captured by the second camera. The first camera and the second camera are arranged such that a first angle of a first virtual line relative to a horizontal plane is different from a second angle of a second virtual line relative to the horizontal plane, the first virtual line connecting between an optical center of the first camera and a predetermined position on a physical object whose image is to be captured by the first camera, the second virtual line connecting between an optical center of the second camera and the predetermined position. The image processor generates a first search area image from the first captured image and a second search area image from the second captured image. The first search area image includes a wider area in an up-down direction than the second search area image does. In a case where the image processor has detected the entrance from the first search area image and has not detected the entrance from the second search area image, the controller controls the height changing mechanism to change the height position of each of the first camera and the second camera.

**Advantageous Effects of Invention**

[0009] The present disclosure makes it possible to precisely detect, for various gate arrangements, the position of an entrance of an aircraft by using captured images captured by cameras provided on the distal end part of a passenger boarding bridge.

**Brief Description of Drawings**

[0010] FIG. 1 is a schematic plan view showing one example of a passenger boarding bridge to which a detection system according to an embodiment of the present invention is applied.

FIG. 2 shows a positional relationship between a first camera and a second camera in the present embodiment.

FIG. 3 is a block diagram showing a schematic configuration of the detection system that is applied to the passenger boarding bridge shown in FIG. 1.

FIG. 4 is a flowchart showing a flow of a search process in the present embodiment.

FIG. 5 is a flowchart showing a flow of the search process in the present embodiment.

FIG. 6 shows an example of a captured image in the present embodiment.

FIG. 7 is a conceptual diagram for setting a first area and a second area on the captured image shown in FIG. 6.

FIG. 8 shows a comparison, in the present embodiment, between an image in which projective transformation has been performed on the first area on a first captured image and the

direction of the aircraft axis AL. Accordingly, the search for the entrance D1 is repeatedly performed while changing the search area image Cai by using the plurality of search area images Cai, which are sequentially generated. Similarly, the search for the entrance D1 is repeatedly performed while changing the search area image Cbi by using the plurality of search area images Cbi, which are sequentially generated. In this manner, the search for the entrance D1 can be performed over the entirety of each of the captured images G1 and G2 while shifting the search area in a direction along the aircraft axis AL of the aircraft 3.

[0080] This makes it possible to perform the search for the entrance D1 in a uniform manner regardless of the type of the aircraft 3 or the gate arrangement. A conventional way of detection of the position of the entrance D1, which depends solely on three-dimensional positions, cannot achieve proper detection for a certain gate arrangement. However, even for such gate arrangement, the present embodiment makes it possible to perform proper detection of the entrance D1, with which the passenger boarding bridge 11 is to be docked. In addition, in the search for the entrance D1, onerous operations such as inputting information corresponding to the parked aircraft 3 can be made unnecessary. That is, merely by a button operation by an operator to start the search process, the search process can be performed for any of various types of aircrafts 3.

[0081] Further, according to the present embodiment, the search area images Cai and Cbi are each generated as an image parallel to the aircraft axis AL by projective transformation. Therefore, even in a case where each of the captured images G1 and G2 is an image captured from a diagonal direction relative to the aircraft 3, shape distortion of the entrance D1 to be searched for can be suppressed in each of the search area images Cai and Cbi. This makes it possible to improve the precision of the search for the entrance D1 in each of the search area images Cai and Cbi.

[0082] Further, according to the present embodiment, each time the search area image generator 31 demarcates the area Eai, which includes a part of the captured image G1, the search area image generator 31 performs projective transformation on the captured image G1 in the area Eai. Similarly, each time the search area image generator 31 demarcates the area Ebi, which includes a part of the captured image G2, the search area image generator 31 performs projective transformation on the captured image G2 in the area Ebi. Thus, for each area Eai, the projective transformation (as well as trimming) is performed on the captured image G1, and for each area Ebi, the projective transformation (as well as trimming) is performed on the captured image G2. In this manner, a reduction in image resolution can be suppressed compared to a case where the projective transformation is performed on the entire captured image G1, and then

direction of the axis of the aircraft to sequentially generate the second search area image; and repeatedly perform a search for the entrance while changing the first search area image by using a plurality of the first search area images that are sequentially generated, and repeatedly perform the search while changing the second search area image by using a plurality of the second search area images that are sequentially generated.

