

ELEVATOR RIDING DETECTION SYSTEM

FIELD

Embodiments described herein relate generally to an elevator riding detection system which detects a
5 passenger who gets into a car.

BACKGROUND

Generally, when an elevator car arrives at a hall, the door of the car is opened, and after a predetermined time elapses, the door is closed and the
10 car departs. At this time, since the passenger of the elevator does not know when the door of the car is going to close, when the passenger gets into the car from the hall, the passenger may be struck by the closing door in some cases.

15 To prevent such collision between the passenger and the door at the time of getting into the car, the passenger is detected by a camera, etc., provided in an upper portion of the car, and the result of detection is reflected in the opening-closing control of the
20 door.

The passenger detection range of the camera provided in the car is fixed beforehand on a building-by-building basis, and the passenger detection range is common to all the floors. However, depending on
25 buildings, the design of the hall varies from floor to floor, and this causes variations in detection accuracy in some cases.

SUMMARY

According to one embodiment, an elevator riding
30 detection system includes an imaging means, a detection area setting means, a passenger detection means and control means. The imaging means captures an image of a predetermined range from a vicinity of a door of a car toward a hall when the car arrives at the hall.
35 The detection area setting means detects a three-sided

frame of the hall using the image captured by the
imaging means, and setting a detection area based on
the three-sided frame. The passenger detection means
detects presence or absence of a passenger having an
intention of getting into the car based on focusing on
5 a movement of a person or an object in the detection
area using the chronologically successive images
captured by the imaging means. The control means
controls an opening-closing operation of the door based
10 on a result of detection by the passenger detection
means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing the structure of an
elevator riding detection system according to an
15 embodiment.

FIG. 2 is an explanatory diagram showing a three-
sided frame of an elevator according to the embodiment.

FIG. 3 is a diagram showing an example of an image
captured by a camera according to the embodiment.

20 FIG. 4 is an explanatory diagram showing a
detection area in real space according to the
embodiment.

FIG. 5 is an explanatory diagram showing deviation
of a detection area according to the embodiment.

25 FIG. 6 is a flowchart showing the flow of
detection area setting processing according to the
embodiment.

FIG. 7 is a diagram showing an example of the
three-sided frame detection by a detection area setting
30 module according to the embodiment.

FIG. 8 is a diagram showing an example of the
detection area setting by the detection area setting
module according to the embodiment.

35 FIG. 9 is a flowchart showing the flow of the
entire processing according to the embodiment.

DETAILED DESCRIPTION

Embodiments will be described with reference to the accompanying drawings.

FIG. 1 is a diagram showing the structure of an elevator riding detection system 1 according to an embodiment. Here, although one car is taken as an example, the same structure can be applied to a plurality of cars.

A camera 12 is provided in a portion of the car 11 above the doorway. More specifically, the camera 12 is provided inside a modesty panel 11a which covers the portion of the car 11 above the doorway such that a lens portion of the camera 12 is directed toward a hall 15. The camera 12 is a small monitoring camera such as a vehicle-mounted camera, has a wide-angle lens, and can successively capture several frame images per second (for example, 30 frames per second). When the car 11 arrives on each floor and the door is opened, the camera 12 captures an image of the scene of the hall 15 including the scene around a car door 13 inside the car 11.

At this time, a longitudinal width of an image capturing range is adjusted to a longitudinal width L1 and a longitudinal width L2 (the longitudinal width L1 > the longitudinal width L2). The longitudinal width L1 is an image capturing range on the hall 15 side and is a range of 3 m from the car door 13 to the hall 15, for example. The longitudinal width L2 is an image capturing range on the car side and is a range of 50 cm from the car door 13 toward the back of the car, for example. Note that the longitudinal width L1 and the longitudinal width L2 are a range in the depth direction. The image capturing range in the width direction (in the direction orthogonal to the depth direction) is greater than at least the width of the

car 11.

In the hall 15 of each floor, a hall door 14 is provided in an openable-closable manner in a place in which the car 11 arrives. The hall door 14 is opened and closed by being engaged with the car door 13 when the car 11 arrives. A power source (door motor) is provided on the car 11 side, and the hall door 14 is opened and closed simply in accordance with the hall door 14. The following description will be based on the assumption 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 image (video) captured by the camera 12 is analyzed in real time by an image processing device 20. Although the image processing device 20 is extracted from the car 11 in FIG. 1 for the sake of convenience, the image processing device 20 is stored inside the modesty panel 11a together with the camera 12 in practice.

