

SAFETY ELEVATOR

BACKGROUND OF THE INVENTION

The present invention relates to an elevator with a safety device mounted on elevator doors that constitute an entrance and more specifically to an elevator that prevents passengers, their belongings or cordlike objects etc. from getting caught between the doors.

5 Conventionally, the elevator doors that constitute an entrance are provided with a sheetlike pressure sensor for detecting passengers or their belongings being caught between the doors and also with an optoelectric sensor for detecting cordlike objects, such as electric cords of vacuum cleaners, or passengers hurrying into an elevator car almost closing its doors, in order to control a torque and speed of the opening or closing doors thereby assuring safety of passengers
10 and a smooth flow of passengers into and out of the elevator car.

For example, the doors are provided with a light emitting portion and a light receiving portion, both being located at opposing positions, so that when a light beam between them is cut off, the doors are kept open or, in the process of closing, are stopped and opened again. Although the conventional elevator can cope with situations where passengers are
15 running into the elevator car as the doors are closed or where they are taking time to get into the car, it cannot detect small objects that fail to interrupt the light beam. In a situation where a passenger with a leashed dog is about to walk into the car and the elevator doors may begin to close when only the leashed dog has entered the car with the dog owner left outside, there is a risk of the doors completely closing without opening again, causing the car to move up, since the
20 beam fails to be cut off long enough to cause detection.

To deal with this risk, it has been known to check for any object standing or moving in the door opening/closing space by using a monitoring camera. It has also been known that, to reduce the required number of cameras and image processing devices, a camera unit is mounted on a top part of the entrance of the car and made to change the imaging area
25 according to the opening/closing state of the elevator doors, for example, from an area inside the car to the door opening/closing path to a landing (JP-A-2008-120548).

Further, to prevent the doors from being detected as obstacles in the image processing and to ensure that only obstacles can be detected, JP-A-2006-89190 for example describes a method that involves attaching a marking for obstacle detection to the upper surface
30 of a doorsill of the elevator doors, imaging the entrance including the marking and detecting the presence of an obstacle based on the marking.

SUMMARY OF THE INVENTION

The conventional technique described above simply changes the imaging area and provides a marking. This approach is not enough to effectively detect a cordlike obstacle under whatever surrounding environment and take necessary actions or make an appropriate
5 announcement to alert passengers in response to movements of the passengers, such as passengers and their belongings getting caught between the doors at the elevator entrance.

An object of this invention is to solve the aforementioned problems experienced with the conventional technique and enhance the functions associated with passenger safety. Another object of this invention is to reduce possible accidents involving the elevator doors to
10 prevent a degradation of elevator operation efficiency and at the same time facilitate maintenance and inspection.

To achieve the above objective, this invention provides a safety elevator having a imaging device installed at an elevator entrance to monitor an open/close operation of elevator doors, the safety elevator comprising: a door controller to control the open/close operation of the
15 elevator doors; and an image processing unit to determine a detection area from a video signal from the imaging device and detect an object to be detected; wherein a size of the detection area is changed in accordance with the elevator doors are opened or closed.

With this invention, since the detection area is changed in accordance with the elevator doors are opened or closed, passengers' behaviors or motions and cordlike objects can
20 be effectively detected, securing passenger safety. Further, an improved detection sensitivity, a reduced processing time because of simplified processing and a reduced memory requirement combine to facilitate the maintenance and inspection of the elevator.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view and a block diagram showing one embodiment of this
25 invention.

Fig. 2 is a top view of the elevator entrance in the embodiment.

Fig. 3 is a flow chart showing a sequence of control (for motion detection) in the embodiment.

Fig. 4 is a top view showing the detection area (for motion detection) in the
30 embodiment.

Fig. 5 is a block diagram showing another embodiment of this invention (for cordlike object detection).

Fig. 6 is a flow chart showing a sequence of control (for cordlike object detection)

in the second embodiment.

Fig. 7 is a top view showing the detection area (for cordlike object detection) in the second embodiment.

Fig. 8 is a block diagram showing still another embodiment of this invention (for motion and cordlike object detection).

DESCRIPTION OF THE EMBODIMENTS

Now, one embodiment of this invention will be described in detail by referring to the accompanying drawings.

Fig. 1 is a front view and a block diagram of an entire safety elevator, showing the state of the elevator as seen from inside an elevator car or cage toward a landing outside. Fig. 2 is a plan view of an imaging device installed in a top frame situated high inside the car at an entrance.

At the entrance of the elevator car 1 there is a pair of car doors 2 for right and left that slide opened or closed. At a landing, there is provided landing doors that open or close a landing entrance. When the car reaches a destination floor, the car doors 2 are connected with the landing doors so that the landing doors are opened or closed in an interlocked relationship with the open/close operation of the car doors 2. The operation of the car doors 2 and the landing doors are controlled by a door controller 3.

