

Description

Title of Invention: FOREIGN MATTER DETECTION SYSTEM

Technical Field

5 [0001] The present disclosure relates to a system for detecting a foreign object located around a shielding object, for example, a vehicle, in a target area, for example, a parking lot. This application claims the benefit of priority to Japanese Patent Application No. 2019-094736 filed on May
10 20, 2019, and contents thereof are incorporated herein.

Background Art

[0002] In a space in which a vehicle enters and stops, for example, a loading/unloading space of a mechanical
15 parking lot, before operations of opening and closing a door of an entry/exit and transporting a pallet carrying the vehicle are performed, it is required to confirm that there is no foreign object, such as a driver, an occupant, or a luggage other than the vehicle. Such operation of confirming
20 absence of a foreign object can be visually performed by the driver or an attendant at the facility, for example, but the confirmation may not be performed thoroughly due to carelessness or other reasons when relying only on manpower. To address this problem, in recent years, in order to
25 reliably confirm absence of a foreign object, there is a demand for a technology of automatically detecting a foreign object in a target area without relying only on manpower.

[0003] Further, when an autonomous driving technology that is currently being developed in various countries is put into practice on a full-scale basis, it is expected that automation is advanced not only in vehicle driving, but also in various operations performed around the vehicle, such as opening and closing of the door and transporting the pallet as described above. For example, there is expected a case in which, after driving the occupant to a destination by autonomous driving, the vehicle automatically moves to a nearby mechanical parking lot to be stored in a storage space. In this case, the vehicle moves under a state in which the occupant is absent, and stops in the loading/unloading space. At this time, operations of opening and closing of the door, and starting to move the pallet, for example, may be executed by the attendant visually confirming absence of a foreign object and providing input on an operation button. However, the operations become smoother when there is a mechanism in which the absence of a foreign object is automatically confirmed, and the operations are started.

[0004] Such a mechanism configured to detect a foreign object may be widely required not only in the mechanical parking lot, but also in locations in which some operation is performed around a stopped vehicle, for example, a power feeding facility for an electric vehicle. Further, a similar mechanism is widely applicable to situations in which it is desired to detect a foreign object around some object without

limiting to the vehicle.

[0005] As a technology for automatically detecting a foreign object in a target area, there are proposed various methods of taking images in the target area with the use of cameras or the like and detecting a foreign object captured in the image. Examples of technical literatures in which such a technology is described include, for example, the following Patent Literatures 1 to 6.

10 Citation List

Patent Literature

[0006] Patent Literature 1: JP 2016-3493 A

Patent Literature 2: JP 2015-55073 A

Patent Literature 3: JP 2014-80735 A

15 Patent Literature 4: JP H08-42184 A

Patent Literature 5: JP S62-194366 A

Patent Literature 6: JP 2012-158968 A

Summary of Invention

20 Technical Problem

[0007] In the technology for detecting a foreign object as described above, minimum accuracy is at least required in the detection, but in addition, it is important in terms of cost required for construction or maintenance, for example, to simplify a device configuration as much as possible. However, the technology as described in any of the above-mentioned Patent Literatures 1 to 6 has not necessarily

reached to a point of sufficiently satisfying both accuracy and cost.

[0008] In view of the above, in the present disclosure, there is described a foreign object detection system that can
5 detect a foreign object with high accuracy with a configuration that is as simple as possible.

Solution to Problem

[0009] According to one embodiment of the present
10 disclosure, there is provided a foreign object detection system including, around a shielding object located in a target area: a first image pickup device arranged on one of a left side or a right side behind the shielding object as viewed from a transmissive portion through which an outside
15 of the target area is visible from an inside of the target area, the first image pickup device being configured to include a space on the other of the left side or the right side in an angle of view thereof; a second image pickup device arranged on the left side in front of the shielding
20 object as viewed from the transmissive portion, the second image pickup device being configured to include a space on a right back side in an angle of view thereof; and a third image pickup device arranged on the right side in front of the shielding object as viewed from the transmissive portion,
25 the third image pickup device being configured to include a space on a left back side in an angle of view thereof.

