

DESCRIPTION

PICKING DEVICE, AND PICKING CONTROL PROGRAM

Technical Field

[0001]

The present invention relates to a picking device and a picking control program capable of accurately specifying a position of a picking target object.

Background Art

[0002]

In the related art, in a shipment stage from a factory, a distribution base, or the like, work such as sorting, reshipment, and unloading of goods has been automated by a robot.

[0003]

For example, Patent Literature 1 has already been proposed as a technique for automatically confirming and measuring a box-shaped picking target object to be grasped. Patent Literature 1 discloses a configuration in which a box-shaped picking target object to be grasped is accurately grasped by using two pieces of information of a two-dimensional image captured by a two-dimensional camera and three-dimensional point group information acquired by a three-dimensional camera or the like in combination.

Citation List

Patent Literature

[0004]

Patent Literature 1: JP 2019-136828 A

Summary of Invention

Technical Problem

[0005]

In Patent Literature 1, it is possible to improve the detection accuracy of the position of the picking target object by using two pieces of information of the two-dimensional image captured by the two-dimensional camera and the three-dimensional point group information acquired by the three-dimensional camera or the like in combination, but when areas with blown-out highlights or blocked-up shadows exist in the two-dimensional image, there remains a possibility that the position of the picking target object is erroneously detected. When the position detection is mistaken, a deviation occurs between the predicted position and the actual position of the picking target object recognized by the picking device, and thus there is a possibility that a controller of the picking device intends to precisely place the picking target object, but actually places the picking target object at a position deviated from the intended position. For example, in a transfer

operation in which it is necessary to precisely load the picking target object on another mounting table or the like without a gap, when a deviation occurs in position detection even by little, the stability of the stacked loads is impaired, and in the worst case, there is a risk that the loads will collapse.

[0006]

The present invention has been made in view of the above problems, and an object of the present invention is to provide a picking device and a picking control program capable of accurately specifying a position of a picking target object.

Solution to Problem

[0007]

A picking device according to the present invention includes: a picking robot including a hand portion that picks a picking target object; a two-dimensional camera for two-dimensionally capturing the picking target object; a three-dimensional camera for acquiring three-dimensional point group information indicating distance information to the picking target object; and a control unit that controls a picking operation of the picking robot, wherein the control unit includes a two-dimensional captured image acquisition function of controlling the two-dimensional

camera to acquire at least one or more pieces of two-dimensional captured image data obtained by capturing all of a plurality of picking target objects loaded, a three-dimensional point group information acquisition function of controlling the three-dimensional camera to acquire three-dimensional point group information related to all of the plurality of picking target objects loaded, a calibration function of commonizing coordinate information between the two-dimensional captured image data and the three-dimensional point group information based on the picking target object as a target, a top surface candidate region extraction function of extracting top surface candidate regions of the plurality of the picking target objects from the three-dimensional point group information, a first four-corner coordinate information acquisition function of acquiring first four-corner coordinate information of each picking target object in the two-dimensional captured image data by inputting the two-dimensional captured image data to a learned model that learned in advance to specify the picking target object from input image data and output coordinate information of four corners of each picking target object, a picking control function of controlling a picking operation and a transfer operation of the picking target object by the picking robot based on the first four-corner coordinate information and the three-dimensional

point group information, a three-dimensional point group information reacquisition function of controlling the three-dimensional camera to reacquire three-dimensional point group information for another picking target object left after the picking target object is picked by the picking robot, a second four-corner coordinate information acquisition function of acquiring, as second four-corner coordinate information, coordinate information of four corners related to the picking target object at a point of time before picking based on a difference between three-dimensional point group information acquired before picking and three-dimensional point group information reacquired after picking, and a controlled variable correction function of correcting a controlled variable of the transfer operation based on a deviation amount between the first four-corner coordinate information and the second four-corner coordinate information.

[0008]

Furthermore, in the picking device according to the present invention, the second four-corner coordinate information acquisition function further acquires second four-corner coordinate information by executing processing of extracting coordinate information of four corners with respect to the region of the picking target object indicated by a difference between the three-dimensional

point group information acquired before picking and the three-dimensional point group information reacquired after picking.