The door controller 3 and a voice announcement device 4 are installed at the top of the car 1. The car entrance and the landing entrance of the car 1 are together referred to as an elevator entrance, and the car doors 2 and the landing doors as elevator doors. The imaging device 5 is installed inside a top frame 7 at the elevator entrance and images a direction of landing from around a doorsill across the car and the landing in the elevator entrance. The imaging device 5 uses a CMOS sensor capable of producing a highly defined image with about 1.2 million pixels.

Image signals optoelectronically converted by the image sensor of the imaging device 5 are outputted as video signals to an image processing unit 6 after an analog/digital conversion, a gain adjustment or signal processing of a horizontal synchronization signal and a vertical synchronization signal etc. is executed for each unit image area which configures the image signals.

An operator connects a personal computer (or PC) 8 to the image processing unit 6 and, while watching the video imaged by the imaging device 5 and displayed on a monitor of the PC 8, performs setting an area to be detected, the number of detection blocks into which the

detection area is divided into a plurality of detection blocks, and the end faces of the elevator doors.

The image processing unit 6 has an operation input unit, a video input unit 11 to take in the video signal from the imaging device 5, an external input unit 12 to take in the
5 information entered from the PC 8, such as the detection area, the number of detection blocks in the detection area and the end faces of the elevator doors, the controller 13 to generate a control signal based on the input at a control input unit, a clock signal generation unit 14 to generate a clock signal for the detection area according to the control signal of the controller 13 based on the clock signals of the horizontal and vertical synchronization signals of the video signal
10 entered into the video input unit 11, and a video output unit 16 to output to the outside a synthesized image of the detection area based on the video signal of the video input unit 11 and the control signal of the controller.

The controller 13 receives the information on the coordinate and size of the detection area and the information on the elevator door end face coordinate, both set by the
15 external input unit 12, and further updates the information on the elevator door end face coordinate and the information on the detection area coordinate and size and outputs them to the clock signal generation unit 14.

The clock signal generation unit 14 outputs to a motion detection unit 17 the information on the size of the detection area and the number of detection blocks into which the
20 detection area is divided.

A detection area setting unit 15 selectively processes the video signal entered into the video input unit 11 based on the clock signal generated by the clock signal generation unit 14 and outputs the processed video signal to the motion detection unit 17.

The motion detection unit 17 adopts a motion detection based on a background
25 difference method and has a frame memory 18 to store background images of the video signals in the detection area. When comparison between a brightness value of a detected pixel in one of the detection blocks making up the background image stored in the frame memory 18 and a brightness value of the detected pixel of the input video signal has found a change greater than a predetermined value, it is decided that a motion has occurred. Then the motions for the
30 detection blocks are summed up to determine a direction of the motions.

The information on motion detected by the motion detection unit 17 is sent to the door controller 3, which then controls the open/close operation of the elevator doors. The motion detection unit 17 continues to track changes in motion as the doors are operated.

The interlocked operation of the image processing unit 6 and the door controller 3

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will be explained by referring to Fig. 3 and Fig. 4. Fig. 3 is a flow chart for assuring safety by a combination of the image processing unit 6 and the door controller 3 of Fig. 1 as the elevator doors are operated.

5 In step 1 the door controller 3, upon receiving an elevator door full-open signal, turns on the power for the imaging device 5 and the image processing unit 6 before proceeding to step 2.

In step 2 the image processing unit 6 checks for any motion in the detection area with the elevator doors fully open (a detection area A in Fig. 4A). The detection area A is configured to be rectangular on the landing, having the opening width of the fully open elevator entrance and a large depth (in a passenger approaching direction), from a point some distance in front of the elevator up to the entrance, so that movements of passengers on the landing can be captured and that they can board the car without a hurry. The check for motion in the detection area A is repeated until motions are no longer detected, at which time the image processing unit 6 moves to step 3.

15 In step 3 the door controller 3 starts to close the elevator doors and moves to step 4.

In step 4 the image processing unit 6, as the elevator doors close, progressively reduces the detection area on the landing by eliminating the appropriate detection blocks of the detection area in such a way that the width of the detection area fits in the decreasing opening width of the elevator doors and that the depth of the detection area also decreases with the decreasing opening width (the reduced detection area B of Fig. 4B with the doors closed halfway measures two detection blocks widthwise at the center and four blocks depthwise, as opposed to the detection area A with the full-open doors which measures six detection blocks in the width direction by five blocks in the depth direction).

25 Further, the image processing unit 6 checks for any motion approaching the detection area B. If it is decided that there is a motion approaching the car, the unit proceeds to step 6. If no motion approaching the car is found in the detection area B, the unit proceeds to step 5.

30 In step 5 the door controller 3 checks for a door signal representing that the elevator doors are closed. If the door closed signal is found, the door controller 3 moves to step 8; and if not, it returns to step 4.

