with respect to the entrance of the aircraft are calculated. Based on these, a control correction amount is calculated, and based on the calculated control correction amount, various drive units are driven to move the head part toward the target point on the aircraft.

Citation List

Patent Literature

[0005] PTL 1: Japanese Patent No. 6720414

PTL 2: Japanese Laid-Open Patent Application Publication No. 2020-175727

Summary of Invention

Technical Problem

[0006] In order to automatically move such a passenger boarding bridge, it is necessary to precisely detect the position of the entrance of the aircraft from a captured image captured by a camera provided on the distal end part of the passenger boarding bridge. In particular, the position of the entrance of the aircraft may significantly vary depending on, for example, the type and size of the aircraft that is parked. Moreover, the gate arrangement at the airport also varies from airport to airport, and it is troublesome to preset an entrance position detection mode for each combination of the parked aircraft and the gate arrangement. Thus, the above Patent Literatures 1 and 2 have a room for improvement in terms of precisely detecting the position of the entrance of each of a plurality of types of aircrafts for various gate arrangements.

[0007] Embodiments of the present disclosure are made to solve the above-described problems. Embodiments of the present disclosure provide a detection system that is capable of precisely detecting, for various gate arrangements, the position of an entrance of an aircraft by using a captured image captured by a camera provided on the distal end part of a passenger boarding bridge.

Solution to Problem

[0008] According to an aspect of the present disclosure, there is provided a detection system for detecting an entrance of an aircraft, the detection system including: a passenger boarding bridge connected to a terminal building; a camera provided on the passenger boarding bridge; and an image processor that detects the entrance of the aircraft from a captured image captured by the camera. The image processor includes: a search area image generator that generates a search area image by demarcating a predetermined area that includes a part of the captured image; and a search performer that performs a search to determine whether or not the entrance is present within the search area image. The search area image generator shifts the predetermined

area on the captured image from one side toward the other side of the aircraft in a direction of an aircraft axis of the aircraft to sequentially generate the search area image. The search performer repeatedly performs the search while changing the search area image by using a plurality of the search area images that are sequentially generated.

[0009] According to the above aspect, a plurality of search area images are generated from the captured image captured by the camera provided on the passenger boarding bridge. On each of the plurality of search area images, the predetermined area, which includes a part of the captured image, is demarcated. Each of the plurality of search area images is generated by shifting the predetermined area from one side toward the other side of the aircraft in the direction of the aircraft axis. Accordingly, the search for the entrance is repeatedly performed while changing the search area image by using the plurality of search area images, which are sequentially generated. In this manner, the search for the entrance can be performed over the entire captured image 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.

[0010] In an embodiment of the above aspect, the search area image generator may perform projective transformation on a virtual plane in the captured image, the virtual plane being perpendicular to a horizontal plane and parallel to the aircraft axis, to transform the virtual plane into an image that is seen from a direction perpendicular to the virtual plane.

[0011] According to the above embodiment, the search area image is generated as an image parallel to the aircraft axis. Therefore, even in a case where the captured image is an image captured from a diagonal direction relative to the aircraft, shape distortion of the entrance to be searched for can be suppressed in the search area image. This makes it possible to improve the precision of the search for the entrance in the search area image.

[0012] In an embodiment of the above aspect, each time the search area image generator demarcates the predetermined area, which includes a part of the captured image, the search area image generator may perform the projective transformation on the captured image in the predetermined area.

[0013] According to the above embodiment, for each predetermined area, the projective transformation is performed on the captured image. 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; and then from the resulting projective-transformed image, the predetermined area is demarcated.

[0014] In an embodiment of the above aspect, the detection system may include: an image-

capturing direction changing mechanism that changes an image-capturing direction of the camera by rotating about a predetermined rotational axis that extends in a direction crossing the horizontal plane; and a controller that controls an operation of the image-capturing direction changing mechanism. The image processor may include a search range determiner that determines whether or not the predetermined area that has been shifted is within a predefined search range and within the captured image. In a case where it is determined that the predetermined area that has been shifted is within the search range, but is not within the captured image, the controller may cause the image-capturing direction changing mechanism to change the image-capturing direction of the camera, and cause the camera to capture an image again.

[0015] According to the above embodiment, by performing the image capturing multiple times while changing the image-capturing direction of the camera, a captured image of the entire search range can be obtained as a plurality of captured images. Accordingly, an image-capturing range for each time of image capturing can be made relatively narrow, which makes it possible to increase the resolution of the search area image obtained from the captured image, or makes it possible to set the search range to be wider than the field of view of the camera.

