

SYSTEM AND METHOD FOR WAREHOUSE ORDER FULFILLMENT

BACKGROUND

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FIELD OF DISCLOSURE

The present disclosure relates generally to a technique of picking and/or storing components in a warehouse system.

10 DESCRIPTION OF RELATED ART

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent the work is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly
15 admitted as prior art against the present disclosure.

Technological advancements have provisioned for an ever-increasing amount of automation in an inventory handling system. Warehouses such as a mail-order warehouse, industrial manufacturing warehouse, and the like, generally include an inventory system, wherein incoming orders are fulfilled with the use of automated-guided-vehicles (AGVs).

20 The AGVs are programmed to retrieve components (e.g., items, parts of machines, etc.) that belong to a particular order, from storage racks that are disposed at predetermined locations within the warehouse. The retrieved components are processed and packaged at a processing station, whereinafter the order is deemed as being complete.

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SUMMARY

An aspect of the present disclosure provides for a vehicle for transporting a user within a workspace. The vehicle includes a platform to support the user, a bin configured to hold an article to be retrieved from, or stored, within the workspace, and circuitry. The circuitry is configured to receive a predetermined position within the workspace at which one of the article is to be retrieved or stored, control the vehicle to move to the predetermined position within the workspace, and output an indication of the article to be retrieved or stored by the user.

By one embodiment there is provided a method for fulfilling an order, the method includes receiving by circuitry, a predetermined position within a workspace at which an article is to be retrieved, the retrieved article to be stored in a bin included in a vehicle that transports a user to the predetermined position, the vehicle including a platform to support the user. The method further includes controlling the vehicle to move to the predetermined position within the workspace and outputting an indication of the article to be retrieved by the user.

One aspect of the present disclosure provides for a non-transitory computer readable medium including executable instructions, which when executed by a computer cause the computer to execute a method for fulfilling an order, the method includes receiving by circuitry, a predetermined position within a workspace at which an article is to be retrieved, the retrieved article to be stored in a bin included in a vehicle that transports a user to the predetermined position, the vehicle including a platform to support the user. The method further includes controlling the vehicle to move to the predetermined position within the workspace and outputting an indication of the article to be retrieved by the user.

By one aspect of the present disclosure is provided a warehouse system including a plurality of distinct vehicles and circuitry. The plurality of distinct vehicles include at least a

first type of vehicle, a second type of vehicle, and a third type of vehicle. The circuitry is configured to receive, via a network interface, an order to be fulfilled, the order including a set of items, determine a processing station in which the order is to be processed, and select a number of vehicles to complete the order, each selected vehicle being one of the first type of vehicle, the second type of vehicle, or the third type of vehicle. A first destination location and a first navigation path corresponding to the first type of vehicle is computed by the circuitry. A second destination location and a second navigation path corresponding to the second type of vehicle is determined by a first operator of the second type of vehicle. A third destination location corresponding to the third type of vehicle is determined by a second operator of the third type of vehicle, and a third navigation path corresponding to the third type of vehicle is computed by the circuitry.

The foregoing paragraphs have been provided by way of general introduction, and are not intended to limit the scope of the following claims. The described embodiments, together with further advantages, will be best understood by reference to the following detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of this disclosure that are proposed as examples will be described in detail with reference to the following figures, wherein like numerals reference like elements, and wherein:

Fig. 1 illustrates an example warehouse system in accordance with an embodiment;

Fig. 2 depicts a block diagram of a warehouse management controller (WMC) that is implemented as part of the warehouse system;

Fig. 3 illustrates a type of transportation vehicle included in the warehouse system;

Fig. 4A illustrates an exemplary display included in a transportation vehicle of the warehouse system;

Fig. 4B illustrates an exemplary flowchart depicting the steps performed in fulfilling an order; and

Fig. 5 illustrates a block diagram of a computing device according to one embodiment.

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DETAILED DESCRIPTION OF EMBODIMENTS

Exemplary embodiments are illustrated in the referenced figures of the drawings. It is intended that the embodiments and figures disclosed herein are to be considered illustrative rather than restrictive. No limitation on the scope of the technology and of the claims that follow is to be imputed to the examples shown in the drawings and discussed herein.

