{DESCRIPTION}

{Title of Invention}

LIFT-CONVEYOR CONTROL DEVICE, MECHANICAL PARKING APPARATUS, AND LIFT-CONVEYOR CONTROL METHOD

{Technical Field}

{0001}

The present invention relates to lift-conveyor control devices, mechanical parking apparatuses, and lift-conveyor control methods.

{Background Art}

{0002}

Typical raising and lowering devices for raising and lowering loads include a raising and lowering machine such as a lift conveyor, a motor for driving the raising and lowering machine, a control device for controlling the motor, and so forth; carry out loading/unloading work, such as storing and taking out the loads, under the control of the control device; and are used, for example, in mechanical parking apparatuses that handle vehicles as loads.

{0003}

In each of these raising and lowering devices (lift conveyors in the case of mechanical parking apparatuses), limits are set on the weights and the sizes of the loads to be raised and lowered; it is determined whether the load in question falls below those limits; and control is performed

based on the determination result, thus preventing accidents or malfunctions.

For example, Patent Literature 1 discloses a control technology for detecting an electrical current value when the raising and lowering machine having a vehicle thereon moves up or down; determining whether the weight of the vehicle exceeds a predetermined weight; and allowing the raising and lowering machine to continue moving up or down if the weight of the vehicle does not exceed the predetermined weight, or unloading the vehicle if the weight of the vehicle exceeds the predetermined weight.

{0004}

Furthermore, known lift conveyors having a vehicle thereon have been controlled such that the speed and acceleration/deceleration are preset to fixed values, a travel distance and a deceleration position are calculated with the control device, and the speed is controlled by switching between a high-speed command and a low-speed command, as shown in the speed pattern of Fig. 12.

{Citation List}

{Patent Literature}

{0005}

Japanese Unexamined Patent Application Publication No. 2001-63971

{Summary of Invention}

{0006}

However, because the speed and the acceleration/deceleration of each of those lift conveyors are fixed values determined based on the rated weight (maximum weight), regardless of the actual weight (vehicle weight) of the vehicle in question, the motor for raising and lowering the lift conveyor operates with much less power than its maximum power if the vehicle in question is lightweight, failing to take full advantage of its performance. In other words, the lift conveyor could be moved up or down at a higher speed for lightweight vehicles.

{0007}

Furthermore, as shown in, Fig. 12, while being moved a short distance, the lift conveyor may be switched between the high-speed command and the low-speed command without experiencing a constant speed period, unlike long-distance travel. For this reason, an abrupt change of acceleration takes place, causing an overshoot in the speed of the lift conveyor, which requires ensuring an extended period of time at low speed in order to stop the lift conveyor at a predetermined floor with high precision. This has been responsible for a prolonged period of time during which the lift conveyor moves up and down.

{0008}

The present invention has been conceived in light of

these circumstances, and an object thereof is to provide a lift-conveyor control device, a mechanical parking apparatus, and a lift-conveyor control method capable of reducing the time required to raise and lower a lift conveyor having a vehicle placed thereon.

{Technical Problem}

{0009}

In order to solve the above-described problem, a lift-conveyor control device, a mechanical parking apparatus, and a lift-conveyor control method according to the present invention provide the following solutions.

{0010}

Specifically, a lift-conveyor control device according to a first aspect of the present invention is a lift-conveyor control device of a mechanical parking apparatus that includes a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon; a motor that raises and lowers the lift conveyor; and storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down. The lift-conveyor control device includes weight estimation means for estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded; derivation means for deriving an acceleration, a deceleration, and a maximum speed at which the lift conveyor is raised and lowered based on the

weight of the vehicle estimated by the weight estimation means; and motor control means for controlling the motor so as to accelerate the lift conveyor, with the vehicle placed thereon and at a standstill, based on the acceleration derived by the derivation means and to stop the lift conveyor at a pre-specified floor by decelerating the lift conveyor based on the deceleration derived by the derivation means after the maximum speed derived by the derivation means is reached.

{0011}

According to the above-described aspect, the lift-conveyor control device is provided in the mechanical parking apparatus including the lift conveyor that is installed in the structure having the plurality of floors and goes up and down with the vehicle placed thereon; the motor that raises and lowers the lift conveyor; and the storage shelves provided on the plurality of floors along the hoistway along which the lift conveyor goes up and down. The vehicle is raised and lowered by the lift conveyor so that it is placed on a pallet.

{0012}

The weight of the vehicle placed on the lift conveyor is estimated by the weight estimation means when the above-described vehicle is to be loaded. In addition, the acceleration, deceleration, and maximum speed at which the lift conveyor is raised and lowered are derived by the derivation means based on the weight of the vehicle estimated

by the weight estimation means.

By doing so, a speed of the lift conveyor appropriate for the weight of the vehicle can be achieved.

{0013}

Furthermore, the motor control means controls the motor so as to accelerate the lift conveyor, having the vehicle placed thereon and at a standstill, based on the derived acceleration and to stop the lift conveyor at the pre-specified floor by decelerating the lift conveyor based on the derived deceleration after the derived maximum speed is reached.

{0014}

As described above, because the motor that raises and lowers the lift conveyor is controlled based on the acceleration, deceleration, and maximum speed appropriate for the weight of the vehicle, it is possible to utilize the performance of the motor more effectively, thereby reducing the time to raise and lower the lift conveyor.

{0015}

Furthermore, in the lift-conveyor control device of the above-described aspect, when the speed of the lift conveyor reaches the maximum speed, the motor control means may maintain the speed at the maximum speed for a predetermined period of time and decelerate the lift conveyor based on the deceleration.

{0016}

According to the above-described aspect, when the speed of the lift conveyor reaches the maximum speed, the lift conveyor is decelerated after the speed is maintained at the maximum speed for the predetermined period of time. Therefore, during the process from acceleration to deceleration of the lift conveyor, an abrupt change of acceleration (torque variation) can be prevented.

{0017}

For this reason, an overshoot of the speed of the lift conveyor resulting from the occurrence of an abrupt change of the acceleration can be prevented. Therefore, it is not necessary to provide a long segment of low speed in order to ensure sufficient stopping precision, thereby reducing the time to raise and lower the lift conveyor.

{0018}

Furthermore, the lift-conveyor control device of the above-described aspect may further include storage means for storing information about vehicles stored on the storage shelves and information about the weights of the vehicles estimated by the weight estimation means in association with each other, wherein the derivation means may read out the information about the weight of the vehicle raised and lowered with the lift conveyor from the storage means and derive the acceleration, deceleration, and maximum speed at which the

lift conveyor is raised and lowered based on the read-out information.

{0019}

According to the above-described aspect, the storage means stores the information about the vehicle stored on the storage shelf and the information about the weight of the vehicle estimated by the weight estimation means in association with each other. Therefore, it is not necessary to estimate the weight of a vehicle whose weight is stored each time the vehicle is to be loaded. For this reason, the time required to load the vehicle can be reduced.

{0020}

Furthermore, in the lift-conveyor control device of the above-described aspect, when the vehicle is being unloaded, the derivation means may read out the information about the weight of the vehicle to be unloaded from the storage means and derive the acceleration, deceleration, and maximum speed at which the lift conveyor is raised and lowered based on the read-out information.

{0021}

According to the above-described aspect, the information about the weight of the vehicle to be unloaded is read out from the storage means when the vehicle is to be unloaded. Therefore, the motor that raises and lowers the lift conveyor can also be controlled based on the acceleration,

deceleration, and maximum speed appropriate for the weight of the vehicle even when the vehicle is to be unloaded.

{0022}

Furthermore, in the lift-conveyor control device of the above-described aspect, in the case of at least one of loading and unloading of the vehicle, the motor control means may control the motor so as to accelerate the lift conveyor, with the vehicle placed thereon and at a standstill, after a torque based on the weight of the vehicle is produced.

{0023}

According to the above-described aspect, the motor produces the torque based on the weight of the vehicle and then accelerates the lift conveyor having the vehicle placed thereon and at a standstill. Therefore, an impact when the motor is started up is reduced. As a result, noise generated when the lift conveyor is raised and lowered can be suppressed, and the service life of mechanical components can be extended.

{0024}

Furthermore, in the lift-conveyor control device of the above-described aspect, the derivation means may derive a positive jerk and a negative jerk, as well as the acceleration, deceleration, and maximum speed at which the lift conveyor is raised and lowered, based on the weight of the vehicle estimated by the weight estimation means; and the

motor control means may control the motor so as to accelerate the lift conveyor, with the vehicle placed thereon and at a standstill, based on the acceleration and the positive jerk derived by the derivation means and to stop the lift conveyor at the pre-specified floor by decelerating the lift conveyor based on the deceleration and the negative jerk derived by the derivation means after the maximum speed derived by the derivation means is reached.

{0025}

According to the above-described aspect, so-called S-shaped control is performed while the lift conveyor is being raised and lowered. Therefore, not only an abrupt change of acceleration but also an impact upon the lift conveyor can be suppressed. As a result, noise generated when the lift conveyor is raised and lowered can be suppressed, and the service life of mechanical components can be extended.

{0026}

Furthermore, in the lift-conveyor control device of the above-described aspect, the weight estimation means may estimate the weight of the vehicle based on the torque that is produced by the motor when the lift conveyor having the vehicle placed thereon is raised at the time of loading the vehicle.

{0027}

According to the above-described aspect, the weight of

the vehicle is estimated based on the torque that is produced by the motor when the lift conveyor having the vehicle placed thereon is raised. Therefore, the weight of the vehicle can be estimated with a simple structure.

{0028}

Furthermore, in the lift-conveyor control device of the above-described aspect, the weight estimation means may estimate the weight of the vehicle based on a value of electrical current flowing in a raising and lowering motor that raises a pallet having the vehicle placed thereon from a predetermined reference position by a predetermined amount at the time of loading the vehicle.

{0029}

According to the above-described aspect, the weight of the vehicle can be estimated based on a value of the electrical current flowing in the raising and lowering motor that raises the pallet having the vehicle placed thereon by the predetermined amount from the predetermined reference position. Therefore, the weight of the vehicle can be estimated with a simple structure.

{0030}

Furthermore, in the lift-conveyor control device of the above-described aspect, the plurality of floors may be classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined

weight may be carried to an upper compartment, whereas a vehicle over the predetermined weight may be carried to a lower compartment. According to the above-described aspect, vehicles with lighter weights exhibit a larger acceleration, deceleration, and maximum speed and hence a shorter operating time. As a result, the wait time for such vehicles to be loaded and unloaded can be reduced even if they are stored on upper floors.

{0031}

On the other hand, a mechanical parking apparatus according to a second aspect of the present invention includes: a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon; a motor that raises and lowers the lift conveyor; storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up an down; and the above-described lift-conveyor control device.

{0032}

In addition, a lift-conveyor control method according to a third aspect of the present invention is a lift-conveyor control method for a mechanical parking apparatus that includes a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon; a motor that raises and lowers the lift conveyor; and storage shelves provided on the plurality

of floors along a hoistway along which the lift conveyor goes up and down. The lift-conveyor control method includes a first step of estimating a weight of the vehicle placed on the lift conveyor when loading the vehicle; a second step of deriving an acceleration, a deceleration, and a maximum speed at which the lift conveyor is raised and lowered based on the estimated weight of the vehicle; and a third step of controlling the motor so as to accelerate the lift conveyor, with the vehicle placed thereon and at a standstill, based on the derived acceleration and to stop the lift conveyor at a pre-specified floor by decelerating the lift conveyor based on the derived deceleration after the derived maximum speed is reached.