Here, the image processing device 20 includes a storage module 21 and a passenger detection module 22. The storage module 21 has a buffer area for successively storing images captured by the camera 12 and temporarily storing data necessary for the processing of the passenger detection module 22. The passenger detection module 22 detects presence or absence of a passenger having an intention of getting into the car by focusing on a movement of a person or an object closest to the car door 13 in a plurality of chronologically successive images captured by the camera 12. The passenger detection module 22 is composed of a detection area setting module 22a, a movement detection module 22b, a position estimation module 22c and a riding intention estimation module 22d.

The detection area setting module 22a sets a detection area in an image captured by the camera 12. In the present embodiment, the detection area is determined based on the shape of a three-sided frame (jamb) of the hall door 14 on a floor-by-floor basis. The three-sided frame will be described later with reference to FIG. 2.

The movement detection module 22b divides the detection area into block units having a certain size, for example, and compares the brightness of each image in block units and detects the movement of a person or an object. The "movement of a person or an object" here is the movement of a mobile object such as a person or a wheelchair in the hall 15.

The position estimation module 22c extracts a block closest to the car door 13 from blocks showing movements detected on an image-by-image basis by the movement detection module 22b, and estimates the block to be the foot position of a passenger.

The riding intention estimation module 22d determines whether the passenger has an intention of getting into the car or not based on the chronological change of the foot position of the passenger estimated by the position estimation module 22c.

These functions (the detection area setting module 22a, the movement detection module 22b, the position estimation module 22c and the riding intention estimation module 22d) may be provided in the camera 12 or may be provided in a car control device 30.

The car control device 30 is connected to an elevator control device (not shown) and transmits and receives various signals such as a hall call and a car call to and from the elevator control device. The "hall call" here is a signal of a call registered by the operation of a hall call button (not shown)

provided in the hall 15 on each floor, and includes information on a registered floor and a destination direction. The "car call" is a signal of a call registered by the operation of a destination call button (not shown) provided inside the car 11, and includes information on a destination floor.

Further, the car control device 30 includes a door opening-closing control module 31. The door opening-closing control module 31 controls opening and closing of the car door 13 when the car 11 arrives at the hall 15. More specifically, the door opening-closing control module 31 opens the car door 13 when the car 11 arrives at the hall 15, and closes the car door 13 after a predetermined time elapses. However, when the car door 13 is still opened and if a person having an intention of getting into the car is detected by the passenger detection module 22 of the image processing device 20, the door opening-closing control module 31 stops the operation of closing the car door 13 and maintains the car door 13 to be opened.

FIG. 2 is an explanatory diagram showing the three-sided frame of the elevator. More specifically, FIG. 2 is a view of the elevator when viewed from the hall 15 side.

The three-sided frame is a frame provided around the hall door 14 and is composed of three frames, namely, a left frame 16A on the left-hand side when viewed from the car 11 side (on the right-hand side when viewed from the hall 15 side), an upper frame 16B above the hall 15, and a right frame 16C on the right-hand side when viewed from the car 11 side (on the left-hand side from the hall 15 side). The left frame 16A and the right frame 16C contact a wall W of a building.

A corner of the left frame 16A in contact with the

ground on the wall W side is a left corner Cl.
Similarly, a corner of the right frame 16C in contact
with the ground on the wall W side is a right corner
Cr.

5 Further, a side of the inner surface of the left
frame 16A in contact with the hall 15 is a left oblique
side Hl. Similarly, a side of the inner surface of the
right frame 16C in contact with the hall 15 is a right
oblique side Hr.

10 FIG. 3 is a diagram showing an example of the
image captured by the camera 12. The image captured by
the camera 12 includes the left frame 16A, the right
frame 16C, the left corner Cl, the right corner Cr, the
left oblique side Hl and the right oblique side Hr of
15 the three-sided frame. Further, the image includes a
detection area E0. The Y-coordinate of the foot
position of the passenger is denoted by yn. In the
following description, the car door 13 is assumed to be
a center opening door, and the camera 12 is assumed to
20 be provided in the center of the car door 13. Further,
the Y-axis has the origin in the center of the car door
13 and extends vertically with respect to the car door
13 in the direction of the hall 15.