[0108] According to the above configuration, a plurality of first search area images are generated from the first captured image captured by the first camera, and each of the plurality of first search area images is demarcated to include its corresponding first area including a part of the first captured image. Similarly, a plurality of second search area images are generated from the second captured image captured by the second camera, and each of the plurality of second search area images is demarcated to include its corresponding second area including a part of the second captured image. Each of the plurality of first search area images is generated by shifting the first area from one side toward the other side of the aircraft in the direction of the axis of the aircraft, and each of the plurality of second search area images is generated by shifting the second area from the one side toward the other side of the aircraft in the direction of the axis of the aircraft. Accordingly, the search for the entrance is repeatedly performed while changing the search area image by using the plurality of search area images that are sequentially generated. In this manner, the search for the entrance can be performed over the entirely of each of the captured images while shifting the search area in a direction along the aircraft axis of the aircraft. This makes it possible to perform the search for the entrance in a uniform manner regardless of the type of the aircraft or the gate arrangement. This makes precise detection of the position of the entrance of the aircraft possible for various gate arrangements.

[0109] [Item 4]

In the detection system according to any one of items 1 to 3, the first camera may be disposed above the second camera.

[0110] [Item 5]

In the detection system according to any one of items 1 to 4, the passenger boarding bridge may include: a cab including a connector to be connected to the entrance of the aircraft; and a lifting/lowering device that lifts and lowers the cab. The first camera and the second camera may be provided on the cab, and the lifting/lowering device may serve as the height changing mechanism.

[0111] According to the above configuration, it is unnecessary to additionally install a mechanism to change the height position of each of the first camera and the second camera, and also, at the time of connecting the connector of the passenger boarding bridge to the entrance of

## CLAIMS

[Claim 1] A detection system for detecting an entrance of an aircraft, the detection system comprising:

a passenger boarding bridge connected to a terminal building;

a first camera and a second camera that are provided on the passenger boarding bridge;

a height changing mechanism configured to change a height position of each of the first camera and the second camera;

a controller that controls an operation of the height changing mechanism; and

an image processor that detects the entrance of the aircraft from a first captured image captured by the first camera and a second captured image captured by the second camera, wherein

the first camera and the second camera are arranged such that a first angle of a first virtual line relative to a horizontal plane is different from a second angle of a second virtual line relative to the horizontal plane, the first virtual line connecting between an optical center of the first camera and a predetermined position on a physical object whose image is to be captured by the first camera, the second virtual line connecting between an optical center of the second camera and the predetermined position, and

the image processor generates a first search area image from the first captured image and a second search area image from the second captured image,

the first search area image includes a wider area in an up-down direction than the second search area image does, and

in a case where the image processor has detected the entrance from the first search area image and has not detected the entrance from the second search area image, the controller controls the height changing mechanism to change the height position of each of the first camera and the second camera.

[Claim 2] The detection system according to claim 1, wherein

the image processor demarcates a first area including a part of the first captured image to generate the first search area image including a partial area of the first captured image, the partial area being demarcated based on the first area, and demarcates a second area including a part of the second captured image to generate the second search area image including a partial area of the second captured image, the partial area being demarcated based on the second area,

the first area and the second area are set to a same area in an actual space, and

the partial area of the first captured image includes a wider area in the up-down direction than the partial area of the second captured image does.

[Claim 3] The detection system according to claim 2, wherein

the image processor:

in a case where the entrance has not been detected from the first search area image, shifts the first area on the first captured image from one side toward the other side of the aircraft in a direction of an axis of the aircraft to sequentially generate the first search area image, and shifts the second area on the second captured image from the one side toward the other side of the aircraft in the direction of the axis of the aircraft to sequentially generate the second search area image; and

repeatedly performs a search for the entrance while changing the first search area image by using a plurality of the first search area images that are sequentially generated, and repeatedly performs the search while changing the second search area image by using a plurality of the second search area images that are sequentially generated.

[Claim 4] The detection system according to any one of claims 1 to 3, wherein

the first camera is disposed above the second camera.

[Claim 5] The detection system according to any one of claims 1 to 3, wherein

the passenger boarding bridge includes:

a cab including a connector to be connected to the entrance of the aircraft; and

a lifting/lowering device that lifts and lowers the cab,

the first camera and the second camera are provided on the cab, and

the lifting/lowering device serves as the height changing mechanism.

[Claim 6] The detection system according to claim 3, comprising:

an image-capturing direction changing mechanism that changes an image-capturing direction of each of the first camera and the second camera by rotating about a predetermined rotational axis that extends in a direction crossing the horizontal plane, wherein

the image processor determines whether or not the first area that has been shifted is within a predefined search range and within the first captured image, and

in a case where it is determined that the first area that has been shifted is within the search range, but is not within the first captured image, the controller causes the image-capturing

direction changing mechanism to change the image-capturing direction of each of the first camera and the second camera, and causes each of the first camera and the second camera to perform image capturing again.