{0033}

Furthermore, in the lift-conveyor control device of the above-described first aspect, it is preferable that at least one of the predetermined weights is set; the compartments are classified into at least two; weight ranges classified according to the predetermined weight are associated with the compartments; pallet-determining means for, from among pallets that carry vehicles placed thereon, taking out an unoccupied pallet, which is a pallet that does not have a vehicle placed thereon, from the compartment corresponding to the weight range covering the weight of the vehicle to be loaded is provided; and the pallet having the vehicle to be loaded

placed thereon is moved to the compartment from which the unoccupied pallet has been taken out.

{0034}

The unoccupied pallet on which to place the vehicle is taken out from the compartment associated with the weight range covering the weight of the vehicle to be loaded and, after the vehicle has been placed thereon, is moved to the compartment from which the pallet has been taken out. In this manner, because vehicles included in a heavy weight range are carried to the relatively lower compartment and vehicles included in a light weight range are carried to the relatively upper compartment, the energy consumed in the loading operation is minimized, thereby contributing to energy saving.

{0035}

Furthermore, the above-described pallet-determining means of the lift-conveyor control device of the above-described first aspect may take out the unoccupied pallet from the compartment corresponding to the weight range one rank lighter than the weight range covering the weight of the vehicle if the unoccupied pallet does not exist in the weight range covering the weight of the vehicle to be loaded.

{0036}

The vehicle is temporarily evacuated to the compartment corresponding to the lighter weight range to ensure an unoccupied pallet in the compartment corresponding to the

heavier weight range (namely, to ensure a compartment in which the vehicle can be loaded). By doing so, it is possible to effectively utilize the compartment corresponding to the heavier weight range and also to minimize the energy consumed in loading even in a case where a vehicle with a high weight is loaded later, compared with a case where there is no choice but to carry a heavy vehicle to the upper compartment because only the compartment corresponding to the lighter weight range is available.

In addition, conventionally, vehicles were loaded sequentially starting with a low floor of the mechanical parking apparatus, without taking the vehicle weight into consideration. For this reason, the lower floors of the mechanical parking apparatus were first occupied, and vehicles with high vehicle weight, when being loaded later, were stored on upper floors. In such a case, the energy consumed in vehicle loading becomes large, especially in the case of an elevated mechanical parking apparatus (with a height of more than 45 m). According to the above-described first aspect, upper floors, i.e., the compartment assigned the lighter weight range, are given priority for vehicle loading. Therefore, a waste of energy, as seen in loading of vehicles with a high weight by the conventional technique, can be prevented.

{0037}

Furthermore, in the lift-conveyor control device of the above-described first aspect, a distribution state of the weights of the vehicles may be calculated at predetermined intervals, and the vehicle weight range may be set based on the distribution state.

{0038}

Because the vehicle weight range is reviewed at predetermined intervals, it can be adjusted to the actual vehicle weight distribution even in a case where the weight of the vehicle to be loaded is not determined and a tentative value is entered when the operation starts. By doing so, the unoccupied pallet is taken out from the compartment appropriate for the vehicle weight and is moved, exhibiting high performance.

{0039}

Furthermore, in the lift-conveyor control device of the above-described first aspect, the number of loading operations of each of the vehicles may be calculated; a corrected weight that exhibits a large value if the number of operations exceeds an average number of loading and unloading operations of all the vehicles and exhibits a small value if the number of operations is smaller than the average number of loading and unloading operations may be calculated based on the vehicle, the number of operations, and the weight of the vehicle; and the vehicle weight range may be set based on the

corrected weight.

{0040}

In this manner, because the corrected weight taking account of the frequency of loading and unloading is calculated and the vehicle weight range is reviewed based on this corrected weight, an unoccupied pallet most appropriate for the frequency can be selected.

{0041}

Furthermore, in the lift-conveyor control device of the above-described first aspect, a unique number of a vehicle that was loaded and unloaded in the past may be associated with the weight of the vehicle; the unique number of the vehicle to be loaded may be acquired when the vehicle is loaded; and if information about the weight of the vehicle corresponding to the unique number exists, the unoccupied pallet may be taken out from the compartment corresponding to the weight range covering the weight of the vehicle corresponding to the unique number.

{0042}

The unique number of the vehicle that was loaded and unloaded in the past is associated with the weight. Therefore, even in the case of the mechanical parking apparatus operated on a pay-by-the-hour basis, the weight of a vehicle can be identified from the unique number of the vehicle if the user has used this apparatus more than once.

This allows a pallet to be taken out and moved from an energy-saving position, preventing energy waste. The unique number of a vehicle is the number on the vehicle identification plate (number plate) and can be acquired, for example, by imaging with a camera or the user entering the number manually.

{0043}

Furthermore, the lift-conveyor control device of the above-described first aspect may set the vehicle weight range for each type of vehicle.

{0044}

Because the vehicle weight range is appropriately classified according to the type of the vehicle (e.g., high roof cars, standard-sized cars) and the heavier weight range is assigned to the compartment below the lighter weight range, compartments are assigned evenly and appropriately for different types of vehicles.

{0045}

Furthermore, the lift-conveyor control device of the above-described first aspect may further include calculation means for calculating the amount of energy required to load and unload the vehicle, wherein the calculation means may calculate a first amount of energy required to search for the unoccupied pallet starting from the lower floor and to place and carry the vehicle on the selected unoccupied pallet; calculate a second amount of energy required to place and

carry the vehicle on the unoccupied pallet selected by the pallet-determining means; and output the first amount of energy and the second amount of energy.

{0046}

By doing so, the user can be presented with the energy saving effect quantitatively and visually because the first amount of energy consumed when the unoccupied pallet is taken out and moved from the low floor, as is done in a known method, can be compared against the second amount of energy consumed when the unoccupied pallet is taken out and moved using the pallet-determining means of the above-described first aspect. Presentation can be achieved, for example, in the form of numerical values or an illustration on the operating panel to show the amount of saved energy, by periodically outputting data on sheets of paper in a report format, and so forth.

{0047}

A fourth aspect of the present invention is a mechanical parking apparatus including one of the above-described lift-conveyor control devices.

{0048}

A fifth aspect of the present invention is a mechanical parking system including the above-described mechanical parking apparatus and a terminal connected to the mechanical parking apparatus so that information can be received and

sent.

With such a structure, maintenance personnel can visit the site at which the mechanical parking apparatus is installed and connect the terminal (e.g., inspection terminal) directly to the mechanical parking apparatus for maintenance. Exchange of information between the mechanical parking apparatus and the terminal is performed, for example, via a special cable or a network cable.

{0049}

In the mechanical parking system of the above-described fifth aspect, the mechanical parking apparatus and the terminal, which are interconnected via a communication network, may be disposed remotely from each other.

With such a structure, if the terminal (e.g., inspection terminal) is connected to the mechanical parking apparatus installed at a site remote from the terminal via, for example, a network so that communication is possible, the maintenance personnel can perform tele-maintenance via the communication network.

{0050}

A sixth aspect of the present invention is a mechanical parking system including a plurality of the above-described mechanical parking apparatuses, wherein the plurality of mechanical parking apparatuses share common user data in the form of information associating the vehicle to be loaded and

unloaded with the weight of the vehicle.

If the plurality of mechanical parking apparatuses share the user data associating the vehicle and the weight of the vehicle, the mechanical parking apparatus appropriate for the vehicle weight and the frequency of loading and unloading can be selected, thereby reducing the wait time for the vehicle to be loaded and unloaded and leading to energy saving. By doing so, an environment-friendly mechanical parking system can be provided.

{Advantageous Effects of Invention}

{0051}

The present invention can afford a superior effect of reducing the time to raise and lower a lift conveyor having a vehicle placed thereon.

{Brief Description of Drawings}

{0052}

{Fig. 1}

Fig. 1 is a schematic diagram of a mechanical parking apparatus according to a first embodiment of the present invention.

{Fig. 2}

Fig. 2 is a function block diagram showing the electrical configuration of a lift-conveyor control device according to the first embodiment of the present invention.

{Fig. 3}

Fig. 3 is a flowchart showing the flow of the process of deciding the loading speed according to the first embodiment of the present invention.

{Fig. 4}

Fig. 4 is a speed pattern of a lift conveyor during vehicle loading according to the first embodiment of the present invention.

{Fig. 5}

Fig. 5 is a flowchart showing the flow of the process of deciding the unloading speed according to the first embodiment of the present invention.

{Fig. 6}

Fig. 6 is a graph showing a change over time in a torque produced by a raising and lowering motor according to the first embodiment of the present invention.

{Fig. 7}

Fig. 7 is a speed pattern of the lift conveyor during vehicle unloading according to the first embodiment of the present invention.

{Fig. 8}

Fig. 8 is a speed pattern of the lift conveyor during vehicle loading according to a second embodiment of the present invention.

{Fig. 9}

Fig. 9 is a speed pattern of the lift conveyor during

vehicle unloading according to the second embodiment of the present invention.

{Fig. 10}

Fig. 10 a flowchart showing the flow of the process of deciding the loading speed according to a third embodiment of the present invention.

{Fig. 11}

Fig. 11 is a structural diagram of an entrance of the mechanical parking apparatus according to another embodiment.

{Fig. 12}

Fig. 12 is a speed pattern in control of a known lift conveyor.

{Fig. 13}

Fig. 13 is a schematic diagram of the lift-conveyor control device according to a fourth embodiment of the present invention.

{Fig. 14}

Fig. 14 is a diagram showing one example of group-determining data according to the fourth embodiment of the present invention.

{Fig. 15}

Fig. 15 is a diagram showing one example of shelf data according to the fourth embodiment of the present invention.

{Fig. 16}

Fig. 16 is a diagram showing one example of user data

according to the fourth embodiment of the present invention.

{Fig. 17}

Fig. 17 is a flowchart showing the flow of taking out an unoccupied pallet during loading according to the fourth embodiment of the present invention.

{Fig. 18}

Fig. 18 is a flowchart showing the flow of energy calculation processing according to the fourth embodiment of the present invention.

{Fig. 19}

Fig. 19 is a diagram showing one example of group-determining data for assigning a vehicle weight range for each car type according to a modification of the fourth embodiment of the present invention.

{Fig. 20}

Fig. 20 is a diagram showing one example of shelf data indicating compartment assignment when a plurality of car types are included, according to a modification of the fourth embodiment of the present invention.

{Fig. 21}

Fig. 21 is a diagram showing one example of user data according to a fifth embodiment of the present invention.

{Fig. 22}

Fig. 22 is a diagram showing one example of group-determining data according to the fifth embodiment of the

present invention.

{Fig. 23}

Fig. 23 is a flowchart showing the flow of taking out an unoccupied pallet during loading, according to the fifth embodiment of the present invention.

{Fig. 24}

Fig. 24 is a schematic diagram of a mechanical parking system according to a seventh embodiment of the present invention.

{Description of Embodiments}

{0053}

An embodiment of a lift-conveyor control device, a mechanical parking apparatus, and a lift-conveyor control method according to the present invention will now be described with reference to the drawings.

{0054}

[First embodiment]

Fig. 1 is a schematic diagram of a mechanical parking apparatus 10 according to a first embodiment.

As shown in Fig. 1, the mechanical parking apparatus 10 includes a lift-conveyor 14 that is provided in a structure having a plurality of floors to raise and lower a vehicle 12; storage shelves 18 that are provided on a plurality of floors along a hoistway 16 along which the lift-conveyor 14 moves up and down; and pallets 20 that are held by the lift-conveyor 14

and receive the vehicle 12 to be loaded or unloaded.

