DESCRIPTION

TITLE OF THE INVENTION:

GRASPING DEVICE AND GRASPING METHOD

Field

[0001] The present disclosure relates to a grasping device and a grasping method, for grasping an item.

Background

[0002] There is known a transport apparatus such as a palletizing apparatus that stacks an item on a tray such as a pallet. The palletizing apparatus is, for example, a robot having an articulated arm. The articulated arm has a front end portion to which a hand to pick up the item is mounted. As the hand, a suction portion capable of holding an upper surface of the item by suction or a pair of grasp portions capable of grasping side portions of the item is known. An example of the palletizing apparatus having a plurality of types of the hands is described in Patent Literature 1.

Citation List

Patent Literature

[0003] Patent Literature 1: JP 7127830 B2

Summary

Technical Problem

[0004] The palletizing apparatus of Patent Literature 1 has a hand body provided with a suction head and a pair of grasp portions, and is configured to handle a plurality of types of items. However, the palletizing apparatus of Patent Literature 1 provided with the suction head and the pair of grasp portions at the hand body has a problem that the structure is complicated.

[0005] The present disclosure has been made to solve the above-described problems, and an object of the present disclosure is to provide a grasping device and a grasping method that provide a simplified structure and provide improved transportability by using an appropriate hand according to the type of item.

Solution to Problem

[0006] To achieve the above object, a grasping device according to the present

disclosure includes: a grasping device body; an upper-surface suction portion that is removably mounted to the grasping device body and has a first suction surface that is capable of holding an upper surface of an item by suction; a side-surface grasp portion that is removably mounted to the grasping device body and has a first grasp portion and a second grasp portion that are capable of grasping an outside surface of the item; and a control device that selects any one of the upper-surface suction portion and the side-surface grasp portion based on transport target data of the item, and sets transport parameters for the selected upper-surface suction portion or side-surface grasp portion.

[0007] A grasping method according to the present disclosure uses a grasping device including: a grasping device body; an upper-surface suction portion that is capable of being removably mounted to the grasping device body and has a first suction surface that is capable of holding an upper surface of an item by suction; and a side-surface grasp portion that is capable of being removably mounted to the grasping device body and has a first grasp portion and a second grasp portion that are capable of grasping an outside surface of the item. The grasping method includes the steps of: selecting any one of the upper-surface suction portion and the side-surface grasp portion based on transport target data of the item; setting transport parameters for the selected upper-surface suction portion or side-surface grasp portion; and mounting the selected upper-surface suction portion or side-surface grasp portion to the grasping device body.

Advantageous Effects of Invention

[0008] According to the grasping device and the grasping method of the present disclosure, the structure can be simplified, and the transportability can be improved by using the appropriate hand according to the type of item.

Brief Description of Drawings

[0009] FIG. 1 is a schematic diagram illustrating a grasping device according to a first embodiment.

FIG. 2 is a block diagram illustrating the grasping device of the first embodiment.

FIG. 3 is a schematic diagram illustrating a selection processing map for a hand according to a form of an item.

FIG. 4 is a flowchart illustrating a procedure of a process of a control device.

FIG. 5 is a flowchart illustrating a procedure of a process of the control device in

the grasping device according to a second embodiment.

FIG. 6 is a block diagram illustrating the grasping device of a third embodiment.

FIG. 7 is a flowchart illustrating a procedure of a process of the control device.

FIG. 8 is a flowchart illustrating a procedure of a process of the control device in the grasping device according to a fourth embodiment.

FIG. 9 is a schematic diagram for illustrating a determination index for items.

Description of Embodiments

[0010] Hereinafter, embodiments according to the present disclosure will be described in detail with reference to the drawings. It is noted that the present invention is not limited to the embodiments. In addition, component elements in the following embodiments include ones that can be readily replaced by those skilled in the art, substantially the same ones, or ones within the range of equivalence. Furthermore, various omissions, substitutions, or changes of the component elements in the following embodiments can be made without departing from the scope of the present disclosure. In the following embodiments, component elements necessary to exemplify the embodiments are described, the other components are omitted, the same component elements are denoted by the same reference numerals, and different component elements are denoted by different reference numerals.

[0011] [First Embodiment]

<Configuration of grasping device>

FIG. 1 is a schematic diagram illustrating a grasping device according to a first embodiment.

[0012] As illustrated in FIG. 1, the grasping device 10 according to the first embodiment is mounted to a front end portion of an arm of a palletizing apparatus, which is not illustrated. The palletizing apparatus is, for example, a robot having an articulated arm, and the grasping device 10 is mounted to a front end portion of the articulated arm. The grasping device 10 includes a base portion (grasping device body) 11, an upper-surface suction portion 12, and a side-surface grasp portion 13. The base portion 11 is mounted to the front end portion of the articulated arm. The upper-surface suction portion 12 and the side-surface grasp portion 13 each function as a hand to pick up an item R. The upper-surface suction portion 12 and the side-surface grasp portion 13 are removably mounted to the base portion 11, and are appropriately

selectively mounted according to a form of the item R.

[0013] In the present embodiment, the item R is stacked on a pallet (not illustrated), has an upper surface Ra on an upper side in a vertical direction, a side surface (outside surface) Rb on a side in a horizontal direction orthogonal to the vertical direction, and a lower surface Rc on a lower side in the vertical direction.

[0014] The base portion 11 is mounted to the front end portion of the articulated arm. The base portion 11 is swingably supported about a swing axis O1 relative to the front end portion of the articulated arm. In addition, the base portion 11 is capable of being raised and lowered in the vertical direction according to the operation of the articulated arm.