[0009]

Furthermore, in the picking device according to the present invention, the controlled variable correction function further detects information on a deviation amount in XY coordinates of the first four-corner coordinate information with respect to the second four-corner coordinate information that is correct coordinate information and a deviation amount of a rotation angle between the first four-corner coordinate information and the second four-corner coordinate information, and corrects the controlled variable.

[0010]

A picking control program according to the present invention is a picking control program for causing a computer to execute processing of controlling a picking robot including a hand portion that picks a picking target object, the computer executing: a two-dimensional captured image acquisition function of controlling a two-dimensional camera for two-dimensionally capturing the picking target object to acquire at least one or more pieces of two-dimensional captured image data obtained by capturing all of a plurality of picking target objects loaded; a three-

dimensional point group information acquisition function of controlling the three-dimensional camera for acquiring three-dimensional point group information indicating distance information to the picking target object to acquire three-dimensional point group information related to all of the plurality of picking target objects loaded; a calibration function of commonizing coordinate information between the two-dimensional captured image data and the three-dimensional point group information based on the picking target object as a target; a top surface candidate region extraction function of extracting top surface candidate regions of the plurality of the picking target objects from the three-dimensional point group information; a first four-corner coordinate information acquisition function of acquiring first four-corner coordinate information of each picking target object in the two-dimensional captured image data by inputting the two-dimensional captured image data to a learned model that learned in advance to specify the picking target object from input image data and output coordinate information of four corners of each picking target object; a picking control function of controlling a picking operation and a transfer operation of the picking target object by the picking robot based on the first four-corner coordinate information and the three-dimensional point group

information; a three-dimensional point group information reacquisition function of controlling the three-dimensional camera to reacquire three-dimensional point group information for another picking target object left after the picking target object is picked by the picking robot; a second four-corner coordinate information acquisition function of acquiring, as second four-corner coordinate information, coordinate information of four corners related to the picking target object at a point of time before picking based on a difference between three-dimensional point group information acquired before picking and three-dimensional point group information reacquired after picking; and a controlled variable correction function of correcting a controlled variable of the transfer operation based on a deviation amount between the first four-corner coordinate information and the second four-corner coordinate information.

Advantageous Effects of Invention

[0011]

According to the present invention, even when a deviation occurs during acquisition of initial first four-corner coordinate information on the picking target object, the second four-corner coordinate information on the picking target object at the time point before picking is

acquired based on the difference between the three-dimensional point group information before and after picking, and the controlled variable of the transfer operation is corrected based on the deviation amount between the first four-corner coordinate information and the second four-corner coordinate information, and thus it is possible to accurately specify the posture of the picking target object during picking and reflect the posture in the control.

Brief Description of Drawings

[0012]

Fig. 1 is an explanatory diagram for describing an overall configuration of a picking device corresponding to at least one of embodiments of the present invention.

Fig. 2 is a block diagram illustrating an example of a configuration of the picking device corresponding to at least one of the embodiments of the present invention.

Fig. 3 is a flowchart illustrating an example of a flow of a picking process of a pickup target object corresponding to at least one of the embodiments of the present invention.

Fig. 4 is an image diagram illustrating an example of two-dimensional captured image data acquired in the picking device corresponding to at least one of the embodiments of

the present invention.

Fig. 5 is an image diagram illustrating an example of three-dimensional point group information acquired in the picking device corresponding to at least one of the embodiments of the present invention.

Fig. 6 is an image diagram illustrating an example of a state of setting first four-corner coordinate information in the picking device corresponding to at least one of the embodiments of the present invention.

Fig. 7 is an explanatory diagram for explaining an example of correcting a controlled variable of a transfer operation based on a difference in three-dimensional point group information before and after picking in the picking device corresponding to at least one of the embodiments of the present invention.

Description of Embodiments

[0013]

[First Embodiment]

Hereinafter, an example of a picking device according to a first embodiment of the present invention will be described with reference to the drawings.

[0014]

Fig. 1 is an explanatory diagram for describing an overall configuration of a picking device corresponding to

at least one of embodiments of the present invention. As illustrated in Fig. 1, a picking device 100 includes at least a picking robot 10, a two-dimensional camera 20, a three-dimensional camera 30, and a control unit 40. The picking device 100 of the present example specifies an accurate position of a top surface of a pickup target object in the control unit 40 based on two-dimensional captured image data captured by the two-dimensional camera 20 and three-dimensional point group information acquired by the three-dimensional camera 30, and controls the picking robot 10 based on the specified information to automatically execute suction work (picking operation) of the picking target object, reshipping work (transfer operation) of the picking target object, and the like.