{0055}

Although the mechanical parking apparatus 10 in this first embodiment is described in terms of a mechanical parking apparatus of the 90° rotation type, the turning angle is not limited to 90° but can be, for example, 30° or 180°. A 90° rotation type employs a technique for turning the vehicle by 90° on a vehicle reception floor 22, from/onto which the vehicle 10 is unloaded/loaded, to store the vehicle 12 on the storage shelf 18 because the orientation of the vehicle 12 received on the vehicle reception floor 22 differs by 90° from the orientation of the vehicle 12 stored on the storage shelf 18. Although the vehicle reception floor 22 is provided on the first floor for the mechanical parking apparatus 10 according to this first embodiment, the vehicle reception floor 22 is not limited to a particular position.

{0056}

As shown in Fig. 1, the mechanical parking apparatus 10 includes the vehicle reception floor 22 on the first floor, i.e., the bottom floor, so that the vehicle 12 is loaded onto the vehicle reception floor 22 via an entrance and stored on the storage shelf 18 above the vehicle reception floor 22. Furthermore, the mechanical parking apparatus 10 takes out the vehicle 12 to be unloaded from the storage shelf 18 and unloads the vehicle 10 from the vehicle reception floor 22 via

the entrance.

{0057}

Fig. 2 is a function block diagram depicting the electrical configuration of a lift-conveyor control device 30 for controlling the raising and lowering the lift-conveyor 14.

{0058}

The lift-conveyor control device 30 includes an on-ground control panel 34 that controls the mechanical parking apparatus 10 based on a user's operation of an operating panel 32 via which operations for loading or unloading the vehicle 12 are input; and a motor control section 38 (inverter) for controlling a raising and lowering motor 36 that raises and lowers the lift-conveyor 14.

{0059}

The on-ground control panel 34 includes a control section 40, which is a CPU (Central Processing Unit); a storage section 42 storing various data; a zero-correction section 44; and a power supply unit 46.

{0060}

The control section 40 controls the raising and lowering of the lift-conveyor 14 based on the weight (vehicle weight) of the vehicle 12 placed on the pallet 20. For this purpose, the control section 40 includes a weight estimation section 48, which estimates the vehicle weight based on the torque (hereinafter, referred to as the "load torque") that is

produced by the raising and lowering motor 36 when the lift-conveyor 14 having the vehicle 12 placed thereon is raised (at the time of vehicle pickup) to load the vehicle 12.

More specifically, the weight estimation section 48 receives the torque current output to the raising and lowering motor 36 by the motor control section 38; acquires a load torque produced by the raising and lowering motor 36 based on the input torque current; and estimates the vehicle weight based on correspondence information indicating the relationship between the load torque and the vehicle weight. The correspondence information, which may be information indicating the relationship between vehicle weights and load torques in terms of a mathematical expression or may be information indicating the relationship between vehicle weights and load torques in the form of a list (table format), is stored in the storage section 42.

{0061}

The zero-correction section 44 compares the weight of the pallet 20 estimated based on the load torque produced by the raising and lowering motor 36 against the reference weight of the pallet 20 stored in the storage section 42.

More specifically, in a state where the pallet 20 does not have the vehicle 12 placed thereon, the zero-correction section 44 compares the load torque produced by the raising and lowering motor 36 against the load torque corresponding to

the weight of the pallet 20 in the correspondence information. Thereafter, if the comparison does not show a match, the zero-correction section 44 corrects the correspondence information based on the load torque, produced by the raising and lowering motor 36, i.e., the load torque corresponding to the weight of the pallet 20 alone.

Correction by the zero-correction section 44 may be carried out each time loading or unloading is completed or at predetermined intervals (e.g., every day, every two weeks, every month).

{0062}

Furthermore, the control section 40 should preferably select the position of the storage shelf 18 according to the estimated vehicle weight. More specifically, after the weight of the vehicle 12 is compared against a predetermined weight, an unoccupied storage shelf 18 that is nearer to the vehicle reception floor 22 is selected if the vehicle 12 has a higher weight than the predetermined weight. On the other hand, an unoccupied storage shelf 18 that is farther away from the vehicle reception floor 22 is selected if the vehicle 12 has a smaller weight than the predetermined weight. This is desirable because the higher the vehicle weight, the larger the load torque, and therefore vehicles 12 with higher weights take a larger torque to travel than vehicles 12 with smaller weights. This means that the power consumption of the

mechanical parking apparatus 10 can be reduced by selecting the storage shelf 18 so as to move vehicles 12 with higher weights over a shorter distance. Furthermore, if the vehicle reception floor 22 is provided on a low floor (e.g., the first floor of the mechanical parking apparatus 10 as shown in Fig. 1), vehicles 12 with higher weights are placed on lower floors, whereas vehicles 12 with smaller weights are placed on higher floors. Therefore, vehicles 12 with smaller weights exhibit a larger acceleration, deceleration, and maximum speed and hence a shorter operating time, thereby reducing the wait time for loading and unloading even for vehicles 12 that are stored on higher floors.

More specifically, with a plurality of floors being classified into a plurality of compartments along the height direction, vehicles with weights equal to or below a predetermined weight are taken to higher compartments (upper floors), whereas vehicles with weights over the predetermined weight are taken to lower compartments (lower floors). One predetermined weight may be set to provide two compartments, or two or more predetermined weights may set to provide three or more compartments.

{0063}

Furthermore, because vehicles 12 with smaller weights are placed on upper floors and vehicles 12 with higher weights are placed on lower floors, the force acting on the mechanical

parking apparatus 10 can be reduced in the event of an earthquake.

{0064}

Furthermore, it is preferable that the control section 40 compare the estimated vehicle weight against the weight that can be carried with the lift-conveyor 14 (rated weight) and, if the estimated vehicle weight exceeds the rated weight, stop carrying the vehicle with the lift-conveyor 14. By doing so, misloading of vehicles 12 with weights equal to or over the rated weight can be prevented, thus protecting devices such as the lift-conveyor 14 from damage or malfunctions.

{0065}

Furthermore, the control section 40 derives an acceleration, deceleration, and maximum speed at which the lift-conveyor 14 is to be raised and lowered based on the vehicle weight estimated by the weight estimation section 48 and then outputs the values of the derived acceleration, deceleration, and maximum speed to the motor control section 38. The storage section 42 stores table information (hereinafter, referred to as a "decision table") representing an acceleration, deceleration, and maximum speed for each vehicle weight, and the control section 40 derives the acceleration, deceleration, and maximum speed according to the vehicle weight based on the decision table.

{0066}

Then, the control section 40 outputs a high-speed command for high-speed operation of the lift-conveyor 14 or a low-speed command for low-speed operation of the lift-conveyor 14 to the motor control section 38.

Upon receiving the high-speed command from the control section 40, the motor control section 38 controls the raising and lowering motor 36 to perform raising and lowering at high speed, whereas upon receiving the low-speed command from the control section 40, the motor control section 38 controls the raising and lowering motor 36 to raise and lower the lift-conveyor 14 at low speed.

{0067}

Furthermore, the control section 40 receives, from a pulse generator 50, current position information indicating the current position of the lift-conveyor 14 detected based on the rotational speed of the raising and lowering motor 36.

{0068}

The power supply unit 46 supplies the mechanical parking apparatus 10 with power to feed power to control devices, such as the raising and lowering motor 36 and the control section 40, of the lift-conveyor 14.

{0069}

Controlling the lift-conveyor 14 for loading, which is carried out in the mechanical parking apparatus 10 according to this first embodiment, will now be described.

{0070}

Fig. 3 is a flowchart showing the flow of the process of deriving the loading speed for deriving an acceleration, deceleration, and maximum speed of the lift-conveyor 14 at the time of loading, carried out in the control section 40 according to this first embodiment. The process of deriving the loading speed is carried out as a result of executing a program for deriving the loading speed stored in the storage section 42. Because the mechanical parking apparatus 10 according to this first embodiment assumes that the vehicle reception floor 22 is the first floor and that the storage shelf 18 is provided above the vehicle reception floor 22, the lift-conveyor 14 having the vehicle 12 placed thereon moves up at the time of loading.

{0071}

First, in step 100, the operation of raising the lift-conveyor 14 having the vehicle 12 placed thereon by a predetermined distance (hereinafter, referred to as "pickup") is carried out.

{0072}

In the subsequent step 102, the load torque produced by the raising and lowering motor 36 is obtained based on the torque current output from the motor control section 38 during pickup, and the weight of the vehicle 12 placed on the lift-conveyor 14 is estimated from this load torque. The vehicle

weight estimated in this step 102 is stored in the storage section 42 as vehicle weight information in association with information about the vehicle 12 (e.g., the number of the storage shelf in which to store the vehicle 12, the identification number of the vehicle 12).

{0073}

In the subsequent step 104, the acceleration, deceleration, and maximum speed of the lift-conveyor 14, depending on the vehicle weight estimated in step 102, are derived from the decision table stored in the storage section 42.

{0074}

In the subsequent step 106, the maximum value of the moving speed of the lift-conveyor 14 is calculated from the travel distance of the lift-conveyor 14. The travel distance of the lift-conveyor 14 represents the distance from the vehicle reception floor 22 to the pre-specified floor on which the loaded vehicle 12 will be stored. In short, the maximum value of moving speed is calculated by multiplying the acceleration derived in step 104 by the travel distance.

{0075}

In the subsequent step 108, it is determined whether the maximum value of moving speed calculated in step 106 is larger than the maximum speed derived in step 104. The flow proceeds to step 110 in the case of an affirmative judgment or step 112

in the case of a negative judgment.

{0076}

In step 110, a deceleration position of the accelerated lift-conveyor 14 is calculated using the maximum speed derived in step 104, and then the flow proceeds to step 114.

The deceleration position represents the position at which the accelerated lift-conveyor 14 is decelerated so that the lift-conveyor 14 can stop at the floor on which to store the vehicle 12. As described below, the deceleration position is calculated by taking account of the predetermined period of time during which the moving speed of the lift-conveyor 14 is maintained at the maximum speed after the moving speed reaches the maximum speed.

{0077}

In step 112, the maximum value of the moving speed calculated in step 106 is set to the maximum speed of the lift-conveyor 14, the deceleration position of the lift-conveyor 14 is calculated using the maximum value of the moving speed calculated in step 106, and then the flow proceeds to step 114.

{0078}

In step 114, the acceleration, deceleration, and maximum speed of the lift-conveyor 14 are output to the motor control section 38, and the high-speed command is selected, thus completing the process of deriving the loading speed.

{0079}

Fig. 4 is a speed pattern of the lift-conveyor 14 at the time of loading based on control by the control section 40 according to this first embodiment.

{0080}

As shown in the speed pattern for short-distance travel in Fig. 4, first, the low-speed command is output from the control section 40 to the motor control section 38, and the lift-conveyor 14 is raised at low speed. At this time, the control section 40 carries out the process of deriving the loading speed.

{0081}

When the high-speed command is output to the motor control section 38 after the control section 40 has carried out the process of deriving the loading speed, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 rises at the acceleration (the optimal acceleration) input from the control section 40.

{0082}

When the moving speed of the lift-conveyor 14 reaches the maximum speed input from the control section 40, the motor control section 38 controls the raising and lowering motor 36 so that the moving speed of the lift-conveyor 14 is maintained at the maximum speed for a predetermined period of time.

{0083}

After the above-described predetermined period of time has elapsed, the control section 40 outputs the low-speed command to the motor control section 38 when it is determined that the lift-conveyor 14 has reached the deceleration position based on current position information input from the pulse generator 50. Upon receiving the low-speed command, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 rises while reducing its speed at the deceleration (optimal deceleration) input from the control section 40.