[0010] In the above-mentioned foreign object detection

system, the first image pickup device may be arranged so that a straight line along an edge on the front side of the angle of view of the first image pickup device as viewed from the transmissive portion in plan view overlaps with a line segment connecting the first image pickup device and an end on the other of the left side or the right side of the transmissive portion, or passes the other of the left side or the right side of the line segment.

[0011] The above-mentioned foreign object detection system may be configured to detect a foreign object in images taken by the image pickup devices by a program using deep learning.

[0012] In the above-mentioned foreign object detection system, the shielding object may be a vehicle.

[0013] In the above-mentioned foreign object detection system, the target area may be a loading/unloading space of a mechanical parking lot.

Advantageous Effects of Invention

[0014] According to the foreign object detection system of the present invention, it is possible to provide an excellent effect that a foreign object is detectable with high accuracy with a configuration that is as simple as possible.

Brief Description of Drawings

[0015] FIG. 1 is a schematic plan view for illustrating

an arrangement of apparatus in a foreign object detection system according to an embodiment of the present disclosure.

FIG. 2 is a block diagram for illustrating a system configuration of the foreign object detection system according to the embodiment of the present disclosure.

FIG. 3 is a schematic plan view for illustrating another arrangement of the apparatus in the foreign object detection system according to the embodiment of the present disclosure.

FIG. 4 is a schematic plan view for illustrating still another arrangement of the apparatus in the foreign object detection system according to the embodiment of the present disclosure.

FIG. 5 is a schematic plan view for illustrating an arrangement of apparatus in a foreign object detection system according to a reference example of the present disclosure.

FIG. 6 is a view for illustrating an example of an image taken in the foreign object detection system of the reference example.

FIG. 7 is a view for illustrating an example of an image which is taken and a part of which is subjected to masking in the foreign object detection system of the reference example.

Description of Embodiments

[0016] Now, embodiments of the present disclosure are described with reference to the accompanying drawings. In a

foreign object detection system according to the embodiment illustrated in FIG. 1, a loading/unloading space of a mechanical parking facility is assumed as a target area A, and a vehicle 1 stopped on a pallet 2 in a center portion of the target area A is assumed as a shielding object. Further, when there is an object (foreign object F) other than the vehicle 1 in the target area A, the foreign object F is detected. The target area A as the loading/unloading space is a space surrounded by walls in four directions, and has provided on a front side thereof (lower side of FIG. 1) a loading/unloading port 4 serving as a transmissive portion, through which the vehicle 1 enters and exits.

[0017] The term "shielding object" as used herein refers to an object that is located in the target area, is other than a detection target, and optically shields a part of angles of view of image pickup device 5, which is described later. Further, the term "foreign object" refers to an object that presents in the target area, is other than the shielding object, is other than objects originally arranged in the target area, and is representatively a driver or an occupant of the vehicle, or an attendant at the facility. Further, a luggage carried in the target area A and placed outside the vehicle 1 is another example of the "foreign object." FIG. 1 shows one foreign object F inside the target area A as an example. FIG. 1 also shows one object O outside the target area A.

[0018] The term "transmissive portion" refers to an

optical opening through which the outside of the target area is visible from the inside thereof. In other words, the transmissive portion in the embodiment is the loading/unloading port 4 that is in communication with an external space both optically and physically. In addition, a glass window through which light is transmitted, for example, can also be expected as a "transmissive portion."

[0019] The pallet 2 configured to transport the vehicle 1 enters or exits the target area A serving as the

loading/unloading space from or into a storage space (not shown) outside the target area A through a transporting port (not shown). A standard position of the pallet 2 in the target area A is a center portion of the target area A. At the time of loading, the vehicle 1 enters the target area A through the loading/unloading port 4, stops on the pallet 2, and is transported to and stored in the storage space together with the pallet 2. At the time of unloading, the vehicle 1 is transported from the storage space into the target area A together with the pallet 2, and then exits to the outside of the target area A through the loading/unloading port 4.