[0015]

Fig. 2 is a block diagram illustrating an example of a configuration of the picking device corresponding to at least one of the embodiments of the present invention. As illustrated in Fig. 2, the picking device 100 includes at least the picking robot 10, the two-dimensional camera 20, the three-dimensional camera 30, and the control unit 40.

[0016]

The picking robot 10 is a robot including a hand portion that picks the picking target object. In the present example, the picking robot 10 including a suction

hand that suctions and lifts a central portion of the picking target object will be described, but the present invention is not limited thereto, and for example, the picking robot may include a hand that grasps the picking target object by sandwiching a side surface of the picking target object. The operation of the picking robot 10 is controlled by the control unit 40 described later.

[0017]

The two-dimensional camera 20 is configured to two-dimensionally capture the picking target object. An installation position and a capturing angle can be set in various ways as long as the picking target object can be captured, but in the configuration in which the top surface of the picking target object is suctioned and grasped as in the present example, it is preferable to install the two-dimensional camera 20 so that the top surface of the picking target object is captured from above.

Specifically, it is conceivable to install the two-dimensional camera 20 in the vicinity of the hand portion at a tip end of the picking robot 10. The vicinity of the hand portion refers to a position that can be moved integrally with the hand portion and a position that does not affect the picking work even when moving in conjunction with the hand portion. Further, the two-dimensional camera 20 is not limited to the case of being installed integrally

with the hand portion, and may be installed in a turret by assembling the turret not to interfere with an operation range of the picking robot 10 near the picking target object separately from the picking robot 10. The execution of capturing of the two-dimensional camera 20 is controlled by the control unit 40 to be described later.

[0018]

The three-dimensional camera 30 is configured to acquire three-dimensional point group information indicating distance information to the picking target object. Any means may be used as long as the three-dimensional point group information can be acquired, and for example, a time-of-flight camera (TOF camera) or the like can be considered. In addition, the distance information may be extracted using a stereo camera, or the three-dimensional point group information may be acquired using light detection and ranging, laser imaging detection and ranging (LiDAR). The execution of capturing of the three-dimensional camera 30 is controlled by the control unit 40 to be described later. Regarding the three-dimensional camera 30, an installation position and a capturing angle can be set in various ways as long as the picking target object can be captured, but in the configuration in which the top surface of the picking target object is suctioned and grasped as in the present

example, it is preferable to install the three-dimensional camera 30 so that the top surface of the picking target object is captured from above. Specifically, it is conceivable to install the three-dimensional camera 30 in the vicinity of the hand portion at a tip end of the picking robot 10. The vicinity of the hand portion refers to a position that can be moved integrally with the hand portion and a position that does not affect the picking work even when moving in conjunction with the hand portion. Further, the three-dimensional camera 30 is not limited to the case of being installed integrally with the hand portion, and may be installed in a turret by assembling the turret not to interfere with the operation range of the picking robot 10 near the picking target object separately from the picking robot 10. Note that, in the example of Fig. 1, the two-dimensional camera 20 and the three-dimensional camera 30 are installed adjacent to each other to have substantially the same capturing angle.

[0019]

The control unit 40 is configured to control capturing by the two-dimensional camera 20, capturing by the three-dimensional camera 30, and the picking operation of the picking robot. The control unit 40 may be configured by any means as long as control described later can be executed, and is realized by, for example, a computer, a

microcomputer, a programmable logic controller (PLC), or a combination thereof. Here, the computer includes a central processing unit (CPU), a memory, and a storage such as a hard disk drive and an SSD, that are normally included in a general computer, and may include an input device such as a mouse and a keyboard, an output device such as a display and a printer, and a communication device for connecting to a communication network, and the units may be connected via a bus. Processing in each unit of an information processing apparatus 10 is realized by reading a program for executing processing in each unit from a memory and executing the program in a CPU, a GPU, or a field programmable gate array (FPGA) that functions as a control circuit (processing circuit, processing circuitry). In other words, the processor (processing circuit) is configured to be able to execute each processing of each device by executing the program. In addition, processing up to acquisition of center coordinate information of the picking target object may be executed by a computer, and operation control of the picking robot 10 using the center coordinate information may be realized using a PLC. In addition, it goes without saying that various data used for the control unit 40 and various data obtained as a result of processing by the control unit 40 are appropriately stored in a storage unit (not illustrated).