{0084}

In this manner, when the moving speed of the lift-conveyor 14 reaches the maximum speed, the mechanical parking apparatus 10 according to this first embodiment maintains the moving speed of the lift-conveyor 14 at the maximum speed for a predetermined period of time and then decelerates the lift-conveyor 14. Therefore, an abrupt change of acceleration (torque change) can be prevented during the process from acceleration to deceleration of the lift-conveyor 14. Therefore, because an overshoot in the moving speed of the lift-conveyor 14 resulting from an abrupt change of acceleration can be prevented, a long low-speed segment is not required to ensure a sufficient stopping precision, allowing the mechanical parking apparatus 10 to reduce the time required to raise and lower the lift-conveyor 14.

{0085}

Then, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 rises at a predetermined low speed to ensure a sufficient stopping precision. Thereafter, when the stopper dog corresponding to the floor at which the lift-conveyor 14 is to stop detects the lift-conveyor 14, the control section 40 turns off the low-speed command to the motor control section 38 to brake the lift-conveyor 14, thus causing the lift-conveyor 14 to stop.

{0086}

The speed pattern for long-distance travel during loading is similar to the above-described speed pattern for short-distance travel.

{0087}

Next, controlling the lift-conveyor 14 for unloading, which is carried out in the mechanical parking apparatus 10 according to this first embodiment, will be described.

{0088}

Fig. 5 is a flowchart showing the flow of the process of deriving the unloading speed for deriving an acceleration, deceleration, and maximum speed of the lift-conveyor 14 during unloading, carried out in the control section 40 according to this first embodiment. The process of deriving the unloading speed is carried out as a result of executing a program for deriving the unloading speed stored in the storage section 42.

Because the mechanical parking apparatus 10 according to this first embodiment assumes that the vehicle reception floor 22 is the first floor and that the storage shelf 18 is provided above the vehicle reception floor 22, the lift-conveyor 14 having the vehicle 12 placed thereon moves down at the time of unloading.

Furthermore, the same steps in Fig. 5 as those in Fig. 3 are denoted with the same reference numerals, and descriptions thereof will be omitted partially or in full.

{0089}

First, in step 200, the vehicle weight of the vehicle 12 to be unloaded is read out from the vehicle weight information stored in the storage section 42.

{0090}

In the subsequent step 202, based on the vehicle weight read out in step 200, the load torque applied when the vehicle 12 with that weight is placed on the lift-conveyor 14 (hereinafter, referred to as the "torque bias value") is calculated. A torque bias value can be calculated from a vehicle weight by, for example, pre-storing scaling ratios used to convert vehicle weights into torque bias values in the storage section 42 and then multiplying the read-out vehicle weight by the scaling ratio.

{0091}

In the subsequent step 204, the torque bias value is

output to the motor control section 38, and the flow proceeds to step 104.

{0092}

Fig. 6 is a graph showing a change over time in a torque produced in the raising and lowering motor 36.

As shown in Fig. 6, while operating the lift-conveyor 14, the motor control section 38 controls the raising and lowering motor 36 so as to produce a load torque taking account of the torque bias.

More specifically, the raising and lowering motor 36 according to this first embodiment produces a torque bias based on the vehicle weight and then accelerates the lift-conveyor 14 that is at a standstill with the vehicle 12 placed thereon. By doing so, because the raising and lowering motor 36 produces a load torque that bears the vehicle weight in advance, the lift-conveyor 14 can reduce an impact generated when the raising and lowering motor 36 is started up (when the lift-conveyor 14 having the vehicle 12 placed thereon starts to go down). Therefore, the mechanical parking apparatus 10 according to this first embodiment reduces noise generated when the lift-conveyor 14 is to go down, which contributes to an extended service life of mechanical components.

{0093}

Fig. 7 is a speed pattern of the lift-conveyor 14 during unloading based on control by the control section 40 according

to this first embodiment.

{0094}

First, when the control section 40 carries out the process of deriving the unloading speed and outputs the high-speed command to the motor control section 38, the motor control section 38, as shown in the speed pattern for short-distance travel of Fig. 7, controls the raising and lowering motor 36 so that the lift-conveyor 14 goes down at the acceleration (the optimal acceleration) input from the control section 40.

{0095}

When the moving speed of the lift-conveyor 14 reaches the maximum speed input from the control section 40, the motor control section 38 controls the raising and lowering motor 36 so that the moving speed of the lift-conveyor 14 is maintained at the maximum speed for a predetermined period of time.

{0096}

After the above-described predetermined period of time has elapsed, upon determining that the lift-conveyor 14 has reached the deceleration position based on the current position information input from the pulse generator 50, the control section 40 outputs the low-speed command to the motor control section 38. Upon receiving the low-speed command, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 goes down while reducing

its speed at the deceleration (optimal deceleration) input from the control section 40.

{0097}

Then, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 goes down at a predetermined low speed to ensure sufficient stopping precision. Thereafter, when the lift-conveyor 14 is detected by the stopper dog corresponding to the vehicle reception floor 22, the control section 40 triggers braking by turning off the low-speed command to the motor control section 38, thereby stopping the lift-conveyor 14.

{0098}

The speed pattern for long-distance travel during unloading is similar to the above-described speed pattern for short-distance travel.

{0099}

As described above, because the mechanical parking apparatus 10 according to this first embodiment controls the raising and lowering motor 36 that raises and lowers the lift-conveyor 14 based on acceleration, deceleration, and maximum speed appropriate for the vehicle weight, the mechanical parking apparatus 10 can take full advantage of the raising and lowering motor 36, thus allowing the lift-conveyor 14 to go up and down in a shorter period of time.

{0100}

[Second embodiment]

A second embodiment according to the present invention will now be described.

{0101}

The structures of the mechanical parking apparatus 10 and the lift-conveyor control device 30 according to this second embodiment are similar to those of the mechanical parking apparatus 10 according to the first embodiment shown in Figs. 1 and 2, and descriptions thereof will be omitted.

{0102}

The control section 40 according to this second embodiment derives a positive jerk and a negative jerk at which to raise and lower the lift-conveyor 14, as well as an acceleration, deceleration, and maximum speed, based on the vehicle weight estimated by the weight estimation section 48 and then outputs these derived values to the motor control section 38. The method of deriving a positive jerk and negative jerk is the same as the method of deriving acceleration and deceleration described in the first embodiment, and a description thereof will be omitted.

Then, the motor control section 38 according to this second embodiment performs control (so called S-shaped control) of the raising and lowering motor 36 so as to accelerate the lift-conveyor 14, which is at a standstill and has the vehicle 12 placed thereon, based on the acceleration

and positive jerk (acceleration, positive jerk, and negative jerk in the example of Figs. 8 and 9 described below) derived by the control section 40 and, after the derived maximum speed has been reached, to decelerate the lift-conveyor based on the derived deceleration and negative jerk (deceleration, negative jerk, and positive jerk in the example of Figs. 8 and 9 described below), thus allowing the lift-conveyor 14 to stop at a pre-specified floor.

{0103}

Fig. 8 shows a speed pattern of the lift-conveyor 14 during loading based on control by the control section 40 according to this second embodiment.

{0104}

As shown in the speed pattern for a short-distance travel in Fig. 8, the low-speed command is first output from the control section 40 to the motor control section 38, and the lift-conveyor 14 rises at low speed. At this time, the control section 40 carries out the process of deriving the loading speed.

{0105}

Then, when the high-speed command is output to the motor control section 38 after the control section 40 has carried out the process of deriving the loading speed, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 rises at the acceleration (the

optimal acceleration) input from the control section 40. At this time, the acceleration is gradually increased at the positive jerk (optimal positive jerk) input from the control section 40 until the optimal acceleration is reached.

{0106}

Then, the motor control section 38 according to this second embodiment decreases the acceleration of the lift-conveyor 14 at the negative jerk (optimal negative jerk) input from the control section 40 when the lift-conveyor 14 is at a predetermined speed before the moving speed of the lift-conveyor 14 reaches the maximum speed input from the control section 40 and then sets the acceleration to zero (0) as soon as the moving speed of the lift-conveyor 14 reaches the maximum speed. Thereafter, the motor control section 38 controls the raising and lowering motor 36 so that the moving speed of the lift-conveyor 14 is maintained at the maximum speed for a predetermined period of time.

{0107}

After the above-described predetermined period of time has elapsed, the control section 40 outputs the low-speed command to the motor control section 38 when it is determined that the lift-conveyor 14 has reached the deceleration position based on current position information input from the pulse generator 50. Upon receiving the low-speed command, the motor control section 38 controls the raising and lowering

motor 36 so that the lift-conveyor 14 decelerates at the negative jerk input from the control section 40 until the deceleration (optimal deceleration) input from the control section 40 is reached to raise the lift-conveyor 14 while decelerating at the optimal deceleration.

{0108}

Then, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 rises at a predetermined low speed to ensure sufficient stopping precision. When the moving speed of the lift-conveyor 14 is to be set at the above-described low speed, the motor control section 38 controls the raising and lowering motor 36 so that the acceleration of the lift-conveyor 14 becomes zero by accelerating the lift-conveyor 14 at an optimal positive jerk, thereby achieving the above-described low speed. Thereafter, when the stopper dog corresponding to the floor at which the lift-conveyor 14 is to stop detects the lift-conveyor 14, the control section 40 turns off the low-speed command to the motor control section 38 to brake the lift-conveyor 14, thus causing the lift-conveyor 14 to stop.

{0109}

The speed pattern for long-distance travel during loading is similar to the above-described speed pattern for short-distance travel.

{0110}

On the other hand, Fig. 9 shows a speed pattern of the lift-conveyor 14 during unloading based on control by the control section 40 according to this second embodiment.

{0111}

First, when the control section 40 carries out the process of deriving the unloading speed and outputs the high-speed command to the motor control section 38, the motor control section 38, as shown in the speed pattern for short-distance travel of Fig. 9, controls the raising and lowering motor 36 so that the lift-conveyor 14 goes down at the acceleration (the optimal acceleration) input from the control section 40. At this time, the acceleration is gradually increased at the positive jerk (optimal positive jerk) input from the control section 40 until the optimal acceleration is reached.

{0112}

Then, the motor control section 38 according to this second embodiment decreases the acceleration of the lift-conveyor 14 at the negative jerk (optimal negative jerk) input from the control section 40 when the lift-conveyor 14 is at a predetermined speed before the moving speed of the lift-conveyor 14 reaches the maximum speed input from the control section 40 and then sets the acceleration to zero (0) when the moving speed of the lift-conveyor 14 reaches the maximum speed. Thereafter, the motor control section 38 controls the

raising and lowering motor 36 so that the moving speed of the lift-conveyor 14 is maintained at the maximum speed for a predetermined period of time.

{0113}

After the above-described predetermined period of time has elapsed, the control section 40 outputs the low-speed command to the motor control section 38 when it is determined that the lift-conveyor 14 has reached the deceleration position based on current position information input from the pulse generator 50. Upon receiving the low-speed command, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 decelerates at the negative jerk input from the control section 40 until the deceleration (optimal deceleration) input from the control section 40 is reached to lower the lift-conveyor 14 while decelerating at the optimal deceleration.

{0114}

Then, the motor control section 38 controls the raising and lowering motor 36 so that the lift-conveyor 14 lowers at a predetermined low speed to ensure sufficient stopping precision. When the moving speed of the lift-conveyor 14 is to be set at the above-described low speed, the motor control section 38 controls the raising and lowering motor 36 so that the acceleration of the lift-conveyor 14 becomes zero (0) by accelerating the lift-conveyor 14 at an optimal positive jerk,

thereby achieving the above-described low speed. Thereafter, when the stopper dog corresponding to the vehicle reception floor 22 detects the lift-conveyor 14, the control section 40 turns off the low-speed command to the motor control section 38 to brake the lift-conveyor 14, thus causing the lift-conveyor 14 to stop.