[0015] The upper-surface suction portion 12 is removably provided at the base portion 11. The base portion 11 includes a mounting/dismounting mechanism, which is not illustrated, and the upper-surface suction portion 12 is mountable/dismountable by the mounting/dismounting mechanism. The upper-surface suction portion 12 has a first opposed surface 12a opposed to the upper surface Ra of the item R, on a lower surface. The upper-surface suction portion 12 is mounted to the base portion 11 so that the first opposed surface 12a is a surface orthogonal to the swing axis O1. The upper-surface suction portion 12 swings according to a swinging operation of the base portion 11, and rises and lowers according to a rising/lowering operation thereof. The upper-surface suction portion 12 has a first suction portion 21 that is capable of holding the upper surface Ra of the item R by suction, on the first opposed surface 12a.

[0016] The first suction portion 21 has, for example, one or a plurality of suction pads protruding downward from the first opposed surface 12a of the upper-surface suction portion 12. The first suction portion 21 includes a lower surface provided with a first suction surface 21a. In the first suction portion 21, application of a suction force on the first suction surface 21a being abutting on the upper surface Ra of the item R enables the first suction surface 21a to hold the upper surface Ra of the item R by suction.

[0017] The side-surface grasp portion 13 is removably provided at the base portion 11. The base portion 11 enables mounting and dismounting of the side-surface grasp portion 13 by using the mounting/dismounting mechanism. The side-surface grasp portion 13 has a first grasp portion 22 and a second grasp portion 23 that are capable of

grasping the side surface Rb of the item. The side-surface grasp portion 13 is arranged so that the first grasp portion 22 and the second grasp portion 23 each hang downward in the vertical direction. The first grasp portion 22 and the second grasp portion 23 each have an upper end movably supported by the side-surface grasp portion 13. The first grasp portion 22 and the second grasp portion 23 are supported by the side-surface grasp portion 13 so that the first grasp portion 22 and the second grasp portion 23 may approach and move away from each other. The first grasp portion 22 and the second grasp portion 23 have substantially the same configuration.

[0018] The first grasp portion 22 and the second grasp portion 23 have a first grasping surface 22a and a second grasping surface 23a that are opposed to the side surfaces Rb on the left and right sides of the item R, respectively. The first grasping surface 22a and the second grasping surface 23a are surfaces opposed to each other and parallel to each other. The side-surface grasp portion 13 is mounted to the base portion 11 so that the first grasping surface 22a and the second grasping surface 23a are parallel to the swing axis O1. The side-surface grasp portion 13 swings according to the swinging operation of the base portion 11, and rises and lowers according to the rising/lowering operation thereof. In the side-surface grasp portion 13, when a pressing force is applied to the item R so that the first grasping surface 22a of the first grasp portion 22 and the second grasping surface 23a of the second grasp portion 23 approach each other while the first grasping surface 22a and the second grasping surface 23a are in abutment on the left and right side surfaces Rb of the item R, respectively, it is possible to grasp the side surfaces Rb of the item R by the first grasping surface 22a and the second grasping surface 23a so that the side surfaces Rb are held therebetween.

[0019] Note that the side-surface grasp portion 13 is not limited to the configuration described above. The side-surface grasp portion 13 may have the first grasp portion 22 and the second grasp portion 23 that are capable of grasping the side surfaces Rb of the item so that the upper end portions of the first grasp portion 22 and the second grasp portion 23 may be turnably supported to the side-surface grasp portion 13. In this configuration, the first grasp portion 22 and the second grasp portion 23 turn downward relative to the side-surface grasp portion 13, and when the pressing force is applied to the item R so that the first grasping surface 22a and the second grasping surface 23a approach each other, it is possible to grasp the side surfaces Rb of the item R by the first

grasping surface 22a and the second grasping surface 23a so that the side surfaces Rb are held therebetween.

[0020] The grasping device 10 may include a side surface suction portion 14. The side surface suction portion 14 functions as the hand that picks up the item R together with the upper-surface suction portion 12. The side surface suction portion 14 is mounted to the upper-surface suction portion 12, but may be removably mounted to the base portion 11, separately from the upper-surface suction portion 12. The side surface suction portion 14 is mounted to a side portion of the upper-surface suction portion 12 so as to be vertically turnable by a turning mechanism 24. The side surface suction portion 14 is turnable between a vertical position and an inclined position turned upward relative to the vertical direction, by the turning mechanism 24. In other words, the side surface suction portion 14 is supported by the turning mechanism 24 so as to approach and move away from a side surface Rb of the item R.

[0021] The side surface suction portion 14 includes a second opposed surface 14a opposed to the side surface Rb of the item R. When stopped at the vertical position by the turning mechanism 24, the side surface suction portion 14 is mounted to the base portion 11 so that the second opposed surface 14a has a surface parallel to the swing axis O1. The side surface suction portion 14 swings according to the swinging operation of the base portion 11, and rises and lowers according to the rising/lowering operation thereof. The side surface suction portion 14 includes a second suction portion 25 that is capable of holding the side surface Rb of the item R by suction, on the second opposed surface 14a.

[0022] The second suction portion 25 has, for example, one or a plurality of suction pads protruding laterally from the second opposed surface 14a of the side surface suction portion 14. The second suction portion 25 includes a side surface provided with a second suction surface 25a. In the second suction portion 25, application of a suction force on the second suction surface 25a being abutting on the side surface Rb of the item R enables the second suction surface 25a to hold the side surface Rb of the item R by suction.

[0023] The grasping device 10 may include a lower-surface support portion 15. The lower-surface support portion 15 functions as the hand to pick up the item R together with the upper-surface suction portion 12 or the side-surface grasp portion 13. The

lower-surface support portion 15 may be supported by the upper-surface suction portion 12 or the side-surface grasp portion 13, or may be removably mounted to the base portion 11 separately from the upper-surface suction portion 12 and the side-surface grasp portion 13. The lower-surface support portion 15 has a first support portion 26 and a second support portion 27 that are capable of supporting the lower surface Rc of the item. The first support portion 26 and the second support portion 27 are supported by the lower-surface support portion 15 so that the first support portion 26 and the second support portion 27 may be raised and lowered and may approach and move away from each other.