 The camera 12 is provided in the portion of the
25 car 11 above the doorway. Therefore, when the door of
the car 11 is opened in the hall 15, an image of a
predetermined range on the hall 15 side (longitudinal
width L1) and a predetermined range inside the car 11
(longitudinal width L2) is captured. Here, a wide
30 detection range can be captured by the camera 12, and a
passenger at some distance from the car 11 can be
detected, accordingly. However, a person simply
passing by the hall 15 (a person having no intention of
getting into the car 11) may be detected erroneously,
35 and the car door 13 may be opened in some cases.

Note that the car door 13 may be a single opening door. In this case, the camera 12 should preferably be provided on a doorstep side. Further, the origin of the Y-axis can be flexibly changed depending on where
5 the camera 12 is provided.

FIG. 4 is an explanatory diagram showing the detection area in real space. FIG. 4 illustrates the detection area E0 on a floor F1.

In the present system, the detection area setting
10 module 22a sets the detection area E0 in the image captured by the camera 12 as described above. Next, the movement detection module 22b divides the detection area into blocks having a certain size and detects a block including a movement of a person or an object.
15 Further, the position estimation module 22c and the riding intention estimation module 22d follow the block including the movement and determine whether a passenger has an intention of getting into the car or not.

20 To detect a movement of a passenger having an intention of getting into the car from the captured image, the movement detection module 22b firstly sets a movement detection area on a block-by-block basis. More specifically, at least a position estimation area
25 E1 and a riding intention estimation area E2 are set as shown in FIG. 4.

The position estimation area E1 is an area for estimating a body part of a passenger, more specifically, a foot position of the passenger coming
30 from the hall 15 toward the car door 13. The position estimation area E1 should preferably be the same as the detection area E0.

The riding intention estimation area E2 is an area for estimating whether the passenger detected in the
35 position estimation area E1 has an intention of getting

into the car or not. The riding intention estimation area E2 is included in the position estimation area E1 and is also an area for estimating the foot position of the passenger. That is, the foot position of the passenger and the riding intention of the passenger are estimated in the riding intention estimation area E2.

In real space, the detection area E0 has a longitudinal width L3 from the center of the car door 13 toward the hall 15. The longitudinal width L3 is set to 2 m (the longitudinal width $L3 \leq$ the longitudinal width L1), for example. A width W1 of the detection area E0 is greater than or equal to a width W0 of the car door 13. Further, a left viewing angle θ_a is set with reference to the left corner C1 of the three-sided frame, and a right viewing angle θ_b is set with reference to the right corner Cr of the three-sided frame as shown in FIG. 4 in the detection area E0. More specifically, the detection area E0 is bordered with a line B1a including the left corner C1 of the three-sided frame and forming the left viewing angle θ_a with the Y-axis, and a line B1b including the right corner Cr of the three-sided frame and forming the right viewing angle θ_b with the Y-axis. The left viewing angle θ_a and the right viewing angle θ_b are 45 degrees, for example. Generally, the left viewing angle θ_a and the right viewing angle θ_b should preferably be the same value, that is, the detection area E0 should preferably be set symmetrically. However, the detection area E0 may be set asymmetrically, for example, depending on presence or absence of an obstacle provided in the hall 15, the shape of the hall 15, etc.

The riding intention estimation area E2 has a longitudinal width L4 from the center of the car door

13 toward the hall 15. The longitudinal width L4 is set to 1 m (the longitudinal width L4 $\leq$ the longitudinal width L3), for example. A width W2 of the riding intention estimation area E2 is set to be a substantially same as the width W0 of the car door 13. The width W2 of the riding intention estimation area E2 may be greater than the width W0. Further, the riding intention estimation area E2 may not have a rectangular shape in real space but may have a shape expanding in the direction of the Y-axis in accordance with the right viewing angle θ_a and the right viewing angle θ_b , similarly to the detection area E0 and the position estimation area E1.