The embodiments are mainly described in terms of particular processes and systems provided in particular implementations. However, the processes and systems will operate effectively in other implementations. Phrases such as "an embodiment", "one embodiment" and "another embodiment" may refer to the same or different embodiments. The embodiments will be described with respect to methods and compositions having certain components. However, the methods and compositions may include more or less components than those shown, and variations in the arrangement and type of the components may be made without departing from the scope of the present disclosure.

The exemplary embodiments are described in the context of methods having certain steps. However, the methods and compositions operate effectively with additional steps and steps in different orders that are not inconsistent with the exemplary embodiments. Thus, the present disclosure is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features described herein and as limited only by the appended claims.

Furthermore, where a range of values is provided, it is to be understood that each intervening value between an upper and lower limit of the range, and any other stated or intervening value in that stated range, is encompassed within the disclosure. Where the stated range includes upper and lower limits, ranges excluding either of those limits are also included. Unless expressly stated, the terms used herein are intended to have the plain and ordinary meaning as understood by those of ordinary skill in the art. The following definitions are intended to aid the reader in understanding the present disclosure, but are not intended to vary or otherwise limit the meaning of such terms unless specifically indicated.

Typically in a warehouse system, only automated-guided-vehicles (AGVs) are used for order fulfillment. Using only AGVs to process the orders provides the advantageous feature of achieving a fully automated mechanism that is based on the concept of making components (i.e., goods or articles) accessible to a human operator. Thus, the AGVs increase the efficiency of order fulfillment by reducing a walk time, and partly eliminating human intervention (and thereby human errors) in processing the orders.

However, utilizing only AGVs to process the orders imposes certain limitations on the warehouse system. Specifically, an area of the warehouse where the AGVs operates (i.e., an active workspace of the warehouse) is required to be a human-free zone, as traversing the active zones may pose safety concerns for the human operators. Moreover, if there are any areas of the warehouse that are to be cordoned off due to a mishap, the AGVs operating in that area are required to be shut off for a time duration corresponding to the time required to address the mishap. Accordingly, the shutting off of AGVs leads to delay and cost overheads in completing the orders, and thereby reduces system efficiency.

Some warehouses include a human-driven vehicle that is primarily used to address the potential mishaps that may occur in the warehouse. However, such human-driven vehicles are used only to address the mishaps, and do not participate in processing and completing newly

generated customer orders. Thus, the overall efficiency of such a warehouse system is reduced. Moreover, absent the occurrence of any mishaps, the human-driven vehicles are not utilized and remain idle. This results in wastage of warehouse resources.

Accordingly, there is a requirement for a warehouse system that utilizes different types of vehicles for the process of fulfilling orders, and thereby increases the efficiency of the warehouse system.

Turning to Fig. 1, there is illustrated an exemplary warehouse system 100 according to an embodiment. The warehouse system 100 may represent any type of inventory system or material-handling system for storing and processing inventory items. For instance, the warehouse system 100 may include, but is not limited to, a mail-order warehouse facility, a merchandise return facility, a manufacturing facility, or any other similar type of system.

The warehouse system 100 may include a workspace 101 that represents an area associated with the warehouse 100, where components typically operate and/or move about. For example, the workspace 101 may represent all or part of a floor of the warehouse. The warehouse may be surrounded by a fence 103, and include different types of transportation devices 105 and 107 that are configured to move within the workspace 101. Furthermore, the workspace 101 may include one or more inventory (i.e., goods or items) holders (referred to herein as racks) 108 that may be disposed in an allocated storage area within the workspace 101.

The workspace 101 may be of variable dimensions and/or arbitrary geometry, and in particular may represent a two-dimensional (2D) workspace (e.g., a floor) or a three-dimensional (3D) workspace. Furthermore, the workspace 101 may be entirely enclosed in a building, or alternatively, some or all of the workspace 101 may be located outdoors, or otherwise unconstrained by any fixed structure. Moreover, in some embodiments, the workspace 101 may include multiple portions that are physically separated from one another,

including but not limited to separate floors, rooms, buildings, and/or portions divided in any other suitable manner. In some embodiments, stairs, ramps, and/or conveyance equipment such as vertical or horizontal conveyors, escalators, elevators, and the like, may be included in the workspace 101 to allow components and/or users of the warehouse system 100 to
5 access the various separate portions of the workspace 101.