In step 6 the door controller 3 reverses the action of the elevator doors to open them, before proceeding to step 7.

In step 7 the image processing unit 6 adds the detection blocks (i.e., expands the

detection area) as the opening width of the elevator doors increases and at the same time checks for any motion approaching the car.

If the motion approaching the car can no longer be found, the image processing unit 6 proceeds to step 3.

5 Step 8 turns off the power for the imaging device 5 and the image processing unit 6.

10 The interlocked relationship between the opening width of the elevator doors and the width of the detection area can be achieved by reducing or expanding the detection area by eliminating or adding an appropriate number of detection blocks based on the open/close speed of the elevator doors preset in the door controller 3 and on the open/close signal of the elevator door from the door controller 3 a predetermined time after the detection of the latter signal. The detection area may be configured to be other than rectangular. For example, it may be formed semicircular.

15 With the above construction, since a margin of operation for reversing the elevator door movement before passengers or their belongings get caught between the doors can be increased, the passengers can have an enhanced sense of security. Further, since the frequency of passengers and their belongings getting caught by the elevator doors can be reduced, possible failures of the elevator doors can also be reduced.

20 The fact that the single imaging device 5 is able to image the elevator entrance and that the burden of image processing is alleviated by restricting the image processing on the video signal from the imaging device only to a desired portion of the detection area can lead to an improved detection sensitivity, a reduced processing time thanks to the simplified processing and a reduced memory size, which in turn realizes a cost reduction.

25 An operation to detect an elongate material such as a cord of a vacuum cleaner will be explained by referring to Fig. 5, Fig. 6 and Fig. 7.

30 Fig. 5 shows an image processing unit 19 for the elevator doors incorporating a cordlike object detection unit 20 instead of the motion detection unit 17 of the image processing unit 6 in Fig. 1. The cordlike object detection unit 20 uses an outline extraction method which is suited to detect linear portions of edges of an object by extracting parts in image data where the brightness sharply changes.

The detection area set by the cordlike object detection unit 20 covers a doorsill between the car and the landing at the elevator entrance and can expand or contract in the direction of the door opening width as the elevator doors open or close. The video signal of the detection area is stored temporarily in a frame memory 18 and then processed by line processing

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for the detection blocks in the detection area to detect edges of an object from a rate of change in brightness between adjoining locations.

The cordlike object detection unit 20 acquires information on the detection area and on the number of detection blocks from the controller 13 and performs detection in the
5 detection area as related to the elevator door opening width (the detection area C in Fig. 7 measures six detection blocks widthwise by two blocks depthwise; and the detection area D measures one block widthwise by two blocks depthwise). In the following, the interlocked operation between the image processing unit 19 and the door controller 3 will be explained by referring to the drawings.

10 Fig. 6 is a flow chart for assuring safety as the image processing unit 19 and the door controller 3 of Fig. 1 cooperate to open or close the elevator doors.

In step 11 the door controller 3, upon receiving an elevator door full-open signal, turns on the power of the imaging device 5 and the image processing unit 19, before proceeding to step 12.

15 In step 12 the image processing unit 19 checks for any cordlike object in the detection area when the elevator doors are fully open (see the detection area C in Fig. 7A). The detection area C spans the entire opening width of the elevator entrance and is configured to be a linear one-dimensional area which is narrow in a direction from the landing toward the elevator entrance. If the check in the detection area C has found no cordlike object, the image
20 processing unit 19 moves to step 13.

In step 13 the door controller 3 starts closing the elevator doors and moves to step
14.

In step 14 the image processing unit 19, as the elevator doors close, reduces the detection area by eliminating the detection blocks so that the width of the detection area fits in
25 the opening width of the elevator doors (see the detection area D of Fig. 7B).

Further, the image processing unit 19 checks for a cordlike object in the detection area D. If it finds the cordlike object, the image processing unit 19 proceeds to step 16. If it is decided that there is no motion in the detection area B approaching the car, the image processing unit 19 moves to step 15.

30 In step 15 the door controller 3 checks if there is a door closed signal indicating that the elevator doors are closed. If it finds the door closed signal, the door controller 3 moves to step 23. If not, the door controller 3 returns to step 14.

In step 16 the door controller 3 stops the elevator doors and makes an announcement by a voice announcement device 4 to inform the passengers: "A cordlike object

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has been found at the doorsill, so we've stopped the doors. Remove the object, please." And then, it proceeds to step 17.

In step 17 the door controller 3 sets a timer to suspend the door operation for a predetermined time. After the predetermined time, it proceeds to step 18.

5 In step 18 the image processing unit 19 checks for a cordlike object in the detection area. If the cordlike object is no longer detected, it moves to step 13. If it decides that the cordlike object still continues to be detected, the image processing unit 19 moves to step 19.