[0020] In the target area A, image pickup devices 5, for example, cameras configured to take images in the target area A, are arranged. In the case of this embodiment, as the image pickup device 5, a total of three image pickup devices 5a to 5c are installed around a stop position of the vehicle 1 as illustrated in FIG. 1. An arrangement of these image

pickup devices 5a to 5c is described later in detail.

[0021] On an outer wall near the loading/unloading port 4, an operation unit 6, a display unit 7, and an alarm unit 8 are provided. The operation unit 6 is an input device

5 through which opening and closing of the loading/unloading port 4, transport of the pallet 2, and other operations of the respective units are input. The display unit 7 is a display configured to display the images in the target area A taken by the image pickup devices 5 as required. The alarm

10 unit 8 is a device configured to issue an alarm when some event to which personnel should be alerted happens in the target area A, or somewhere in the facility including the target area A. Examples of the "some event to which

personnel should be alerted" include a case in which, when 15 the vehicle 1 is to be transported to the storage space outside the target area A, for example, a foreign object F other than the vehicle 1 is detected in the target area A.

As a content of the alarm, a suitable form may be selected as long as the personnel can be alerted, such as an alarm sound, 20 lighting of a warning lamp, and display of a warning message.

[0022] The positions where the operation unit 6, the display unit 7, and the alarm unit 8 are installed at are not limited to the positions described here. For example,

devices corresponding thereto may be provided in a control

25 room (not shown) or the like, or some of those devices may be provided in different locations. Further, in this example, for convenience of description, the operation unit 6, the

display unit 7, and the alarm unit 8 are illustrated separately, but there may be provided a touch panel display having the functions of the operation unit 6 and the display unit 7 in an integrated manner, for example. Still further, the function of the alarm unit 8 may be performed also by the display unit 7 (that is, information corresponding to an alarm may be displayed on the display unit 7). In addition, the operation unit 6, the display unit 7, and the alarm unit 8 may be changed accordingly depending on the layout of the target area A and other conditions.

[0023] FIG. 2 shows an example of a system configuration involved in control of the image pickup devices 5, the operation unit 6, the display unit 7, and the alarm unit 8. The image pickup devices 5, the operation unit 6, and the alarm unit 8 are informationally connected to a controller 9 through a communication bus, for example, Ethernet (trademark). The controller 9 is a device configured to monitor the entire mechanical parking lot including the target area A as the loading/unloading space and operate the respective units, and is configured to control opening and closing of the loading/unloading port 4, transport of the pallet 2, and actuation of the image pickup devices 5, for example.

[0024] Further, the display unit 7 is connected to the communication bus via an image processing unit 10. The image processing unit 10 is an information processing device configured to perform appropriate processing on the images of

the target area A taken by the image pickup devices 5, and is also configured to transmit image data to the display unit 7 and cause the display unit 7 to display the images as required.

5 [0025] As image processing performed in the image processing unit 10, detection of a foreign object F (see FIG. 1) is particularly assumed in this embodiment. In other words, in the image processing unit 10, the images of the target area A acquired by the image pickup devices 5 are
10 analyzed to determine whether a foreign object F, for example, a person, exists in the images. When a foreign object F is detected from the images processed in the image processing unit 10, the controller 9 issues an alarm via the alarm unit 8.

15 [0026] The image processing unit 10 stores therein a program for detecting a foreign object F captured in the images. This program is configured to detect objects of particular types by a deep learning method with the use of a multilayer neural network. As an algorithm for the deep
20 learning, for example, various algorithms such as regional-convolutional neural network (R-CNN), Fast R-CNN, Faster R-CNN, You Only Look Once (YOLO), and Single Shot Multibox Detector (SSD) can be used, but another appropriate algorithm may be used.