The racks 108 may store one or more types of inventory items. The warehouse system 100 may be capable of moving these inventory items between locations within the workspace 101 to facilitate entry, processing, and/or removal of inventory items from the warehouse 100, and the completion of other tasks involving inventory items. The items from the racks
10 may be transported from one location to another by means of transportation vehicles 105 and 107, respectively. Note that 'inventory items' as used herein, may represent any objects of a particular type that are suitable for storage, retrieval, and/or processing in the warehouse system 100 as that depicted in Fig. 1. For instance, inventory items may include merchandise, pieces of luggage, components of a manufacturing kit, and the like.

By one embodiment, either some of the items from a particular rack 108 (or the whole rack 108) is transported to a specific location by the transportation vehicles in response to instructions received from a warehouse management controller (WMC) 110. The WMC 110 monitors the overall processing of the warehouse system 100. The WMC 110 may be a server that controls the navigational functionality of the transportation devices, the monitoring of
20 activities in the warehouse, and other tasks described herein. It must be appreciated that the WMC 110 as depicted in Fig. 1 may include one or more servers working in conjunction with one or more databases. Furthermore, it must be appreciated that the servers described herein are not limited to any specific combination or hardware circuitry and/or software. The WMC 110, in one embodiment, includes circuitry (described later with reference to Fig. 5) that is
25 configured to perform the functions described herein.

The warehouse system 100 further includes one or more inventory stations 112 where particular tasks involving inventory items can be completed. For instance, an order fulfillment process that includes packaging of all items belonging to the order may be performed by an operator 113 at the station 112. Furthermore, the tasks performed by the operator 113 may also include tasks such as removal of inventory items from the racks 108, the introduction of inventory items into the racks 108, the counting of inventory items, and similar inventory-related tasks. Additionally, the warehouse 100 may include dedicated stations 115, wherein only certain types of vehicles such as a human-driven (HD) vehicle and/or a semi-automated (SA) vehicle are authorized to process items. The HD and SA vehicles are described later with reference to Fig. 3.

By one embodiment, the warehouse system 100 includes a plurality of different types of transportation vehicles, each having unique capabilities. For instance, the warehouse system 100 includes a first type of transportation vehicle 107, which is a fully automated (FA) transportation vehicle, referred to hereinafter as FA-vehicle. The FA-vehicle 107 may correspond to a transportation vehicle such as a transportation robot. The FA-vehicle 107 is controlled by the WMC 110, and may be used, for instance, in the order fulfillment process. The FA-vehicle receives instructions from the WMC 110, which controls all navigational aspects of the vehicle. For instance, the WMC 110 may determine a destination within the warehouse 100, and further provide navigational directions (described later with reference to Fig. 2) to the FA-vehicle 107.

According to one embodiment, the warehouse system 100 includes a second type of transportation vehicle 105, which is a human-driven (HD) transportation vehicle, referred to hereinafter as a HD-vehicle. The HD-vehicle 105 is described in detail with reference to Fig. 3. An aspect of the HD-vehicle 105 is that it provisions for an operator of the vehicle to maneuver the vehicle within the warehouse. The WMC 110 monitors the movement of the

HD-vehicle, and may send alert signals informing the HD-vehicle operator whether the vehicle has entered an unsafe area. The HD-vehicle 105 finds application in several scenarios as outlined below.

By one embodiment, there may be circumstances where it is necessary for operators to traverse the workspace 101. For instance, a failed (i.e., a vehicle that may have broken down) FA-vehicle 107, or an FA-vehicle depleted of charge may alert the WMC 110 that it is in need of maintenance, or requires to be charged at a charging station 117 of the warehouse 100. Further, operators may need to traverse the workspace 101, when the WMC 110 may receive an indication of fallen inventory items within the workspace 101. As another example, a user may request transport within the workspace 101 to get to a destination location within or across the workspace, such as a restroom located a significant distance from the user. Accordingly, the HD-vehicle 105 may be configured to transport users between points within the workspace 101 in a manner that is minimally intrusive to the ongoing production and operation of the warehouse system 100. Furthermore, it must be appreciated that rather than dedicating the HD-vehicle 105, solely for the purpose of addressing maintenance like issues such as those described above, an aspect of the present disclosure provisions for the use of the HD-vehicles 105 in order fulfillment processes as well. Accordingly, the warehouse system improves the overall efficiency of the warehouse system 100 in completing pending orders.