[0024] The lower-surface support portion 15 swings according to the swinging operation of the base portion 11, and rises and lowers according to the rising/lowering operation thereof. In the lower-surface support portion 15, the first support portion 26 and the second support portion 27 are capable of supporting the lower surface Rc of the item R while the first support portion 26 and the second support portion 27 are positioned below the lower surface Rc of the item R.

[0025] FIG. 2 is a block diagram illustrating the grasping device of the first embodiment.

[0026] As illustrated in FIGS. 1 and 2, the grasping device 10 further includes a swivel mechanism 31, a lifting mechanism 32, a first suction mechanism 33, a second suction mechanism 34, a grasping mechanism 35, and a support mechanism 36.

[0027] The swivel mechanism 31 turns the base portion 11 about the swing axis O1. For example, when the palletizing apparatus is a multi-axis robot, turning of the base portion 11 by the swivel mechanism 31 corresponds to the operation of the multi-axis robot. The swivel mechanism 31 is implemented by known mechanisms such as a rotary actuator including a motor, a rack-and-pinion mechanism including an air cylinder, and a wire or a link mechanism.

[0028] The lifting mechanism 32 moves the base portion 11 in the vertical direction. For example, when the palletizing apparatus is the multi-axis robot, movement of the base portion 11 by the lifting mechanism 32 is implemented by cooperative operation between a plurality of axes of the multi-axis robot. When the palletizing apparatus is a Cartesian coordinate robot, movement of the base portion 11 by the lifting mechanism 32 corresponds to the operation of a prismatic joint of the Cartesian coordinate robot in

the vertical direction. In this configuration, the lifting mechanism 32 is implemented by known mechanisms such as a linear actuator including a motor, an air cylinder, and the like, and a rack-and-pinion mechanism.

[0029] The first suction mechanism 33 is configured to operate the upper-surface suction portion 12. The first suction mechanism 33 includes, for example, a vacuum generator that is connected to the first suction surface 21a via air piping, not illustrated, to suck air from the first suction surface 21a. For example, when the first suction portion 21 includes the plurality of suction pads, each of the suction pads is connected to the first suction mechanism 33 that is the vacuum generator, via the air piping.

[0030] The second suction mechanism 34 is configured to operate the side surface suction portion 14. The second suction mechanism 34 includes, for example, a vacuum generator that is connected to the second suction surface 25a via air piping, not illustrated, to suck air from the second suction surface 25a. For example, when the second suction portion 25 includes the plurality of suction pads, each of the suction pads is connected to the second suction mechanism 34 that is the vacuum generator, via the air piping.

[0031] The grasping mechanism 35 is configured to operate the side-surface grasp portion 13. The grasping mechanism 35 moves the first grasp portion 22 and the second grasp portion 23 so that the first grasp portion 22 and the second grasp portion 23 may approach and move away from each other. The grasping mechanism 35 is implemented by known mechanisms such as a rotary actuator including a motor, a rack-and-pinion mechanism including an air cylinder, and a wire or a link mechanism.

[0032] The support mechanism 36 is configured to operate the lower-surface support portion 15. The support mechanism 36 moves the first support portion 26 and the second support portion 27 so that the first support portion 26 and the second support portion 27 may be raised and lowered and may approach and move away from each other. The support mechanism 36 is implemented by known mechanisms such as a rotary actuator including a motor, a rack-and-pinion mechanism including an air cylinder, and a wire or a link mechanism.

[0033] In addition, the grasping device 10 includes a control device 41, an imaging device 42, an input/output device 43, and an accumulation unit 44. Note that in the present embodiment, "the grasping device 10 includes a control device 41, an imaging

device 42, an input/output device 43, and an accumulation unit 44" also includes a mode in which each function of each of the devices is included as a function of a part of the palletizing apparatus to which the grasping device 10 is mounted or a transport system in which the palletizing apparatus is arranged.

[0034] The imaging device 42 images at least the item R stacked on the pallet, and outputs image data enabling identification of a position of an imaging target or identification of an individual, to the control device 41. The imaging device 42 is arranged at least at a position where the item R stacked on the pallet can be observed. At this time, the imaging device 42 may be mounted to the grasping device 10 or may be arranged separately from the grasping device 10. The imaging device 42 includes one or a plurality of cameras.

[0035] The input/output device 43 includes an input device to which an operator inputs various information for operating the grasping device 10, and an output device for presenting the various information to the operator. The input device is implemented by, for example, a keyboard, a mouse, a physical switch, a button, a touch screen, or the like. The output device is implemented by, for example, a display device including a liquid crystal display device, an organic electro luminescence (EL) display device, or the like, a light emission device including a light emitting diode (LED) or the like or a speaker, or the like. The input/output device 43 may be an information terminal enabling inputting and outputting of various information.

[0036] The accumulation unit 44 is connected to the control device 41, and transmits and receives various data to and from the control device 41. The accumulation unit 44 accumulates transport parameters (minimum operation condition), according to operation condition items. The control device 41 is configured to rewrite each of the transport parameters of the accumulation unit 44 as needed.

[0037] The control device 41 is a computer that controls the grasping device 10. The control device 41 includes a communication unit 51, a storage unit 52, a control unit 53, and a determination unit 54. The control device 41 is connected to a management device 61. The communication unit 51 is a module used by the control unit 53 to communicate with an external device such as the management device 61, and may include, for example, an antenna or the like. A communication method used by the communication unit 51 is assumed to be wireless communication in the present

embodiment, but any communication method may be used. The storage unit 52 is a memory that stores calculation contents and programs of the control unit 53 and various information acquired from the management device 61 via the communication unit 51, and includes, for example, at least one of a main storage device such as a random access memory (RAM) and a read only memory (ROM), and an external storage device such as a hard disk drive (HDD).

