

IMAGE PROCESSOR AND MARKER

FIELD

Embodiments described herein relate generally to an image processor and a marker.

5

BACKGROUND

Various technologies have recently been devised to prevent people and objects from being caught in elevator car doors. For example, a technology is devised in which a user moving toward an elevator is detected using a camera to extend the door open time of the elevator.

In the above technology, a user moving toward an elevator needs to be accurately detected from images captured by a camera. If, however, the camera is displaced from its installation position, an image captured by the camera is rotated or shifted in the lateral direction, which may reduce the detection accuracy of the user.

It is therefore desired to develop a technology capable of detecting that a camera is displaced from its installation position and improve the accuracy of the detection.

SUMMARY

According to one embodiment, an image processor is provided close to a door of a car to detect that a camera, which captures an image including an interior of the car and an elevator hall, is displaced from an installation position thereof. The image processor comprises an image acquisition unit and a detection process unit. The image acquisition unit is configured to acquire from the camera an image captured with a marker placed along a side wall of the car distinguishably from a floor of the car and a floor of the elevator hall. The displacement detection unit is configured to recognize a plurality of patterns

included in the marker from the captured image, and to
detect that the camera is displaced from the
installation position, based on the marker including
the recognized patterns, when a distance between
5 adjacent two of the recognized patterns, which are
arranged in a first direction along a sill of the car,
is a preset distance. The marker is rectangular. The
patterns are so arranged that the distance between
adjacent two patterns in the first direction is caused
10 to differ from a distance twice as long as a distance
from one of the two patterns, which is close to the
side wall of the car, to one side of the marker which
is in contact with the side wall of the car.

BRIEF DESCRIPTION OF THE DRAWINGS

15 FIG. 1 is an exemplary schematic block diagram of
an elevator system according to an embodiment.

FIG. 2 is an exemplary hardware block diagram of
an image processor included in the elevator system.

20 FIG. 3 is a diagram showing an image captured when
a camera is not displaced from its installation
position.

FIG. 4 is a diagram showing an image captured when
the camera is displaced from its installation position.

25 FIG. 5 is a diagram showing an example of a marker
placed within an imaging range of the camera.

FIG. 6 is an exemplary functional block diagram of
the image processor.

FIG. 7 is a diagram showing an example of an image
captured by the camera.

30 FIG. 8 is a diagram illustrating the relationship
in position between the marker shown in FIG. 5 and its
mirror image.

FIG. 9 is a diagram showing an example of a
pattern included in the marker.

35 FIG. 10 is a diagram illustrating the relationship

in position between the marker shown in FIG. 9 and its mirror image.

FIG. 11 is a diagram showing another example of the pattern included in the marker.

5 FIG. 12 is a diagram illustrating the relationship in position between the marker shown in FIG. 11 and its mirror image.

FIG. 13 is a diagram showing still another example of the pattern included in the marker.

10 FIG. 14 is a flowchart showing an example of a processing procedure of the image processor in a calibration function.

FIG. 15 is a diagram supplementarily illustrating the flowchart shown in FIG. 14 and showing an image
15 captured by the camera.

FIG. 16 is a flowchart showing an example of a marker recognition processing procedure.

DETAILED DESCRIPTION

Embodiments will be described below with reference
20 to the drawings. The disclosure of the embodiments is nothing but one example, and the invention is not limited by the descriptions of the embodiments. Modifications that could easily be conceived by a person with ordinary skill in the art are included in
25 the scope of the disclosure. To clarify the descriptions, the drawings may show, for example, the size and shape of each component more schematically than those in the actual aspect. Elements corresponding to each other in the drawings are denoted by the same
30 reference numeral and their detailed descriptions may be omitted.

FIG. 1 is an exemplary schematic block diagram of an elevator system according to an embodiment.

35 A camera 12 is installed above the entrance of a car 11. Specifically, the camera 12 is installed in a

modesty panel 11a covering the part above the entrance of the car 11 such that its lens portion is directed toward both the interior of the car 11 and elevator hall 15. The camera 12 is a small-sized surveillance camera such as an in-vehicle camera, and includes a wide-angle lens to continuously capture images of several tens of frames per second (e.g., 30 frames per second).

The camera 12 is always on. It may capture images at all times or start capturing images with predetermined timing and stop doing so with predetermined timing. For example, the camera 12 may turn on when the car 11 moves at a speed that is lower than a predetermined speed, and may turn off when it moves at a speed that is not lower than the predetermined speed. In this case, when the car 11 starts decelerating to stop on a predetermined floor and the movement speed is lower than the predetermined speed, the camera 12 turns on and starts taking images. When the car 11 starts accelerating to move to a floor other than the predetermined floor and the movement speed is not lower than the predetermined speed, the camera 12 turns off and stops taking images. In other words, the camera 12 continues to take images from when the car 11 starts decelerating to stop on a predetermined floor and its movement speed becomes lower than a predetermined speed until the car 11 starts accelerating to move to another floor from the predetermined floor and its movement speed does not less than the predetermined speed, including a period during which the car 11 stops on the predetermined floor.