In the present embodiment, the riding intention estimation area E2 includes an elevator proximity detection area. However, the riding intension estimation area E2 may be set as an area except the proximity detection area. The proximity detection area is an area where an object in proximity to the car door 13 or the hall door 14 can be detected by executing the image processing on an image captured by the camera 12 or by using a sensor such as a proximity sensor.

FIG. 5 is an explanatory diagram showing deviation of the detection area. For example, the detection area E0 on the floor F1 shown in FIG. 4 is set to the elevator riding detection system 1, and the detection area E0 is also used on the other floors.

Here, the shape of the three-sided frame on the floor F2 shown in FIG. 5 differs from the shape of the three-sided frame on the floor F1 shown in FIG. 4. On the floor F2 shown in FIG. 5, the right corner Cr and the left corner Cl of the three-sided frame are located closer to the hall door 14. That is, a proper detection area E0_B of the floor F2 is an area bordered

with a line B2a and a line B2b.

Here, if the detection area E0 is used on the floor F2, an area A surrounded by the lines B1a and B2a and the lines B1b and B2b is not included in the detection area E0, and thus a person or an object approaching the elevator through the area A cannot be appropriately detected. Therefore, an optimal detection area should preferably be set on a floor-by-floor basis.

The processing of setting the detection area E0 by the detection area setting module 22a will be described with reference to FIGS. 6 to 8.

FIG. 6 is a flowchart showing the flow of the detection area setting processing. Steps S101 and S102 shown in FIG. 6 will be described with reference to FIG. 7. FIG. 7 is a diagram showing an example of the three-sided frame detection by the detection area setting module 22a.

Firstly, the detection area setting module 22a detects the left corner C1 and the right corner Cr of the three-sided frame (step S101). The method of detecting the left corner C1 and the right corner Cr of the three-sided frame includes a method of performing image processing such as edge detection or corner detection with respect to the image captured by the camera 12, for example. Alternatively, markers may be provided in the left corner C1 and the right corner Cr of the three-sided frame beforehand, and the left corner C1 and the right corner Cr may be detected by executing the image processing of the image of these markers captured by the camera 12.

If the shape of the three-sided frame is complicated and several left corners C1 or right corners Cr are detected, the left corner C1 and the right corner Cr which are most distant from the hall

door 14 should preferably be maintained.

Next, the detection area setting module 22a calculates an inclination θ_l representing the inclination of the left oblique side H_l extending from the hall door 14 to the left corner C_l , and an inclination θ_r representing the inclination of the right oblique side H_r extending from the hall door 14 to the right corner C_r (step S102).

Steps S103 to S105 shown in FIG. 6 will be described with reference to FIG. 8. FIG. 8 is a diagram showing an example of the setting of the detection area E_0 by the detection area setting module 22a.

The detection area setting module 22a determines the left viewing angle θ_a and the right viewing angle θ_b by the inclination θ_l and the inclination θ_r (step S103). Here, the left viewing angle θ_a is equal to the inclination θ_l of the left oblique side H_l , and the right viewing angle θ_b is equal to the inclination θ_r of the right oblique side H_r . That is, a line $B3a$, which serves as one border of the detection area E_0 and has the inclination of the left viewing angle θ_a , is a line extended from the left oblique side H_l toward the hall 15, and a line $B2b$, which serves as the other border of the detection area E_0 and has the inclination of the right viewing angle θ_b , is a line extended from the right oblique side H_r toward the hall 15. However, different values may be set to the left viewing angle θ_a and the inclination θ_l and to the right viewing angle θ_b and the inclination θ_r . For example, the wide-range detection area E_0 which opens outward from the left oblique side H_l (or the right oblique side H_r) of the three-sided frame can be obtained by making the left viewing angle θ_a (or the right viewing angle θ_b) greater than the inclination θ_l (or the inclination

θ_r).

Further, the detection area setting module 22a sets an area defined by the width W_0 of the hall door 14, the line B3a, the line B3b, the width W_1 and the longitudinal width L_3 , as the detection area E0 (step S104). Further, the position estimation area E1 is assumed to be the same as the detection area E0.