25 [0027] The program stored in the image processing unit 10 is configured to identify the type of the object captured in the images, and output a probability that the object

corresponds to the type, coordinates of a center of gravity of the object, a width and a height of the object with the use of the above-mentioned algorithms. The first type of the foreign objects F expected in the target area A as the

5 loading/unloading space of the mechanical parking lot is a person, and hence the program stored in the image processing unit 10 is required to be configured to be able to discriminate at least a person from the image. As other objects that can enter the target area A together with the
10 vehicle 1, various objects such as a pet and other animals, a bag, and a baby carriage are expected, and hence the program may be adapted to be able to detect those objects in addition to a person. It is also assumed that, when the type of the target area in which the foreign object detection system is
15 applied is different, types of objects to be detected as the foreign objects are also different. The program may be configured to be able to detect, without limiting to a person, various objects expected depending on the type of the target area.

20 [0028] When the vehicle 1 is to be loaded, the driver or the occupant of the vehicle 1, or the attendant or other personnel at the facility operates and instructs the operation unit 6 to start loading. The controller 9 opens the loading/unloading port 4 in response to the instruction.
25 When the loading is started, the loading/unloading port 4 is opened under a state in which an empty pallet 2 is deployed in the center portion, which is the standard position in the

target area A.

[0029] After the loading/unloading port 4 is opened, the driver moves the vehicle 1 into the target area A, and stops the vehicle 1 on the pallet 2. After the stopping, the
5 driver and other occupants get off the car, and exit the target area A. After all of the driver and other personnel exit, the driver or other personnel visually checks the inside of the target area A to see whether there is no person, luggage, or other foreign object F in the target area
10 A. Thereafter, the driver or other personnel operates the operation unit 6 to input that the vehicle 1 has stopped on the pallet 2. The controller 9 closes the loading/unloading port 4, and transports the pallet 2 carrying the vehicle 1 to the storage space outside the target area A.

15 [0030] When the vehicle 1 is to be unloaded, the driver or the occupant of the vehicle 1, or the attendant or other personnel at the facility operates and instructs the operation unit 6 to start unloading. The controller 9 transports the corresponding pallet 2 into the target area A,
20 and opens the loading/unloading port 4 in response to the instruction. After the loading/unloading port 4 is opened, the driver gets on the vehicle 1 on the pallet 2, and moves to the outside of the target area A. After the vehicle 1 exits to the outside, the driver of the vehicle 1 or the
25 attendant or other personnel operates the operation unit 6 again to input that the unloading is completed. The controller 9 closes the loading/unloading port 4 in response

to the instruction.

[0031] The series of operation has been described above taking as an example the case in which the driver drives the vehicle 1, but there may also be a case in which the vehicle
5 1 is a self-driving car. In this case, a part or all of the above-mentioned operation of the vehicle 1 is performed without intervention of the driver.

[0032] In the image processing unit 10 (see FIG. 2), foreign object detection is executed at an appropriate
10 timing. For example, at the time of loading, when the vehicle 1 stops on the pallet 2, and the driver inputs it to the operation unit 6, the foreign object detection is performed. At this time, the driver visually confirms the absence of a foreign object F in the target area A.
15 Furthermore, the confirmation can be thoroughly conducted when the image processing unit 10 automatically executes the foreign object detection at the same time. In addition, the foreign object detection can be performed at any timing when it is considered necessary to check a state in the target
20 area A, for example, when the instruction to start unloading is input, when the completion of unloading is input and the loading/unloading port 4 is to be closed, or at normal times when no operation is performed.