The imaging range of the camera 12 is set to $L1 + L2$ ($L1 \geq L2$). $L1$ is an imaging range of the elevator hall 15 and is set from a car door 13 toward the

elevator hall 15. L2 is an imaging range of the car 11 and is set from the car door 13 toward the back of the car. Note that L1 and L2 are ranges in the depth direction and the range in the width direction (which
5 is perpendicular to the depth direction) is greater than at least the breadth of the car 11.

In the elevator hall 15 on each floor, a hall door 14 is installed openably and closably at the doorway of the car 11. The hall door 14 opens and closes in
10 engagement with the car door 13 when the car 11 arrives. Note that a power source (door motor) is located in the car 11 and the hall door 14 only opens and closes in accordance with the opening and closing of the car door 13. It is assumed in the following
15 descriptions that the hall door 14 is open when the car door 13 is open, and the hall door 14 is closed when the car door 13 is closed.

Images (video images) continuously captured by the camera 12 are processed in real time by the image
20 processor 20. Specifically, the image processor 20 detects (the movement of) a user closest to the car door 13, based on a change in the brightness of an image in a preset area (hereinafter referred to as a detection area), to determine whether the detected user
25 has the intention of getting in the car 11, to determine whether the detected user's hand or arm is likely to get stuck in the door pocket, and the like. The result of image processing by the image processor 20 is reflected on the control processing (mainly door
30 open/close control processing) by an elevator controller 30 when the need arises.

The elevator controller 30 controls the opening/closing of the car door 13 when the car 11 arrives at the elevator hall 15. Specifically, the
35 elevator controller 30 opens the car door 13 when the

car 11 arrives at the elevator hall 15, and closes the door after a lapse of predetermined time.

However, when the image processor 20 detects a user who has the intention of getting in the car 11, the elevator controller 30 inhibits the car door 13 from closing and maintains the door open state (extends the opening time of the car door 13). When the image processor 20 detects a user whose hand or arm is likely to get stuck in the door pocket, the elevator controller 30 inhibits the car door 13 from opening, or makes the opening speed of the car door 13 slower than usual, or notifies the user that his or her hand or arm may get stuck in the door pocket by sending a message urging the user to move away from the car door 13.

In FIG. 1, the image processor 20 is taken out of the car 11 for the sake of convenience, but it is actually placed inside the modesty panel 11a together with the camera 12. In FIG. 1, the camera 12 and the image processor 20 are provided separately; however, they may be provided integrally as one unit. Furthermore, in FIG. 1, the image processor 20 and the elevator controller 30 are provided separately; however, the function of the image processor 20 may be included in the elevator controller 30.

FIG. 2 is an exemplary hardware block diagram of the image processor 20.

As shown in FIG. 2, in the image processor 20, a nonvolatile memory 22, a CPU 23, a main memory 24, a communication device 25 and the like are connected to a bus 21.

The nonvolatile memory 22 stores a variety of programs including an operating system (OS) and the like. The programs stored in the nonvolatile memory 22 includes a program for the foregoing image processing (more specifically, a user detection process described

later) and a program for implementing a calibration function described later (referred to as a calibration program hereinafter).

5 The CPU 23 is, for example, a processor that executes the programs stored in the nonvolatile memory 22. The CPU 23 controls the entire image processor 20.

 The main memory 24 is used as, for example, a work area required when the CPU 23 executes the programs.

10 The communication device 25 has a function of controlling communications (signal transmission and reception) with an external device such as the camera 12 and the elevator controller 30 by wire or wireless.

 Here, the image processor 20 performs the foregoing user detection process of detecting a user
15 closest to the car door 13, based on a change in the brightness of an image in a preset detection area. In the user detection process, attention is given to the change in brightness of an image in the preset detection area and thus the detection area needs to be
20 always set in a predetermined position on the image.

 If, however, the camera 12 is displaced from its installation position (installation angle) due to, for example, an impact on the car 11 and the camera 12 during the operation of the elevator system, the
25 detection area will also be displaced and the image processor 20 will be directed to a change in the brightness of an image in an area other than the area to which the image processor 20 should be directed. It is therefore likely that a user (or an object) to be
30 detected cannot be detected, a user (or an object) not to be detected will erroneously be detected, or the like.

 FIG. 3 shows an image captured when the camera 12 is not displaced from its installation position.
35 Although not shown in FIG. 1, a sill (referred to as a

car sill hereinafter) 13a which guides the opening and closing of the car door 13 is provided alongside the car 11. Similarly, a sill (referred to as a hall sill hereinafter) 14a which guides the opening and closing of the hall door 14 is provided alongside the elevator hall 15. In FIG. 3, the hatching indicates a detection area e1 set on the image. It is assumed here as an example that in order to detect a user on the elevator hall 15, the detection area e1 is set to have a predetermined range from one of the long sides of the car sill 13a shaped like a rectangle, which is close to the car 11, toward the elevator hall 15. In order to prevent the user's hand or arm from getting stuck in the door pocket, the detection area may be set in the car 11, or a plurality of detection areas may be set in both the elevator hall 15 and the car 11.

