

[Document Name] Description

[Title of Invention] **AUTOMATIC TABLEWARE WASHING SYSTEM, AUTOMATIC TABLEWARE WASHING METHOD, AUTOMATIC TABLEWARE WASHING PROGRAM AND STORAGE MEDIUM**

[Technical Field]

[0001]

The present invention relates to an automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium for automatically washing tableware and the like.

[Background Art]

[0002]

In recent years, due to the shortage of employees in restaurants, there has been a demand for automating processes of operations and services in restaurants. There is also a demand for automation of tableware washing, and techniques such as those in the patent literature 1 have been conventionally proposed.

[0003]

In a tableware washing system described in the patent literature 1, a symbol or a character that can be identified by a person is provided on foot of pottery in order to identify the pottery, and an image of the pottery on a washing conveyor is acquired by a camera, and the symbol or the character provided in the pottery is read from the acquired image by template matching to identify the pottery, and the pottery is picked up by a robot arm mechanism.

[0004]

In a tableware washing system described in the patent literature 2, an identifier, which can be identified by a person and is for distinguishing the type of tableware (size, bowl, dish, etc.), and a symbol for specifying the position, the range and the orientation of the identifier are provided on foot of the tableware, and an image of the tableware on a washing conveyor is acquired by a camera, and the identifier provided in a pottery is identified from the acquired image by pattern matching, and the tableware is picked up by a robot arm mechanism. Further, in the patent literature 2, the identifier can be identified by a person and does not include a barcode, a two-dimensional code, a magnetic code and the like.

[0005]

In a tableware washing system described in the patent literature 3, tableware is taken out from a tableware washer, transferred from a waiting area and placed in a picking area. An image is acquired in the picking area and processed to identify the type of the tableware and calculate the position of the center of gravity of the tableware. Then, the tableware is picked up by a robot arm mechanism and stacked in a release area for each type

of tableware. In the patent literature 3, pattern matching processing is performed as image processing, and the type of tableware, the position of the center of gravity of the tableware, and the orientation of a plate in the longitudinal direction when viewed from above (the orientation of the rectangular plate) are determined.

[0006]

In a tableware washing system described in the patent literature 4, a robot arm performs operation of carrying a washing rack into a washing room, opening and closing the door of the tableware washer, pressing a washing switch, carrying out the washing rack from the washing room to a carrying-out table, picking up tableware from the carrying-out table, and transferring the tableware to a stock rack. In a state where the washing rack does not move, an image of the picking area on the carrying-out table corresponding to the position of the washing rack is acquired by a picking camera. Then, the acquired image is processed by pattern matching to determine the type of the tableware, the position of the center of gravity of the tableware, and the orientation of a plate in the longitudinal direction when viewed from above (the orientation of the rectangular dish).

[Citation List]

[Patent Literature]

[0007]

[Patent Literature 1] JP 2018-126272 A

[Patent Literature 2] JP 2019-037349 A

[Patent Literature 3] WO 2018/034251A

[Patent Literature 4] WO 2018/034252A

[Summary of Invention]

[Technical Problem]

[0008]

In the tableware washing system described in the patent literature 1, a symbol or a character that can be identified by a person is provided on foot of pottery, and an image of the pottery is acquired by a camera, and the symbol or character provided in the pottery is read from the acquired image by template matching to identify the pottery, and the pottery is picked up by a robot arm mechanism. However, it is premised that the system is used in a state where all the pottery is lined up horizontally facing downward on the conveyor (a state where the foot faces upward), and it is not described that the type of the pottery is identified. In a case where the pottery are conveyed on the conveyor at three-dimensionally different angles, the tableware washing system described in the patent literature 1 cannot handle the situation. In addition, the symbol or character provided on the foot of the pottery is limited to those that

can be identified by a person. Furthermore, the process of arranging the pottery in the washing conveyor is not automated.

[0009]

In the tableware washing system described in the patent literature 2, an identifier for distinguishing the type of tableware, and a symbol for specifying the position, the range and the orientation of the identifier are provided on foot of tableware, and the tableware washing system performs pattern matching to identify the type of the tableware. However, it is premised that the system is used in a state where all the tableware is lined up horizontally facing downward on the conveyor (a state where the foot faces upward), and in a case where the tableware are conveyed on the conveyor at three-dimensionally different angles, the tableware washing system described in the patent literature 2 cannot handle the situation. In addition, the symbol or character provided on the foot of the pottery is limited to those that can be identified by a person. Furthermore, the process of arranging the tableware in the washing conveyor is not automated.

[0010]

In the tableware washing system described in the patent literature 3, the type of tableware is determined by processing an image of the tableware, which does not move in the picking area, acquired by the picking area camera. Therefore, it is necessary to separate a picking conveyor in the picking area and a washing conveyor and further provide a relay conveyor between them, which complicates the structure of the conveyors. In addition, it is premised that the system is used in a state where all the tableware is lined up horizontally facing downward on the conveyor (a state where the foot faces upward), and in a case where the tableware are conveyed on the conveyor at three-dimensionally different angles, the tableware washing system described in the patent literature 3 cannot handle the situation. Furthermore, the process of arranging the tableware in the washing conveyor is not automated.

[0011]

In the tableware washing system described in the patent literature 4, in a state where the washing rack does not move, an image of the picking area on the carrying-out table corresponding to the position of the washing rack is acquired by the picking camera. Then, the acquired image is processed by pattern matching to determine the type of tableware. Therefore, the system cannot be used for picking up tableware moving on a conveyor. In addition, it is premised that the system is used in a state where all the tableware is lined up horizontally facing downward on the conveyor (a state where the foot faces upward), and in a case where the tableware are conveyed on the conveyor at three-dimensionally different angles, the tableware washing system described in the patent literature 4 cannot handle the situation. Furthermore, the process of arranging the tableware in the washing conveyor is not

automated.

[0012]

In the above-described patent literatures 1 to 4, it is not considered that the robot picks up the tableware in a state where a plurality of tableware are conveyed on the conveyor in a state where their three-dimensional angles are different. The inventor of the present invention made embodiments of the present invention as a result of research and development of a fully automatic tableware washing system by statically and dynamically analyzing tableware and a robot under some conditions. The conditions are, for example, that processes from arranging the tableware on the conveyor before being washed are automated, the angle of arranging the tableware is substantially not only the angle at which the foot faces upward, the tableware moving on the conveyor is picked up, and the posture of the robot has limitation. That is to say, an object of the present invention is to provide an automatic tableware washing system in which, in a state where tableware are transported on the conveyor at three-dimensionally different angles, the type and the state of each tableware is determined, and the tableware are safely picked up by a robot and can be placed in predetermined storage positions.

[Solution to Problem]

[0013]

The above object of the present invention can be achieved by the following configuration. That is to say, an automatic tableware washing system of the embodiment 1 of the present invention comprises:

- a tableware washing section for washing tableware input from a tableware input section from which the tableware is input;

- a tableware transport section for transporting the tableware washed in the tableware washing section;

- a tableware information acquisition section for identifying the tableware transported by the tableware transport section and acquiring information on the tableware;

- a tableware placement section on which the tableware transported by the tableware transport section is placed; and

- a tableware pick-up section for picking up the tableware from the tableware transport section and placing the tableware on the tableware placement section, wherein

- the information acquired by the tableware information acquisition section includes at least any one of a type of the tableware, size of the tableware, a shape of the tableware, color of the tableware, a position of the tableware, posture of the tableware, orientation of the tableware, a marker attached to the tableware, or a code attached to the tableware, and wherein

when the tableware information acquisition section identifies the tableware being transported by the tableware transport section, the tableware pick-up section picks up the tableware according to a state of the tableware on the basis of the information acquired by the tableware information acquisition section.

[Advantageous Effect of Invention]

[0014]

According to the embodiment of the present invention, an automatic tableware washing system can be provided in which, in a state where tableware are transported on the conveyor at three-dimensionally different angles, the type and the state of each tableware is determined, and the tableware are safely picked up by the robot and can be placed in predetermined storage positions.

[Brief Description of Drawings]

[0015]

Figure 1 is a process chart of an automatic tableware washing system.

Figures 2 are overall configuration diagrams of the automatic tableware washing system.

Figure 3 is a block diagram of a tableware take-out section.

Figure 4A is a plan view of the tableware take-out section, and Figure 4B is a perspective view of the tableware take-out section.

Figure 5 is an explanatory diagram of an example using a marker.

Figure 6 is a perspective view of a hand.

Figure 7A is a perspective view of a modified example of the hand, and Figure 7B is a side view of the modified example of the hand.

Figure 8A is a perspective view of another modified example of the hand, and Figure 8B is a side view of another modified example of the hand.