Although the WMC 110 provisions the HD-vehicle 105 to self-navigate through the warehouse 100, by one aspect of the present disclosure, the WMC 110 may perform an override operation, wherein the WMC takes control of the navigational operation of the HD-vehicle 105. For instance, the WMC 110 may determine an amount of time the HD-vehicle 105 is left unattended on the warehouse floor 101, or an amount of time the HD-vehicle is detected to be in a restricted zone. Further, based on a comparison of the determined amount

of time, and a predetermined time threshold, the WMC 110 may initiate the override operation.

By one embodiment, the warehouse system 100 includes a third type of transportation vehicle referred to herein as a semi-automated-human-directed (SA-HD) vehicle, referred to hereinafter as SA-vehicle. The SA-vehicle has a structure that is substantially similar to the HD-vehicle. However, from functionality prospective, unlike the HD-vehicle, the navigational aspect of the SA-HD vehicle is completely controlled by the WMC 110.

The SA-vehicle is different from the FA-vehicle 107 in that the SA-vehicle provisions for the operator of the vehicle to select a particular destination location. Upon selection of the particular destination location, the WMC 110 controls the movement of the SA-vehicle and directs the vehicle to the intended destination. In contrast, the FA-vehicle is fully automated in that the destination location, as well as the navigational directions for the FA-vehicle is completely controlled by the WMC 110.

Accordingly, by one embodiment of the present disclosure, the HD-vehicle, the SA-vehicle, and the FA-vehicle may be deployed in the warehouse to fulfill one or more incoming orders. An incoming order may include a plurality of items that are stored in various racks across the warehouse 101. The WMC 110 may assign a subset of items included in the order (and their corresponding locations in the warehouse), to the FA-vehicle. In a similar manner, the WMC 110 may assign a list of remaining items in the order to the SA-vehicle and/or HD-vehicle.

In processing the assigned list of items that are to be retrieved from the racks and transported to a predetermined processing station, the FA-vehicle retrieves the items in a sequential manner. Specifically, as the FA-vehicle is completely under the control of the WMC 110, and does not have the provision to select a destination at will, the FA-vehicle retrieves the items in a sequential manner. Each item is retrieved based on navigation

instructions provided by the WMC 110. In contrast, the SA-vehicle receives the assigned list of items that are to be retrieved from various racks across the warehouse. However, the SA-vehicle has the provision of selecting a particular destination (e.g., location of an item to be retrieved) at will, and thus may not necessarily follow a sequential manner of retrieving the items from the racks. Note however, that upon selecting a particular destination (by the SA-vehicle operator), the SA-vehicle is guided to the particular destination under the control of the WMC 110.

By one embodiment, the WMC 110 generates task assignments based, in part, on requests or alerts that the WMC 110 receives from components of the warehouse system 100 and/or from external components in communication with the WMC 110. The requests or alerts may include, maintenance alerts to fix or manage equipment (e.g., charging station 117) within the workspace 101, user requests to be transported within or across the workspace 101, and the like. Further, the WMC 110 may generate task assignments in response to the occurrence of a particular event (e.g., in response to a failed transportation vehicle alerting the WMC110 that it is in need of maintenance, a vehicle detecting objects or obstacles on the floor of the workspace 101, and alerting the WMC 110, etc.)

It must be appreciated that the WMC 110 may be configured to generate other types of tasks assignments such as those related to scheduled recharging or replacement of transportation vehicle batteries, storage of empty racks 108, designation of parking spaces for the vehicles, or any other operations associated with the functionality supported by the warehouse system 100 and its various components. For instance, by one embodiment, the warehouse system 100 may assign a task to one of the different types of transportation vehicles to rearrange the items of a particular type on a rack based on an expiration date of the item. Thus, the items that are to expire earlier, as compared to items which have a later

expiration date, are stacked ahead in the shelves of the rack, in order to be used earlier in the order fulfillment process.