FIG. 4 shows an example of an image captured when the camera 12 is displaced from its installation position. As in FIG. 3, the hatching in FIG. 4 also indicates the detection area e1 set on the image.

When the camera 12 is displaced from its installation position as shown in FIG. 4, the image captured by the camera 12 is, for example, rotated (tilted) as compared with the image shown in FIG. 3. Since, however, the detection area e1 is set in a predetermined position on the image as in FIG. 3, it is originally set to have a predetermined range from one of the long sides of the rectangular car sill 13a, which is close to the car 11, toward the elevator hall 15 as shown in FIG. 3, but as shown in FIG. 4, the detection area e1 will be set to have a predetermined range from a position that is totally irrelevant to the long sides of the rectangular car sill 13a. It is thus likely that a user who should be detected cannot be detected and a user who need not be detected will

erroneously be detected, as described above. In the example of FIG. 4, the image is rotated due to displacement of the installation position of the camera 12. Similarly, it is likely that the image is displaced in the lateral direction due to displacement of the installation position of the camera 12.

The image processor 20 according to the present embodiment therefore has a calibration function for detecting whether the camera 12 is displaced from its installation position and for, when it is displaced, setting a detection area in an appropriate position in accordance with the displacement. The calibration function will be described in detail below.

In order to implement the calibration function, a marker m including a pattern, which is distinguishable from other objects (e.g., the floors of the car 11 and elevator hall 15) included in the imaging range of the camera 12, needs to be placed within the imaging range of the camera 12, as shown in FIG. 5, for example. The details of the pattern included in the marker m will be described later. The marker m is placed by, for example, a maintenance person who maintains and inspects the elevator system. In view of the convenience of the maintenance person at the time of placement of the marker m, the marker m is preferably shaped such that it can be placed without considering the vertical and horizontal directions. In the present embodiment, the marker m is square. However, the marker m may have any shape as long as it is at least rectangular.

FIG. 6 is an exemplary functional block diagram of the image processor 20 according to the present embodiment. The functional configuration of the foregoing calibration function will mainly be described.

As shown in FIG. 6, the image processor 20 includes a storage unit 201, an image acquisition unit 202, a displacement detection unit 203, a setting process unit 204, a notification process unit 205 and the like. As shown in FIG. 6, the displacement detection unit 203 further includes a recognition process unit 231, a calculation process unit 232, a detection process unit 233 and the like.

In the present embodiment, the units 202 to 205 will be described as being achieved, for example, by the CPU 23 shown in FIG. 2 (the computer of the image processor 20) which executes the calibration program (software) stored in the nonvolatile memory 22. However, the units 202 to 205 may be achieved by hardware or by the combination of software and hardware. Furthermore, in the present embodiment, the storage unit 201 is configured by the nonvolatile memory 22 shown in FIG. 2, another storage device, or the like.

The storage unit 201 stores setting values for the calibration function. The setting values include a value indicating the relative position of a marker to a reference point (referred to as a first setting value hereinafter). The reference point is a position that is an index for detecting whether the camera 12 is displaced from its installation position, and corresponds to, for example, the midpoint of one of the long sides of the rectangular car sill 13a, which is close to the car 11. The reference point is not the above midpoint, but may be set in an optional position if the optional position is included in the imaging range of the camera 12 when the camera 12 is not displaced from its installation position.

The calibration setting values also include a value indicating the relative position of the camera 12

to the reference point included in an image (reference image) when the camera 12 is not displaced from its installation position (referred to as a second setting value hereinafter).

5 In addition, the calibration setting values include a value indicating the relative position of each of the vertexes (four corners) of the car sill 13a to the reference point (referred to as a third setting value hereinafter). In the present embodiment, it is
10 assumed that the detection area is set to have a predetermined range from one of the long sides of the rectangular car sill 13a, which is close to the car 11, toward the elevator hall 15. The calibration setting values thus include, as the third setting value, a
15 value indicating the relative position of each vertex of the car sill 13a to the reference point. The third setting value is not limited to this value, but the calibration setting values may include, as the third setting value, a value in accordance with an area in
20 which the detection area should be set. For example, when the detection area is set close to the door pocket for the purpose of preventing the user's hand or arm from getting stuck in the door pocket, the calibration setting values may include, as the third setting value,
25 a value indicating the relative position of each characteristic point of the door pocket to the reference point.

 The calibration setting values also include values indicating the height from the floor of the car 11 to
30 the camera 12 and the angle of view (focal length) of the camera 12 (referred to as camera setting values hereinafter).

 The storage unit 201 may store an image (reference image) captured when the camera 12 is not displaced
35 from its installation position.

The image acquisition unit 202 acquires an image (referred to as a captured image hereinafter) captured by the camera 12 with the marker m placed on the floor of the car 11. In this embodiment, it is assumed that a plurality of markers m are placed on the floor of the car 11 along the side walls of the car 11 and at both ends of one of the long sides of the rectangular car sill 13a, which is close to the car 11, hereinafter, simply referred to as the markers m placed at both ends of the car sill 13a.