Still further, the detection area setting module 22a sets an area from the hall door 14 to the longitudinal width L_4 in the position estimation area E1, for example, as the riding intention estimation area E2 (step S105). Note that the width W_2 of the riding intention estimation area E2 may be set beforehand. In this case, the riding intention estimation area E2 may not be set by following the above-described processing procedure but may be set as a trapezoid having the width W_0 and the width W_2 as the lower base and the upper base.

As described above, the detection area setting module 22a can set the detection area E0, the position estimation area E1 and the riding intention estimation area E2 based on the shape of the three-sided frame.

Note that the line B3a may not pass through the left corner C1 but may be located on the outer side from the left corner C1, for example. The same also applies to the line B3b. Further, the line B3a and the line B3b serving as the borders of the detection area E0 are not limited to a straight line but may be a curved line, for example.

FIG. 9 is a flowchart showing the flow of the entire processing of the elevator riding detection system 1.

When the car 11 arrives at the hall 15 on an arbitrary floor (Yes in step S11), the car control device 30 opens the car door 13 and waits for a

passenger to get into the car 11 (step S12).

At this time, an image of a predetermined range on the hall side (longitudinal width L1) and a predetermined range inside the car (longitudinal width L2) are captured by the camera 12 provided in the upper portion of the car 11 above the doorway at a predetermined frame rate (for example, 30 frames per second). The image processing device 20 obtains images captured chronologically by the camera 12 and stores these images successively in the storage module 21 (step S13).

Subsequently, if the detection area E0 on the floor on which the car 11 has arrived is not set yet (No in step S14), the detection area setting module 22a of the passenger detection module 22 executes the detection area setting processing (step S15). Since the detection area setting processing is already described with reference to FIGS. 6 to 8, detailed description thereof will be omitted here.

Note that the detection area E0 which is set on a floor-by-floor basis in step S15 may be stored in the storage module 21. In this way, the detection area setting module 22a can omit calculation of the detection area when the car arrives on the same floor afterward. More specifically, the detection area setting module 22a firstly searches the storage module 21 each time the car arrives on a different floor and examines whether the detection area E0 of the floor is already stored in the storage module 21 or not. If the detection area E0 of the floor is already stored, the detection area setting module 22a does not need to calculate the detection area E0 in step S15 by reading the detection area E0 from the storage module 21 and setting the detection area E0.

Next, the passenger detection module 22 of the

image processing device 20 executes the following passenger detection processing in real time (step S16). The passenger detection processing is divided into movement detection processing executed by the movement
5 detection module 22b (step S16-1), position estimation processing executed by the position estimation module 22 (step S16-2) and riding intention estimation processing executed by the riding intention estimation module 22d (step S16-3).

10 Firstly, the movement detection module 22b divides the current image and the previous image stored in the storage module 21 into blocks, respectively, and calculates and compares the average brightness values of the blocks. As a result, if a block having a
15 brightness difference greater than a preset value exists in the current image, the movement detection module 22b determines the block as a block including a movement.

Subsequently, the movement detection module 22b
20 repeats determination of presence or absence of a movement, similarly, by comparing the brightness value of each image captured by the camera 12, chronologically on a block-by-block basis.

Next, the position estimation module 22c extracts
25 a block closest to the car door 13 from blocks including movements in the current image based on the detection result of the movement detection module 22b. The movement detection module 22b then obtains the Y-coordinate of the block as foot position data, and
30 stores it in the storage module 21.

Subsequently, the position estimation module 22c similarly obtains the foot position data of the passenger and stores it in the storage module 21. The foot position estimation processing is performed not
35 only in the position estimation area E1 but also in the

riding intention estimation area E2.

Further, the riding intention estimation module 22d levels the foot position data of the passenger obtained by the above-described position estimation processing. For example, the leveling method is assumed to be a common method such as an average value filter or a Kalman filter, and detailed description thereof will be omitted here.

In the leveled foot position data series, if data having an amount of change greater than or equal to a predetermined value exists, the riding intention estimation module 22d excludes the data as an outlier. The predetermined value is determined by the standard walking speed of the passenger and the frame rate of the captured image. Further, the riding intention estimation module 22d may find and exclude an outlier before leveling the foot position data.

As a result of the riding intention estimation processing, if the passenger having an intention of getting into the car is detected (Yes in step S17), a passenger detection signal is output from the image processing device 20 to the car control device 30. When receiving the passenger detection signal, the car control device 30 stops the operation of closing the car door 13 and maintains the car door 13 to be opened (step S18).