[0038] The control unit 53 is an arithmetic processing device, and includes, for example, an arithmetic circuit such as a central processing unit (CPU). The control unit 53 reads a program (software) from the storage unit 52 and executes the program to perform various processing. Note that the control unit 53 may perform processing by one CPU, or may include a plurality of CPUs to perform processing by using the plurality of CPUs.

[0039] The control unit 53 acquires upstream data from the management device 61 via the communication unit 51. The upstream data includes, for example, transport target data such as the type, weight, and size of the item R stacked on the pallet, the presence or absence (length) of perforation of a box, the presence or absence (length) of a zipper, the number of glue spots, side flaps, and package (presence or absence of shrink package). The control unit 53 causes the imaging device 42 to perform imaging at any timing to acquire the image data. The control unit 53 performs image processing on the acquired image data, and recognizes a state of the item R in the image data.

[0040] The control unit 53 determines the transport parameters of the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, on the basis of the image data and the transport target data. In this case, there is no need to use the image data. Here, the transport parameters include a speed and acceleration of swing by the swivel mechanism 31, a speed and acceleration of rising by the lifting mechanism 32, a pressure and time of holding the item R by the first suction mechanism 33, a pressure and time of holding the item R by the second suction mechanism 34, a pressure and time of pressing the item R by the grasping mechanism 35, a time of supporting the item R by the support mechanism 36, and the like.

[0041] Note that a reference value of each of the transport parameters for the transport target data is set in advance. The control unit 53 controls the swivel mechanism 31,

the lifting mechanism 32, the first suction mechanism 33, the second suction mechanism 34, the grasping mechanism 35, and the support mechanism 36, on the basis of the transport parameters having been set. Furthermore, the control unit 53 performs control for moving the grasping device 10 itself in a horizontal direction, in the palletizing apparatus to which the grasping device 10 is mounted. When the palletizing apparatus is an articulated robot, movement of the grasping device 10 itself in the horizontal direction is implemented by cooperative operation between a plurality of axes of the articulated robot.

[0042] The determination unit 54 is an arithmetic processing device similarly to the control unit 53, and includes, for example, an arithmetic circuit such as a central processing unit (CPU). The determination unit 54 reads a program (software) from the storage unit 52 and executes the program to perform various processing. Note that the determination unit 54 may be integrated with the control unit 53 so as to be provided as one of the functions of the control unit 53.

[0043] The determination unit 54 selects a hand most suitable for picking the item R to be transported, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, on the basis of the transport target data of the item R. The determination unit 54 outputs a determination result to the control unit 53. The control unit 53 controls the grasping device 10 to mount the selected hand to the base portion 11. In the first embodiment, the transport target data of the item R is data such as the type, weight, and size of the item R, the presence or absence (the length) of the perforation of the box, the presence or absence (the length) of the zipper, the number of glue spots, the side flaps, and the package (the presence or absence of the shrink package) that have been acquired as the upstream data from the management device 61. However, the transport target data of the item R is not limited thereto.

[0044] The determination unit 54 estimates difficulty in suction by the upper-surface suction portion 12, that is, suction difficulty, on the basis of the transport target data of the item R, and determines whether it is possible to pick the item R only by the upper-surface suction portion 12, whether the side surface suction portion 14 is needed in addition to the upper-surface suction portion 12, whether it is impossible to perform picking by the upper-surface suction portion 12 and the side surface suction portion 14

without the side-surface grasp portion 13, or whether the lower-surface support portion 15 is needed.

[0045] For example, the suction difficulty of the upper-surface suction portion 12 is set according to the type of the item R. Here, when the item R is a cardboard box, it is easy for the upper-surface suction portion 12 to suck the item R. When the item R is a plastic package, it is easy for the upper-surface suction portion 12 to suck the item R. When the item R is a sheet bundle, it is difficult for the upper-surface suction portion 12 to suck the item R. When the item R is a bag, it is easy for the upper-surface suction portion 12 to suck the item R. When the item R is a wooden box, it is difficult for the upper-surface suction portion 12 to suck the item R. When the item R is a frozen box, it is easy for the upper-surface suction portion 12 to suck the item R. In other words, when the first suction surface 21a of the upper-surface suction portion 12 abuts on the upper surface Ra of the item R and the suction force is applied to the first suction surface 21a, if the suction force leaks from the first suction surface 21a according to the shape of the upper surface Ra of the item R, it is difficult to suck the item R.

[0046] Furthermore, the increasing weight of the item R makes it difficult for the upper-surface suction portion 12 to suck the item R. The increasing size of the item R makes it difficult for the upper-surface suction portion 12 to suck the item R. When the box of the item R has perforation, as the length of the perforation increases, it is difficult for the upper-surface suction portion 12 to suck the item R. When the item R has the zipper, as the length of the zipper increases, it is difficult for the upper-surface suction portion 12 to suck the item R. The increasing number of glue spots of the item R makes it difficult for the upper-surface suction portion 12 to suck the item R. The increasing number of side flaps of the item R makes it difficult for the upper-surface suction portion 12 to suck the item R. When the item R is a shrink package, it is difficult for the upper-surface suction portion 12 to suck the item R.

[0047] The determination unit 54 selects and determines a hand suitable for picking the item R, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, on the basis of the transport target data such as the type, weight, and size of the item R. Note that the determination unit 54 selects a suitable hand, on the basis of one piece of data or a plurality of pieces of data of the transport target data.

[0048] In addition, the determination unit 54 may estimate the difficulty in suction by the upper-surface suction portion 12, that is, the hardness of the item R, on the basis of the transport target data of the item R, and select a hand suitable for picking the item R, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15. In other words, when the hardness of the item R decreases, it is difficult for the upper-surface suction portion 12 to suck the item R.

[0049] FIG. 3 is a schematic diagram illustrating a selection processing map for a hand according to a form of an item.