The displacement detection unit 203 recognizes the image acquired by the image acquisition unit 202 to extract a marker m included in the captured image. Specifically, for example, when the marker m shown in FIG. 5 is used, the displacement detection unit 203 recognizes four black circles included in the square as patterns. When the distance between the patterns (specifically, the distance between the centers of adjacent two black circles along the car sill 13a) is a preset distance, the displacement detection unit 203 recognizes an object including the patterns as the marker m. The recognition of the patterns included in the marker m may be achieved, for example, by recognizing a predetermined shape (e.g., a circle) in advance as a pattern included in the marker m, or using other well-known image recognition technologies.

In the present embodiment, the recognition of the marker m includes calculation of coordinate values of the marker m on the captured image. It is assumed in the present embodiment that the coordinate values of the marker m on the captured image are calculated by regarding the center (center of gravity) of a rectangle formed by connecting the centers of the four black circles included in an object recognized as the marker m to be the marker m. Though the center of gravity of a

rectangle formed by connecting the centers of four
black circles included in an object recognized as the
marker m is regarded as the marker m, any part of the
object recognized as the marker m can be regarded as
5 the marker m.

The displacement detection unit 203 detects that
the camera 12 is displaced from its installation
position, based on the result of the foregoing
recognition process. The functions of the recognition
10 process unit 231, calculation process unit 232 and
detection process unit 233, which are included in the
displacement detection unit 203, will be described in
detail later with reference to the flowchart.

When the displacement detection unit 203 detects
15 that the camera 12 is displaced from its installation
position, the setting process unit 204 sets a detection
area in an appropriate position of the captured image
acquired by the image acquisition unit 202 in
accordance with the displacement of the camera 12.

20 Accordingly, a detection area is set on the captured
image in consideration of the displacement of the
camera 12 from its installation position. Note that the
coordinate values of the detection area set in an
appropriate position corresponding to the displacement
25 may be stored in the storage unit 201.

When the displacement detection unit 203 detects
that the camera 12 is displaced from its installation
position, the notification process unit 205 notifies a
monitoring center (an administrator thereof) for
30 monitoring, e.g., the operating state of the elevator
system and a maintenance person (or his or her own
terminal) who maintains and inspects the elevator
system by placing a marker m, of the displacement of
the camera 12 from its installation position
35 (abnormality). This notification is performed, for

example, via the communication device 25.

As described above, the displacement detection unit 203 recognizes a plurality of markers m placed at both ends of the car sill 13a from the captured image, and detects displacement of the camera 12 from its installation position, based on the recognized markers m . It is thus necessary to recognize the markers m accurately from the captured image and calculate the coordinate values of the markers m accurately on the captured image. However, when the marker m shown in FIG. 5 is used, the following problem may occur.

In most cases, doorway columns near the car sill 13a on which the marker m is placed are generally made of a metallic material having a shine (material having specular reflection properties) such as aluminum and stainless steel. In recent years, not only the foregoing doorway columns but also the side walls of the car 11 are often formed of a metallic material having a shine and subjected to mirror finishing or the like, in order to improve designing. Therefore, in the case where the marker m is placed near a portion formed of a metallic material having a shine, such as the case where the marker m is placed at both ends of the car sill 13a as described above, the mirror image m' of the marker m (in the case of FIG. 7, the mirror image m' of the marker m_1) is likely to be reflected in the portion formed of the metallic material having a shine (in the case of FIG. 7, the side walls of the car 11), as in the captured image i_1 shown in FIG. 7.

From the above, since the patterns included in the marker m shown in FIG. 5 are arranged at regular intervals, the displacement detection unit 203 may recognize an object including part of the mirror image m' reflected in a portion formed of a metallic material having a shine erroneously as the marker m . This

problem will be described in detail below with reference to FIG. 8.

FIG. 8 illustrates the relationship in position between the marker m shown in FIG. 5 whose mirror image m' is reflected in a portion formed of a metallic material having a shine and the mirror image m'.

As illustrated in (a) of FIG. 8, among circles c1 to c4 included in the marker m, the distance between the centers of adjacent two circles c1 and c2 in a direction along the car sill 13a (hereinafter referred to as a first direction) is d1. The distance d1 corresponds to a distance set in advance to recognize the marker m. On the other hand, as shown in (b) of FIG. 8, the distance between the centers of the circle c1 included in the marker m and the circle c1' included in the mirror image m' is d2.

The four circles c1 to c4 included in the marker m shown in FIG. 5 are so arranged that the centers of four squares into which the marker m is divided by two center lines connecting opposite midpoints of four sides constituting the marker m, correspond to their respective centers of the circles c1 to c4. Accordingly, the distances d1 and d2 are the same as shown in FIG. 8.

When the displacement detection unit 203 recognizes the circles c1 and c4 included in the marker m and the circles c1' and c4' included in the mirror image m' as patterns, it is likely to recognize an object including these circles c1 and c4 and the circles c1' and c4' erroneously as the marker m since the distances d1 and d2 are the same as described above.