[0033] When the foreign object detection is to be
25 performed, the controller 9 first actuates the image pickup devices 5 to take images in the target area A. In the image processing unit 10, foreign object detection processing is

executed by the program on the images taken by the image pickup devices 5. When an object of a type expected to be a foreign object F (for example, person) is detected in at least one image of the taken images, the controller 9

5 actuates the alarm unit 8 to issue an alarm. At the same time, operations of the pallet 2, the loading/unloading port 4, or other units are prohibited. Further, a message that the foreign object F has been detected may be displayed on the display unit 7.

10 [0034] The arrangement of the image pickup devices 5 is described. In this embodiment, a total of three image pickup devices 5a to 5c are arranged around the vehicle 1 located in the target area A. The first image pickup device 5a is arranged on one of a left side or a right side (in the
15 illustrated example, left side) behind the vehicle 1 that is the shielding object, when the inside of the target area A is viewed from the loading/unloading port 4 that is the transmissive portion. The second and third image pickup devices 5b and 5c are arranged in front of the vehicle 1 in
20 the target area A at positions to the left and right of the loading/unloading port 4, respectively. A height at which the image pickup devices 5 are installed is near a ceiling of the target area A.

[0035] Each of the image pickup devices 5a to 5c has an
25 angle of view of about 90° as indicated by the broken lines in FIG. 1. The image pickup device 5a installed on one of the left side or the right side (left side) behind the stop

position of the vehicle 1 as viewed from the loading/unloading port 4 is arranged so as to include a space on the other of the left side or the right side (right side) in the angle of view thereof. Further, the image pickup

5 device 5a is arranged so that a straight line L1 along an edge on the front side (loading/unloading port 4 side) of the angle of view of the image pickup device 5a in plan view overlaps with a line segment L2 (indicated by the one-dot chain line in the figure) connecting the image pickup device
10 5a and an end on the other of the left side and the right side (right side) of the loading/unloading port 4, or passes the other of the left side and the right side (right side) of the line segment L2. FIG. 1 shows a case in which the straight line L1 passes the other of the left side and the
15 right side of the line segment L2. FIG. 3 shows a case in which the straight line L1 overlaps with the line segment L2.

[0036] The image pickup device 5b arranged on the left side as viewed from the loading/unloading port 4 is arranged so as to include a space on the right back side in the target
20 area A as viewed from the image pickup device 5b in the angle of view thereof. The image pickup device 5c arranged on the right side as viewed from the loading/unloading port 4 is arranged so as to include a space on the left back side in the target area A as viewed from the image pickup device 5c
25 in the angle of view thereof.

[0037] With this configuration, in the angles of view of the image pickup devices 5b and 5c, the loading/unloading

port 4 is not located, or is located on an endmost portion. Further, as especially indicated by the hatching in FIG. 1 and FIG. 3, the loading/unloading port 4 as the transmissive portion is not located in the angle of view of the image

5 pickup device 5a. In this example, there has been exemplified the case in which the image pickup device 5a located on the back side as viewed from the loading/unloading port 4 is arranged on the left side as viewed from the loading/unloading port 4, but in contrast, the image pickup
10 device 5a may be arranged on the right back side as viewed from the loading/unloading port 4 (FIG. 4 shows the arrangement of the image pickup device 5a in this case).

[0038] Reasons for the above-mentioned arrangement of the image pickup devices 5 are described. When a foreign
15 object F in the target area A as illustrated in FIG. 1 is to be detected based on the images in the target area A taken by the image pickup devices 5, the following two points are required in order to ensure detection accuracy.

- Not to generate a blind spot.
- 20 •Not to detect an object O outside the target area A as a foreign object.

[0039] When there is a blind spot in images to be taken, the foreign object F may not be detected if a foreign object F is located in the blind spot (under-detection may occur).
25 Meanwhile, when even an object O outside the target area A is detected, over-detection occurs.

[0040] Further, in constructing the system, from the

viewpoints of reducing costs of equipment and maintenance, the following point is important.

•To form the system including minimum devices.