[0050] FIG. 3 is a map for selection processing for a hand based on a relationship between the hardness of the item R and unevenness of the upper surface. The hardness of the item R is a degree of hardness of the upper surface Ra, and is estimated on the basis of data such as the type and size of the item R, the presence or absence (the length) of the perforation of the box, the presence or absence (the length) of the zipper, the number of glue spots, the side flaps, and the package (the presence or absence of the shrink package). In addition, the unevenness of the upper surface of the item R is a height of the unevenness of the upper surface Ra, and is estimated on the basis of data such as the type of the item R, the presence or absence (length) of the perforation of the box, the presence or absence (length) of the zipper, and the package (the presence or absence of the shrink package).

[0051] As illustrated in FIG. 3, as a numerical value of the hardness (the degree of hardness) of the item R is higher and a numerical value of the unevenness of the upper surface is lower, it is easy for the upper-surface suction portion 12 to suck the upper surface Ra of the item R, and therefore, a region of a pattern P1 is indicated, and the upper-surface suction portion 12 is selected as the hand. As the numerical value of the hardness (the degree of hardness) of the item R is lower and the numerical value of the unevenness of the upper surface is higher, it is difficult for the upper-surface suction portion 12 to suck the upper surface Ra of the item R, and therefore, a region of a pattern P3 is indicated, and the side-surface grasp portion 13 is selected as the hand. Then, in the region of a pattern P2 between the region of the pattern P1 and the region of the pattern P3, the upper-surface suction portion 12 and the side surface suction portion 14 are selected.

[0052] The management device 61 is a system that manages the operation of each device in a logistics facility in which the grasping device 10 of the present embodiment is arranged. The management device 61 is, for example, a warehouse control system (WCS) or a warehouse management system (WMS), but is not limited to the WCS and the WMS and may be any system, for example, a back-end system such as another production management system. The management device 61 may be provided at any place, and may be provided in the facility where the grasping device 10 is provided, or may be provided at a position distant from the facility to manage the facility from the distant position.

[0053] <Process of control device>

FIG. 4 is a flowchart illustrating a procedure of a process of the control device.

[0054] A description will be made of a procedure of the process of selecting a hand suitable for picking the item R, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, by the control device 41, in transport by the grasping device 10. Note that the process illustrated in FIG. 4 is performed by the control device 41 on the basis of a program and data stored in the storage unit 52 in advance. For example, the control device 41 receives a predetermined control signal giving an instruction for driving of the grasping device 10, from the management device 61, thereby proceeding to Step S11 illustrated in FIG. 4 and starting the process.

[0055] As illustrated in FIGS. 1, 2, and 4, in Step S11, the control device 41 acquires the transport target data. In the present embodiment, the control device 41 acquires the transport target data from the management device 61 via the communication unit 51. In the present processing, the transport target data is data such as the type, weight, and size of the item R, the presence or absence (the length) of the perforation of the box, the presence or absence (the length) of the zipper, the number of glue spots, the side flaps, and the package (the presence or absence of the shrink package).

[0056] In Step S12, the control device 41 acquires captured image data. In the present embodiment, the control device 41 causes the imaging device 42 to image a predetermined region including the item R. In this case, the imaging device 42 outputs the captured image data indicating data of a captured image after imaging, to the control device 41. The captured image data may be associated with, for example, coordinate

data of a coordinate system based on the grasping device 10 or based on a predetermined position of the facility in which the grasping device 10 is arranged. The control device 41 performs image processing on the captured image data to recognize the shape and the like of the item R.

[0057] In Step S13, the control device 41 selects a hand (at least one of the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15) to be mounted to the base portion 11, on the basis of the transport target data. In this configuration, for example, the control device 41 selects the upper-surface suction portion 12 if the item R has the upper surface Ra easy to suck, on the basis of the transport target data, and selects the side-surface grasp portion 13 if the item R has the upper surface Ra difficult to suck.

[0058] In Step S14, the control device 41 determines the transport parameter. The transport parameter is data corresponding to the selected hand (at least one of the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15). The transport parameters are the speed and acceleration of swing of the swivel mechanism 31, the speed and acceleration of rising of the lifting mechanism 32, the pressure and time of sucking of the first suction mechanism 33, the pressure and time of sucking of the second suction mechanism 34, the pressure and time of pressing of the grasping mechanism 35, the time of supporting of the support mechanism 36, and are set on the basis of the transport target data acquired in Step S11.

[0059] In Step S15, the item R is transported (unloaded). In other words, the control device 41 controls the devices corresponding to the selected hand (the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, or the lower-surface support portion 15), that is, the swivel mechanism 31, the lifting mechanism 32, the first suction mechanism 33, the second suction mechanism 34, the grasping mechanism 35, or the support mechanism 36.

[0060] [Second Embodiment]

FIG. 5 is a flowchart illustrating a procedure of a process of the control device in the grasping device according to a second embodiment. Note that the basic configuration of the second embodiment is similar to that of the first embodiment described above and will be described with reference to FIGS. 1 and 2, and members

having similar functions to those of the first embodiment described above are denoted by the same reference numerals and detailed description thereof will not be repeated.

[0061] As illustrated in FIGS. 1 and 2, the grasping device 10 includes the base portion 11, the upper-surface suction portion 12, the side-surface grasp portion 13, the swivel mechanism 31, the lifting mechanism 32, the first suction mechanism 33, the second suction mechanism 34, the grasping mechanism 35, the support mechanism 36, the control device 41, the imaging device 42, the input/output device 43, and the accumulation unit 44. The control device 41 includes the communication unit 51, the storage unit 52, the control unit 53, and the determination unit 54.

[0062] The determination unit 54 selects a hand suitable for picking the item R to be transported, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, on the basis of characteristic data of the item R in addition to the transport target data of the item R. The determination unit 54 outputs a determination result to the control unit 53. The control unit 53 controls the grasping device 10 to mount the selected hand to the base portion 11. In the second embodiment, the characteristic data of the item R is actual transport data and is accumulated in the accumulation unit 44.