[0020]

As illustrated in Fig. 2, the control unit 40 includes a two-dimensional captured image acquisition function 41, a three-dimensional point group information acquisition function 42, a calibration function 43, a top surface candidate region extraction function 44, a first four-corner coordinate information acquisition function 45, a picking control function 46, a three-dimensional point group information reacquisition function 47, a second four-corner coordinate information acquisition function 48, and a controlled variable correction function 49.

[0021]

The two-dimensional captured image acquisition function 41 has a function of controlling the two-dimensional camera 20 to acquire at least one or more pieces of two-dimensional captured image data obtained by capturing the entire plurality of loaded picking target objects. Note that, when performing capturing a plurality of times, the two-dimensional captured image acquisition function 41 can acquire a plurality of pieces of two-dimensional captured image data having different exposure times by changing an exposure time at the time of capturing and select image data without blown-out highlights or blocked-up shadows from the acquired plurality of pieces of two-dimensional captured image data, or may generate image data without

blown-out highlights or blocked-up shadows by performing HDR processing or the like on the plurality of pieces of two-dimensional captured image data. Here, the high-dynamic-range (HDR) processing refers to processing of selecting a portion with optimum brightness (without blown-out highlights or blocked-up shadows) from a plurality of pieces of two-dimensional captured image data captured with various exposure times and synthesizing the selected portions into one image. Although the HDR processing is a known technique and thus will not be described in detail, it is possible to generate synthesized image data without blown-out highlights or blocked-up shadows by performing the HDR processing, and thus, synthesized image data obtained by such HDR processing may be used in the first four-corner coordinate information acquisition function 45 to be described later.

[0022]

The three-dimensional point group information acquisition function 42 has a function of controlling the three-dimensional camera 30 to acquire three-dimensional point group information related to the entire plurality of loaded picking target objects. Here, the three-dimensional point group information is information obtained by calculating a distance to an object existing in a capture range for each measurement point, and it is possible to

specify a surface and a shape of the object by analyzing the information of the point group.

[0023]

The calibration function 43 has a function of commonizing coordinate information based on a target picking target object between two-dimensional captured image data and three-dimensional point group information. It is possible to mutually convert coordinate information between the two-dimensional captured image data and the three-dimensional point group information by executing commonization of the coordinate information, so-called calibration, based on the pickup target object commonly appearing between the two-dimensional captured image data and the three-dimensional point group information. As a result, it is also possible to perform processing of redrawing the three-dimensional point group information at the same angle of view as the two-dimensional captured image data. By the processing of commonizing the coordinate information in the calibration function 43, it is possible to acquire XY coordinates of each point on the top surface of the pickup target object appearing in the two-dimensional captured image data and a Z coordinate (distance information in the vertical direction) that is the distance from the capturing point by the two-dimensional camera 20 to the top surface of the pickup

target object.

[0024]

The top surface candidate region extraction function 44 has a function of extracting top surface candidate regions of a plurality of picking target objects from the three-dimensional point group information. By the processing of commonizing the coordinate information in the calibration function 43, the distance information to each point of the pickup target object becomes clear. Here, when a search range is gradually expanded in a Z coordinate direction from the capturing point, it is possible to detect a portion where a plurality of point groups exist planarly near a certain Z coordinate. As in the present example, when a picking target object is captured from above and picking is performed by the picking robot 10 from above, it is preferable to extract, as the top surface candidate region, a planar portion closest in distance in the Z direction to the capturing position of the three-dimensional camera 30. Note that, when detecting a portion where the point group exists in a planar manner, a search may be performed for a portion having a margin in a distance in the Z direction. It is possible to appropriately set, according to the work environment, a distance range in the Z direction in which the point group is assumed to be in the same plane.