More specifically, when the car door 13 is fully-opened, the car control device 30 starts counting the door open time, and at the time of counting to predetermined time T (for example, one minute), the car control device 30 closes the car door 13. If a passenger having an intention of getting into the car is detected in this period and a passenger detection signal is transmitted, the car control device 30 stops counting and clears a count value. In this way, the

car door 13 is maintained to be opened for the time T. If a passenger having an intention of getting into the car is newly detected in this period, a count value is cleared again, and the car door 13 is maintained to be
5 opened for the time T. The count value may not be cleared each time a passenger is detected, but may be cleared every T minutes.

However, if a passenger comes again and again during the time T, the car door 13 cannot be closed
10 forever, and therefore it is preferable that permissible time T_x (for example, three minutes) should be set and the car door 13 should be forced to be closed when the permissible time T_x elapses.

If the time T is counted (step S19), the car
15 control device 30 closes the car door 13 and causes the car 11 to leave for a destination floor (step S20).

According to the present embodiment, by analyzing an image of the hall 15 captured by the camera 12 provided in the upper portion of the car 11 above the
20 doorway, a passenger coming from a place at some distance from the car 11 toward the car door 13 can be detected and the detection result can be reflected in the door opening-closing operation, for example.

According to the present embodiment, while the
25 elevator is in operation, the elevator riding detection system 1 automatically detects the left corner C_l and the right corner C_r and sets the detection area E_0 having the left viewing angle θ_a and the right viewing angle θ_b based on the left corner C_l and the right
30 corner C_r . Further, while the elevator is in operation, the elevator riding detection system 1 sets the detection area E_0 based on the inclinations (the inclination θ_l and the inclination θ_r) of the oblique sides of the three-sided frame. That is, even if the
35 design of the three-sided frame varies from floor to

floor, an optimal detection area E0 can be set on floor-by-floor basis. Accordingly, an elevator riding detection system which suppresses variations in detection performance from floor to floor and achieves a high level of safety can be provided.

Further, since the detection area E0 is automatically set, specification check at the time of factory shipment, and setting work at the time of elevator installation are not required.

In the present embodiment, different values (angles) can be set to the inclinations (the inclination θ_l and the inclination θ_r) of the oblique sides of the three-sided frame and the viewing angles (the viewing angle θ_a and the viewing angle θ_b) of the detection area E0, respectively. In this way, the detection area E0 can be flexibly set on a floor-by-floor basis based on the shape of the three-sided frame.

In the present embodiment, the longitudinal widths 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 in accordance with an environment near the hall 15 on each floor. For example, the detection area setting module 22a may automatically detect the depth and width of the hall 15 on a floor-by-floor basis from an image captured by the camera 12 and may increase or reduce the longitudinal widths L3 and L4 and the widths W1 and W2, accordingly. In this way, the detection area E0 can be set more appropriately on a floor-by-floor basis.

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
5 inventions. The accompanying claims and their
equivalents are intended to cover such forms or
modifications as would fall within the scope and spirit
of the inventions.

WHAT IS CLAIMED IS:

1. An elevator riding detection system comprising:

5 imaging means for capturing an image of a predetermined range from a vicinity of a door of a car toward a hall when the car arrives at the hall;

detection area setting means for detecting a three-sided frame of the hall using the image captured by the imaging means, and setting a detection area
10 based on the three-sided frame;

passenger detection means for detecting presence or absence of a passenger having an intention of getting into the car based on focusing on a movement of a person or an object in the detection area using the
15 chronologically successive images captured by the imaging means; and

control means for controlling an opening-closing operation of the door based on a result of detection by the passenger detection means.

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

the detection area setting means detects corners of a right frame and a left frame of three frames which constitute the three-sided frame, the corners being
25 located on a building wall side and being in contact with a ground, and

the detection area setting means sets the detection area including the corners.

30 3. The elevator riding detection system of one of Claims 1 and 2, wherein

the detection area setting means detects inclinations of inner side surfaces of a right frame and a left frame of three frames which constitute the three-sided frame, and sets borders of the detection
35 area based on the inclinations.