[0063] The actual transport data is set, for example, corresponding to the transport target data. The transport target data is data such as the type, weight, and size of the item R, the presence or absence (the length) of the perforation of the box, the presence or absence (the length) of the zipper, the number of glue spots, the side flaps, and the package (the presence or absence of the shrink package). The actual transport data is data of a suitable hand (the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, or the lower-surface support portion 15) having been selected according to the transport target data.

[0064] The actual transport data is set on the basis of verification data of a manufacturer of the grasping device 10 and an operation record (including trouble) during use of the grasping device 10 by a user (customer). In other words, the actual transport data represents a type of the hand in the grasping device 10 that makes it possible for the grasping device 10 to transport the item R without dropping the item R on the basis of the verification data of the grasping device 10 and operation performance thereof in the past. Note that the actual transport data may be set by machine learning of the

verification data of the manufacturer of the grasping device 10 and the operation record (including the trouble) during use of the grasping device 10 by the user (customer).

[0065] As illustrated in FIGS. 1, 2, and 5, in Step S11, the control device 41 acquires the transport target data. In the present embodiment, the control device 41 acquires the transport target data from the management device 61 via the communication unit 51. In Step S12, the control device 41 acquires the captured image data.

[0066] In Step S21, the control device 41 acquires the actual transport data. The actual transport data is accumulated in the accumulation unit 44, and the control device 41 acquires the actual transport data from the accumulation unit 44.

[0067] In Step S13, the control device 41 selects a hand (at least one of the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15) to be mounted to the base portion 11, on the basis of the transport target data and the actual transport data. In this case, for example, the control device 41 confirms the hand having been selected on the basis of the transport target data, on the basis of the actual transport data, and changes the hand if necessary.

[0068] In Step S14, the control device 41 determines the transport parameter. In Step S15, the item R is transported (unloaded).

[0069] [Third Embodiment]

FIG. 6 is a block diagram illustrating the grasping device according to a third embodiment, and FIG. 7 is a flowchart illustrating a procedure of a process of the control device. Note that the basic configuration of the third embodiment is similar to that of the first embodiment described above and will be described with reference to FIG. 1, and members having similar functions to those of the first embodiment described above are denoted by the same reference numerals and detailed description thereof will not be repeated.

[0070] As illustrated in FIGS. 1 and 6, the grasping device 10 includes the base portion 11, the upper-surface suction portion 12, the side-surface grasp portion 13, the swivel mechanism 31, the lifting mechanism 32, the first suction mechanism 33, the second suction mechanism 34, the grasping mechanism 35, the support mechanism 36, the control device 41, the imaging device 42, the input/output device 43, the accumulation unit 44, a moisture detector 45, and a shape detector 46. The control device 41

includes the communication unit 51, the storage unit 52, the control unit 53, and the determination unit 54.

[0071] The determination unit 54 selects a hand suitable for picking the item R to be transported, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, on the basis of the characteristic data in addition to the transport target data of the item R. The determination unit 54 outputs a determination result to the control unit 53. The control unit 53 controls the grasping device 10 to mount the selected hand to the base portion 11. In the third embodiment, the characteristic data of the item R is actual transport data and is accumulated in the accumulation unit 44. In addition, the characteristic data of the item R is moisture amount data and deformation amount data of the item R, and is detected by the moisture detector 45 and the shape detector 46.

[0072] The grasping device 10 is provided with the moisture detector 45 and the shape detector 46. The moisture detector 45 and the shape detector 46 are provided at the grasping device 10 or provided separately from the grasping device 10. The moisture detector 45 acquires the moisture amount data of the cardboard box constituting the item R. The shape detector 46 acquires the deformation amount data of the cardboard box constituting the item R. The moisture detector 45 is, for example, a contact or non-contact moisture sensor, and detects a moisture content of the cardboard box. The shape detector 46 is, for example, a contact displacement meter or a non-contact laser displacement meter, and detects a deformation amount (deformation rate) from the shape of the cardboard box.

[0073] For example, the determination unit 54 estimates the difficulty in suction by the upper-surface suction portion 12, that is, the suction difficulty on the basis of the moisture amount data and the deformation amount data of the item R, and determines whether it is possible to pick the item R only by the upper-surface suction portion 12 or whether it is not possible to perform picking without the side-surface grasp portion 13. For example, when the moisture amount of the item R is larger than a determination value set in advance, the item R has a low hardness and is weak, and therefore, it is determined that the upper-surface suction portion 12 is difficult to suck the item R. In addition, when the deformation amount of the item R is larger than a predetermined determination value, the item R is deformed and the upper surface Ra is not flat, and

therefore, it is determined that the upper-surface suction portion 12 is difficult to suck the item R.

[0074] As illustrated in FIGS. 1, 6, and 7, in Step S11, the control device 41 acquires the transport target data. In the present embodiment, the control device 41 acquires the transport target data from the management device 61 via the communication unit 51. In Step S12, the control device 41 acquires the captured image data.

[0075] In Step S21, the control device 41 acquires the actual transport data. The actual transport data is accumulated in the accumulation unit 44, and the control device 41 acquires the actual transport data from the accumulation unit 44. In Step S22, the control device 41 acquires detection data. The detection data is the moisture amount data of the item R detected by the moisture detector 45 and the deformation amount data of the item R detected by the shape detector 46. The control device 41 acquires the moisture amount data of the item R detected by the moisture detector 45 and the deformation amount data of the item R detected by the shape detector 46.

[0076] In Step S13, the control device 41 selects a hand (at least one of the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15) to be mounted to the base portion 11, on the basis of the transport target data, the actual transport data, the moisture amount data, and the deformation amount data. In this case, for example, the control device 41 confirms the hand having been selected on the basis of the transport target data, on the basis of the actual transport data, and changes the hand if necessary. In addition, the control device 41 confirms the changed hand on the basis of the moisture amount data and the deformation amount data, and changes the hand if necessary.