[0025]

The first four-corner coordinate information acquisition function 45 has a function of acquiring first four-corner coordinate information of each picking target object in two-dimensional captured image data by inputting the two-dimensional captured image data to a learned model that learned in advance to specify the picking target object from input image data and output coordinate information of four corners of each picking target object. Here, the learned model refers to a model that learned to output coordinate information of four corners when image data showing a picking target object is input by performing machine learning using a plurality of teacher data sets in which image data showing the picking target object and correct answer data of coordinate information of the four corners of the picking target object in the image data are set. The learned model may be any model, and for example, a learned model including a neural network is conceivable. As the teacher data set used for learning, various images can be adopted. Furthermore, the present invention is not limited to the learned model that outputs only the four-corner coordinate information, and a learned model that learned to output both the four-corner coordinate information of the top surface of the picking target object and the center coordinate information may be adopted. That

is, it is preferable for the learned model to learn so that information necessary for controlling the control target picking robot 10 to execute the picking work can be acquired. As such, the four-corner coordinate information output from the learned model is acquired as the first four-corner coordinate information.

[0026]

Note that the method for setting the first four-corner coordinate information in the first four-corner coordinate information acquisition function 45 is not necessarily a method based on the learned model, and the first four-corner coordinate information may be extracted by a rule-based system adopting some algorithm for extracting the coordinate information of the four corners.

[0027]

The picking control function 46 has a function of controlling a picking operation and a transfer operation of the picking target object by the picking robot based on the first four-corner coordinate information and the three-dimensional point group information. The first four-corner coordinate information and the height information (Z coordinate information) are acquired as information necessary for the picking operation and the transfer operation of the picking target object. Here, when a plurality of pickup target objects have a top surface at

the same height, it is possible to appropriately set which picking target object is selected for execution of the picking operation and the transfer operation. As an example, it is conceivable to set a rule to select the pickup target object closest to the hand portion. The control after the pickup target object is grasped by the hand portion can be appropriately executed based on a known technique.

[0028]

The three-dimensional point group information reacquisition function 47 has a function of controlling the three-dimensional camera to reacquire three-dimensional point group information for another picking target object left after the picking target object is picked by the picking robot. When the capturing direction and the capture range of the three-dimensional camera are fixedly set, since the same capture range as the three-dimensional point group information acquired by the three-dimensional point group information acquisition function 42 is captured, calibration may be omitted. When the capturing direction and the capture range of the three-dimensional camera change, it is necessary to execute calibration by the calibration function 43 for the two-dimensional captured image data and the three-dimensional point group information acquired by the three-dimensional point group

information reacquisition function 47. Also, for the three-dimensional point group information acquired by the three-dimensional point group information reacquisition function 47, the top surface candidate regions of the plurality of picking target objects are extracted from the three-dimensional point group information based on the top surface candidate region extraction function 44.

[0029]

The second four-corner coordinate information acquisition function 48 has a function of acquiring, as the second four-corner coordinate information, the coordinate information of the four corners related to the picking target object at the time point before picking based on a difference between the three-dimensional point group information acquired before picking and the three-dimensional point group information reacquired after picking. Specifically, the second four-corner coordinate information is acquired by executing processing of extracting coordinate information of four corners with respect to the region of the picking target object indicated by a difference between the three-dimensional point group information acquired before picking and the three-dimensional point group information reacquired after picking. Here, the method for obtaining the difference may be a method for obtaining a difference after converting

each piece of three-dimensional point group information before and after picking into two-dimensional information representing a plane including the top surface candidate region extracted based on the top surface candidate region extraction function 44. By calculating the difference, only the top surface candidate region of the picked picking target object is extracted. The second four-corner coordinate information is extracted and acquired by executing image processing or some rule-based processing on the top surface candidate region of the picked picking target object.

[0030]

The controlled variable correction function 49 has a function of correcting a controlled variable of the transfer operation based on a deviation amount between the first four-corner coordinate information and the second four-corner coordinate information. Specifically, the controlled variable is corrected by detecting information on the deviation amount in the XY coordinates of the first four-corner coordinate information with respect to the second four-corner coordinate information that is correct coordinate information (that is extremely likely to be correct coordinate information) and the deviation amount of the rotation angle between the first four-corner coordinate information and the second four-corner coordinate

information. That is, although the pickup is executed assuming that the acquired first four-corner coordinate information is accurate as the coordinate information of the four corners of the pickup target object, since the second four-corner coordinate information is information with higher accuracy, the transfer operation can be executed with higher accuracy by correcting the controlled variable of the pickup robot 10 based on the second four-corner coordinate information.