When the displacement detection unit 203 recognizes the marker m erroneously, it calculates not the point pm shown in (a) of FIG. 8 but the point pm'

shown in (b) of FIG. 8 as the coordinate value of the marker m. The coordinate value of the marker m is not accurately calculated. This may cause a problem that it is not possible to accurately detect whether the camera 12 is displaced from its installation position.

Therefore, in the present embodiment, as shown in FIG. 9, a marker m is used which includes four circles c1 to c4 arranged in such a manner that when the marker m is placed at both ends of the car sill 13a, distance da between adjacent two circles arranged in the first direction and a distance twice as long as distance db from one of two circles close to the side wall of the car 11 to one side of the marker m contacting the side wall of the car 11 in the first direction are different.

The different distances make it possible to prevent the marker m from being recognized erroneously.

FIG. 10 illustrates the relationship in position between the marker m shown in FIG. 9 whose mirror image m' is reflected in a portion formed of a metallic material having a shine and the mirror image m'.

As illustrated in (a) of FIG. 10, among four circles c1 to c4 included in the marker m, the distance between the centers of adjacent two circles c1 and c2 in the first direction is d3. The distance d3 corresponds to a distance set in advance to recognize the marker m when the marker m shown in FIG. 9 is used. The distance d3 corresponds to the distance da. On the other hand, as shown in (b) of FIG. 10, the distance between the centers of the circle c1 included in the marker m and the circle c1' included in the mirror image m' is d4. The distance d4 corresponds to a distance twice as long as the distance db. As described above, since the four circles c1 to c4 included in the marker m shown in FIG. 9 are arranged with the

relationship of $d_a \neq d_b * 2$, the distances d_3 and d_4 are, of course, different as shown in FIG. 10.

Even though the displacement detection unit 203 recognizes the circles c_1 and c_4 included in the marker m and the circles c_1' and c_4' included in the mirror image m' as patterns, the different distances d_3 and d_4 make it possible to prevent an object including the circles c_1 and c_4 and the circles c_1' and c_4' from being recognized erroneously as the marker m .

In view of the convenience of the maintenance person at the time of placement of the marker m , it is desirable that the patterns included in the marker m can be placed without considering the vertical and horizontal directions. It is thus desirable that the patterns included in the marker m are arranged symmetrically with regard to the center line and the diagonal line.

The use of the marker m placed as shown in FIG. 9 has been described, but the patterns included in the marker m is not limited to the placement shown in FIG. 9. For example, when the displacement detection unit 203 recognizes the patterns included in the marker m and the distance between the patterns is a preset one, an object including the patterns is recognized as the marker m . But how to recognize the marker m is not limited to this, the displacement detection unit 203 can also recognize an object including the patterns as the marker m when the arrangement of the patterns coincides with preset arrangement. In a latter case, the marker m as shown in FIG. 11 may be used to prevent the marker m from being recognized erroneously.

FIG. 11 shows a marker m including patterns different from those of the marker m shown in FIG. 9. In FIG. 11, the marker m includes two types of patterns of circles and squares and also includes patterns of

the same type arranged on a diagonal.

This arrangement makes it possible to prevent the marker m from being recognized erroneously.

FIG. 12 illustrates the relationship in position
5 between the marker m shown in FIG. 11 whose mirror image m' is reflected in a portion formed of a metallic material having a shine and the mirror image m'.

In the marker m illustrated in (a) of FIG. 12,
circles c1 and c2 are arranged on one diagonal and
10 squares s1 and s2 are arranged on the other diagonal. That is, the circle c1 and square s1 are arranged in the upper stage from the left in the figure, with the center of the marker m as a boundary, and the square s2 and circle c2 are arranged in the lower stage from the
15 left in the figure. This arrangement corresponds to that of patterns set in advance to recognize the marker m when the marker m shown in FIG. 11 is used.

In the above case, it is assumed that part of the mirror images m' is recognized as a pattern and, more
20 specifically, the circle c1 and square s2 included in the marker m and the circle c1' and square s2' included in the mirror image m' are recognized as patterns, as shown in (b) of FIG. 12. As the arrangement of these patterns, circles c1' and c1 are arranged in order in
25 the upper stage and squares s2' and s2 are arranged in order in the lower stage. This arrangement of patterns differs from that of patterns described with reference to (a) of FIG. 12.

Even though the displacement detection unit 203
30 recognizes the circle c1 and square s2 included in the marker m and the circle c1' and square s2' included in the mirror image m' as patterns, an object including the circle c1 and square s2 and the circle c1' and square s2' can be prevented from being recognized
35 erroneously as the marker m since the arrangement of

the patterns differs from that of patterns set in advance.

When the marker m is recognized by paying attention to the arrangement of patterns, it can be prevented from being recognized erroneously, for example, by causing all of the four patterns included in the marker m to differ from one another, as shown in FIG. 13. However, in view of the convenience of the maintenance person at the time of placement of the marker m , it is desirable that the patterns included in the marker m can be arranged without considering the vertical and horizontal directions. It is thus desirable that the patterns included in the marker m are shaped like circles and squares and arranged symmetrically with regard to the diagonal line.