[0077] In Step S14, the control device 41 determines the transport parameter. In Step S15, the item R is transported (unloaded).

[0078] [Fourth Embodiment]

FIG. 8 is a flowchart illustrating a procedure of a process of the control device in the grasping device according to a fourth embodiment, and FIG. 9 is a schematic diagram illustrating a determination index for items. Note that the basic configuration of the fourth embodiment is similar to that of the first embodiment described above and will be described with reference to FIGS. 1 and 2, and members having similar functions to those of the first embodiment described above are denoted by the same

reference numerals and detailed description thereof will not be repeated.

[0079] As illustrated in FIGS. 1 and 2, the grasping device 10 includes the base portion 11, the upper-surface suction portion 12, the side-surface grasp portion 13, the swivel mechanism 31, the lifting mechanism 32, the first suction mechanism 33, the second suction mechanism 34, the grasping mechanism 35, the support mechanism 36, the control device 41, the imaging device 42, the input/output device 43, and the accumulation unit 44. The control device 41 includes the communication unit 51, the storage unit 52, the control unit 53, and the determination unit 54.

[0080] The determination unit 54 selects a hand suitable for picking the item R to be transported, from among the upper-surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15, on the basis of the characteristic data in addition to the transport target data of the item R. The determination unit 54 outputs a determination result to the control unit 53. The control unit 53 controls the grasping device 10 to mount the selected hand to the base portion 11. In the first embodiment, the characteristic data of the item R is the moisture amount data and the deformation amount data of the item R, and is detected by the moisture detector 45 and the shape detector 46.

[0081] The determination unit 54 calculates the determination index using the suction difficulty in suction of the item R by the upper-surface suction portion 12 as an index on the basis of the transport target data and the characteristic data of the item R, and determines whether it is possible to pick the item R only by the upper-surface suction portion 12 and whether it is not possible to perform picking without the side-surface grasp portion 13, on the basis of the determination index.

[0082] As illustrated in FIG. 9, the transport parameters of the item R include the type, weight, and size of the item R, the presence or absence (the length) of the perforation of the box, the presence or absence (the length) of the zipper, the side flaps, the package (the presence or absence of the shrink package), air permeability, moisture, a load collapse prevention agent, sloshing of beverage in the box, the number of glue spots, box swelling, and hole or scratch in the upper surface. The type, weight, and size of the item R, the presence or absence (the length) of the perforation of the box, the presence or absence (the length) of the zipper, the side flaps, the package (the presence or absence of the shrink package), and the number of glue spots represent the transport

target data of the item R. The air permeability is estimated from the type of the item R. The moisture represents the moisture amount data. The load collapse prevention agent is estimated from the type of the item R or the image data captured by the imaging device 42. The sloshing of beverage in the box is estimated from the type of the item R. The box swelling represents the deformation amount data. The hole or scratch in the upper surface is estimated from the type of the item R or the image data captured by the imaging device 42.

[0083] The determination index being the index of suction difficulty of the item R is determined for each of the transport parameters, for a plurality of items R1 and R2. A determination index of 1 is an index indicating the highest suction property, and a determination index of 3 is an index indicating the lowest suction property. The determination index of the item R is a total value of the determination indices determined for the respective transport parameters, for the plurality of items R1 and R2. When all the transport parameters have a determination index of 1, the determination index of the item R is 14, and when all the transport parameters have a determination index of 3, the determination index of the item R is 42. The determination value is set between the determination index 14 and the determination index 42, when the determination index is equal to or less than the determination value, the upper-surface suction portion 12 is selected, and when the determination index exceeds the determination value, the side-surface grasp portion 13 is selected.

[0084] As illustrated in FIGS. 1, 2, and 8, in Step S11, the control device 41 acquires the transport target data. In the present embodiment, the control device 41 acquires the transport target data from the management device 61 via the communication unit 51. In Step S12, the control device 41 acquires the captured image data.

[0085] In Step S22, the control device 41 acquires the detection data. The detection data is the moisture amount data of the item R detected by the moisture detector 45 and the deformation amount data of the item R detected by the shape detector 46. The control device 41 acquires the moisture amount data of the item R detected by the moisture detector 45 and the deformation amount data of the item R detected by the shape detector 46. In Step S23, the control device 41 calculates and acquires the determination index.

[0086] In Step S13, the control device 41 selects a hand (at least one of the upper-

surface suction portion 12, the side-surface grasp portion 13, the side surface suction portion 14, and the lower-surface support portion 15) to be mounted to the base portion 11, on the basis of the determination index. In Step S14, the control device 41 determines the transport parameter. In Step S15, the item R is transported (unloaded).

[0087] [Operation and effects of present embodiment]

The grasping device according to a first aspect includes the base portion (grasping device body) 11, the upper-surface suction portion 12 that is removably mounted to the base portion 11 and includes the first suction surface 21a capable of holding the upper surface Ra of the item R by suction, the side-surface grasp portion 13 that is removably mounted to the base portion 11 and includes the first grasp portion 22 and the second grasp portion 23 that are capable of grasping the side surfaces Rb of the item R, and the control device 41 that selects any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 on the basis of the transport target data of the item R.

[0088] In the grasping device according to the first aspect, the upper-surface suction portion 12 or the side-surface grasp portion 13 is selected on the basis of the transport target data of the item R, and the selected hand is mounted to the base portion 11. Therefore, any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 is mounted to the base portion 11, leading to a simplified structure. In addition, it is possible to use an appropriate hand according to the type of the item R, suppressing the dropping of the item R for improvement of the transportability.