Figure 9A is an explanatory diagram of a stacking-up type tableware placement section, and Figure 9B is an explanatory diagram of the stacking-down type tableware placement section.

Figures 10 are explanatory diagrams of AR markers engraved on the back surfaces of tableware.

Figures 11 are explanatory diagrams of tableware, which are coated after AR markers are printed on the back surfaces of the tableware.

Figure 12 is an explanatory diagram of image recognition of tableware without using a tableware marker.

Figure 13 is a plan view of the tableware take-out section of the embodiment 4.

Figure 14A is a top view of the automatic tableware washing system, and Figure 14B

is a perspective view of the automatic tableware washing system.

Figure 15 is a diagram showing the vicinity of a relay table of the automatic tableware washing system.

[Description of Embodiments]

[0016]

Hereinafter, with reference to drawings, an automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to embodiments of the present invention will be described. However, the embodiments described below exemplify automatic tableware washing systems for embodying the technical concept of the present invention. Thus, the present invention is not limited to these embodiments, and equally applicable to other embodiments included in the scope of claims.

[0017]

[Embodiment 1]

An automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to the embodiment 1 of the present invention will be described with reference to Figs. 1 to 9.

[0018]

Fig. 1 is an example of a process chart of the automatic tableware washing system according to the present embodiment. The automatic tableware washing system of the present embodiment includes a tableware input section 1, a tableware washing section 2 and a tableware take-out section 3. Further, in the automatic tableware washing system of the present embodiment, there are included a process S1 of removing residues and dust from the tableware, a process S2 of arranging the tableware side by side on a conveyor, a process S3 of washing the tableware with a water stream and detergent, a process S4 of drying the tableware, and a process S5 of transferring the tableware from the conveyor to a storage place. In the tableware input section 1, the process S1 of removing residues and dust from the tableware and the process S2 of arranging the tableware side by side on the conveyor are performed, and in the tableware washing section 2, the process S3 of washing the tableware with a water stream and detergent and the process of drying the tableware are performed, and in the tableware take-out section 3, the process S5 of transferring the tableware from the conveyor to the storage place is performed.

[0019]

Figs. 2 show an example of an overall configuration diagram of the automatic tableware washing system according to the present embodiment. Tableware 11 includes, for example regardless of the type of Western tableware, Japanese tableware, the shape thereof

and the like, all the tools and utensils used for meals such as plates, bowls and the like for serving food, cups, glasses, teacups, winecups and the like for containing beverages, chopsticks, forks, knives, spoons, muddlers, noodle spoons and the like for handling food, and pans, frying pans, chopping boards, kitchen knives, knives, bowls, cups, containers, turners, spatulas, ladles and the like that are cooking utensils or kitchen utensils. The tableware 11 is transported from the tableware input section 1 to the tableware take-out section 3 via the tableware washing section 2 by a tableware transport section 10. The tableware transport section 10 may be, for example, a single conveyor for transporting tableware from the tableware input section 1 through the tableware washing section 2 to the tableware take-out section 3. However, the tableware transport section 10 may be composed of a plurality of conveyors, which are, for example, a conveyor for the tableware input section 1, a conveyor for the tableware washing section 2, and a conveyor for the tableware take-out section 3. Further, the tableware transport section 10 may be provided with a plurality of conveyors in each section, or may have a single conveyor instead of the plurality of conveyors.

[0020]

The tableware transport section 10 is not particularly limited, but is, for example, a conveyor capable of transporting tableware. The types of the conveyor include, for example, a) a flat conveyor, which has a flat surface and on which tableware is placed facing downward, b) an under-flight conveyor, which has a space into which tableware is inserted under the surface of the conveyor and which can transport everything from thin tableware to washing racks, c) a flight conveyor, on which tableware is washed in a state where the tableware leans against protrusions on the conveyor and which can transport everything from thin tableware to washing racks, d) a rack conveyor used to wash tableware stored in a washing rack, and the like. Thus, all types of conveyors can be applied to the tableware transport section 10.

[0021]

The tableware take-out section 3 is provided with an articulated robot 12 as a tableware pick-up section, a tableware placement section 13 on which tableware picked up from the tableware transport section 10 at the tableware pick-up section are collectively placed, and a tableware information acquisition section 14 for identifying tableware transported in the tableware transport section 10 and acquiring the information on the tableware. In the tableware take-out section 3, based on the information on the tableware from the tableware information acquisition section 14, the tableware is picked up by the articulated robot 12 as the tableware pick-up section, and the picked-up tableware are placed together on the tableware placement section 13. Here, the articulated robot 12 is exemplified as the tableware pick-up section, but the present embodiment is not limited to this configuration, and as long as the tableware pick-up section includes a mechanism for picking up tableware such as, for example, an industrial robot including a robot having a deformable arm and a lifting robot, all

means for picking up tableware are included in the tableware pick-up section. In the tableware placement section 13, the tableware picked up by the tableware pick-up section are placed together, for example, depending on the types of tableware. As a method of placing the tableware together in the tableware placement section 13, for example, the same type of tableware is placed facing downward and stacked in the same direction. Since the tableware take-out section 3 can grasp the type and the posture of tableware from the information from the tableware information acquisition section 14, for example, tableware can be placed on the tableware placement section 13 in an overlapping manner in a state where the long sides and the short sides of rectangular tableware are aligned. The types of tableware include the size, the shape, and the color of tableware. Further, the articulated robot 12 can pick up tableware from the tableware transport section 10 even when the tableware is being transported by the tableware transport section 10, that is, even when the tableware is moving.

[0022]

In the present embodiment, the automatic tableware washing system is described from the viewpoint of fully automating, but for example, it is also possible to manually perform a part of the tableware input section 1.

[0023]

The tableware input section 1 includes a tableware immersion unit, a tableware raising unit and a washing pump, and the tableware immersion unit has a tableware immersion sink and a jet nozzle, and the tableware raising unit has a tableware raising conveyor and a tableware alignment section and a strainer. Water is stored in the tableware immersion sink, and the water flow from the jet nozzle removes residues and dust from tableware. The water filtered by the strainer is pressurized by the washing pump and ejected from the jet nozzle. Tableware from which residues and dust have been removed by the water flow from the jet nozzle is conveyed to the tableware washing section 2 by the tableware raising conveyor. The washing pump is illustrated at the bottom of the tableware washing section, the strainer is illustrated at the bottom of the tableware washing conveyor, and the jet nozzle is illustrated at the front of the tableware raising conveyor, but this arrangement is only an example. According to the shapes and the arrangement of the tableware immersion unit, the tableware raising unit and the tableware washing section, the arrangement of the washing pump, the strainer and the jet nozzle can be appropriately changed.

[0024]

The tableware alignment section is means for aligning tableware to be transported to the tableware washing section on the tableware raising conveyor according to the types and the postures of the tableware. As the tableware alignment section, for example, an industrial robot such as an articulated robot can be used. If there is no tableware alignment section, tableware that are raised by the tableware raising conveyor may be in an overlapping state or

the posture of the tableware may be unsuitable to be washed in the tableware washing section 2. The tableware alignment section aligns tableware according to the arrangement and the posture of thereof, so that it can be easier to wash the tableware in the tableware washing section 2, and further, it can be easier to take out the tableware in the tableware take-out section 3. For example, when a large plate is transported facing downward on the tableware raising conveyor, other relatively small tableware such as a small plate and a bowl may be overlapped under the large plate, and in the tableware washing section 2 in the subsequent process, the tableware may be left unwashed. Further, when tableware overlap, the tableware information acquisition section 14 may not acquire the information on the tableware, and there is a possibility that the tableware take-out section 3 may not take out the tableware. For these reasons, when the large plate is placed facing downward on the tableware raising conveyor, for example, the tableware alignment section aligns the large plate to a state where the large plate leans against protrusions on the tableware raising conveyor so that the large plate does not overlap with other tableware.

[0025]

Further, when the posture of tableware is aligned with respect to the transport direction of the conveyor, for example, when the tableware is arranged so that the back surface (thread bottom) of the tableware faces the traveling direction of the conveyor, each tableware can be appropriately washed in the tableware washing section 2 and it can be easier to take out each tableware in the tableware take-out section 3. Further, as will be described later, by inputting tableware in the tableware input section 1 according to predetermined rules regarding the type, the position and the posture of tableware, the accuracy of the image recognition of the type, the position and the posture of the tableware in the tableware take-out section 3 can be improved, and failure of picking up tableware can be reduced, and the speed of picking up tableware can be also increased.

