth and width.

Thus, the position estimation area E1 and the riding intention estimation area E2 can be set more suitably in each level.

5 In the present embodiment, the detection area setting unit 22a may store coordinates of apexes in image and length of sides in image of each of the areas of left frame A1 and right frame A2 of the jamb, sill A3, left front post A4, and right front post A5 in the storage unit 21. Furthermore, the detection area
10 setting unit 22a may calculate dimensions of each part of the elevator in the real space on the basis and may store the calculated dimensions in the storage unit 21. For example, the width of the sill A3 may be calculated and stored in the storage unit 21 as a length of the
15 elevator width.

Furthermore, in the present embodiment, the detection area setting unit 22a detects at least one of the left frame A1 and right frame A2 of the jamb, sill A3, left front post A4, and right front post A5, and
20 may set at least one of the detection area E (position estimation area E1, riding intention estimation area E2, sill area E3, and front post area E4).
[Second embodiment]

25 In the present embodiment, a variation of the first embodiment will be explained.

In the detection area setting process of the first embodiment (as in FIG. 5), the internal parameters of the camera 12 are preliminarily input with respect to the elevator riding detection system 1, and the
30 detection area setting unit 22a calculates the mount position and the rotation parameter of the camera 12.

On the other hand, in the present embodiment, internal parameters, mount position, and rotation parameter of the camera 12 are preliminarily input in
35 the elevator riding detection system 1. That is, a

corresponding relationship between a coordinate system in an image captured by the camera 12 and a coordinate system in the real space is known, and thus, process load of the detection area setting unit 22a can be reduced.

In the present embodiment, a variation of the detection area setting process by the detection area setting unit 22a will be explained with reference to FIGS. 14 and 15.

FIG. 14 shows a flowchart of an example of the detection area setting process of the present embodiment.

In step S201, the detection area setting unit 22a performs edge detection with respect to an image captured by the camera 12. The edge detection process is performed similarly to step S101 of FIG. 5, and thus, the description will be omitted.

In step S202, the detection area setting unit 22a detects a sill A3.

Here, in the present embodiment, the detection area setting unit 22a can calculate a position of the origin O in the image captured by the camera 12 on the basis of the internal parameters, mount position, and rotation parameter of the camera 12. Then, the detection area setting unit 22a determines a quadrangular area below the origin O as a sill A3 in the image after edge detection obtained in step S201. Note that the search and detection of the quadrangular area are performed by, as in step S102 of FIG. 5, a template matching process or the like.

FIG. 15 shows an example of detection of sill area by the detection area setting unit 22a. In FIG. 15, a quadrangle upper side of which is a line segment including the origin O is recognized as a sill A3.

Then, the detection area setting unit 22a the left

frame A1 and the right frame A2 of the jamb on the basis of the sill A3 (step S203). Similarly, the detection area setting unit 22a detects the left front post A4 and the right front post A5 of the door pocket on the basis of the sill A3 (step S204). Furthermore, the detection area setting unit 22a sets the detection area E (position estimation area E1, riding intention estimation area E2, sill area E3, and front post area E4) on the basis of the left frame A1 and right frame A2 of the jamb, sill A3, left front post A4, and right front post A5 detected above. Since steps S203 to S205 and steps S104 to S106 are the same, the description thereof is omitted.

In the present embodiment described as above, the internal parameters, mount position, and rotation parameter of the camera 12 are preliminarily applied to the elevator riding detection system 1, and thus, the elevator riding detection system 1 can calculate the position of the origin O in the real space in the image, and the sill A3 can be detected accurately on the basis of the position of the origin O in the image. That is, the accuracy of detection of the left frame A1 and right frame A2 of the jamb, and left front post A4 and right front post A5 of the door pocket, which is performed on the basis of the sill A3 can be improved. Furthermore, since the calculation of the rotation parameter is omitted, process load of the elevator riding detection system 1 can be reduced.

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.

CLAIMS:

[Claim 1]

An elevator boarding detection system characterized by
5 comprising:

image capturing means configured to capture an image of a
certain range when a car arrives a floor, the range between the
proximity of a door of the car and the floor;

detection area setting means configured to set a detection
10 area in the image captured by the image capturing means;

user detection means configured to detect a user focusing
on a motion of a person and/or an object within the detection
area using a plurality of chronologically consecutive images
captured by the image capturing means; and

15 control means configured to control an open/close operation
of the door on the basis of a detection result from the user
detection means, characterized in that

the detection area setting means is configured to:

20 detect a sill between the car and the floor included in the
image;

detect an area of a jamb based on corners at a side close
to the floor of corners of the sill, in the image; and

set the detection area not including the area of the jamb
in the image.

25 [Claim 2]

The elevator boarding detection system of claim 1,
characterized in that the detection area setting means is

configured to:

detect a first line segment extending from the proximity of the corners at the side close to the floor toward the floor;

detect second and third line segments extending
5 perpendicularly from both ends of the first line segment, and extending toward an edge of the image; and

detect an area surrounded by the first to third line segments as being the area of the jamb.

[Claim 3]

10 The elevator boarding detection system of claim 1 or 2, characterized in that the detection area setting means detects an area of a post of a door pocket based on corners at a side close to the car of the corners of the sill, in the image, and sets the detection area not including the area of the post of
15 the door pocket in the image.

[Claim 4]

The elevator boarding detection system of claim 3, characterized in that the detection area setting means is configured to:

20 detect a fourth line segment extending from the proximity of the corner at the side close to the car toward the car;

detect fifth and sixth line segments extending perpendicularly from both ends of the fourth line segment, and extending toward an edge of the image; and

25 detect an area surrounded by the fourth to sixth line segments as being the area of the post of the door pocket.

[Claim 5]

The elevator boarding detection system of claim 1,
characterized in that the detection area setting means
calculates three-dimensional coordinates indicating a position
5 where the image capturing means is installed in a real space,
on the basis of a position of the sill and an internal parameter
of the image capturing means, and calculates a rotation
parameter which associates a coordinate system of the real space
and a coordinate system of the image, on the basis of the three-
10 dimensional coordinates.

[Claim 6]

The elevator boarding detection system of claim 1,
characterized in that the detection area setting means detects a
position of the sill on the basis of three-dimensional
15 coordinates indicating a position where the image capturing
means is installed in a real space, an internal parameter of the
image capturing means, and a rotation parameter which associates
a coordinate system of the real space and a coordinate system of
the image.