[0031]

Fig. 3 is a flowchart illustrating an example of a flow of a picking process of the pickup target object corresponding to at least one of the embodiments of the present invention. As illustrated in Fig. 3, the picking process is started by acquiring one or more pieces of two-dimensional captured image data obtained by capturing the picking target object in the control unit 40 of the picking device 100 (step S101). Next, the control unit 40 acquires three-dimensional point group information obtained by capturing the picking target object (step S102). Next, the control unit 40 executes calibration to commonize coordinate information between the two-dimensional captured image data and the three-dimensional point group information (step S103). Next, the control unit 40 extracts top surface candidate regions from the three-

dimensional point group information (step S104). Next, the control unit 40 inputs the two-dimensional captured image data to an AI to acquire the first four-corner coordinate information on the picking target object (step S105). Next, the control unit 40 controls the picking operation and the transfer operation of the picking target object by the picking robot (step S106). Next, the control unit 40 reacquires the three-dimensional point group information after picking (step S107). Next, the control unit 40 acquires the second four-corner coordinate information based on a difference between the three-dimensional point group information before and after picking (step S108). Then, the control unit 40 corrects the controlled variable based on the deviation amount between the first four-corner coordinate information and the second four-corner coordinate information, executes control of the picking operation and the transfer operation of the picking target object by the picking robot based on the corrected controlled variable (step S108), and ends the picking process.

[0032]

Next, the operation of the picking device 100 according to the present example will be described using a specific image as an example.

[0033]

Fig. 4 is an image diagram illustrating an example of the two-dimensional captured image data acquired in the picking device corresponding to at least one of the embodiments of the present invention. The image diagram illustrated in Fig. 4 represents two-dimensional captured image data obtained by the two-dimensional camera 20 by capturing a state in which three box-shaped pickup target objects are placed at the lower stage and two box-shaped pickup target objects are placed thereon.

[0034]

Fig. 5 is an image diagram illustrating an example of the three-dimensional point group information acquired in the picking device corresponding to at least one of the embodiments of the present invention. The image diagram illustrated in Fig. 5 represents three-dimensional point group information obtained by capturing the same pickup target object as in Fig. 4 by the three-dimensional camera 30, in which one image represents three-dimensional point group information captured from an oblique direction, one image represents three-dimensional point group information illustrated at an angle of view of the two-dimensional camera, and the last one image represents an extracted top surface candidate region.

[0035]

Fig. 6 is an image diagram illustrating an example of a

state of setting the first four-corner coordinate information in the picking device corresponding to at least one of the embodiments of the present invention. The two-dimensional image data illustrated in Fig. 6 illustrates four picking target objects, and the first four-corner coordinate information is set for each picking target object. Here, as indicated by an arrow portion in Fig. 6, in the setting of the first four-corner coordinate information by the learned model or the rule-based system, there is a possibility that an error occurs in recognition of the positions of the four corners.

[0036]

Fig. 7 is an explanatory diagram for explaining an example of correcting the controlled variable of the transfer operation based on the difference in the three-dimensional point group information before and after picking in the picking device corresponding to at least one of the embodiments of the present invention. As illustrated in Fig. 7, by calculating the difference between the three-dimensional point group information before and after picking (in the example of Fig. 7, the point group information is extracted only for the two-dimensional plane including the top surface candidate region), it is possible to extract only the region of the picked picking target object. Since the area indicated by

the difference accurately represents the position of the picking target object before picking, the second four-corner coordinate information is acquired by executing the processing of extracting the four-corner coordinate information with respect to the area indicated by the difference. When the second four-corner coordinate information can be acquired, the controlled variable can be corrected from the deviation amount with respect to the first four-corner coordinate information.