[0026]

The arrangement of the tableware input section 1 and the tableware take-out section 3 is adjusted according to the type of the tableware washing section 2, that is, according to the arrangement of the tableware input position and the tableware take-out position. Therefore, the overall configuration diagram of the automatic tableware washing system shown in Figs. 2 is only an example of the present embodiment, and the system of the linear type is described. The present embodiment is not limited to the layout shown in this diagram, and the present embodiment can adopt various layouts corresponding to various types of tableware washing sections 2 such as a corner type and a round type.

[0027]

Fig. 3 shows an example of a block diagram of the tableware take-out section 3 according to the present embodiment. The tableware take-out section 3 includes an image

acquisition section as the tableware information acquisition section 14, a tableware take-out calculation section 30 and the articulated robot 12. The tableware take-out calculation section 30 can be composed of, for example, a personal computer (hereinafter referred to as “PC”), a tablet terminal or the like, and includes a tableware position/posture detection section 31, a tableware take-out order plan section 32 and a tableware take-out operation command section 33. The tableware position/posture detection section 31 acquires information on the position, the posture, the type and the like of tableware from the tableware information acquisition section 14.

[0028]

A tableware take-out order plan section 31 issues a command to the tableware transport section 10 to operate or stop the conveyor, and also issues a command to operate or stop the tableware input section 1 according to the operation of the conveyor.

Further, if the tableware position/posture detection section 31 is connected to the tableware input section 1, the tableware transport section 10, the tableware washing section 2 and the like in addition to the tableware information acquisition section 14 and can communicate with each section, the tableware position/posture detection section 31 can use various information to obtain information on the position, the posture, the type and the like of tableware. The various information are for example, information on the position or the posture of the tableware at the time of inputting the tableware from the tableware input section 1, information on the tableware transport speed by the tableware transport section, information on the strength of the washing water stream by the tableware washing section, and the like.

[0029]

The tableware take-out operation command section 33 issues a tableware take-out operation command to the articulated robot 12, and based on this command, the articulated robot 12 picks up tableware from the tableware transport section 10 and places the tableware all together on the tableware placement section.

[0030]

Figs. 4 show an example of an overview diagrams of the tableware take-out section 3 according to the present embodiment. Fig. 4A is a plan view of the tableware take-out section 3, and Fig. 4B is a perspective view of the tableware take-out section 3. In the tableware take-out section 3, the articulated robot 12 as the tableware pick-up section picks up tableware transported by the tableware transport section 10 based on the information on the tableware from the tableware information acquisition section 14, and places the picked-up tableware all together in the tableware placement section 13. Here, in Figs. 4A and 4B, the arrangement of the articulated robot 12, the tableware transport section 10 and the tableware placement section 13 is an example of the present embodiment, for example, the tableware transport

section 10 can be arranged on the opposite side of the articulated robot 12 with the tableware transport section 10 being therebetween. In this way, by setting the distance between the position, at which the articulated robot 12 picks up tableware on the tableware transport section 10, and the tableware placement section 13 as short as possible, the operation of a tableware pick-up section 12 can be speeded up.

[0031]

A tableware receiving section (not shown) for receiving tableware that could not be picked up by the articulated robot 12 is provided at the end of the downstream side in the transport direction of the tableware transport section 10. Since each joint of the articulated robot 12 has a movable limit, when the articulated robot 12 moves from one posture to the next posture, there is a limit due to the movable limit. Depending on the posture of tableware, it may not be possible to pick up the tableware due to the movable limit of the articulated robot 12. Further, if the tableware information acquisition section 14 cannot properly read an AR marker 42, for example, if tableware overlap with each other, the articulated robot 12 may not be able to pick up the tableware. Therefore, by providing the tableware receiving section at the end of the downstream side in the transport direction of the tableware transport section 10, even if the articulated robot 12 cannot pick up tableware, the tableware can be safely received. Therefore, the automatic tableware washing system can be configured to be redundant.

[0032]

Fig. 5 is an example of an explanatory diagram of an example using a marker according to the present embodiment. In the present embodiment, a marker, for example, the AR marker 42 is provided on the back surface (thread bottom) of tableware, and by acquiring and recognizing the image of the tableware with a tableware detection camera as the tableware information acquisition section 14, tableware is recognized and information on the position, the posture and the type of the tableware can be obtained.

[0033]

As shown in Figs. 4, the tableware detection cameras as the tableware information acquisition sections 14 are provided, for example, above the tableware transport section 10, on the upstream side of the tableware pick-up section 12, and on both sides of the tableware transport section 10 so as to face the center in the width direction of the tableware transport section 10. On the back surface (thread bottom) of tableware, a marker that is different for each type of tableware, for example, the AR marker 42 is provided. The marker of the present embodiment is not limited to the AR marker 42, and any marker can be used as long as the marker with which at least any one of the type, the position and the posture of the tableware can be identified.

Although Figs. 4 illustrate a configuration in which the two tableware information

acquisition sections 14 are provided, the number of the tableware information acquisition sections 14 is not limited to two and may be any number of one or more. For example, the four tableware information acquisition sections 14 may be provided. If the four tableware information acquisition sections 14 are provided, the tableware information acquisition sections 14 are provided at the same height and separated from each of the two tableware information acquisition sections 14 shown in Figs. 4 in the transport direction of the conveyor. For example, If the four tableware information acquisition sections 14 are arranged at positions corresponding to each corner of the square line, and the orientations of the four tableware information acquisition sections 14 are adjusted so that the optical axes are gathered in a predetermined area at the center in the width direction of the conveyor, the four tableware information acquisition sections 14 can acquire images of tableware from both of the upstream side and the downstream side in the transport direction.

That is, if the four tableware information acquisition sections 14 are provided, even if there is the tableware 11 that is out of the rule, in which the tableware 11 are arranged so that the back surface (thread bottom) of the tableware 11 faces the transport direction of the conveyor, the image of the back surface (thread bottom) of the tableware 11 can be acquired by the tableware information acquisition section 14 whose optical axis is inclined toward the transport direction of the conveyor.

[0034]

Regarding the AR marker 42, "An AR marker is, in the image recognition type AR (Augmented Reality) system, an image with a fixed pattern, which functions as a marker for designating a position at which the additional information is indicated." (from e-Words, Website IT Glossary). When the tableware detection camera detects an image of the tableware, the image of the tableware changes depending on the viewing angle and the distance from the camera. However, if the AR marker 42 is used, the digital information added to the AR marker 42 can be read, and the posture of the AR marker 42, that is, the posture of the tableware with the AR marker can be detected. Further, if the AR marker 42 is a code including the information of the type of tableware, the position, the posture, the type and the like of the tableware can be detected as the information of the tableware by taking the picture of the AR marker using the tableware detection camera. The position information of tableware acquired by taking the picture of the AR marker 42 includes the information of the center position of the back surface (thread bottom) of the tableware.

[0035]

A hand 40 is attached to the tip end side of the arm of the articulated robot 12, and a suction portion 41 for sucking tableware is provided on the tip end side of the hand 40.

[0036]

Fig. 6 shows an example of a perspective view of the hand 40 according to the present

embodiment. The hand 40 includes an extending portion 45, a hand mounting portion 46 on one end side of the extending portion 45, the suction portion 41 on the other end side of the extending portion 45, and a vacuum hose 47. The hand mounting portion 46 is mounted on the arm side of the articulated robot 12. The vacuum hose 47 extends through the extending portion 45 to the suction portion 41, and the suction portion 41 can suck the back surface (thread bottom) of tableware by vacuum. The other end of the vacuum hose is mounted to a robot-side vacuum hose mounting portion (not shown) provided in the articulated robot 12, and the suction portion 41 is evacuated by this robot-side vacuum hose mounting portion.

[0037]

When the articulated robot 12 sucks and transports tableware, if the tableware is large or heavy and carried at high speed, vibration becomes large. As a result, the subsequent process of stacking tableware may fail. The cause of this vibration is that the suction portion 41 of the hand 40 is deformed after sucking the tableware. Thus, if a ring-shaped member having a higher rigidity than the pad is provided so as to surround the suction portion 41 to suck the tableware with an internal force at the time of suction and suppress the deformation of the hand 40, the vibration of the tableware can be significantly reduced while the articulated robot 12 sucks and transports the tableware.

[0038]

Figs. 7 show an example of a perspective view of another example of a hand 40A according to the present embodiment. The hand 40A is provided with the extending portion 45, the hand mounting portion 46 on one end side of the extending portion 45, a joining portion 49 on the other end side of the extending portion 45, a first suction portion 41A and a second suction portion 41B provided in the joining portion, and a hand-side vacuum hose mounting portion 48. A vacuum hose (not shown) is attached to the hand-side vacuum hose mounting portion 48, and the other end of the vacuum hose is mounted to the robot-side vacuum hose mounting portion (not shown). The hose is arranged from the hand-side vacuum hose mounting portion to the suction portions 41A and 41B through the extending portion 45, and the suction portions 41A and 41B can suck the back surface (thread bottom) of tableware by vacuum. Both suction portions 41A and 41B are provided on the joining portion 49 at an angle substantially orthogonal to each other. By providing the two suction portions 41A and 41B, the articulated robot 12 does not take a posture that exceeds the movable limit so that the articulated robot 12 can pick up tableware. Thereby, the rate of failure, in which the tableware is not taken out, can be reduced.