{0115}

The speed pattern for long-distance travel during unloading is similar to the above-described speed pattern for short-distance travel.

{0116}

According to the mechanical parking apparatus 10 of this second embodiment, because raising and lowering of the lift-conveyor 14 is subjected to S-shaped control, an abrupt change of acceleration can be suppressed, an impact, for example, upon the lift-conveyor 14 can be suppressed, noise generated when the lift-conveyor 14 is raised and lowered can be suppressed, and the service life of mechanical components can be extended.

{0117}

[Third embodiment]

A third embodiment according to the present invention will now be described.

{0118}

The structures of the mechanical parking apparatus 10 and

the lift-conveyor control device 30 according to this third embodiment are similar to those of the mechanical parking apparatus 10 according to the first embodiment shown in Figs. 1 and 2, and descriptions thereof will be omitted.

{0119}

The motor control section 38 according to this third embodiment controls the raising and lowering motor 36 in the case of loading the vehicle 12 so that the lift-conveyor 14 at a standstill having the vehicle 12 placed thereon is also accelerated after a torque bias has been produced based on the vehicle weight.

Fig. 10 is a flowchart showing the flow of the process of deriving the loading speed according to this third embodiment. Furthermore, the same steps in Fig. 10 as those in Fig. 3 are denoted with the same reference numerals, and descriptions thereof will be omitted partially or in full.

{0120}

First, in step 100, the operation of raising the lift-conveyor 14 having the vehicle 12 placed thereon by a predetermined distance (hereinafter, referred to as "pickup") is carried out.

{0121}

In the subsequent step 102, the vehicle weight is estimated based on the load torque that is produced by the raising and lowering motor 36 and is also obtained from the

torque current output to the raising and lowering motor 36 by the motor control section 38 during pickup.

{0122}

In the subsequent step 300, the operation of the lift-conveyor 14 is stopped.

{0123}

In the subsequent step 302, a torque bias value is calculated from the vehicle weight.

{0124}

In the subsequent step 304, the torque bias value is output to the motor control section 38 to resume the operation of the lift-conveyor 14, and then the flow proceeds to step 104.

{0125}

Upon receiving the command for resuming the operation of the lift-conveyor 14, as well as the torque bias value, the motor control section 38 controls the raising and lowering motor 36 so that a load torque taking account of the torque bias is produced while the lift-conveyor 14 is being driven.

{0126}

Therefore, because the mechanical parking apparatus 10 according to this third embodiment can suppress an impact generated when the lift-conveyor 14 having the vehicle 12 placed thereon is raised, noise generated when the lift-conveyor 14 is raised is suppressed, and the service life of

mechanical components can be extended.

{0127}

Although the present invention has been described using the foregoing embodiments, the technical scope of the invention is not limited to the scope described in those embodiments. Various modifications or improvements can be applied to each of the foregoing embodiments without departing from the scope of the present invention, and such modified and improved embodiments are also included in the technical scope of the present invention.

{0128}

Although a vehicle weight is estimated based on the load torque produced by the raising and lowering motor 36 in each of the above-described embodiments, the present invention is not limited to this. For example, the vehicle weight may be estimated based on the value of the current that flows in the raising and lowering motor when the pallet 20 having the vehicle 12 placed thereon is raised a predetermined distance from the predetermined reference position during loading of the vehicle 12.

More specifically, as shown in Fig. 11, the mechanical parking apparatus 10 includes a turning device 60 that is provided on the vehicle reception floor from/to which the vehicle 12 is unloaded/loaded to turn the pallet 20 having the vehicle 12 placed thereon. Then, when turning the pallet 20

having the vehicle 12 placed thereon in the direction for storing the vehicle 12 on the storage shelf 18 during loading of the vehicle 12, the turning device 60 raises the pallet 20 and the vehicle placed on the pallet 20 from the predetermined reference position using a raising and lowering motor (not shown in the figure). At this time, the control section 40 estimates the weight of the vehicle 12 based on the current flowing in the raising and lowering motor.

{0129}

Furthermore, although each of the above-described embodiments is described by way of example of how to control the vehicle 12 which is loaded into and unloaded from the mechanical parking apparatus 10 for the first time, the present invention is not limited to this example. For example, when a predetermined vehicle 12 is be stored on a predetermined storage shelf 18 in the case of the mechanical parking apparatus 10 for residential housing, the weight of the vehicle 12 may be read out from the vehicle weight information stored in the storage section 42 to derive acceleration, deceleration, maximum speed, and so forth.

By doing so, in cases where the shelf on which the vehicle 12 is to be stored is predetermined, loading of the vehicle 12 can be carried out smoothly because estimation of the vehicle weight can be skipped.

{0130}

Furthermore, the flow of the process of deciding the loading speed and the process of deciding the unloading speed described in each of the foregoing embodiments is just one example. Unwanted steps may be deleted, new steps may be added, or the processing order may be changed without departing from the scope of the present invention.

{0131}

[Fourth embodiment]

A fourth embodiment according to the present invention will now be described.

The structures of the mechanical parking apparatus 10 according to this fourth embodiment are similar to those of the mechanical parking apparatus 10 according to the first embodiment shown in Fig. 1, and descriptions thereof will be omitted.

A plurality of floors in the mechanical parking apparatus 10 are classified into a plurality of compartments along the height direction, vehicles 12 with weights equal to or below a predetermined weight are taken to higher compartments (upper floors), whereas vehicles 12 with weights over the predetermined weight are taken to lower compartments (lower floors). This embodiment assumes that five predetermined weights are set and is described by way of example of a mechanical parking apparatus 10 with five compartments.

This embodiment is described assuming that a contract

user directly operates the mechanical parking apparatus and furthermore, that the mechanical parking apparatus to be operated is predetermined.

{0132}

Fig. 13 shows the structure of the lift-conveyor control device 30 according to this fourth embodiment.

In addition to the components described in the above-described embodiments, the lift-conveyor control device 30 includes a pallet-determining section (pallet-determining means) 61, a data management section 62, and a calculation section 63.

Of the pallets 20 used to carry vehicles, the pallet-determining section 61 takes out an unoccupied pallet, i.e., a pallet 20 having no vehicle 12 placed thereon, from the compartment corresponding to the weight range covering the weight of the vehicle 12 to be loaded. A weight range is range of weights classified according to a predetermined weight, and each weight range corresponds to one of the compartments classified along the height direction of the mechanical parking apparatus 10. Furthermore, it is desirable that compartments covering relatively low floors of the mechanical parking apparatus 10 correspond to heavier weight ranges and that compartments covering relatively higher floors correspond to lighter weight ranges.

{0133}

The data management section 62 stores various types of information, including shelf data, user data, and group-determining data. Various types of information stored in the data management section 62 will be described below.

Group-determining data associates weight ranges classified according to weight with compartments in the mechanical parking apparatus 10. For example, if predetermined weights are assumed to be 2300 Kg, 1900 Kg, 1600 Kg, 1300 Kg, and 1000 Kg, as shown in Fig. 14, the weight range from 1901 Kg to 2300 Kg is associated with compartment A, the weight range from 1601 Kg to 1900 Kg is associated with compartment B, the weight range from 1301 Kg to 1600 Kg is associated with compartment C, the weight range from 1001 Kg to 1300 Kg is associated with compartment D, and the weight range equal to or below 1000 Kg is associated with compartment E.

{0134}

User data associates user IDs indicating the identification information of vehicles 12 with information about the weights of the vehicles 12. For example, the user data is shown as shown in Fig. 15. Furthermore, as described in the first to third embodiments, information about vehicle weights in the user data is information about estimated weights of vehicles 12 acquired by the weight estimation section 48 of the control section 40. When acquired by the

lift-conveyor control device 30, the weight information is stored in the storage section 42 and also stored in the user data in association with identification information of the vehicle 12. Furthermore, user ID in the user data is information such as personal identification number, IC card, or remote control, which is used as a user authentication key required when the mechanical parking apparatus 10 is to be used.

{0135}

Shelf data associates compartments classified according to weight range with floors of the mechanical parking apparatus 10. For example, as shown in Fig. 16, if a 15-story mechanical parking apparatus 10 is classified into five compartments from compartments A to E shown in Fig. 14, the first floor to the third floor are associated with compartment A, the fourth floor to the sixth floor are associated with compartment B, the seventh floor to the ninth floor are associated with compartment C, the tenth floor to the twelfth floor are associated with compartment D, and the thirteenth floor to the fifteenth floor are associated with compartment E. Although this embodiment is described by way of an example where the mechanical parking apparatus 10 is a 15-story building and has five weight ranges, the number of floors of the mechanical parking apparatus and the number of compartments corresponding to weight ranges are not

particularly limited. Values of predetermined weights according to which weight ranges are classified are not particularly limited.

{0136}

Furthermore, shelf data associates identification information of each storage shelf with information about the presence of a vehicle 12 on the storage shelf (whether a vehicle 12 is loaded or not). With reference to this shelf data, availability of an unoccupied pallet, i.e., a pallet 20 having no vehicle placed thereon, as well as the storage shelves 18 having the vehicles 12 stored thereon, can be identified. Information indicating the presence of a vehicle is information that is overwritten (updated) according to a change in the usage of storage shelves as a result of loading and unloading.

{0137}

The calculation section 63 calculates the amount of energy required to load and unload the vehicle 12. More specifically, the calculation section 63 calculates a first amount of energy Ea required to place and carry the vehicle 12 on an unoccupied pallet that has been searched for starting with a low floor and selected, calculates a second amount of energy Eb required to place and carry the vehicle 12 on an unoccupied pallet selected by the pallet-determining section, and outputs the first amount of energy Ea and the second

amount of energy Eb. Still more specifically, the required amounts of energy are calculated using mathematical Expressions (1) and (2) below and are presented as numerical values so that the amounts of energy can be compared.

Furthermore, the calculation section 63 stores energy saving data, such as first energy Ea, second energy Eb, and the amount of saved energy (amount of saved energy; difference between the first energy Ea and the second energy Eb), in the data management section 62.

{0138}

First amount of energy Ea = Height h1 [m] from ground to floor with unoccupied pallet × measured vehicle weight [kg] × gravitational acceleration [9.8 m/s^2] ... (1)

Second amount of energy Eb = Height h2 [m] from ground to the floor with unoccupied pallet × measured vehicle weight [kg] × gravitational acceleration [9.8 m/s^2] ... (2)

Amount of saved energy = (first energy Ea) - (second amount of energy Eb) ... (3)

{0139}

The height h1 indicates the height of the floor (position) on which an unoccupied pallet is available, i.e., a pallet that has been selected after being searched for, starting with a low floor in the mechanical parking apparatus. The height h2 indicates the height of the floor (position) on which an unoccupied pallet is available, i.e., a pallet that

has been selected after being sequentially searched for in compartments assigned in consideration of vehicle weights by the method according to the present invention. In other words, the height h1 and the height h2 are determined through different procedures.

{0140}

Control of the lift-conveyor 14 during loading, which is carried out in the mechanical parking apparatus 10 according to this fourth embodiment, will be described below.

Fig. 17 is a flowchart showing the flow of taking out the pallet 20 during loading, which is carried out in the lift-conveyor control device 30 according to this fourth embodiment.

When the vehicle 12 to be loaded is placed on the vehicle reception floor 22 and the user enters a user ID via the operating panel 32, the user data in the data management section 62 is searched, and it is determined whether vehicle weight data corresponding to the identification information (user ID) of the vehicle 12 to be loaded exists (step SA1).