Fig. 2 is depicts an exemplary block diagram 200 illustrating functional components of the WMC of the warehouse. The functional components 200 are implemented by circuitry and use any suitable arrangement, for example a suitable computing device with associated processor(s), memory, and data storage (described later with reference to Fig. 5). In an embodiment, the functional components 200 include one (or more) servers working in conjunction with one or more databases. It must be appreciated that the WMC described herein is not limited to any specific combination or hardware circuitry and/or software.

The functional components 200 include a data storage device 201, such as a hard disc drive (HDD) or a solid state device (SSD), although it will be understood that any suitable data storage arrangement is contemplated by embodiments described herein. The data storage device 201 is arranged to store marker data indicative of a marker map 203 of the warehouse. Marker map 203 can include the unique identifying information associated with each marker and the navigational relationships with other markers.

The WMC also includes an inventory manager 210 that manages the process of adding new goods items in the warehouse, and records the current inventory of goods items in an inventory database 206. The inventory database 206 also includes information indicative of the respective storage locations of the racks in the warehouse and of the locations of the goods items on the racks. In this way, the storage locations of all goods items in the warehouse are known.

An order generator 208 manages receipt of orders from customers, such as orders received through an on-line checkout system associated with an electronic commerce website. Created orders are managed by an order manager 209 that stores details of the created orders as order entries in a pending orders database 211. The order manager 209

handles the orders posted by a client, such as posted orders through a network interface 212. The network interface 212 formats the incoming order to process them and posts them to the system 200 using one or more order application programming interfaces (APIs). The orders are posted to the pending orders list.

5 By one embodiment, the order manager 209 forms an order processing loop in which pending orders are to be processed, in order to find the optimum order under present conditions in which to process the pending orders. For a large volume of pending orders, filters can be used to obtain desired results. For instance, a first exemplary filter is an incoming racks filter. If any pending orders can be fulfilled by a rack that is already located
10 at an order-processing station, those orders are placed at a higher position on the pending orders queue to increase the chances of those orders being processed, while at least one of the necessary racks is still located at the order-processing station. Additionally, a second exemplary filter may be a client priority filter, or an orders priority filter in which specially-designated orders have been flagged for expedited service. A third exemplary filter may be an
15 age filter (i.e., how long has a current order been pending the system) in which older orders are processed before newer orders. Moreover, the order manager 209 also manages the timing fulfilment of the pending orders in the orders database 211. In an example, the order manager 209 is configured to initiate the processing of a pending order when a trigger signal is generated to indicate that an order processing station is available to fulfil an order.

20 By one embodiment, the order manager 209 manages the sequence of fulfillment of pending orders by computing a number of each type of transportation vehicle that is to be used to retrieve items for fulfilling the order. Specifically, the WMC 200 implements a cooperative scheduling mechanism (described later) wherein a number of the FA, SA, and the HD vehicles are computed, which are used to fulfill the order. The WMC computes a ‘cost’
25 of fulfilling each order based on certain predetermined objective functions. For instance, as

described later, the WMC may compute the cost of fulfilling each order based on an amount of time required by the transportation vehicles (assigned to fulfill the order) in retrieving the respective goods items from their respective racks. However, it must be appreciated that other cost factors may replace or be considered along with the time taken in other embodiments.

5 Additionally, the functional components of block diagram 200 also include a task manager 220 that selects at least one vehicle for the fulfilment of an order, when the order is selected for processing. The vehicles may be selected based on availability, task priority, and ‘cost’ of the task. Details regarding the selection of vehicles to fulfil a particular order are described later with reference to a cooperative scheduling model implemented by the WMC
10 200. The vehicles selected for the order are stored in an assigned vehicles database 213 that maintains, for each task, a number of the different types of assigned vehicles.

 The functional components of the block diagram 200 also include a planner 230 that controls and coordinates the planning and reservation of navigation paths for a subset of the transportation vehicles (i.e., only for a certain types of transportation vehicles). The planner
15 230 also plans for implementation of the movements of the subset of the vehicles to and from the selected processing station, including control over vehicle start/stop actions and vehicle pausing/unpausing actions. The planner 230 also manages charging of the vehicles, including checking the charge state of the vehicles and movement of the vehicles requiring charging to a vehicle charging station.