[0039]

Fig. 8A is a perspective view of another modified example of the hand, and Fig. 8B is a side view of another modified example of the hand. In Figs. 8, the same reference numerals are used for the same configurations as those in Figs. 7, and the descriptions thereof will be

omitted.

[0040]

Due to an error in the recognition of the tableware 11 (regarding the position and the posture of the tableware 11), the articulated robot 12 may move to pick up the tableware 11 to a position where the tableware 11 is not located. For example, the articulated robot 12 may move to pick up the tableware 11 to a position behind the tableware 11.

At that time, a part of the hand 40 such as the suction portion 41 may come into contact with the conveyor and other members of the tableware transport section 10 and press the hand 40 against the conveyor in a state where the tableware is not picked up. Here, there is a risk of damaging the conveyor, the tableware 11 or the hand 40.

[0041]

Conventionally, a force sensor (6-axis sensor) is provided on the hand 40, and the force applied to the hand 40 is detected by the force sensor. Then, when an excessive external force is applied to the hand 40, the operation of the articulated robot 12 is stopped.

However, there is a demand for omitting the installation of the force sensor because the force sensor is vulnerable to water, is easily broken by impact force, and is expensive.

[0042]

A hand 40C includes a plurality of spring mechanisms 60 and a ball joint 61. Further, the hand 40C also includes a force sensor 62.

The plurality of the spring mechanisms 60 and the ball joint 61 reduce the reaction force (external force) that the hand 40C receives from the pressing destination such as the conveyor and the pressing force that the conveyor and/or the tableware 11 receives from the hand 40C.

The plurality of the spring mechanisms 60 are provided between the hand mounting portion 46, which is a circular plate-shaped portion, and the circular plate-shaped member arranged to face the hand mounting portion 46.

[0043]

When the hand 40C is pressed against the conveyor or the like, the elastic portion of the spring mechanism 60 is elastically deformed between the hand mounting portion 46 and the circular plate-shaped member in response to an external force. As a result, the external force is reduced.

By appropriately setting the spring constant of the spring mechanism 60, the spring mechanism 60 is not deformed in an elastically neutral state where no external force is applied, and only when an excessive external force is applied, the spring mechanism 60 is elastically deformed.

[0044]

The ball joint 61 is arranged at the center position of the hand mounting portion 46.

As a result, the elastic force of the spring mechanism 60 acts only in the rotational direction around the ball joint 61.

Therefore, due to the configuration in which the suction portions 41A and 41B are located away from the wrist (the hand mounting portion 46) of the hand 40C, even if a moment larger than the translational force is applied to the wrist, unnecessary deflection of the hand 40C in the translational direction is prevented, and the spring mechanism 60 is elastically deformed according to the moment received from the suction portions 41A and 41B.

[0045]

By adopting the hand 40C, even if a part of the hand 40C such as the suction portion 41 is pressed against the conveyor in a state where the hand 40 cannot pick up the tableware 11, since the reaction force (external force) that the hand 40C receives from the pressing destination of the conveyor or the like and the pressing force that the conveyor and/or the tableware 11 receives from the hand 40C can be reduced, it can be prevented that the conveyor, the tableware 11 and/or the hand 40C are damaged.

[0046]

In the present embodiment, the elastic force acts only in the rotational direction around the ball joint 61, but the elastic force may also act in the axial direction of the ball joint 61.

[0047]

Figs.9 are explanatory diagrams of the tableware placement section 13 according to the present embodiment, Fig. 9A is an explanatory diagram of a stacking-up type tableware placement section, and Fig. 9B is an explanatory diagram of a stacking-down type tableware placement section. Fig. 9A shows a case of the stacking-up type tableware placement section 13, and the upper surface of the tableware placement section 13 is a flat surface. The articulated robot 12 stacks tableware at a predetermined position in the tableware placement section 13 for each type of tableware based on the tableware type information acquired by the tableware information acquisition section 14. Since the tableware take-out calculation section 30 counts how much tableware are placed in the tableware placement section 13 for each type of tableware, the height at which tableware is stacked-up can be predicted according to the type and the number of tableware. Further, the tableware placement section 13 may be provided with means for detecting the presence or absence of tableware according to the position and means for detecting the height at which tableware is stacked-up. For example, it is possible to detect the position, the type and the number of tableware placed on the tableware placement section 13 by analyzing a tableware placement section image acquisition section (not shown) that takes the picture of the tableware placement section 13.

[0048]

Fig. 9B shows a case of the stacking-down type tableware placement section 13. By

deciding the position to stack-down tableware for each type and providing means for raising and lowering stacked tableware according to the weight of the stacked tableware at each stacking-down position, it can be adjusted so that the next tableware to be stacked will be just on the upper surface of the tableware placement section 13. In this way, since the articulated robot 12 can grasp in advance the place and the height at which the tableware is to be stacked-down, it is possible to accurately stack-down each tableware. If means for raising and lowering stacked tableware according to the weight of the stacked tableware is not provided at each stacking-down position, the tableware take-out calculation section 30 counts how much tableware are placed on the tableware placement section 13 for each type of tableware. In this way, by providing means for detecting the height at which tableware are stacked, each tableware can be placed up to a predetermined stacking-down height. Further, if appropriate means for detecting the height on which each tableware is placed is provided, it is also possible to issue a command to the articulated robot 12 regarding the stacking-down position of each tableware.

[0049]

[Tableware information acquisition section]

In order to stack the tableware in the tableware placement section 13 for each type of tableware, different AR markers are provided on the back surfaces (thread bottom) of tableware for each type. By providing AR markers on tableware, the articulated robot 12 can pick up tableware even if the position and the posture of the tableware are not constant. By using inputs of the plurality of tableware detection cameras as the tableware information acquisition section 14, the AR markers are individually tracked by the Kalman filter. This makes it possible to improve the accuracy of recognizing the position and the posture of tableware. Further, even when the tableware transport section 10 is in operation, the articulated robot 12 can pick up moving tableware.

[0050]

[Tableware pick-up section]

There are innumerable postures of the articulated robot 12 for picking up tableware. However, postures that the robot can actually or easily take are limited. If the posture of the robot is not properly selected, the robot will be in an immovable posture or a posture close to the movable limit, and the robot will stop the operation. For example, if the posture of the robot is at a singular point, the robot may stop. Therefore, by using the operable value, which is an index of the mobility of the articulated robot 12, and the proximity to the movable limit, a posture in which the robot is easy to move is selected from several posture candidates to pick up tableware.

[0051]

Normally, the movement of the articulated robot 12 tries to move the shortest

distance from the start to the goal, but when picking up tableware, if the articulated robot 12 moves the shortest distance, the joints may exceed the movable range. Thus, the movement of the articulated robot 12 from the start to the goal is simulated in advance, and the angle of the joint that may exceed the movable range is adjusted in advance to an angle close to the angle when moving the shortest distance to the goal, and then the movement of the articulated robot 12 is started. This makes it possible to prevent a situation in which a specific joint exceeds the movable range before reaching the goal.

[0052]

When tableware is stacked on the tableware placement section 13, if the height of the tableware does not match the height of the tableware placement section 13, the tableware may be dropped and the noise may be increased, or the tableware may be damaged by being pressed. Therefore, a force sensor is provided between the arm and the hand 40 of the articulated robot 12 to detect a force with which the tableware is pressed so that the tableware is prevented from begin fallen. Further, by using the compliance control, the tip of the arm or the hand 40 of the articulated robot 12 is provided with a virtual spring property so that the tableware will not be damaged even if the tableware is pressed by the articulated robot 12. The force sensor detects the shifting direction of the stacked tableware, and the hand 40 is controlled to follow the direction in which the tableware is actually stacked.

[0053]

For example, in a case where there is an error in recognizing tableware and the tableware cannot be sucked, the tableware or the tableware transport section 10 may be touched and pushed by a portion other than the suction portion 41, and the articulated robot 12 or the tableware transport section 10 may break down or the tableware may be broken. In a case where a force sensor detects the shifting direction of stacked tableware and detects that a force exceeding the predetermined force threshold is applied to the hand while the compliance control is used, if an abnormal process (process such as missing tableware or measuring again the correct position and posture of the tableware with the sensor) is performed as a pickup failure, it becomes possible to continue the operation.