{0141}

If there is no weight data for the vehicle 12 to be loaded, a search is made for an unoccupied pallet sequentially starting from a low floor (e.g., the first floor in the case of the mechanical parking apparatus with the first to fifteenth floors) (step SA2). If, as a result of determining

whether there is an unoccupied pallet, there is an unoccupied pallet (Yes in step SA3), that unoccupied pallet is selected as the pallet 20 onto which the vehicle 12 is to be loaded (step SA4), thus completing the first loading. On the other hand, if there is no unoccupied pallet, a search is made for an unoccupied pallet sequentially upward, starting with the floor one story above the above-mentioned low floor that has been searched, and this processing is repeated (No in step SA3).

{0142}

On the other hand, if there is vehicle weight data corresponding to the identification information of the vehicle 12 to be loaded, group-determining data is searched for to read out information about the compartment corresponding to the vehicle weight range covering the vehicle weight data of the vehicle 12 to be loaded (step SA5). Based on the read-out information about the compartment, it is determined whether there is an unoccupied pallet in the relevant compartment of the mechanical parking apparatus 10 (step SA6). If there is an unoccupied pallet, the unoccupied pallet in the relevant compartment is selected as the pallet 20 onto which the vehicle 12 is to be loaded (step SA7), thus completing this processing. If there is no unoccupied pallet, the process of reading out information about the compartment corresponding to the subsequent weight range (step SA8) and determining whether

there is an unoccupied pallet in the compartment corresponding to that subsequent weight range is repeated until an unoccupied pallet is found.

{0143}

Here, the "subsequent weight range" that is searched for an unoccupied pallet represents the "weight range one rank lighter" than the weight range to be searched. If there is no unoccupied pallet in the "one-rank lighter weight range," the "one-rank lighter still weight range" is selected as the compartment to be searched for an unoccupied pallet. In addition, if there is no unoccupied pallet when the one-rank lighter weight ranges have been searched one after another in this manner, the "weight range one rank heavier" than the original weight range is selected as the compartment to be searched for an unoccupied pallet. If there is no unoccupied pallet in the "one-rank heavier weight range," the "one-rank heavier still weight range" is selected as the compartment to be searched for an unoccupied pallet. As described above, if there is no unoccupied pallet in the weight range covering the weight of the vehicle 12 to be loaded, lighter weight ranges are searched with priority for an unoccupied pallet, and the vehicle 12 is stored temporarily in a lighter weight range to prevent parking compartments corresponding to heavier weight ranges from storing vehicles, thus effectively utilizing heavy weight ranges.

{0144}

When the weight range from which an unoccupied pallet is to be taken out is determined, the unoccupied pallet is taken out from the relevant weight range, the vehicle 12 is placed on the taken unoccupied pallet, and the pallet 20 having the vehicle 12 placed thereon is stored on the storage shelf 18 from which the unoccupied pallet has been taken out.

Furthermore, during the process from selection of the unoccupied pallet to be taken out until storage of the vehicle 12 on the storage shelf 18, the weight of the vehicle 12 is estimated by the methods described in the first to third embodiments, and speed adjustment etc. is performed based on this estimated weight.

{0145}

The process of the calculation section 63 calculating and presenting information about energy will be described below with reference to the flowchart in Fig. 18.

First, if there is a vehicle to be loaded, the amount of energy Ea that would be required to load the vehicle on a mechanical parking apparatus according to a conventional technique is calculated. In the case of loading the vehicle using the mechanical parking apparatus according to a conventional technique, a search is made for a storage shelf having an unoccupied pallet onto which the vehicle can be placed, based on the current number of vehicles stored in the

mechanical parking apparatus, and then the number of floors counted starting with a low floor of the mechanical parking apparatus is referred to (step SB1). When the position of the unoccupied pallet used for loading (the number of floors counted starting with a low floor) is determined, the first amount of energy Ea required to load the vehicle at that position is calculated (step SB2).

{0146}

On the other hand, a search is made for a storage shelf having an unoccupied pallet that has been selected as a loading pallet by the pallet-determining section 61 according to this embodiment, and then the number of floors is referred to (step SB3). When the position of the unoccupied pallet to be used for loading is determined, the second energy Eb required to load the vehicle at that position is calculated (step SB4). Subsequently, the difference between the first amount of energy Ea and the second amount of energy Eb is calculated based on the above-described Expression (3), and then the amount of saved energy is calculated (step SB5).

{0147}

When information about the amount of saved energy, the first amount of energy, and the second amount of energy is calculated, these calculation results can be displayed as numerical values on the screen of the operating panel 32 for the sake of the owner of the mechanical parking apparatus 10,

or alternatively, these calculation results can be presented visually (e.g., displayed in terms of CO_2) via, for example, an external output device, or output to a printer to be printed on sheets of paper in a report format (step SB6). {0148}

As described above, according to a lift-conveyor control device 10 of this fourth embodiment, if falling in a heavier weight range, the vehicle 12 is carried to a relatively lower compartment during loading, and if falling in a lighter weight range, the vehicle 12 is carried to a relatively higher compartment during loading. Therefore, the energy during the loading operation is minimized, thus achieving energy saving and reducing the wait time. Furthermore, if there is no unoccupied pallet in the weight range covering the weight of the vehicle 12 to be loaded, the pallet-determining section 61 of the lift-conveyor control device 10 according to the present invention temporarily evacuates the vehicle 12 to a compartment corresponding to a lighter weight range by taking out an unoccupied pallet from the compartment corresponding to the weight range one-rank lighter than the weight range covering the weight of the vehicle 12, thus ensuring a vacancy in the compartments corresponding to heavier weight ranges (i.e., compartments in which the vehicles 12 falling in heavier weight ranges can be loaded). By doing so, not only can the compartments corresponding to heavier weight ranges be

used effectively, but also the energy used for loading can be minimized, compared with the case in which there is no choice but to carry a heavy vehicle 12 to a higher floor because only compartments corresponding to lighter weight ranges have a vacancy when the heavy vehicle 12 is to be loaded.

{0149}

Furthermore, the energy saving effect can be made appealing to the user quantitatively and visually by comparing the first amount of energy Ea required in the case where an unoccupied pallet is taken out from a low floor and moved, as would be done in a known method, against the second amount of energy Eb required in the case where an unoccupied pallet is taken out using the pallet-determining section 61 according to the present invention and moved. In addition, because the energy saving effect can be made appealing by displaying energy saving data in real time on the operating panel 32 as numerical values or an illustration and also can be preserved as records by periodically outputting the energy saving data on sheets of paper for the purpose of presentation, the results of energy saving can be understood from various viewpoints.

{0150}

The group-determining data may be changed by periodically sorting vehicle weight information in the order of weight and reviewing the weight ranges based on the sorted vehicle weight

information.

In this manner, the vehicle weight ranges can be adjusted to the weight distribution of actually stored vehicles through periodical review of the vehicle weight ranges based on that weight distribution. By doing so, highly controlled transport by the mechanical parking apparatus 10 becomes possible because an unoccupied pallet is taken out and moved from an appropriate compartment corresponding to the vehicle weight.

{0151}

Furthermore, information about operating data, such as shelf data, user data, and group-determining data, stored in the data management section 62, analysis of vehicle weight distribution used to sort vehicle weight information, and so forth may be subjected to maintenance, for example, via an inspection terminal. In addition, maintenance may be carried out by maintenance personnel who go to the site at which the mechanical parking apparatus 10 is installed and connect the mechanical parking apparatus 10 directly to the inspection terminal, or alternatively, may be remotely carried out by maintenance personnel who connect the inspection terminal to the mechanical parking apparatus 10 via a network to communicate with the mechanical parking apparatus 10 for maintenance via the network.

Although the present invention is described with three items of data, namely, the shelf data, user data, and group-

determining data, stored in the data management section 62, the technical scope of the present invention is not limited to the above-described three items of data. Various modifications or improvements can be applied to each of the foregoing data without departing from the scope of the present invention, and such modified and improved embodiments are also included in the technical scope of the present invention.

{0152}

[Modification of the fourth embodiment]

Also, in the lift-conveyor control device 30, the vehicle weight range may be set according to the type of the vehicle 12. To make vehicle weight ranges be appropriately classified according to the type of the vehicle (e.g., high roof cars, standard-sized cars), the group-determining data sets compartments A to D for weight ranges (shaded areas in the list) of high roof cars and compartments E to H for weight ranges (white voids in the list) of standard-sized cars, as shown in Fig. 19. In addition, assignment of the storage shelves in these compartments A to H is carried out evenly and appropriately regardless of the different types of the vehicle 12 by, for example, assigning vehicle types alternately every two compartments, as shown in Fig. 20, without deviating from the vehicle weight range for a particular type of the vehicle 12. By doing so, variations in wait time depending on vehicle type can be prevented.

{0153}

[Fifth embodiment]

A fifth embodiment according to the present invention will be described below.

The structures of the mechanical parking apparatus 10 according to this fifth embodiment are similar to that of the mechanical parking apparatus 10 according to the first embodiment shown in Fig. 1, and the structures of the lift-conveyor control device 30 are similar to that of the mechanical parking apparatus 10 according to the fourth embodiment shown in Fig. 13. Differences from the foregoing embodiments will be mainly described. This fifth embodiment differs from the above-described embodiments in that the unoccupied pallet to be taken out is selected taking into account the number of loading and unloading operations to determine the loading position.

{0154}

In addition to the components of the fourth embodiment, the lift-conveyor control device 30 includes a counting section (not shown in the figure). The counting section counts the number of loading and unloading operations of each vehicle and stores the number as user data by associating information about the number of loading and unloading operations with vehicle identification information.

The user data associates the user ID indicating the

identification information of the vehicle 12, information about the weight of the vehicle 12, information about the number of times the vehicle is loaded and unloaded, and a corrected weight (e.g., see Fig. 21). As described in the first to third embodiments, information about the weight of the vehicle 12 stored as user data is information about an estimated weight of the vehicle 12 acquired by the weight estimation section 48 of the control section 40.

{0155}

Group-determining data associates corrected weight ranges (weight ranges), which are calculated by multiplying a magnification indicating a frequency weighting (e.g., ×2.0, ×0.6) by the tentative corrected weight (e.g., 2500), with compartments (see Fig. 22). When the number of items of data stored in the group-determining data is increased (in other words, the number of loading and unloading operations is increased enough to give a discernable distribution), it is preferable that a corrected weight be calculated based on a predetermined calculation expression, as described below, and that thresholds that serve as corrected weight ranges of group-determining data be reviewed and changed.

A fixed value may be set for the magnification indicating the frequency weighting, or alternatively, maintenance personnel, for example, may change the magnification depending on the environment by externally entering a value.

{0156}

A procedure for reviewing the threshold of a corrected weight will now be described. The corrected weight is calculated based on the number of times the vehicle 12 is loaded and unloaded in a predetermined period of time and the average number of times all the vehicles 12 are loaded and unloaded, as shown in Expression (4) below.

Corrected weight = measured weight [Kg] × number of loading and unloading operations / average number of times all vehicles are loaded and unloaded ... (4)

As is understood from the above-described Expression (4), a corrected weight for the same measured weight is set, for example, so as to become small when the number of loading and unloading operations is small and to become large when the number of loading and unloading operations is large.

In this manner, based on the corrected weight taking into consideration the frequency of loading and unloading, an unoccupied pallet most appropriate for the frequency can be selected by reviewing the vehicle weight range.

{0157}

Control of the lift-conveyor 14 during loading, which is carried out in the mechanical parking apparatus 10 according to this fifth embodiment, will be described below.

Fig. 23 is a flowchart showing the flow of taking out the pallet 20 during loading, which is carried out in the lift-

conveyor control device according to this fifth embodiment.