The processing procedure of the image processor 20 in the calibration function of the present embodiment will be described with reference to the flowchart of FIG. 14. It is here assumed that the marker m shown in FIG. 9 is used. A series of processes shown in FIG. 14 may be performed, for example, at the time of regular maintenance, before the operation of the elevator system, or the like.

First, the image acquisition unit 202 acquires from the camera 12 an image captured (captured image) in a state where a plurality of markers m are placed on the floor of the car 11 (step S1). Here is an example where the captured image $i2$ shown in FIG. 15 is acquired by the image acquisition unit 202. As shown in FIG. 15, the captured image $i2$ includes two markers $m1$ and $m2$ placed at both ends of the car sill 13a and a mirror image m' of the marker $m1$.

Subsequently, the recognition process unit 231 included in the displacement detection unit 203 recognizes the captured image acquired by the image

acquisition unit 202, and extracts a plurality of markers m included in the captured image (step S2).

5 An example of the recognition procedure of the recognition process unit 231 (detailed processing procedure of step S2) will be described with reference to the flowchart of FIG. 16.

10 First, the recognition process unit 231 recognizes a plurality of patterns having a preset shape (predetermined shape) from the captured image acquired by the image acquisition unit 202 (step S21).

Subsequently, the recognition process unit 231 calculates the distance between adjacent two of the patterns recognized in step S21, the adjacent two being arranged along the car sill 13a (step S22).

15 Then, the recognition process unit 231 determines whether the distance calculated in step S22 is a preset distance for recognition of the marker m (step S23).

20 If the recognition process unit 231 determines in step S23 that the distance between the two patterns is a preset distance (YES in step S23), it recognizes the object including the two patterns as the marker m (step S24), and terminates the series of processes.

25 If the recognition process unit 231 determines in step S23 that the distance between the two patterns is not a preset distance (NO in step S23), it determines that the object including the two patterns includes the mirror image m' (step S25) and notifies a maintenance person that the marker m was not recognized normally (step S26), and terminates the series of processes.

30 Note that the notification to the maintenance person is performed, for example, via the communication device 25.

35 It is assumed below that markers m_1 and m_2 are recognized from the captured image i_2 by the recognition process unit 231 through the foregoing

series of recognition processes.

5 In the present embodiment, when the recognition process unit 231 determines in step S25 that the object including the two patterns include the mirror image m' , it notifies a maintenance person that the marker m was not recognized normally. However, for example, in step S22, a plurality of pairs of candidates for adjacent two patterns along the car sill 13a may be prepared. When the foregoing series of processes is performed for
10 a first pair of candidates, and the distance between the patterns of the first pair of candidates is not a preset distance but the patterns include the mirror image m' , the series of processes is performed again for another pair of candidates prepared in step S22,
15 and repeated until the marker m can be recognized normally. In this case, only if the foregoing series of processes is performed for all the pairs of candidates for patterns prepared in step S22, but the marker m was not recognized normally, the notification to the
20 maintenance person is performed.

The case where the marker m shown in FIG. 9 is used, that is, the case where the recognition process unit 231 determines whether two patterns include the mirror image m' by paying attention to the distance
25 between the two patterns, has been described. Similarly, in the case where the marker m shown in FIG. 11 is used, that is, the case where the recognition process unit 231 determines whether the patterns include the mirror image m' by paying
30 attention to the arrangement of the patterns, the recognition process unit 231 has only to recognize a plurality of patterns from the captured image and determine whether the arrangement of the recognized patterns coincides with preset arrangement of patterns
35 thereby to determine whether the patterns include the

mirror image m' .

The description of FIG. 14 will be given again. Based on the camera setting values (the height and angle of view of the camera 12) stored in the storage unit 201, the recognition process unit 231 calculates a relative position of the camera 12 to each of the markers m obtained as a result of the recognition process in step S2 and the angle of three axes of the camera 12 (the installation angle of the camera 12) (step S3). As described above, when the markers $m1$ and $m2$ are recognized from the captured image $i2$ in step S2, the recognition process unit 231 calculates a relative position of the camera 12 to the marker $m1$ and a relative position of the camera 12 to the marker $m2$ as relative positions of the camera 12 to the markers m . In FIG. 15, point $p1$ corresponds to a portion regarded as the marker $m1$, and point $p2$ corresponds to a portion regarded as the marker $m2$.

The calculation process unit 232 included in the displacement detection unit 203 calculates a relative position of the camera 12 to the reference point based on the relative positions of the camera 12 to the markers m calculated by the recognition process unit 231 and the first setting value stored in the storage unit 201 (step S4).

When the relative positions of the camera 12 to the markers $m1$ and $m2$ are calculated in step S3 as described above, the calculation process unit 232 combines the relative position of the camera 12 to the marker $m1$ and the relative position of the marker $m1$ to the reference point that is the first setting value to calculate the relative position of the camera 12 to the reference point. Similarly, the calculation process unit 232 combines the relative position of the camera 12 to the marker $m2$ and the relative position of the

marker m2 to the reference point that is the first setting value to calculate the relative position of the camera 12 to the reference point. In FIG. 15, point p3 corresponds to the reference point.