20 The planner 230 includes a path calculator 232 that calculates transportation paths for a subset of the vehicles in the set of vehicles selected for fulfilment of an order. Calculated transportation paths for the vehicles are stored in a defined paths database 242. By one embodiment, a transportation path is defined by a sequence of markers that the transportation vehicle follows in order to transport items between the rack storage location and the
25 processing station. By one embodiment, the transportation paths are computed using an A*

algorithm, as described in PCT International Publication No: WO 2016/124999, which is incorporated herein by reference in its entirety.

The planner 230 also includes a vehicle navigator 234 that manages movements of the FA and the SA-vehicles according to the respective transportation paths defined for the vehicles. The vehicle navigator 234 is responsible for controlling movement of these vehicles along the sequence of markers in the transportation path, and handling communications received from the vehicles.

Additionally, by one embodiment, the WMC 200 may also include a reservation manager 236 that manages reservations of markers and navigation paths between markers to avoid collisions between vehicles. The planner 230 stores information indicative of the reserved markers and navigation paths in a reserved paths and markers database 244.

Furthermore, the WMC 200 is also configured to detect the current positions of the vehicles in the warehouse and store the vehicle locations in a location database 215. As a result, the planner 230 is aware of the locations of all vehicles at all times. The WMC 200 may further store the calculated transportation paths in a path database 242.

Moreover by one embodiment, the path planner 230 includes a vehicle manager 238 that monitors and maintains vehicle parameters such as speed of the vehicle for the FA-vehicle and the SA-vehicle. Further, the vehicle manager 238 may also ensure that the vehicles are sufficiently charged for normal operation.

In what follows is described with reference to Fig. 3 the HD-vehicle included in the warehouse system. Moreover, distinction between each of the three types of transportation vehicles (i.e., FA-vehicle, SA-vehicle, and HD-vehicle) is also described.

The FA-vehicle (e.g., vehicle 107 in Fig. 1) may be a transportation robot. The FA-vehicle is fully controlled by the WMC 110, and may be used in the order fulfillment process.

It must be noted that all the navigational aspects, as well as the determination of a particular destination at which the FA-vehicle is expected to reach are determined by the WMC.

Fig. 3 depicts an exemplary HD-vehicle 300 that is used in the warehouse system. In contrast to the FA-vehicle, the HD-vehicle is navigated by an operator, who is also

5 responsible for determining a destination location for the HD-vehicle. As shown in Fig. 4A, the HD-vehicle includes a body 301 disposed on a set of wheels 303. At least some of the wheels 303 are individually controllable so as to control the speed and direction of movement of the vehicle 300. Various types and sizes of wheels 303 are contemplated by embodiments described herein, which may depend upon the type of floor surface. For example, smaller
10 wheels can be used on a smooth hard floor surface, whereas larger rubber wheels may be needed on a rough floor surface.

The vehicle 300 includes a support platform 305 that is affixed to a contact plate which is connected at a center of the body 301 of the vehicle. The platform provides space for an operator 315 to stand while operating the vehicle 300. By one embodiment, the contact
15 plate can be controllably raised or lowered relative to the body 301, in order to raise or lower the support platform 305, thereby facilitating height adjustments for the operator 315.

The operator 315 stands on the support platform 305 and holds a handle 310 that is attached to the support platform 305 via a vertical member 309. By one embodiment, the handle 310 may include a display panel disposed thereof, which provides visual depiction of
20 the warehouse layout and other features, which are described later with reference to Fig. 4A. Alternatively, or in addition to the display panel, the vehicle may include a joystick that enables the operator 315 to navigate the vehicle 300 across the warehouse.

The vehicle 300 also includes an obstacle detector 312 that is disposed substantially at a location where the vertical member 309 and the handle 310 are attached. The obstacle
25 detector 312 may be a laser that is used to detect the presence of obstacles in the path of the

vehicle 300, and provide a feedback to the user. For instance, by one embodiment, the vehicle 300 may include circuitry that is configured to display a message on the display panel of the vehicle to indicate to the operator the presence of obstacles in the path of the vehicle. A graphical depiction of the obstacle may also be displayed on the display panel of the vehicle.