When the vehicle 12 to be loaded is placed on the vehicle reception floor 22 and the user enters a user ID via the operating panel 32, the user data in the data management section 62 is searched, and it is determined whether information about the corrected weight corresponding to the identification information (user ID) of the vehicle 12 to be loaded exists (step SC1).

{0158}

If there is no information about the corrected weight of the vehicle 12 to be loaded, a search is made for an unoccupied pallet sequentially starting from a low floor (e.g., the first floor in the case of the mechanical parking apparatus with the first to fifteenth floors) (step SC2). If, as a result of determining whether there is an unoccupied pallet, there is an unoccupied pallet (Yes in step SC3), that unoccupied pallet is selected as the pallet onto which the vehicle 12 is to be loaded (step SC4) and the number of loading operations is incremented by the counting section, thus completing the first loading. On the other hand, if there is no unoccupied pallet (No in step SC3), a search is made for an unoccupied pallet sequentially upward starting with the floor one story above the low floor that has been searched, and this processing is repeated.

{0159}

On the other hand, if there is information about the corrected weight corresponding to the identification information of the vehicle 12 to be loaded, group-determining data is searched for to read out information about the compartment corresponding to the corrected weight range (weight range associated with each compartment shown in Fig. 22) covering the corrected weight of the vehicle 12 to be loaded (step SC5). Based on the read-out information about the compartment, it is determined whether there is an unoccupied pallet in the relevant compartment of the mechanical parking apparatus 10 (step SC6). If there is an unoccupied pallet, the unoccupied pallet in the relevant compartment is selected as the pallet onto which the vehicle 12 is to be loaded, and the number of loading operations is incremented by the counting section, thus completing this processing (step SC7).

{0160}

If there is no unoccupied pallet, the process of reading out information about the compartment corresponding to the subsequent corrected weight range (step SC8) and determining whether there is an unoccupied pallet in the compartment corresponding to that subsequent corrected weight range is repeated until an unoccupied pallet is found.

Here, the "subsequent corrected weight range" represents the "corrected weight range one rank smaller" than the

corrected weight range to be searched, so that the one-rank smaller corrected weight range can be searched. If there is no unoccupied pallet in the "one-rank smaller corrected weight range," the "one-rank smaller still corrected weight range" is selected as the compartment to be searched for an unoccupied pallet. In addition, if there is no unoccupied pallet when the one-rank smaller corrected weight ranges have been searched one after another in this manner, the "corrected weight range one rank larger" than the original corrected weight range is selected as the compartment to be searched for an unoccupied pallet. If there is no unoccupied pallet in the "one-rank larger corrected weight range," the "one-rank larger still corrected weight range" is selected as the compartment to be searched for an unoccupied pallet.

{0161}

Furthermore, during the process from selection of the unoccupied pallet to be taken out until storage of the vehicle 12 on the storage shelf 18, the weight of the vehicle 12 is estimated by the methods described in the first to third embodiments, and speed adjustment etc. is performed based on this estimated weight.

{0162}

As described above, if there is no unoccupied pallet in the corrected weight range covering the corrected weight of the vehicle 12 to be loaded, a vacancy is ensured in a

compartment corresponding to a large corrected weight range (i.e., vehicles with high frequencies of loading and unloading and high weights) to effectively utilize a large corrected weight range by giving priority to a compartment corresponding to a small corrected weight range (i.e., vehicles with low frequencies of loading and unloading and low weights) when searching for an unoccupied pallet, and furthermore, a situation suitable for sorting vehicle weights is created by temporarily storing the vehicle 12 in a small corrected weight range.

{0163}

As described above, energy-saving operation is achieved according to the lift-conveyor control device 10 of this fifth embodiment because the loading position is determined based on the corrected weight taking account of the frequency of loading and unloading and vehicle weight. Furthermore, an unoccupied pallet most appropriate for the frequency and vehicle weight can be selected because the vehicle weight ranges are reviewed based on the corrected weight.

{0164}

[Sixth embodiment]

A sixth embodiment according to the present invention will be described below.

The structures of the mechanical parking apparatus 10 according to this sixth embodiment are similar to that of the

mechanical parking apparatus 10 according to the first embodiment shown in Fig. 1, and the structures of the lift-conveyor control device 30 are similar to that of the mechanical parking apparatus 10 according to the fourth embodiment shown in Fig. 13. Differences from the foregoing embodiments will be mainly described. Although the foregoing embodiments have been described by way of an example where a user ID is used as the identification information of the vehicle 12 assuming that a mechanical parking apparatus used by a contract user is determined in advance, this sixth embodiment differs from the above-described embodiments in that a user is not determined in advance and a unique number of a vehicle is used as the identification information. Furthermore, this embodiment is described by way of example of being applied to a pay-by-the-hour mechanical parking apparatus.

{0165}

User data stores the unique number of each vehicle acquired as identification information in association with information about the vehicle weight. The unique number of a vehicle is the number shown on the vehicle identification plate (number plate) and can be acquired, for example, by carrying out image processing with an imaging device, such as a camera, installed at the position of the vehicle waiting to be loaded or unloaded. By doing so, the identification

information of the vehicle to be loaded or unloaded can be easily acquired and stored in the user data as number information.

{0166}

When the unique number of the vehicle 12 to be loaded is acquired by image processing with, for example, a camera when loading the vehicle 12, the user data in which the unique numbers of the vehicles 12 that were loaded or unloaded are associated with the weights of the vehicles 12 is referred to to determine whether the vehicle is a vehicle that was loaded or unloaded in the past. If there is information about the weight of the vehicle corresponding to the unique number in the user data, an unoccupied pallet is taken out from the compartment corresponding to the weight range covering the weight of the vehicle 12 corresponding to the unique number.

{0167}

Furthermore, during the process from selection of the unoccupied pallet to be taken out until storage of the vehicle 12 on the storage shelf 18, the weight of the vehicle 12 is estimated by the methods described in the first to third embodiments, and speed adjustment etc. is performed based on this estimated weight.

{0168}

In this manner, as a result of the unique number of a vehicle that was loaded or unloaded in the past being

associated with the weight, a pallet can be taken out and moved from an energy-saving position also in the case of a mechanical parking apparatus that is operated on a pay-by-the-hour basis because the weight can be estimated from the unique number for a user who has used the mechanical parking apparatus more than once.

{0169}

In addition, the weight ranges classified in the data decision table should preferably be changed, for example, depending on the day in a week or busy periods (year-end and New Year days or event-intensive periods) for pay-by-the-hour mechanical parking apparatuses, because more standard-sized cars for business use are expected on weekdays, whereas more box cars for family use, heavier than standard-sized cards, are expected on weekends. By doing so, a pallet most appropriate for the vehicle weight can be selected.

{0170}

[Seventh embodiment]

A seventh embodiment according to the present invention will be described below.

The structures of the mechanical parking apparatus 10 according to this seventh embodiment are similar to that of the mechanical parking apparatus 10 according to the first embodiment shown in Fig. 1, and a description thereof will be omitted. This seventh embodiment differs from the above-

described embodiments in that a mechanical parking system 100 includes a plurality of the mechanical parking apparatuses 10, as shown in Fig. 24, and that user data for vehicles to be loaded and unloaded and vehicle weights is shared among the plurality of mechanical parking apparatuses. This embodiment is described assuming that there are a plurality of mechanical parking apparatuses that can be used by contract users in, for example, a condominium building. Although the mechanical parking system 100 is described as including three mechanical parking apparatuses 10, the number of mechanical parking apparatuses is not particularly limited.

{0171}

The mechanical parking system 100 includes three mechanical parking apparatuses 10a, 10b, and 10c and a monitor section 6. The mechanical parking apparatuses 10a, 10b, and 10c and the monitor section 6 are connected to each other so as to communicate with each other, i.e., to send and receive information to and from each other.

The monitor section 6 includes the data management section described in the foregoing embodiments and selects a mechanical parking apparatus into which the vehicle 12 is to be loaded with reference to the user data stored in the data management section, which is information associating loaded vehicles with the weights of the vehicles. The data management section shares the common user data among all the

mechanical parking apparatuses 10a, 10b, and 10c.

{0172}

The operating mode used to select a mechanical parking apparatus that is made to load or unload a vehicle in the mechanical parking system will be described below. For operation, the mechanical parking apparatuses switch the operating mode among a loading and unloading mode, a standby mode, an energy saving mode, a power-off mode, and so forth.

The loading and unloading mode is an operating mode in which a vehicle is loaded onto or unloaded from a storage shelf, in which various devices are supplied with electrical power. The standby mode is an operating mode that is entered after a vehicle has been loaded or unloaded and reduces electrical power by a certain amount compared with that consumed in the loading and unloading mode. The energy saving mode is an operating mode that is entered a predetermined period of time after entering the standby mode and further reduces electrical power by a certain amount compared with that consumed in the standby mode. In the power-off mode, neither the mechanical parking apparatus 1 nor various devices are supplied with electrical power. In this embodiment, mechanical parking apparatuses that have an unoccupied pallet and therefore have a capacity for loading the vehicle 12 are given priority to accept loading in the order of the standby mode, the loading and unloading mode, and the energy saving

mode. By doing so, the mechanical parking apparatuses can be effeciently operated, which helps save energy.

{0173}

In the mechanical parking system, when the user enters, for example, the user ID via the operating panel in a situation where there is a vehicle to be loaded, the data management section of the monitor section 6 determines if weight information about the vehicle corresponding to the user ID is available with reference to the user data. If there is no weight data for the vehicle 12 to be loaded in the user data, the operating modes of the mechanical parking apparatuses are compared, and the mechanical parking apparatus in an operating mode with high priority for loading a vehicle is selected as the mechanical parking apparatus 10 that accepts loading. If it is not possible to select a mechanical parking apparatus 10 based on the operating mode, the mechanical parking apparatus 10 with a large unoccupied shelf is selected, and then a search is made for an unoccupied pallet sequentially starting from a low floor (e.g., the first floor if the mechanical parking apparatus has 1 to 15 stories) of the selected mechanical parking apparatus 10. If, as a result of determining whether there is an unoccupied pallet, there is an unoccupied pallet, that unoccupied pallet is selected as the pallet to load the vehicle 12, thus completing the first loading.

{0174}

If the user data contains vehicle weight data corresponding to the identification information of the vehicle 12 to be loaded, the group-determining data is searched to read out information about the compartment corresponding to the vehicle weight range covering the vehicle weight data of the vehicle 12 to be loaded. Subsequently, it is determined whether each of the mechanical parking apparatuses has an unoccupied shelf in the compartment corresponding to the read-out vehicle weight range. If only one mechanical parking apparatus 10 has an unoccupied shelf, the mechanical parking apparatus having the unoccupied shelf is selected as the apparatus into which to load the vehicle. If two or more mechanical parking apparatuses 10 have an unoccupied shelf, the following procedure is performed to select one.

{0175}

Among the mechanical parking apparatuses 10, when two or more mechanical parking apparatuses 10 that have an unoccupied pallet in the relevant compartment are found, the operating modes are compared, and the mechanical parking apparatus 10 used for loading is determined based on the operating mode. Furthermore, if no mechanical parking apparatus 10 can be selected even based on the operating mode, storage shelves having no vehicle loaded thereon, more specifically the number of unoccupied shelves, are compared, so that the mechanical

parking apparatus 10 with a larger number of unoccupied shelves is selected. When the mechanical parking apparatus 10 into which to load the vehicle is selected in this manner, the unoccupied pallet is taken out from the desired compartment of the selected mechanical parking apparatus 10, thus completing this processing.