[0041] In other words, in performing foreign object
5 detection by image processing, it is desired not to provide devices (for example, position sensor) other than the image pickup devices 5 as much as possible. It is also desired that the number of image pickup devices 5 be as small as possible, as long as the accuracy of the foreign object
10 detection can be ensured. In particular, when image processing is performed by the program using the deep learning as described above, a considerable computing load is caused in the image processing unit 10. FIG. 2 shows the image processing unit 10 as one block, but in some real
15 cases, for example, one information processing device may be necessary for each image pickup device 5. Accordingly, reducing the number of image pickup devices 5 is very important in terms of cost, and it can be said that the configuration of the present embodiments including the
20 arrangement of the image pickup devices 5 to be described below may be particularly suitable for the system for performing the foreign object detection by the program using the deep learning.

[0042] When images in the target area A are taken by a
25 small number of image pickup devices 5 so as not to generate a blind spot, for example, arranging two image pickup devices 5 as illustrated in FIG. 5 as a reference example may be

considered. In other words, two image pickup devices 5d and 5e are arranged forward on the one side (front left side) and backward on the other side (back right side) across the vehicle 1. The image pickup device 5d on the front left side includes a space on the back right side with respect to the image pickup device 5d in an angle of view thereof, and the image pickup device 5e on the back right side includes a space on the front left side with respect to the image pickup device 5e in an angle of view thereof. With this configuration, areas corresponding to the blind spots for the image pickup devices 5 (the right side behind the vehicle 1 for the image pickup device 5d, and the left side behind the vehicle 1 for the image pickup device 5e) because of the vehicle 1 are compensated by each other, and images of the entire area in the target area A can be taken without any blind spots.

[0043] However, when the image pickup devices 5 are arranged as illustrated in FIG. 5 in order to eliminate the blind spots, the loading/unloading port 4 is included in a large portion of the angle of view of the image pickup device 5d located on the front left side. As a result, as illustrated in FIG. 6, the object O located on the outside of the target area A may be captured in the image through the loading/unloading port 4 that is the transmissive portion. When the object O (here, person) is an object of a type that is detectable by the program stored in the image processing unit 10 (see FIG. 2), over-detection may be caused.

[0044] In order to prevent over-detection, there is considered a method including, as illustrated in FIG. 7, for example, masking an area corresponding to the transmissive portion (loading/unloading port 4) captured in the image to execute the foreign object detection. However, in this case, a part of the foreign object F in front of the loading/unloading port 4 as viewed from the image pickup device 5d is also masked, and the foreign object F may not be detected though being present in the target area A.

[0045] Further, in addition to the masking as illustrated in FIG. 7, it is also possible to adopt such various mechanisms as to, for example, determine the inside and the outside of the target area A in the images (for example, by separately providing a depth image sensor, or introducing another determination algorithm in the image processing process). However, even if such a mechanism is adopted, it is not always the case that the inside and the outside of the target area A are determined correctly, and there are disadvantages in that an additional cost is

incurred for installation of sensors and the like, and the computing load on the image processing unit 10 is increased.

[0046] Alternatively, although not shown, it may also be considered to arrange the image pickup devices 5 at a higher position in the target area A to be directed downward, and take an image of the target area A from above, thereby covering the entire area in the target area A while excluding the outside of the loading/unloading port 4 from an angle of

view of the image pickup devices 5. However, a loading/unloading port of a mechanical parking lot generally has a low ceiling, and hence it is difficult to take an image of a sufficiently wider range with the image pickup devices 5 directed downward. Further, even if the image pickup device 5 can be installed at a higher position, it might be a problem that the maintenance of the image pickup devices 5 has to be performed in a higher place. Still further, when some structure (for example, mechanism for transporting the pallet 2) is located between the floor of the target area A and a height where the image pickup devices 5 is installed, an image of the entire area in the target area A may not be taken due to such a structure serving as a shielding object. Yet further, considering that a person in the target area A is detected as the foreign object F, there is a problem in that an image of a person taken from the above is poor in feature amounts of a person, and hence it is difficult to automatically detect the person.