[0016] In an embodiment of the above aspect, the passenger boarding bridge may include a first boarding bridge and a second boarding bridge. The camera may include a first camera provided on the first boarding bridge and a second camera provided on the second boarding bridge. The search area image generator may shift the predetermined area on the captured image captured by the first camera from a front side toward a back side of the aircraft in the direction of the aircraft axis to sequentially generate the search area image, and may shift the predetermined area on the captured image captured by the second camera from the back side toward the front side of the aircraft in the direction of the aircraft axis to sequentially generate the search area image.

[0017] According to the above embodiment, based on the captured image captured by the first camera provided on the first boarding bridge, the entrance of the aircraft to which the first boarding bridge is to be connected is searched for, and based on the captured image captured by the second camera provided on the second boarding bridge, the entrance of the aircraft to which the second boarding bridge is to be connected is searched for. At the time, in the search for the entrance with use of the captured image captured by the first camera, the search is performed from the front side toward the back side of the aircraft in the direction of the aircraft axis, whereas in the search for the entrance with use of the captured image captured by the second camera, the search is performed from the back side toward the front side of the aircraft in the direction of the aircraft axis. In this manner, based on the captured image captured by the first camera, the entrance that is positioned on the front side of the aircraft can be detected

preferentially, and based on the captured image captured by the second camera, the entrance that is positioned on the back side of the aircraft can be detected preferentially. Therefore, the entrance to which the first boarding bridge is to be connected, and the entrance to which the second boarding bridge is to be connected, can be precisely searched out within a short period of time.

[0018] In an embodiment of the above aspect, the search performed by the search performer may include a first search and a second search, and the search performer may perform the first search and the second search in parallel, the first search using the search area image that is generated from the captured image captured by the first camera, the second search using the search area image that is generated from the captured image captured by the second camera. According to the above embodiment, the search for the entrance to which the first boarding bridge is to be connected, and the search for the entrance to which the second boarding bridge is to be connected, are concurrently performed in parallel, which makes it possible to shorten the search period.

[0019] In an embodiment of the above aspect, in a case where a distance between a first position and a second position, the first position being a position at which the entrance is detected by the first search using the search area image generated from the captured image captured by the first camera, the second position being a position at which the entrance is detected by the second search using the search area image generated from the captured image captured by the second camera, is less than a predetermined reference value, if both the first position and the second position are included in at least one of a first search range set for the first camera or a second search range set for the second camera, the search performer may determine that the entrance has been detected at the first position or the second position.

[0020] According to the above embodiment, in a case where the distance between the position of the entrance detected by the first search (the first position) and the position of the entrance detected by the second search (the second position) is short, if both the first position and the second position are included in at least one of the first search range or the second search range, then it is determined that one entrance has been detected by the two searches. Thus, even in a case where the first position and the second position are close to each other, only in a case where the detection of one entrance by two searches is assumed to be reliable, a determination that one entrance has been detected is made, which makes it possible to suppress the occurrence of erroneous detection.

Advantageous Effects of Invention

[0021] Embodiments of the present disclosure make it possible to precisely detect, for

various gate arrangements, the position of an entrance of an aircraft by using a captured image captured by a camera provided on the distal end part of a passenger boarding bridge.

Brief Description of Drawings

[0022] 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 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. 3 is a flowchart showing a flow of a search process in the present embodiment.

FIG. 4 shows an example of a captured image in the present embodiment.

FIG. 5 is a conceptual diagram for setting a predetermined area on the captured image shown in FIG. 4.

FIG. 6 shows a comparison, in the present embodiment, between an image in which projective transformation has been performed on the predetermined area and the image in which the projective transformation has not yet been performed on the predetermined area.

FIG. 7 is a flowchart showing a flow of one example of an automatic docking control process in the present embodiment.

FIG. 8 is a flowchart showing a flow of a same door detection determination process of FIG. 7.

FIG. 9 is a conceptual diagram illustrating division into cases in the same door detection determination process.

Description of Embodiments

[0023] Hereinafter, a preferred embodiment of the present disclosure is described with reference to the drawings. In the drawings, the same or corresponding elements are denoted by the same reference signs, and repeating the same descriptions is avoided below. The drawings show each component schematically in order to facilitate the understanding thereof. Therefore, in some cases, the drawings may not display accurate shapes, accurate dimensional ratios, etc. The present disclosure is not limited to the embodiment described below.

[0024] FIG. 1 is a schematic plan view showing one example of a passenger boarding bridge to which a detection system according to the present embodiment is applied. In the example of FIG. 1, a passenger boarding bridge 1 includes a first boarding bridge 11 and a