{0176}

Furthermore, during the process from selection of the unoccupied pallet to be taken out until storage of the vehicle 12 on the storage shelf 18, the weight of the vehicle 12 is estimated by the methods described in the first to third embodiments, and speed adjustment etc. is performed based on this estimated weight.

{0177}

As described above, in the mechanical parking system 100 according to this seventh embodiment, the mechanical parking apparatus 10 appropriate for the vehicle weight and the frequency of loading and unloading can be selected by sharing the user data associating vehicles with the weights of the vehicles among the plurality of mechanical parking apparatuses, thereby contributing to a reduction in user's wait time for loading and unloading in the entire mechanical parking system. Furthermore, the mechanical parking system helps save energy. As a result, an environment-friendly mechanical parking system 100 can be provided.

{Reference Signs List}

{0178}

10 mechanical parking apparatus

12 vehicle

14 lift conveyor

30 lift-conveyor control device

36 raising and lowering motor

38 motor control section

40 control section

42 storage section

48 weight estimation section

61 pallet-determining section

62 data management section

63 calculation section

{CLAIMS}

CLAIMS:

{Claim 1}

A lift-conveyor control device of a mechanical parking apparatus that includes:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor; and

storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down,

wherein the plurality of floors are classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined weight is carried to an upper compartment, whereas a vehicle over the predetermined weight is carried to a lower compartment,

the lift-conveyor control device comprising:

weight estimation means for estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded;

pallet-determining means for setting at least one of the predetermined weight, classifying the compartment into at least two, searching group determination data in which weight ranges classified according to the predetermined weights are

associated with the compartments, and, taking out an unoccupied pallet, which is a pallet that does not have the vehicle placed thereon, among pallets that carry vehicles placed thereon, by reading out information of the compartment corresponding to the weight range covering the weight of the vehicle to be loaded, from the readout compartment,

wherein the pallet having the vehicle to be loaded placed thereon is moved to the compartment from which the unoccupied pallet has been taken out, and

wherein the weight range of the group-determining data is changed, by periodically sorting weight information of the vehicle of user data in which identification information of the vehicle is associated with weight information of the vehicle in the order of weight, according to weight distribution of the vehicle of the sorted user data.

{Claim 2}

A lift-conveyor control device of a mechanical parking apparatus that includes:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor; and

storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down,

wherein the plurality of floors are classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined weight is carried to an upper compartment, whereas a vehicle over the predetermined weight is carried to a lower compartment,

the lift-conveyor control device comprising:

weight estimation means for estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded;

pallet-determining means for setting at least one of the predetermined weight, classifying the compartment into at least two, searching group determination data in which weight ranges classified according to the predetermined weights are associated with the compartments, and, among pallets that carry vehicles placed thereon, taking out an unoccupied pallet, which is a pallet that does not have the vehicle placed thereon, by reading out information of the compartment corresponding to the weight range covering the weight of the vehicle to be loaded, from the readout compartment,

wherein the pallet having the vehicle to be loaded placed thereon is moved to the compartment from which the unoccupied pallet has been taken out, and

wherein, based on user data in which the number of loading operations of the vehicle repeating loading and unloading, identification information of the vehicle, and

weight information of the vehicle are associated with each other, a corrected weight that exhibits a large value if the number of operations exceeds an average number of loading and unloading operations of all the vehicles and exhibits a small value if the number of operations is smaller than the average number of loading and unloading operations is calculated, and the weight range of the group determination data is set based on the corrected weight

.

{Claim 3}

A lift-conveyor control device of a mechanical parking apparatus that includes:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor; and

storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down,

wherein the plurality of floors are classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined weight is carried to an upper compartment, whereas a vehicle over the predetermined weight is carried to a lower compartment,

the lift-conveyor control device comprising:

weight estimation means for estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded;

pallet-determining means for setting at least one of the predetermined weight, classifying the compartment into at least two, searching group determination data in which weight ranges classified according to the predetermined weights are associated with the compartments, and, among pallets that carry vehicles placed thereon, taking out an unoccupied pallet, which is a pallet that does not have the vehicle placed thereon, by reading out information of the compartment corresponding to the weight range covering the weight of the vehicle to be loaded, from the readout compartment; and

calculation means for calculating amount of energy required to load and unload the vehicle,

wherein the pallet having the vehicle to be loaded placed thereon is moved to the compartment from which the unoccupied pallet has been taken out and

wherein the calculation means calculates a first amount of energy required to search for the unoccupied pallet starting from the lower floor and to place and carry the vehicle on the selected unoccupied pallet, calculates a second amount of energy required to place and carry the vehicle on the unoccupied pallet selected by the pallet-determining means, and outputs the first amount of energy and the second

amount of energy.

{Claim 4}

The lift-conveyor control device according to one of Claims 1 to 3,

wherein, when the unoccupied pallet does not exist in the weight range covering the weight of the vehicle to be loaded, the pallet-determining means takes out the unoccupied pallet from the compartment corresponding to the weight range one rank lighter than the weight range covering the weight of the vehicle.

{Claim 5}

The lift-conveyor control device according to one of Claims 2 to 4,

wherein, the weight range of the group-determining data is changed, by periodically sorting weight information of the vehicle of user data in which identification information of the vehicle is associated with weight information of the vehicle in the order of weight, according to weight distribution of the vehicle of the sorted user data.

{Claim 6}

The lift-conveyor control device according to one of Claims 3 to 5,

wherein, based on user data in which the number of loading operations of the vehicle repeating loading and unloading, identification information of the vehicle, and weight information of the vehicle are associated with each other,

a corrected weight that exhibits a large value if the number of operations exceeds an average number of loading and unloading operations of all the vehicles and exhibits a small value if the number of operations is smaller than the average number of loading and unloading operations is calculated, and

the weight range of the group determination data is set based on the corrected weight.

{Claim 7}

The lift-conveyor control device according to one of Claims 1 to 6,

wherein, if a unique number as identification information of the vehicle to be loaded is acquired when the vehicle is loaded, user data in which the unique number of the vehicle that was loaded and unloaded in the past is associated with the weight of the vehicle is referenced,

if information about the weight of the vehicle corresponding to the unique number exists, information of the compartment corresponding to the weight range covering the weight of the vehicle corresponding to the unique number is

read out from the group-determining data,

and the unoccupied pallet is taken out from the readout compartment.

{Claim 8}

The lift-conveyor control device according to one of Claims 1 to 7,

wherein the weight range of the group-determining data is set for each type of the vehicle such as a high roof car or a standard-sized car within weight ranges classified according to the predetermined weight.

{Claim 9}

The lift-conveyor control device according to one of Claims 1 to 8,

wherein the weight estimation means estimates the weight of the vehicle based on the torque that is produced by the motor when the lift conveyor having the vehicle placed thereon is raised at the time of loading the vehicle.

{Claim 10}

The lift-conveyor control device according to one of Claims 1 to 9,

wherein the weight estimation means estimates the weight of the vehicle based on a value of electrical current flowing

in a raising and lowering motor that raises a pallet having the vehicle placed thereon from a predetermined reference position by a predetermined amount at the time of loading the vehicle.

{Claim 11}

A mechanical parking apparatus comprising:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor;

storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down; and

the lift-conveyor control device according to one of Claims 1 to 10.

{Claim 12}

A mechanical parking system comprising:

the mechanical parking apparatus according to Claim 11; and

a terminal connected to the mechanical parking apparatus so that information can be received and sent.

{Claim 13}

The mechanical parking system according to Claim 12,

wherein the mechanical parking apparatus and the terminal, which are interconnected via a communication network, are disposed remotely from each other.

{Claim 14}

A mechanical parking system comprising:

a plurality of the mechanical parking apparatuses according to one of Claims 11 to 13,

wherein the plurality of mechanical parking apparatuses share common user data in the form of information associating the vehicle to be loaded and unloaded with the weight of the vehicle.

{Claim 15}

A lift-conveyor control method for a mechanical parking apparatus that includes:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor; and

storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down,

wherein the plurality of floors are classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined weight is carried to an

upper compartment, whereas a vehicle over the predetermined weight is carried to a lower compartment,

the lift-conveyor control method comprising:

a first step of estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded;

a second step of setting at least one of the predetermined weight, classifying the compartment into at least two, searching group determination data in which weight ranges classified according to the predetermined weights are associated with the compartments, and, taking out an unoccupied pallet, which is a pallet that does not have the vehicle placed thereon, among pallets that carry vehicles placed thereon, by reading out information of the compartment corresponding to the weight range covering the weight of the vehicle to be loaded, from the readout compartment;

a third step of moving the pallet having the vehicle to be loaded placed thereon to the compartment from which the unoccupied pallet has been taken out; and

a forth step of changing the weight range of the group-determining data, by periodically sorting weight information of the vehicle of user data in which identification information of the vehicle is associated with weight information of the vehicle in the order of weight, according to weight distribution of the vehicle of the sorted user data.

{Claim 16}

A lift-conveyor control method for a mechanical parking apparatus that includes:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor; and

storage shelves provided on the plurality of floors along a hoistway along which the lift conveyor goes up and down,

wherein the plurality of floors are classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined weight is carried to an upper compartment, whereas a vehicle over the predetermined weight is carried to a lower compartment,

the lift-conveyor control method comprising:

a first step of estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded;

a second step of setting at least one of the predetermined weight, classifying the compartment into at least two, searching group determination data in which weight ranges classified according to the predetermined weights are associated with the compartments, and, among pallets that carry vehicles placed thereon, taking out an unoccupied pallet, which is a pallet that does not have the vehicle placed thereon, by reading out information of the compartment

corresponding to the weight range covering the weight of the vehicle to be loaded, from the readout compartment;

a third step of moving the pallet having the vehicle to be loaded placed thereon to the compartment from which the unoccupied pallet has been taken out; and

a forth step of, based on user data in which the number of loading operations of the vehicle repeating loading and unloading, identification information of the vehicle, and weight information of the vehicle are associated with each other, calculating a corrected weight that exhibits a large value if the number of operations exceeds an average number of loading and unloading operations of all the vehicles and exhibits a small value if the number of operations is smaller than the average number of loading and unloading operations, and setting the weight range of the group determination data based on the corrected weight.

{Claim 17}

A lift-conveyor control method for a mechanical parking apparatus that includes:

a lift conveyor that is installed in a structure having a plurality of floors and goes up and down with a vehicle placed thereon;

a motor that raises and lowers the lift conveyor; and

storage shelves provided on the plurality of floors along

a hoistway along which the lift conveyor goes up and down,

wherein the plurality of floors are classified into a plurality of compartments in a height direction, and a vehicle equal to or below a predetermined weight is carried to an upper compartment, whereas a vehicle over the predetermined weight is carried to a lower compartment,

the lift-conveyor control method comprising:

a first step of estimating a weight of the vehicle placed on the lift conveyor when the vehicle is loaded;

a second step of setting at least one of the predetermined weight, classifying the compartment into at least two, searching group determination data in which weight ranges classified according to the predetermined weights are associated with the compartments, and, among pallets that carry vehicles placed thereon, taking out an unoccupied pallet, which is a pallet that does not have the vehicle placed thereon, by reading out information of the compartment corresponding to the weight range covering the weight of the vehicle to be loaded, from the readout compartment;

a third step of calculating amount of energy required to load and unload the vehicle;

a forth step of moving the pallet having the vehicle to be loaded placed thereon to the compartment from which the unoccupied pallet has been taken out; and

a fifth step of calculating a first amount of energy

required to search for the unoccupied pallet starting from the lower floor and to place and carry the vehicle on the selected unoccupied pallet, calculating a second amount of energy required to place and carry the vehicle on the unoccupied pallet selected in the second step, and outputting the first amount of energy and the second amount of energy.