5 Subsequently, the detection process unit 233 included in the displacement detection unit 203 determines whether the camera 12 is displaced from its installation position, based on the relative position of the camera 12 to the reference point calculated by
10 the calculation process unit 232 and the second setting value stored in the storage unit 201 (step S5). Specifically, the detection process unit 233 determines whether the relative position of the camera 12 to the reference point calculated by the calculation process
15 unit 232 coincides with the relative position of the camera 12 to the reference point that is the second setting value to detect whether the camera 12 is displaced from its installation position.

 When the detection process unit 233 determines
20 that the relative positions of the camera 12 to the reference point coincide with each other and the camera 12 is not displaced from its installation position (YES in step S5), it determines that the camera 12 is not displaced from its installation position and the
25 detection area need not be set again, and terminates the series of processes.

 When the detection process unit 233 determines that the positions of the camera 12 relative to the reference point do not coincide with each other and the
30 camera 12 is displaced from its installation position (NO in step S5), the setting process unit 204 sets a detection area in an appropriate position of the captured image acquired by the image acquisition unit 12, which corresponds to the displacement of the camera
35 12, based on the relative position of the camera 12 to

the reference point calculated by the calculation process unit 232 and the third setting value and the camera setting value stored in the storage unit 201 (step S6).

5 In the present embodiment, it is assumed that a detection area having a predetermined range is set from the car sill 13a toward the elevator hall 15. Thus, the setting process unit 204 first combines the relative position of the camera 12 to the reference point
10 calculated by the calculation process unit 232 and the relative position of each vertex of the car sill 13a to the reference point that is the third setting value to calculate the relative position of each vertex of the car sill 13a to the camera 12. In FIG. 15, points p4 to
15 p7 correspond to the vertexes of the car sill 13a.

 After that, the setting process unit 204 sets a detection area based on the calculated relative position of each vertex of the car sill 13a to the camera 12, the three-axis angle of the camera 12
20 calculated by the recognition process unit 231, and the angle of view of the camera 12 stored as a camera setting value in the storage unit 201.

 In the captured image i2 acquired by the image acquisition unit 202, therefore, a detection area e1
25 that corresponds to the displacement of installation position of the camera 12, that is, a detection area e1 having a predetermined range from one of the long sides of the car sill 13a, which is close to the car 11, toward the elevator hall 15, is set, as indicated by
30 hatching in FIG. 15.

 After that, the notification process unit 205 notifies a monitoring center (an administrator thereof) and a maintenance person (or his or her own terminal) via the communication device 25 that the camera 12 is
35 displaced from its installation position (step S7), and

terminates the series of processes.

5 In step S5 shown in FIG. 14, it is determined (detected) whether the camera 12 is displaced from its installation position according to whether the relative position of the camera 12 to the reference point included in the captured image coincides with the relative position of the camera 12 to the reference point included in the reference image. Even though the camera 12 is displaced from its installation position, 10 a detection area need not be set again if it is displaced to such an extent that the displacement does not affect the accuracy of the foregoing user detection process. That is, the process of step S5 is performed based on whether the difference (divergence) between 15 the relative position of the camera 12 to the reference point included in the captured image and the relative position of the camera 12 to the reference point included in the reference image falls within a preset range. When the divergence does not fall within the 20 preset range, it may be determined that the camera 12 is displaced from its installation position.

25 In the present embodiment, when the setting of a detection area indicates the resetting of the already set detection area, it may be expressed as a correction of the detection area. In this case, the relative position of the camera 12 to the reference point may be expressed as a correction value because it is a value necessary to correct the detection area, together with the three-axis angle of the camera 12 described above.

30 In the present embodiment described above, the image processor 20 acquires from the camera 12 an image captured with the marker m placed distinguishably from the floor of the car 11 and the floor of the elevator hall 15, recognizes the marker m from the acquired 35 image, detects that the camera 12 is displaced from its

installation position, based on the recognized marker m, and sets a setting value regarding image processing (user detection process) when it is detected that the camera 12 is displaced from its installation position.

5 The setting value regarding the image processing includes a detection area (its coordinate values) to detect the user closest to the car door 13 set for the captured image.

10 According to the foregoing configuration, even when the camera 12 is displaced from its installation position, an appropriate detection area can be set for an image (e.g., a rotated image and a laterally displaced image) captured by the camera 12. Thus, user detection accuracy can be prevented from decreasing.

15 In the present embodiment, furthermore, the image processor 20 acquires from the camera 12 an image captured with a marker m displaced along the side wall of the car distinguishably from the floor of the car 11 and the floor of the elevator hall 15, recognizes a
20 plurality of patterns included in the marker m from the image, and detects that the camera 12 is displaced from its installation position, based on the marker m including the recognized patterns, when the distance between adjacent two of the recognized patterns, which
25 are arranged in the first direction along the car sill 13a, is a preset distance. The shape of the marker m is a rectangle, and the patterns included in the marker m are arranged such that the distance between adjacent two patterns in the first direction is caused to differ
30 from the distance twice as long as the distance along the first direction from one of the two patterns, which is close to the side wall of the car 11, to one side of the marker m which is in contact with the side wall of the car 11.