[0054]

When tableware is stacked on the tableware placement section 13, if the position of the tableware placement section 1 is deviated from the proper position, or the position or the posture of the tableware placed earlier is deviated from the proper position or posture, a force pressing the tableware occurs. As a result, the tableware may be damaged, or the tableware may be moved and failed to be placed. Therefore, by using the compliance control, the rate of these failure can be reduced. In addition, since the direction in which the hand shifts can be recognized by the compliance control, by moving the target value of the hand in the direction in which the tableware is actually stacked (that is, by controlling the hand to follow the

direction in which the tableware is actually stacked), it is possible to estimate and eliminate the shift in the position and the posture.

[0055]

[Forecast]

When detecting an AR marker, as a general characteristic of a camera, the accuracy in the optical axis direction (depth direction) of the camera is low. If the detection of the position of the AR marker is not accurate, the position where the robot picks up tableware may shift and the picking up operation may fail. In addition, if the orientation of the AR marker is not clearly visible from the camera, or if the AR marker is hidden, the tableware may not be detected. Therefore, multiple cameras are used to track the AR marker. In order to track the AR marker, the Kalman filter is used. The positions and orientations of the marker measured from the multiple cameras are mixed and estimated with the Kalman filter. Then, even if there is a moment when the AR marker cannot be measured from the camera, the position and the orientation of the tableware can be tracked without missing the AR marker.

[0056]

The following two improvements are made in order to estimate the position and the orientation of an AR marker more accurately using the Kalman filter.

(A) The error amount (error covariance matrix) can be set as a parameter in the Kalman filter. Since it is known that the error in the optical axis direction of a camera is large in principle, setting a large value of the error in the optical axis direction of the camera improves the estimation accuracy of the position and the posture.

(B) In the Kalman filter, other parameters can be estimated as state quantities. For example, (a) difference between the actual size and the assumed size of a marker, (b) difference between the actual posture and the assumed posture of a camera, (c) subtle difference between the actual orientation and the assumed orientation of a conveyor. By using these state quantities, the position and the orientation of a marker can be estimated more accurately.

[0057]

Regarding the arrangement of cameras, it is known that the measurement accuracy is low in the optical axis direction of the camera. Therefore, by arranging the cameras in a state where the optical axis directions thereof are as different as possible, it is possible to prevent the bias of deterioration of the accuracy. Therefore, the two cameras as the image acquisition sections are arranged so that the optical axes thereof face the center of the conveyor from both sides of the conveyor.

[0058]

Since there are certain rules for inputting tableware into the tableware washing section, based on these rules, the position of tableware at the time of taking out can be predicted. Further, if marker information is read when tableware is input into a tableware

washer, since the arrangement of the tableware on the conveyor is known in advance, the position where the tableware is picked up can be predicted accurately.

[0059]

In addition, procedures for picking up tableware may be as follows. 1) A marker is measured by multiple cameras, and the position of the marker is estimated by the Kalman filter, and 2) when the marker is out of the field of view of the cameras, the position of the marker is continued to be estimated from the movement amount of the conveyor (the movement amount directly measured by using the encoder installed on the conveyor), and 3) the robot picks up the tableware based on the estimated position. If the tableware comes into contact with something else on the conveyor or is unstable on the conveyor, the tableware may move while the camera is not observing the marker. Therefore, it is most certain that the cameras keep observing the marker until just before the robot picks up the tableware. If the tableware can always be kept within the field of view of the cameras, the accuracy of measuring the position of the tableware will be further improved. However, the Kalman filter itself is necessary to improve the accuracy of observation in using multiple cameras even if the tableware is always in the field of view of the camera. If a camera is arranged close to the robot in order to bring the field of view of the camera close to the robot's operating range, the robot may come into contact with the camera, and it is necessary to devise the overall configuration and the arrangement of the cameras.

[0060]

[Learning]

If tableware is input by a robot, the rules for inputting tableware can be corrected at any time based on pick-up failures. By learning from failures, the rules for inputting tableware can be optimized so that the robot does not take a posture exceeding the movable limit. For example, it is possible to optimize the rules for inputting tableware by using a mechanism such as learning, for example, reinforcement learning regarding how to input tableware suitable for being picked-up, how to regularly input tableware, or how to input tableware in the orientation in which the tableware is easy to be taken out.

[0061]

Reinforcement learning is a method of setting a reward for the result of a robot's action and acquiring an action that raises the reward as much as possible. As an example, the result of success or failure of tableware pickup is judged by a pressure sensor of vacuum suction, and a reward is given when the tableware can be picked up. It is effective to set an observed image or the like of tableware as input and to perform reinforcement learning in which the correction amount of the trajectory during the pick-up operation is acquired so that this reward is maximized.

In addition, in order to actually perform reinforcement learning while operating the

automatic tableware washing system of the present embodiment, a predetermined number of trials is required. Therefore, it is effective to adopt the above-described compliance control in order to prevent damage or failure due to collision between tableware and the arm during the period until reinforcement learning progresses and the pick-up accuracy is improved.

[0062]

Since the posture of the robot is limited, it may not be possible to move the tip of the arm in the shortest distance. In order to smoothly pick up the next tableware following the operation of picking up the current tableware, it is possible to learn to optimize the correction amount of the trajectory of the arm tip of the articulated robot 12 and the selection of tableware to be picked up. For example, if a trained AI is used, the robot can move smoothly like a skilled person and can quickly pick up tableware from the time at which the tableware washer is started to be used. It is effective to optimize the correction amount by learning, and it also contributes to speeding up the robot. The learning is, for example, reinforcement learning, in which a correction amount is input to the trajectory of the robot in the pick-up operation to improve the probability of success, or supervised learning by DNN (deep neural network).

[0063]

[Embodiment 2]

With reference to Figs. 10 to 11, an automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to the embodiment 2 of the present invention will be described. In the present embodiment, a plurality of modified examples of the marker used in the embodiment 1 will be described.

[0064]

[Modified example 1]

In the modified example 1, a method of attaching a sticker on which an AR marker is printed will be described. Although not particularly limited, for example, any one of sheet members of

(A) a sheet member on which an AR marker is printed with black ink on a white sheet member,

(B) a sheet member on which an AR marker is printed with black ink on a transparent sheet member,

(C) a sheet member on which an AR marker is printed with white ink on a black sheet member, or

(D) a sheet member on which an AR marker is printed with white ink on a transparent sheet member,

is attached to the back surface (thread bottom) of tableware with an adhesive. Here, the colors of the sheet member and the ink are not limited to transparent, white or black. Regarding the

color combination, it is sufficient that the AR marker can be read when the printed sheet member is attached to the back surface of the tableware. By adjusting the image recognition software, it is possible to use various color combinations. However, since the color of tableware is generally white or black, combinations of black ink on a white background and white ink on a black background are often used. In this case, for tableware on a black background, the color pattern of the marker for the tableware on a white background can be used by inverting black and white. The sheet member of above (B) is used for tableware of the color such as white, that is, tableware of a light color in which black ink can be identified, and the sheet member of above (D) is used for tableware of the color such as black, that is, tableware of a dark color in which white ink can be identified.

[0065]

As a waterproof sheet, for example, it is desirable to use a sheet having a waterproof film or a waterproof coating on the surface of the sheet member and having high water resistance and high heat resistance. It is desirable that the adhesive for attaching the sheet member to the tableware also has high water resistance and high heat resistance so that tableware can be repeatedly washed and used. Further, the shape and the material of tableware may be arbitrary as long as the sheet member can be attached. The AR marker needs to be provided on a flat surface such as a thread bottom on the back surface of tableware. Since the sheet member can be attached to existing tableware later, there is no need to prepare special tableware.

[0066]

It has been explained that a waterproof sheet or a waterproof coating having high water resistance and high heat resistance is used, but the present example is not limited to this configuration. Since tableware is repeatedly washed and used for serving food, it is desirable that the waterproof sheet or the waterproof coating is chemically and physically durable. That is, it is desirable that the waterproof sheet or the waterproof coating is, for example, alkali-resistant, acid-resistant or the like, resistant to various foods and detergent, difficult to peel off even after repeated washing, and durable against friction during use and washing.

[0067]

[Modified example 2]

With reference to Fig. 10, the modified example 2 will be described. The modified example 2 is a method of engraving the AR marker 42 on the back surface of tableware by laser processing. Tableware used in the modified example 2 may be made of a material capable of being engraved by laser processing, and for example, may be made of melamine. The shape of tableware may be any shape as long as it has a flat surface portion (for example, a thread bottom on a flat surface on the back surface) to which an AR marker is provided.