[0047] In contrast, when three image pickup devices 5 are arranged as illustrated in FIG. 1, the entire area of the target area A can be included in the images without any blind spots. Further, the loading/unloading port 4 is not included in the angle of view of the image pickup device 5a located on the back side, and hence the loading/unloading port 4 is not captured in the taken image. The loading/unloading port 4 is not included in the angles of view of the image pickup devices 5b and 5c located on the front side, or is included

at the end of the angles of view, if any. Therefore, the loading/unloading port 4 is not captured in the images taken by the image pickup devices 5b and 5c, or is captured in the endmost portion of each of the images, if any. When the position where the loading/unloading port 4 is captured is the endmost portion, there is low possibility that a foreign object F located in the target area A is masked to cause under-detection, even in a case in which the area of the loading/unloading port 4 in the image is masked, for example. In this manner, with the arrangement as in the embodiment, possibilities of over-detection caused by the loading/unloading port 4 as the transmissive portion captured in the image and under-detection caused by the masking can be eliminated with a simple device configuration using a small number of image pickup devices 5, and the foreign object detection can be performed with high accuracy.

[0048] The foreign object detection system including three image pickup devices 5 has been exemplified herein. However, the three image pickup devices 5 is a minimum number required to ensure the detection accuracy, and is not to preclude addition of another image pickup device and other sensors for the purpose of further increasing the detection accuracy, for example.

[0049] Arrangements of image pickup devices described in Patent Literatures 1 to 6 listed above are also considered. In the systems described in FIG. 2 of Patent Literature 1, FIG. 8 of Patent Literature 2, FIG. 3 of Patent Literature 3,

and FIG. 2 of Patent Literature 6, four or five cameras are installed around a vehicle, and the number is more than that in this embodiment. Further, when the arrangements described in those figures are adopted, some of the cameras include a portion corresponding to the transmissive portion in this embodiment in angles of view thereof from the front, and hence it is highly possible that a foreign object on the outside may be erroneously detected.

[0050] FIG. 2 of Patent Literature 4 shows one

television camera at a position corresponding to a side of a vehicle. However, with such an arrangement, there is a blind spot that is not captured in an image, thereby causing under-detection. Further, FIG. 1 of Patent Literature 5 shows how a camera is arranged above a platform, but arranging an image pickup device above the target area has the problems as described above.

[0051] In this manner, in order to cover the inside of the target area A without any blind spot and perform the foreign object detection with minimum image pickup devices 5, it is optimal to arrange three image pickup devices 5 as illustrated in FIG. 1.

[0052] In this embodiment, a loading/unloading space of a mechanical parking lot has been assumed as the target area A, but a similar foreign object detection system is applicable to any kind of space in which some object is located as the shielding object. For example, a power feeding facility for an electric vehicle may be assumed, or a

similar foreign object detection system is also applicable, for example, to security in a warehouse storing some items.

[0053] As described above, the foreign object detection system of this embodiment described above includes, around

5 the shielding object (vehicle 1) located in the target area A: the first image pickup device 5a arranged on one of the left side or the right side behind the shielding object (vehicle 1) as viewed from the transmissive portion

(loading/unloading port 4) through which the outside of the

10 target area A is visible from the inside of the target area A, the first image pickup device 5a being configured to include the space on the other of the left side or the right

side in the angle of view thereof; the second image pickup device 5b arranged on the left side in front of the shielding

object (vehicle 1) as viewed from the transmissive portion

15 (loading/unloading port 4), the second image pickup device 5b being configured to include the space on the right back side in the angle of view thereof; and the third image pickup device 5c arranged on the right side in front of the

20 shielding object (vehicle 1) as viewed from the transmissive portion (loading/unloading port 4), the third image pickup device 5c being configured to include the space on the left back side in the angle of view thereof. With this

configuration, the entire area in the target area A can be

25 captured in the images without any blind spot. Further, the loading/unloading port 4 is not captured, or is captured in an endmost portion in each of the images taken by the image

pickup devices 5. Therefore, possibilities of over-detection caused by the transmissive portion (loading/unloading port 4) being captured in the image, and of under-detection caused by the masking can be eliminated with a simple device

5 configuration using a small number of image pickup devices 5, and the foreign object detection can be performed with high accuracy.