[0037]

As described above, the picking device 100 according to the present invention includes a picking robot including a hand portion that picks a picking target object; a two-dimensional camera that two-dimensionally captures the picking target object; a three-dimensional camera for acquiring three-dimensional point group information indicating distance information to the picking target object; and a control unit that controls a picking operation of the picking robot, in which the control unit includes a two-dimensional captured image acquisition function of controlling the two-dimensional camera to acquire at least one or more pieces of two-dimensional captured image data obtained by capturing all of a plurality of picking target objects loaded, a three-dimensional point group information acquisition function of

controlling the three-dimensional camera to acquire three-dimensional point group information related to all of the plurality of aforementioned picking target objects loaded, a calibration function of commonizing coordinate information between the two-dimensional captured image data and the three-dimensional point group information based on the picking target object as a target, a top surface candidate region extraction function of extracting top surface candidate regions of the plurality of the picking target objects from the three-dimensional point group information, a first four-corner coordinate information acquisition function of acquiring first four-corner coordinate information of each picking target object in the two-dimensional captured image data by inputting the two-dimensional captured image data to a learned model that learned in advance to specify the picking target object from input image data and output coordinate information of four corners of each picking target object, a picking control function of controlling a picking operation and a transfer operation of the picking target object by the picking robot based on the first four-corner coordinate information and the three-dimensional point group information, a three-dimensional point group information reacquisition function of controlling the three-dimensional camera to reacquire three-dimensional point group

information for another picking target object left after the picking target object is picked by the picking robot, a second four-corner coordinate information acquisition function of acquiring, as second four-corner coordinate information, coordinate information of four corners related to the picking target object at a point of time before picking based on a difference between three-dimensional point group information acquired before picking and three-dimensional point group information reacquired after picking, and a controlled variable correction function of correcting a controlled variable of the transfer operation based on a deviation amount between the first four-corner coordinate information and the second four-corner coordinate information, and thus it is possible to accurately specify and reflect the posture of the picking target object at the time of picking on the control.

[0038]

Furthermore, the second four-corner coordinate information acquisition function further acquires second four-corner coordinate information by executing processing of extracting coordinate information of four corners with respect to the region of the picking target object indicated by a difference between the three-dimensional point group information acquired before picking and the three-dimensional point group information reacquired after

picking, and thus, the processing of extracting the coordinate information of the four corners is performed with respect to the accurately extracted region of the picking target and accurate second four-corner coordinate information can be acquired.

[0039]

Furthermore, the controlled variable correction function further detects information on a deviation amount in XY coordinates of the first four-corner coordinate information with respect to the second four-corner coordinate information that is correct coordinate information and a deviation amount of a rotation angle between the first four-corner coordinate information and the second four-corner coordinate information, and corrects the controlled variable, and thus it is possible to calculate the parallel movement amount and the rotational movement amount to correct the controlled variable with high accuracy.

[0040]

[Second Embodiment]

In the first embodiment, the description has been given assuming that the two-dimensional captured image data is acquired using the two-dimensional camera 20 and the three-dimensional point group information is acquired using the three-dimensional camera 30, but the present invention is

not limited thereto. For example, a stereo camera may be adopted, and both acquisition of two-dimensional captured image data and acquisition of three-dimensional point group information may be realized by the stereo camera.

[0041]

According to the stereo camera, after two pieces of two-dimensional captured image data are acquired by performing capturing respectively at two different capturing angles, depth information (distance information) is acquired by stereo matching using the two pieces of two-dimensional captured image data, and three-dimensional point group information can be generated. By using one of the two pieces of two-dimensional captured image data used here as a substitute for the two-dimensional captured image data acquired by the two-dimensional camera 20 in the first embodiment, both the acquisition of the two-dimensional captured image data and the acquisition of the three-dimensional point group information can be realized by the stereo camera. The stereo camera can also perform a calibration function between the two-dimensional captured image data and the three-dimensional point group information.

Reference Signs List

[0042]