[0068]

Hatched grooves having intervals of, for example, about 0.3 mm, that is, a plurality of substantially parallel linear grooves are processed by a laser in a portion of the back surface of tableware to be filled with ink corresponding to the AR marker. The ink of a color different from the color of the tableware is filled in this groove. The hatching interval is not particularly limited, and may be narrower than, for example, about 0.3 mm, or may be wider than this interval. As the ink, water-resistant ink is used, and it is desirable that the ink has heat resistance. Since the ink filled in the grooves is held in the grooves and has durability, it is not necessary to provide a coating or the like. However, in order to further improve the durability, a waterproof film or a waterproof coating having water resistance and heat resistance may be provided on the AR marker portion. Since a laser processing is applied to existing tableware later, there is no need to prepare special tableware.

[0069]

Fig. 10A is an example in which black ink is filled in tableware on a white background. The size of the marker is not particularly limited, but may be about 20 mm, may be a smaller size such as about 15 mm in order to be used in smaller tableware, and may be larger than about 30 mm or the like. Fig. 10B is an example of filling black tableware with white ink. The color of tableware and the color of ink are not limited to black and white, and any combination of colors with which the AR marker 42 can be read may be used. By adjusting the image recognition software, it is possible to adopt various color combinations and markers of various sizes. It is desirable to unify the sizes of the AR markers in order to simplify the image recognition algorithm and improve the recognition accuracy of the positions and the postures of the AR markers.

[0070]

[Modified example 3]

With reference to Fig. 11, the modified example 3 will be described. The modified example 3 is a method in which the AR marker 42 is directly printed on the back surface of tableware and then is coated. First, in the manufacturing process of melamine tableware, a method of providing an AR marker will be described. In the manufacturing process of melamine tableware, an AR marker is printed on tableware with appropriate ink, and a coating (for example, melamine coating) is applied to the surface of the AR marker. The material of the coating is not limited to melamine, but in a case where the material of the tableware is, for example, melamine, it is desirable that the coating on the surface of the AR marker is also a melamine coating. The ink is not particularly limited, but for example, ultraviolet color-developing ink, ultraviolet discoloring ink, ultraviolet curable ink, or the like can be used.

[0071]

Although the melamine tableware has been described as an example, the object of the AR marker printing method of the modified example 3 is not limited to the melamine tableware. This printing method can be applied to various tableware such as pottery, glass, resin or the like, and an appropriate coating according to the material, for example, a resin coating is applied. In addition, the AR marker can be printed later on the existing tableware. In this case, since a laser processing is applied to existing tableware later, there is no need to prepare special tableware. Further, since the AR marker is coated, the AR marker has high durability.

[0072]

Fig. 11A is an example of printing black ink on tableware on a black background. The color of the black ink may be weakened depending on the material of the tableware, the specifications and condition of the ink, and the specifications and condition of the coating. Even when the color of the black ink is weakened in this way, the AR marker can be recognized by adjusting the image recognition software. Fig. 11B is an example of printing white ink on tableware on a black background. The white ink may be, for example, slightly brown depending on the material of the tableware, the specifications and condition of the ink, and the specifications and condition of the coating. However, the AR marker can be recognized by adjusting the image recognition software. The combination of the tableware color and the ink color of the modified example 3 is not limited to black and white, and various other color combinations may be adopted as long as the AR marker can be identified. By adjusting the image recognition software, it is possible to recognize AR markers of various color combinations.

[0073]

[Modified example 4]

In the modified example 4, a method of adhering a tag having an AR marker to tableware will be described. For example, an AR marker is printed on a coin-shaped (thin circular-shaped) tag, and the tag is attached to the back surface of tableware, for example, a thread bottom with an adhesive, with the printed surface of the tag being the front surface. It is desirable to provide a waterproof film or waterproof coating having water resistance and heat resistance on the printed surface of the tag. Further, it is desirable that the adhesive for attaching the tag to the tableware also has water resistance and heat resistance. The specifications such as the shape and material of the tag of the modified example 4 are not limited to the coin shape, and may be any specification as long as the tag has an AR marker. Since the tag with the AR marker is attached to existing tableware later, there is no need to prepare special tableware.

[0074]

[Modified example 5]

In the modified example 5, the types of a marker and the positions of a marker will be described. Although the example in which the AR marker is used as the marker has been described in the modified examples 1 to 4, the marker is not limited to the AR marker in the present embodiment. As the marker, any marker may be used as long as it can be used to identify at least one of the type of the tableware, the position of the tableware, and the posture of the tableware.

[0075]

Further, the marker can be arranged on the back side of tableware, for example, in the center of the thread bottom, but the present embodiment is not limited to this configuration. For example, if the marker is at a predetermined position for each type of tableware, by registering the position in advance in the image recognition software, it is possible to grasp the position at which tableware is picked up.

[0076]

[Embodiment 3]

An automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to the embodiment 3 of the present invention will be described with reference to Fig. 12. In Fig. 12, the same reference numerals are used for the components described with reference to Figs. 1 to 11, and the descriptions thereof will be omitted. In the embodiments 1 and 2, the tableware information acquisition section 14 recognizes tableware using AR markers, but in the embodiment 2, the example of recognizing the tableware without an AR marker will be described.

[0077]

By recognizing tableware using images from a plurality of tableware detection cameras as the tableware information acquisition sections 14 and a three-dimensional point group (obtained from the plurality of camera images, for example), even if an AR marker is not used, the position and the posture of the tableware can be recognized. Although not particularly limited, for example, by using a camera of the Intel RealSense Depth Camera D400 series, which can measure the depth of an object, the position and the posture of the tableware can be recognized by stereo vision. This camera is equipped with an image sensor set (with two depth sensors, maximum resolution 1280 x 720) that can detect the difference between two images and perform real-time depth image processing, and can scale color data. Further, it is equipped with an IR projector and operates with USB power supply. For example, in order to obtain more accurate depth data even when observing a plain white wall, a random dot pattern of infrared light is projected using an active IR projector that illuminates the object and the pattern is added on the apparent object to make it easier to match the two camera images.

[0078]

In addition to the stereo camera method described above, the following methods can also be used as methods for obtaining a three-dimensional point group. 1) a method of irradiating a pattern such as laser light or LED, taking a picture of the pattern's reflection, and obtaining a three-dimensional point cloud (Structured Light method), 2) a method of irradiating light such as laser light or LED and measuring the time until the laser returns after reflection (Time of Flight method), and 3) a method of searching the position where the image is in focus and acquiring the depth information (focusing method).

[0079]

Further, for example, as shown in Fig. 12, if DNN is used for image recognition of tableware, it is possible to cut out an image or a point cloud area containing only the tableware, so that the detection accuracy of the position and the posture of the tableware is also improved. In Fig. 12, the recognized tableware is indicated with a detection frame 50, and the type is further indicated as a type indication 51.

[0080]

In the embodiment 3, images from a plurality of tableware detection cameras and a method of recognizing tableware by a three-dimensional point group has been described. However, the present embodiment is not limited to this configuration. For example, a method of detecting tableware using a two-dimensional image, a method of recognizing tableware by learning control, a method of detecting a thread bottom from an image of tableware and a method of combining these methods can also be applied to the present embodiment. For example, since it is possible to detect the position and the posture of tableware even from a two-dimensional image, it is possible to recognize the tableware with the image without an AR marker, and to suck the thread bottom of the tableware with the hand 40 having the suction portion 41 of the articulated robot 12 on the basis of the image recognition to pick up the tableware.

[0081]

[Embodiment 4]

An automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to the embodiment 4 of the present invention will be described with reference to Fig. 13. Fig. 13 is a plan view of the tableware take-out section of the embodiment 4. In Fig. 13, the same reference numerals are used for the same configurations as those in Figs. 1 to 12, and the descriptions thereof will be omitted. In the embodiment 4, an example in which a container storage robot 56 is used together with the articulated robot 12 will be described.

[0082]

In a case where the tableware 11 is picked up from the tableware transport section

10 and stored in a container 57 by one articulated robot 12, for example, a 6-axis articulated robot, since the movable range of the articulated robot 12 is limited, it is difficult to horizontally stack and store tableware in the container 57. Therefore, if all the operations of picking up the tableware 11 from the tableware transport section 10 and storing tableware in the container 57 are performed by one articulated robot 12, the apparatus becomes large.

[0083]

In Fig. 13, the tableware 11 is picked up from the tableware transport section 10 and stored in the container 57 by using the container storage robot 56 together with the articulated robot 12. The articulated robot 12 picks up the tableware 11 from the tableware transport section 10 and places the tableware 11 on a relay table 55 in a state where the tableware 11 faces downward, that is, in a posture in which the thread bottom faces upward. The tableware 11 placed on the relay table 55 is contained in the container 57 by the container storage robot 56. Not particularly limited, but for example, a horizontal articulated robot can be used as the container storage robot 56.