35 According to the foregoing configuration, even

though the marker m is placed at either end of the car sill 13a and its mirror image m' is reflected in a portion formed of a metallic material having a shine, an object including part of the mirror image m' can be prevented from being erroneously recognized as the marker m ; accordingly, a problem that it is impossible to accurately detect whether the camera 12 is displaced from its installation position, can be prevented from occurring.

Furthermore, in the present embodiment, the image processor 20 acquires from the camera 12 an image captured with the marker m placed distinguishably from the floor of the car 11 and the floor of the elevator hall 15, recognizes different patterns included in the marker m from the image, and detects that the camera 12 is displaced from its installation position, based on the marker m including the recognized different patterns when the arrangement of the recognized different patterns coincides with a preset displacement. The marker m is rectangular, and the different patterns included in the marker m include a plurality of first patterns (e.g., circular patterns) and a plurality of second patterns (e.g., square patterns). The different first patterns are placed on one diagonal of the marker m , and the different second patterns are placed on the other diagonal of the marker m .

The above configuration can also prevent an object including part of the mirror image m' from being erroneously recognized as the marker m and accordingly prevent a problem that it is impossible to accurately detect whether the camera 12 is displaced from its installation position, from occurring.

According to the embodiment described above, it is possible to provide the image processor 20 and the

marker m which can improve the accuracy of detection of the displacement of the installation position of the camera 12.

5 While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and
10 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
15 of the inventions.

WHAT IS CLAIMED IS:

1. An image processor provided close to a door of a car to detect that a camera, which captures an image including an interior of the car and an elevator hall,
5 is displaced from an installation position thereof, the image processor comprising:

image acquisition unit configured to acquire from the camera an image captured with a marker placed along a side wall of the car distinguishably from a floor of
10 the car and a floor of the elevator hall; and

displacement detection unit configured to recognize a plurality of patterns included in the marker from the captured image, and to detect that the camera is displaced from the installation position,
15 based on the marker including the recognized patterns, when a distance between adjacent two of the recognized patterns, which are arranged in a first direction along a sill of the car, is a preset distance,

wherein:

20 the marker is rectangular; and

the patterns are so arranged that the distance between adjacent two patterns in the first direction is caused to differ from a distance twice as long as a distance from one of the two patterns, which is close
25 to the side wall of the car, to one side of the marker which is in contact with the side wall of the car.

2. The image processor of Claim 1, wherein the patterns are arranged symmetrically with regard to each of two center lines, which connect midpoints of sides
30 of the rectangular marker and midpoints opposite thereto, and each of two diagonal lines.

3. The image processor of Claim 1, further comprising notification process unit configured to notify a maintenance person that the displacement
35 detection process determines that the distance between

two patterns is not a preset distance but one of the two patterns is a pattern included in a mirror image of the marker.

4. The image processor of Claim 1, wherein when
5 the distance between two patterns is not a preset distance, the displacement detection unit is configured to determine whether a distance between other adjacent two patterns in the first direction is the preset distance.

10 5. An image processor provided close to a door of a car to detect that a camera, which captures an image including an interior of the car and an elevator hall, is displaced from an installation position thereof, the image processor comprising:

15 image acquisition unit configured to acquire from the camera an image captured with a marker that is distinguishable from a floor of the car and a floor of the elevator hall; and

20 displacement detection unit configured to recognize different patterns included in the marker from the captured image, and to detect that the camera is displaced from the installation position, based on the marker including the recognized different patterns, when arrangement of the recognized different patterns
25 coincides with preset arrangement.

6. The image processor of Claim 5, wherein:

the marker is rectangular;

the different patterns include first patterns and second patterns other than the first patterns;

30 the first patterns are each arranged on a first diagonal line which is one of two diagonal lines of the marker; and

the second patterns are each arranged on a second diagonal line which is one of the two diagonal lines of
35 the marker and which differs from the first diagonal

line.

7. The image processor of Claim 6, wherein the different patterns are arranged symmetrically with regard to each of the first diagonal line and the second diagonal line.

8. A marker which is a rectangle provided close to a door of a car and used to detect that a camera, which captures an image including an interior of the car and an elevator hall, is displaced from an installation position thereof,

wherein:

the rectangle includes a plurality of patterns arranged adjacent to each other in a first direction along a sill of the car when the marker is placed along a side wall of the car; and

the patterns are so arranged that a distance between adjacent two patterns in the first direction is caused to differ from a distance twice as long as a distance from one of the two patterns, which is close to the side wall of the car, to one side of the rectangle which is in contact with the side wall of the car.

9. A marker which is a rectangle provided close to a door of a car and used to detect that a camera, which captures an image including an interior of the car and an elevator hall, is displaced from an installation position thereof,

wherein:

the rectangle includes first patterns and second patterns other than the first patterns;

the first patterns are each arranged on a first diagonal line which is one of two diagonal lines of the rectangle; and

the second patterns are each arranged on a second diagonal line which is one of the two diagonal lines of

the rectangle and which differs from the first diagonal line.