100 Picking device

10 Picking robot

20 Two-dimensional camera

30 Three-dimensional camera

40 Control unit

41 Two-dimensional captured image acquisition function

42 Three-dimensional point group information acquisition
function

43 Calibration function

44 Top surface candidate region extraction function

45 First four-corner coordinate information acquisition
function

46 Picking control function

47 Three-dimensional point group information reacquisition
function

48 Second four-corner coordinate information acquisition
function

49 Controlled variable correction function

CLAIMS

1. A picking device comprising:

a picking robot including a hand portion that picks a picking target object;

a two-dimensional camera for two-dimensionally capturing the picking target object;

a three-dimensional camera for acquiring three-dimensional point group information indicating distance information to the picking target object; and

a control unit that controls a picking operation of the picking robot,

wherein the control unit includes

a two-dimensional captured image acquisition function of controlling the two-dimensional camera to acquire at least one or more pieces of two-dimensional captured image data obtained by capturing all of a plurality of picking target objects loaded,

a three-dimensional point group information acquisition function of controlling the three-dimensional camera to acquire three-dimensional point group information related to all of the plurality of picking target objects loaded,

a calibration function of commonizing coordinate information between the two-dimensional captured image data and the three-dimensional point group information based on the picking target object as a target,

a top surface candidate region extraction function of extracting top surface candidate regions of the plurality of the picking target objects from the three-dimensional point group information,

a first four-corner coordinate information acquisition function of acquiring first four-corner coordinate information of each picking target object in the two-dimensional captured image data by inputting the two-dimensional captured image data to a learned model that learned in advance to specify the picking target object from the input image data and output coordinate information of four corners of each picking target object,

a picking control function of controlling a picking operation and a transfer operation of the picking target object by the picking robot based on the first four-corner coordinate information and the three-dimensional point group information,

a three-dimensional point group information reacquisition function of controlling the three-dimensional camera to reacquire three-dimensional point group information for another picking target object left after the picking target object is picked by the picking robot,

a second four-corner coordinate information acquisition function of acquiring, as second four-corner coordinate information, coordinate information of four corners related

to the picking target object at a point of time before picking based on a difference between three-dimensional point group information acquired before picking and three-dimensional point group information reacquired after picking, and

a controlled variable correction function of correcting a controlled variable of the transfer operation based on a deviation amount between the first four-corner coordinate information and the second four-corner coordinate information.

2. The picking device according to claim 1,

wherein the second four-corner coordinate information acquisition function further acquires second four-corner coordinate information by executing processing of extracting coordinate information of four corners with respect to the region of the picking target object indicated by a difference between the three-dimensional point group information acquired before picking and the three-dimensional point group information reacquired after picking.

3. The picking device according to claim 1 or 2,

wherein the controlled variable correction function further detects information on a deviation amount in XY coordinates of the first four-corner coordinate information with respect to the second four-corner coordinate

information that is correct coordinate information and a deviation amount of a rotation angle between the first four-corner coordinate information and the second four-corner coordinate information, and corrects the controlled variable.

4. A picking control program for causing a computer to execute processing of controlling a picking robot including a hand portion that picks a picking target object,

the computer executing:

a two-dimensional captured image acquisition function of controlling a two-dimensional camera for two-dimensionally capturing the picking target object to acquire at least one or more pieces of two-dimensional captured image data obtained by capturing all of a plurality of picking target objects loaded;

a three-dimensional point group information acquisition function of controlling the three-dimensional camera for acquiring three-dimensional point group information indicating distance information to the picking target object to acquire three-dimensional point group information related to all of the plurality of picking target objects loaded;

a calibration function of commonizing coordinate information between the two-dimensional captured image data and the three-dimensional point group information based on

the picking target object as a target,

a top surface candidate region extraction function of extracting top surface candidate regions of the plurality of the picking target objects from the three-dimensional point group information,

a first four-corner coordinate information acquisition function of acquiring first four-corner coordinate information of each picking target object in the two-dimensional captured image data by inputting the two-dimensional captured image data to a learned model that learned in advance to specify the picking target object from the input image data and output coordinate information of four corners of each picking target object,

a picking control function of controlling a picking operation and a transfer operation of the picking target object by the picking robot based on the first four-corner coordinate information and the three-dimensional point group information,

a three-dimensional point group information reacquisition function of controlling the three-dimensional camera to reacquire three-dimensional point group information for another picking target object left after the picking target object is picked by the picking robot,

a second four-corner coordinate information acquisition function of acquiring, as second four-corner coordinate

information, coordinate information of four corners related to the picking target object at a point of time before picking based on a difference between three-dimensional point group information acquired before picking and three-dimensional point group information reacquired after picking, and

a controlled variable correction function of correcting a controlled variable of the transfer operation based on a deviation amount between the first four-corner coordinate information and the second four-corner coordinate information.