[0084]

The articulated robot 12 and the container storage robot 56 have means for picking up the tableware 11. For example, the articulated robot 12 has the hand 40 provided with the suction portion 41, and the suction portion 41 can suck the thread bottom of the tableware 11 to pick up the tableware 11. Further, for example, the container storage robot 56 also has the suction portion 41 on the tip end side of the arm, and the suction portion 41 can suck the thread bottom of the tableware 11 to pick up the tableware 11.

[0085]

The articulated robot 12 picks up the tableware 11 transported by the tableware transport section 10 and places the tableware 11 on the relay table 55. The container storage robot 56 picks up the tableware 11 placed on the relay table 55 and stores the tableware 11 in the container 57. In Fig. 13, four containers are arranged within the range in which the container storage robot 56 can store tableware, but the number of containers is not limited to four, and one or more containers are arranged inside the range in which the container storage robot 56 can store tableware. The container storage robot 56 can store the tableware 11 in a predetermined container according to the type of the tableware 11. For example, one type of the tableware 11 can be stored in one container.

[0086]

The movable areas of the articulated robot 12 and the container storage robot 56 overlap each other around the relay table 55 and the like. Therefore, the articulated robot 12 and the container storage robot 56 are controlled to coordinate so as not to interfere with each other. In the present embodiment, the roles of the operations of the articulated robot 12 and the container storage robot 56 are clearly separated, and the scenes of interference in the

operations are limited. Therefore, for example, a simple interlock control or the like can be applied to the coordinating control of the present example, and the complicated control is not necessarily required. Further, various control methods can be adopted as this coordinating control.

[0087]

When storing the tableware 11 in the container 57, in a case where the outer shape of the tableware, that is, the width in flat stacking (for example, the radius in the case of circular tableware, the length of one side (particularly the long side) in the case of square tableware, or the like) is not surely acquired, there is a risk that the tableware 11 comes into contact with each part of the automatic tableware washing system and the tableware is damaged. If the outer shape of the tableware 11 cannot be reliably obtained, for example, if the size of the tableware is estimated by image recognition, an image acquisition section needs to be added or a computer for image processing is required, which results in high cost.

[0088]

Therefore, a screen member having a predetermined shape is provided at a predetermined position on the relay table 55. When the articulated robot 12 lowers the tableware 11 onto the relay table 55 in a flat posture, the tableware 11 is horizontally moved until the side surface of the tableware 11 is pressed against the screen member, and the position where the tableware 11 comes into contact with the screen member is detected. For this detection, various sensors such as a force sensor, a vibration sensor or an acceleration sensor that are installed on the arm end portion, the hand 40 or the like of the articulated robot 12, a load current sensor of the drive motor of the articulated robot 12, or an image acquisition section can be used. Since the position of the screen member is known in advance and the path of the articulated robot 12 can be calculated, the outer shape of the tableware can be calculated from the position where the tableware 11 picked up by the articulated robot 12 comes into contact with the screen member. Further, if the outer shape of the tableware 11 can be calculated in this way, even if the dimensions of the tableware 11 are not registered, it is possible to automate the storage of the tableware 11 in the container 57.

[0089]

[Embodiment 5]

An automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to the embodiment 5 of the present invention will be described with reference to Fig. 14. Fig. 14A is a top view of the automatic tableware washing system, and Fig. 14B is a perspective view of the automatic tableware washing system. In Fig. 14, the same reference numerals are used for the same configurations as those in Figs. 1 to 13, and the descriptions thereof will be omitted. In the embodiment 5, an example in which the container storage robot 56 is used together with the

articulated robot 12 as in the embodiment 4 will be described.

[0090]

If the articulated robot 12 is arranged beside the tableware transport section 10 (see Fig. 13), it is difficult for the hand 40 of the articulated robot 12 to reach the area around the end of the tableware transport section 10 on the opposite side to the installation side of the articulated robot 12, and thus the range in which the posture can be taken is narrowed. As a result, if the articulated robot 12 is arranged beside the tableware transport section 10, it may be difficult to pick up the tableware 11 depending on the transport area of the tableware 11 in the tableware transport section 10.

[0091]

Further, if the articulated robot 12 is arranged beside the tableware transport section 10, the entire system becomes large, and the space efficiency becomes low.

[0092]

The automatic tableware washing system of the present embodiment includes a transport section straddling stand 70 for installing the articulated robot 12 at a position straddling the tableware transport section 10 in the lateral width direction of the tableware transport section 10.

[0093]

The transport section straddling stand 70 has a gate shape, and the articulated robot 12 is fixed to a wall bridging the upper portions. In the present embodiment, the articulated robot 12 is fixed to the transport section straddling stand 70 so that the movable range of the articulated robot 12 is a symmetrical range with the center of the symmetry being the center of the tableware transport section 10 in the lateral width direction.

[0094]

In the automatic tableware washing system of the present embodiment 5, since the articulated robot 12 is fixed to the transport section straddling stand 70 so that the movable range of the articulated robot 12 is a symmetrical range with the center of the symmetry being the center of the tableware transport section 10 in the lateral width direction, the articulated robot 12 can pick up the tableware 11 in a wide range in the width direction of the tableware transport section 10, and can easily take various postures.

[0095]

Further, in the automatic tableware washing system of the present embodiment 5, since the articulated robot 12 is arranged near and above the exit of the tableware transport section 10, around which the space has not been effectively utilized so far, it is possible to make the entire system compact and not to make the articulated robot 12 occupy the passage so that the space can be saved.

[0096]

[Embodiment 6]

An automatic tableware washing system, an automatic tableware washing method, an automatic tableware washing program and a storage medium according to the embodiment 6 of the present invention will be described with reference to Fig. 15. Fig. 15 is a diagram showing the vicinity of the relay table 55 of the automatic tableware washing system. In Fig. 15, the same reference numerals are used for the same configurations as those in Figs. 1 to 14, and the descriptions thereof will be omitted.

[0097]

When the articulated robot 12 picks up the tableware 11 and places the tableware 11 facing downward on the relay table 55, if the type of the tableware 11 and the height of the tableware 11 are recognized, the tableware 11 can be placed with the height of the tableware 11 being adjusted to the height of the relay table 55. However, if the type of the tableware 11 is erroneously recognized, the tableware 11 may be pressed against the relay table 55 or the tableware 11 may be dropped from above the relay table 55.

If the type of the tableware 11 is erroneously recognized in this way, the tableware 11 may be damaged or the position of the tableware 11 on the relay table 55 may be significantly displaced, so that there is a problem that the container storage robot 56 cannot properly operate.

Such a problem can be solved by reducing the speed of the articulated robot 12 and increasing the certainty of the recognition of the tableware 11, but the performance of processing the tableware 11 is lowered.

[0098]

The automatic tableware washing system of the present embodiment includes a detector 80 that detects that the tableware 11 crosses a horizontal plane separately arranged above the relay table 55 by a predetermined interval.

[0099]

The detector 80 is realized by, for example, a transmissive sensor. If a transmissive sensor is used as the detector 80, the detector 80 projects a linear laser onto, for example, a horizontal plane a few centimeters above the relay table 55 to detect that the tableware 11 crosses the laser.

[0100]

In the automatic tableware washing system, when the articulated robot 12 picks up the tableware 11 and places the tableware 11 facing downward on the relay table 55, even in a case where the type of the tableware 11 is not recognized or the height of the tableware 11 is not recognized, at the timing when the detector 80 detects that the tableware 11 crosses the horizontal plane separately arranged above the relay table 55 by a predetermined interval, the speed of the articulated robot 12 is reduced and the height of the tableware 11 is estimated.

As a result, the tableware 11 can be placed according to the height of the relay table 55.

[0101]

In the automatic tableware washing system of the present embodiment 6, the detector 80 detects that the tableware 11 crosses the horizontal plane separately arranged above the relay table 55 by a predetermined interval, so that the tableware 11 can be placed according to the height of the relay table 55 without relying on image recognition of the tableware 11, and the tableware 11. Therefore, the tableware 11 can be processed at high speed and reliably.

[0102]

Although some embodiments of the present invention have been described above, these embodiments only exemplify an automatic tableware washing system for embodying the technical concept of the present invention, and the present invention is not limited to these embodiments. The present invention can be equally applied to other embodiments, and it is possible to omit, add or change a part of these embodiments, or to combine the aspect of each embodiment.