10 In step 19 the door controller 3 starts opening the elevator doors and moves to step 20.

In step 20 the image processing unit 19 expands the detection area in accordance with the increasing opening width of the elevator doors and at the same time performs the cordlike object check in the detection area. If the motion toward the car is no longer found, the image processing unit 19 returns to step 13. If the cordlike object is found, it proceeds to step 21.

In step 21 a check is made as to whether the cordlike object presence decision has persisted for more than a predetermined time. If not, the image processing unit 19 returns to step 20. If the cordlike object has existed for more than the predetermined time, it proceeds to step 22 and sends an alarm signal to the control center to stop the elevator operation.

20 Step 23 turns off the power for the imaging device 5 and the image processing unit 19. As described above, in the event that a cordlike object, such as an electric cord of a vacuum cleaner, is detected to straddle over a doorsill between the landing and the car, the door closing operation is stopped and at the same time an appropriate announcement is made to inform the passengers, thereby giving them an enhanced sense of security.

25 Referring to Fig. 8, how the motion detection and the cord detection are both realized in one and the same device will be explained.

Fig. 8 shows an image processing unit 21 that replaces the elevator door image processing unit 6 shown in Fig. 1. The image processing unit 21 allows a detection area for motion detection and a detection area for cordlike object detection to be independently set by the operation input unit. Each detection area is checked by the motion detection unit and the cordlike object detection unit. Therefore, the image processing unit 21 can detect passengers and their belongings entering the car and also cordlike objects such as electric cords of vacuum cleaners.

In this construction, the detection area may be shrunk or expanded by making

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small or large each of the detection blocks in the detection area without changing the number of detection blocks, rather than by eliminating or adding an appropriate number of detection blocks of fixed size. This method can improve the sensitivity in detecting a motion and a cordlike object, ensuring a reliable object detection even under undesirable circumstances where there are
5 high levels of noise in the video signal from the imaging device or where contrast is not good because of ambient environment.

With the embodiments described above, since passengers hurrying into the elevator car and a cordlike object getting caught between doors are detected reliably as distinctive from the normal conditions of elevator use, undesired detections of normal behaviors
10 can be eliminated, preventing a possible degradation of operation efficiency. Further, these embodiments can achieve an improved detection sensitivity, a shortened processing time thanks to simplified processing and a reduced memory requirement, which in turn facilitates maintenance and inspection.

CLAIMS

1. A safety elevator having an imaging device (5) installed at an elevator entrance to monitor an open/close operation of elevator doors, the safety elevator comprising:

a door controller (3) to control the open/close operation of the elevator doors; and

an image processing unit (6, 9, 21) to determine a detection area from a video signal from the imaging device (5) and detect an object to be detected;

wherein a size of the detection area is changed in accordance with the elevator doors are opened or closed, and

wherein the detection area is divided into a plurality of detection blocks and the number of detection blocks is changed when the elevator doors are opened or closed.

2. A safety elevator according to claim 1, wherein the size of the detection area is determined in accordance with an opening width of the elevator doors when the elevator doors are opened or closed.

3. A safety elevator according to claim 1, wherein the detection area is reduced as an opening width of the elevator doors when the elevator doors are opened or closed is reduced.

4. A safety elevator having an imaging device (5) installed at an elevator entrance to monitor an open/close operation of elevator doors, the safety elevator comprising:

a door controller (3) to control the open/close operation of the elevator doors; and

an image processing unit (6, 9, 21) to determine a detection area from a video signal from the imaging device (5) and detect an object to be detected;

wherein a size of the detection area is changed in accordance with the elevator doors are opened or closed, and

wherein the detection area is divided into a plurality of detection blocks and is reduced without changing the number of detection blocks as an opening width of the elevator doors when the elevator doors are opened or closed is reduced.

5. A safety elevator according to claim 1 or 4, wherein the imaging device (5) is arranged above the elevator entrance and the detection area is formed as a rectangular area with a large depth in a direction from a landing to the elevator entrance.
6. A safety elevator according to claim 1 or 4, wherein the imaging device (5) is arranged above the elevator entrance and the detection area is formed as a one-dimensional area with a small depth in a direction from a landing to the elevator entrance.
7. A safety elevator according to claim 1 or 4, wherein the detection area can be set as a rectangular area with a large depth in a direction from a landing to the elevator entrance or as a one-dimensional area with a small depth in the direction from the landing to the elevator entrance.
8. A safety elevator according to claim 1 or 4, wherein the door controller (3) controls the open/close operation of the elevator doors in accordance with a result of detection by the image processing unit (6, 19, 21).
9. A safety elevator according to claim 1 or 4, wherein the door controller (3) stops or reverses the operation of the elevator doors when the elevator doors move from a fully open state to a closed state, in accordance with a result of detection by the image processing unit (6, 19, 21).