[0054] In the foreign object detection system described above, the first image pickup device 5a is arranged so that
10 the straight line L1 along the edge on the front side of the angle of view of the first image pickup device 5a as viewed from the transmissive portion (loading/unloading port 4) in plan view overlaps with the line segment L2 connecting the first image pickup device 5a and the end on the other of the
15 left side or the right side of the transmissive portion (loading/unloading port 4), or passes the other of the left side or the right side of the line segment L2. With this configuration, the loading/unloading port 4 is not captured in the image taken by the image pickup device 5a, and hence
20 the accuracy of the foreign object detection can be maintained further reliably.

[0055] The foreign object detection system described above is configured to detect a foreign object F in images taken by the respective image pickup devices 5, by the
25 program using deep learning. With this configuration, in the system for performing the foreign object detection by the deep learning, the foreign object detection can be suitably

executed.

[0056] In the foreign object detection system described above, the shielding object may be the vehicle 1, and with this configuration, the foreign object detection can be
5 suitably executed around the vehicle 1.

[0057] In the foreign object detection system described above, the target area A may be the loading/unloading space of the mechanical parking lot, and with this configuration, the foreign object detection can be executed suitably in the
10 loading/unloading space of the mechanical parking lot.

[0058] Therefore, according to the embodiments described above, a foreign object is detectable with high accuracy with a configuration that is as simple as possible.

[0059] The foreign object detection system according to
15 the present invention that have been described in the present disclosure are not limited only to the embodiments described above, and it is to be understood that various changes can be made thereto without departing from the scope of the present disclosure.

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Reference Signs List

[0060] 1: shielding object (vehicle), 2: pallet, 4: transmissive portion (loading/unloading port), 5: image pickup device, 5a: image pickup device (first image pickup
25 device), 5b: image pickup device (second image pickup device), 5c: image pickup device (third image pickup device), 5d: image pickup device, 5e: image pickup device, 6:

operation unit, 7: display unit, 8: alarm unit, 9:
controller, 10: image processing unit, A: target area, F:
object (foreign object), L: line segment, O: object

Claims

1. A foreign object detection system, comprising, around a shielding object located in a target area:

a first image pickup device arranged on one of a left side or a right side behind the shielding object as viewed from a transmissive portion through which an outside of the target area is visible from an inside of the target area, the first image pickup device being configured to include a space on the other of the left side or the right side in an angle of view thereof;

a second image pickup device arranged on the left side in front of the shielding object as viewed from the transmissive portion, the second image pickup device being configured to include a space on a right back side in an angle of view thereof; and

a third image pickup device arranged on the right side in front of the shielding object as viewed from the transmissive portion, the third image pickup device being configured to include a space on a left back side in an angle of view thereof,

wherein the first image pickup device is arranged so that a straight line along an edge on the front side of the angle of view of the first image pickup device as viewed from the transmissive portion in plan view overlaps with a line segment connecting the first image pickup device and an end on the other of the left side or the right side of the transmissive portion, or passes the other of the left side or the right side of the line segment.

2. The foreign object detection system according to claim 1, wherein the foreign object detection system is configured to detect a foreign object in images taken by the image pickup devices by a program using deep learning.

3. The foreign object detection system according to any one of claims 1 to 2, wherein the shielding object is a vehicle.

4. The foreign object detection system according to any one of claims 1 to 3, wherein the target area is a loading/unloading space of a mechanical parking lot.