[Reference Signs List]

[0103]

- 1 tableware input section
- 2 tableware washing section
- 3 tableware take-out section
- 10 tableware transport section
- 11 tableware
- 12 articulated robot
- 13 tableware placement section
- 14 tableware information acquisition section
- 30 tableware take-out calculation section
- 31 tableware position/posture detection section
- 32 tableware take-out order plan section
- 33 tableware take-out operation command section
- 35 image acquisition section
- 36 tableware input section
- 37 tableware transport section
- 38 tableware washing section
- 40, 40C hand
- 41 suction portion
- 41A first suction portion

41B	second suction portion
42	AR marker
45	extending portion
46	hand mounting portion
47	vacuum hose
48	hand-side vacuum hose mounting portion
49	joining portion
50	detection frame
51	type indication
55	relay table
56	container storage robot 56
57	container
60	spring mechanism
61	ball joint
62	force sensor
70	transport section straddling stand
80	detector

[Document Name] Claims

[Claim 1]

An automatic tableware washing system comprising:

a tableware washing section for washing tableware input from a tableware input section from which the tableware is input;

a tableware transport section for transporting the tableware washed in the tableware washing section;

a tableware information acquisition section for using a plurality of image acquisition sections to identify the tableware transported by the tableware transport section and to acquire information on the tableware;

a tableware placement section, on which the tableware transported by the tableware transport section is placed; and

a tableware pick-up section for picking up the tableware from the tableware transport section and placing the tableware on the tableware placement section, wherein

the information acquired by the tableware information acquisition section includes at least a position of the tableware, and posture of the tableware, and wherein

when the tableware information acquisition section identifies the tableware being transported by the tableware transport section, the tableware information acquisition section keeps tracking the position and the posture of the identified tableware by mixing the information of the identified tableware measured by the plurality of image acquisition sections, and the tableware pick-up section uses the information including the position and the posture of the identified tableware to pick up the tableware in a state where the tableware is being transported by the tableware transport section.

[Claim 2]

An automatic tableware washing system comprising:

a tableware washing section for washing tableware input from a tableware input section from which the tableware is input;

a tableware transport section for transporting the tableware washed in the tableware washing section;

a tableware information acquisition section for identifying the tableware transported by the tableware transport section and acquiring information on the tableware;

a tableware placement section on which the tableware transported by the tableware transport section is placed; and

a tableware pick-up section for using an articulated robot to pick up the tableware from the tableware transport section and to place the tableware on the tableware placement

section, wherein

the information acquired by the tableware information acquisition section includes at least a position of the tableware, and posture of the tableware, and wherein

when the tableware information acquisition section identifies the tableware being transported by the tableware transport section, the tableware pick-up section simulates a range of a motion of the articulated robot based on the information including the position and the posture of the tableware acquired by the tableware information acquisition unit, and when the articulated robot has a joint which have possibility of exceeding a movable range, first the angle of the joint is adjusted to an angle close to the goal angle, and then the articulated robot is drive controlled to the position where the tableware is picked up.

[Claim 3]

An automatic tableware washing system comprising:

a tableware washing section for washing tableware input from a tableware input section from which the tableware is input;

a tableware transport section for transporting the tableware washed in the tableware washing section;

a tableware information acquisition section for identifying the tableware transported by the tableware transport section and acquiring information on the tableware;

a tableware placement section on which the tableware transported by the tableware transport section is placed; and

a tableware pick-up section for using an articulated robot with a force sensor to pick up the tableware from the tableware transport section and to place the tableware on the tableware placement section,

wherein

the information acquired by the tableware information acquisition section includes at least any one of a type of the tableware, size of the tableware, a shape of the tableware, color of the tableware, a position of the tableware, posture of the tableware, orientation of the tableware, a marker attached to the tableware, or a code attached to the tableware, and wherein

when the tableware information acquisition section identifies the tableware being transported by the tableware transport section, the tableware pick-up section picks up the tableware according to a state of the tableware on the basis of the information acquired by the tableware information acquisition section and the information of the force to be pressed detected by the force sensor, and the position and the posture of the picked-up tableware are controlled to follow the direction according to the state of the tableware placement section.

[Claim 4]

The automatic tableware washing system according to claim 2 or 3, wherein the tableware information acquisition section includes one or more image acquisition section.

[Claim 5]

The automatic tableware washing system according to any one of claims 1 to 4, wherein the tableware information acquisition section includes an imaging section and can acquire the information on the tableware from one or a plurality of images acquired by the imaging sections.

[Claim 6]

The automatic tableware washing system according to any one of claims 1 to 5, wherein the tableware pick-up section picks up the tableware in a state where the tableware is being transported by the tableware transport section.

[Claim 7]

The automatic tableware washing system according to any one of claims 1 to 6, wherein if the information acquired by the tableware information acquisition section is a marker,

the marker is provided by at least any one of

- (1) being attached as a sticker,
- (2) being formed by laser processing,
- (3) being printed,
- (4) being coated, or
- (5) attaching another member on which the marker is printed.

[Claim 8]

The automatic tableware washing system according to any one of claims 1 to 7, wherein the tableware is identified in a state where the tableware is not provided with a marker.

[Claim 9]

The automatic tableware washing system according to any one of claims 1 to 8, wherein the tableware information acquisition section or the tableware pick-up section predicts the position of the tableware.

[Claim 10]

The automatic tableware washing system according to any one of claims 1 to 9, wherein the tableware pick-up section includes an elastic member.

[Claim 11]

The automatic tableware washing system according to any one of claims 1 to 10, wherein at least any one of the tableware input section, the tableware information acquisition section, or the tableware pick-up section is controlled by using machine learning.

[Claim 12]

The automatic tableware washing system according to any one of claims 1 to 11, wherein the tableware pick-up section includes an articulated robot for picking up the tableware using a suction portion, and wherein

the suction portion includes a plurality of suction portions in which suction directions thereof are different.

[Claim 13]

The automatic tableware washing system according to any one of claims 1 to 12, a container storage robot is further used to store the tableware in a container.

[Claim 14]

An automatic tableware washing method including:

a tableware washing process for washing input tableware;

a tableware transport process for transporting the tableware washed in the tableware washing process;

a tableware information acquisition process for using a plurality of image acquisition sections to identify the tableware transported in the tableware transport process and to acquire information on the tableware; and

a tableware pick-up process for picking up the tableware being transported in the tableware transport process and placing the picked-up tableware, wherein

the information acquired in the tableware information acquisition process includes at least a position of the tableware, and posture of the tableware, and wherein

when the tableware being transported in the tableware transport process is identified in the tableware information acquisition process, the position and the posture of the identified tableware keep being tracked by mixing the information of the identified tableware measured by the plurality of image acquisition sections, and, in the tableware pick-up process, the information including the position and the posture of the tracked tableware is used to pick up

the tableware, which is transported by the tableware transport section.

[Claim 15]

An automatic tableware washing method including:

a tableware washing process for washing input tableware;

a tableware transport process for transporting the tableware washed in the tableware washing process;

a tableware information acquisition process for identifying the tableware transported in the tableware transport process and acquiring information on the tableware; and

a tableware pick-up process for using an articulated robot to pick up the tableware being transported in the tableware transport process and to place the picked-up tableware, wherein

the information acquired in the tableware information acquisition process includes at least a position of the tableware, and posture of the tableware, and wherein

when the tableware being transported in the tableware transport process is identified in the tableware information acquisition process, in the tableware pick-up process, a range of a motion of the articulated robot is simulated based on the information including the position and the posture of the tableware acquired by the tableware information acquisition unit, and when the articulated robot has a joint which have possibility of exceeding a movable range, first the angle of the joint is adjusted to an angle close to the goal angle, and then the articulated robot is drive controlled to the position where the tableware is picked up.

[Claim 16]

An automatic tableware washing method including:

a tableware washing process for washing input tableware;

a tableware transport process for transporting the tableware washed in the tableware washing process;

a tableware information acquisition process for identifying the tableware transported in the tableware transport process and acquiring information on the tableware; and

a tableware pick-up process for using an articulated robot with a force sensor to pick up the tableware being transported in the tableware transport process and to place the picked-up tableware on the tableware placement section, wherein

the information acquired in the tableware information acquisition process includes at least any one of a type of the tableware, size of the tableware, a shape of the tableware, color of the tableware, a position of the tableware, posture of the tableware, orientation of the tableware, a marker attached to the tableware, or a code attached to the tableware, and wherein

when the tableware being transported in the tableware transport process is identified in the tableware information acquisition process, in the tableware pick-up process, the tableware is picked up according to a state of the tableware on the basis of the information acquired in the tableware information acquisition process and the information of the force to be pressed detected by the force sensor, and the position and the posture of the picked-up tableware are controlled to follow the direction according to the state of the tableware placement section.

[Claim 17]

An automatic tableware washing program, characterized in that each process in the automatic tableware washing method according to any one of claims 14 to 16 can be executed by a computer section.

[Claim 18]

A storage medium storing the automatic tableware washing program according to claim 17.