[0089] The grasping device according to a second aspect is the grasping device according to the first aspect, and further includes the accumulation unit 44 that accumulates the actual transport data as the characteristic data of the item R, in which the control device 41 selects any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 on the basis of the actual transport data. Therefore, the upper-surface suction portion 12 or the side-surface grasp portion 13 is selected on the basis of the actual transport data in addition to the transport target data of the item R, thus improving accuracy in selection of the hand.

[0090] The grasping device according to a third aspect is the grasping device according to the first aspect or the second aspect, and further includes the moisture detector 45 that acquires the moisture amount data as the characteristic data of the item R, in which the

control device 41 selects any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 on the basis of the moisture amount data. Therefore, the upper-surface suction portion 12 or the side-surface grasp portion 13 is selected on the basis of the moisture amount data in addition to the transport target data of the item R, thus improving accuracy in selection of the hand.

[0091] The grasping device according to a fourth aspect is the grasping device according to any one of the first aspect to the third aspect, and further includes the shape detector 46 that acquires the deformation amount data as the characteristic data of the item R, in which the control device 41 selects any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 on the basis of the deformation amount data. Therefore, the upper-surface suction portion 12 or the side-surface grasp portion 13 is selected on the basis of the deformation amount data in addition to the transport target data of the item R, thus improving accuracy in selection of the hand.

[0092] The grasping device according to a fifth aspect is the grasping device according to the first aspect or the fourth aspect, in which the control device 41 further calculates the determination index using the suction difficulty in suction of the item R by the upper-surface suction portion 12, as the index, on the basis of the transport target data of the item R, and selects any one of the upper-surface suction portion 12 and the side-surface grasp portion 13, on the basis of the determination index. Therefore, the upper-surface suction portion 12 or the side-surface grasp portion 13 is selected by the determination index calculated on the basis of the transport target data of the item R, thus simplifying the processing and improving accuracy in selection of the hand.

[0093] The grasping device according to a sixth aspect is the grasping device according to the first aspect or the fifth aspect, in which the control device 41 further generates the selection processing map according to the hardness of the item R and the unevenness of the upper surface Ra of the item R, and selects any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 on the basis of the selection processing map. Therefore, the upper-surface suction portion 12 or the side-surface grasp portion 13 is selected on the basis of the selection processing map, thus, simplifying the processing.

[0094] The grasping device according to a seventh aspect is the grasping device according to the first aspect or the sixth aspect, and further includes the side surface

suction portion 14 that is removably mounted to the base portion 11 and includes the second suction surface 25a capable of holding the side surface Rb of the item R by suction, in which the control device 41 determines necessity of the side surface suction portion 14 on the basis of the transport target data of the item R. Therefore, provision of the side surface suction portion 14 enables use of the suitable hand according to the type of the item R, thus suppressing dropping of the item R.

[0095] The grasping device according to an eighth aspect is the grasping device according to the first aspect or the seventh aspect, and further includes the lower-surface support portion 15 that includes the first support portion 26 and the second support portion 27, both removably mounted to the base portion 11 and capable of supporting the lower surface Rc of the item R, in which the control device 41 determines the necessity of the lower-surface support portion 15 on the basis of the transport target data of the item R. Therefore, provision of the lower-surface support portion 15 enables use of the suitable hand according to the type of the item R, thus suppressing dropping of the item R.

[0096] The grasping device according to a ninth aspect is the grasping device according to the eighth aspect, and further includes the moisture detector 45 that acquires the moisture amount data as the characteristic data of the item R, in which the control device 41 determines the necessity of the lower-surface support portion 15 on the basis of the moisture amount data. Therefore, necessity of the lower-surface support portion is determined on the basis of the moisture amount data in addition to the transport target data of the item R, thus improving accuracy in selection of the hand.

[0097] The grasping device according to a tenth aspect is the grasping device according to the eighth aspect, and further includes the shape detector 46 that acquires the deformation amount data as the characteristic data of the item R, in which the control device 41 determines the necessity of the lower-surface support portion 15 on the basis of the deformation amount data. Therefore, necessity of the lower-surface support portion 15 is determined on the basis of the deformation amount data in addition to the transport target data of the item R, thus improving accuracy in selection of the hand.

[0098] A grasping method according to an eleventh aspect includes a step of selecting any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 on the basis of the transport target data of the item R, and a step of mounting the selected

upper-surface suction portion 12 or side-surface grasp portion 13 to the base portion 11. Therefore, any one of the upper-surface suction portion 12 and the side-surface grasp portion 13 is mounted to the base portion 11, leading to the simplified structure. In addition, it is possible to use an appropriate hand according to the type of the item R, suppressing the dropping of the item R for improvement of the transportability.

Reference Signs List

[0099]
10 GRASPING DEVICE
11 BASE PORTION (GRASPING DEVICE BODY)
12 UPPER-SURFACE SUCTION PORTION
13 SIDE-SURFACE GRASP PORTION
14 SIDE SURFACE SUCTION PORTION
15 LOWER-SURFACE SUPPORT PORTION
21 FIRST SUCTION PORTION
22 FIRST GRASP PORTION
23 SECOND GRASP PORTION
24 TURNING MECHANISM
25 SECOND SUCTION PORTION
26 FIRST SUPPORT PORTION
27 SECOND SUPPORT PORTION
31 SWIVEL MECHANISM
32 LIFTING MECHANISM
33 FIRST SUCTION MECHANISM
34 SECOND SUCTION MECHANISM
35 GRASPING MECHANISM
36 SUPPORT MECHANISM
41 CONTROL DEVICE
42 IMAGING DEVICE
43 INPUT/OUTPUT DEVICE
44 ACCUMULATION UNIT
45 MOISTURE DETECTOR
46 SHAPE DETECTOR
51 COMMUNICATION UNIT

52 STORAGE UNIT

53 CONTROL UNIT

54 DETERMINATION UNIT

61 MANAGEMENT DEVICE

5 R ITEM

Ra UPPER SURFACE

Rb SIDE SURFACE