5 By one embodiment, the circuitry may be configured to provide a haptic response (e.g., minor vibrations of the handle) to indicate the presence of obstacles. It must be appreciated that the location of the obstacle detector 312 is in no way restricted to that as shown in Fig. 3. Other locations along the length of the vertical member 309 may be feasible as well. However, one must ensure that the obstacle detector 312 is disposed at a height sufficiently above the
10 ground level in order to detect the presence of obstacles. Furthermore, the vehicle 300 may also include a position sensor such as a GPS sensor that is used to transmit the location of the vehicle 300 to the WMC. The location information may be transmitted continuously, periodically, or at other intervals. Thereby, the WMC may monitor the location of each vehicle in the warehouse. In one embodiment, the display may show one or more paths or
15 allowable movement directions to an operator of the vehicle 300. The allowable paths may indicate a path and/or movement direction that is expected to be clear of other vehicles as determined by the WMC 110.

The vehicle 300 also includes a collection bin 307 that may be affixed to the support platform 305. The collection bin 307 may be used to store items that are to be retrieved or
20 stored by the vehicle operator from the storage racks in the warehouse workspace. Furthermore, the vehicle 300 may include multiple bins that are stacked, one on top of the other to provide additional storage space for the items. The vehicle 300 also includes a charging port 321. The vehicle operator may connect the vehicle 300 to a charging station (shown in Fig. 1) to charge a battery included in the vehicle 300. Furthermore, the operator
25 315 may be equipped with a headset 320. The operator 315 may receive (via the headset 320)

audio instructions transmitted from the WMC of the warehouse. A visual depiction of the transmitted instructions may also be achieved by displaying the instructions on the display panel (described later with reference to Fig. 4A) of the vehicle, head mounted display, wearable display device (e.g., a smart watch), or other portable device (e.g., a smart phone)..

5 By one embodiment, the SA-vehicle has a similar structure to that of the HD-vehicle 300 as described above. However, the SA-vehicle is different in operation from the HD-vehicle in that, although the destination location of the SA-vehicle is chosen by the operator of the SA-vehicle, the SA-vehicle is navigated completely under the control of the WMC, rather than being navigated to the destination location by the operator of the SA-vehicle. In
10 one embodiment, a vehicle may be configured to operate in either the SA and HD modes according to a mode selection. For example, the vehicle 300 may be switched between the SA and HD modes to reduce or prevent operator fatigue, maintain a level of awareness or interest for the operator, or based on other criteria such as distance to be traveled.

 Moreover referring to Fig. 1, by one embodiment of the present disclosure, the
15 structure of the FA-vehicle 107 includes only portions of the HD-vehicle 300 described above. Specifically the FA-vehicle includes only the main body portion 301 disposed on a set of wheels 303, and the contact plate. In the case of the FA-vehicle, the contact plates may be configured to lift an entire rack (or alternatively a collection of bins attached to the contact plate) across the warehouse.

20 Turning now to Fig. 4A, there is illustrated an exemplary display panel 400 included in the transportation vehicle 300 of the warehouse system. The circuitry included in the vehicle 300 may be configured to display a plurality of features on the display panel 400.

 For instance, by one embodiment, the display includes a map 410 depicting a current location of the vehicle 401 and a depiction of a direction 403 in which the vehicle is currently

moving. Furthermore, the map 410 may also include a display of the markers 405a and 405b that are disposed on the floor of the warehouse.

The display panel 400 may also include a joystick (or other directional controller) 420 including arrows 421 corresponding to a leftward, rightward, upward, and backward movement of the vehicle. An operator may navigate the vehicle 300 by performing a touch operation on at least one of the arrows 421. Additionally, the display panel may include an icon labeled 'alarm' 441, wherein the operator of the vehicle may perform a touch operation to transmit a signal to the WMC, thereby indicating that the vehicle is in need of assistance.

The display 400 may also include an icon labeled 'controls and settings' 440 by which the operator of the vehicle can adjust, for instance, the height of the support platform, display settings of the display panel such as brightness, contrast, etc. Moreover, the display may also provide a visual depiction of various parameters 430 related to the vehicle. For instance, the parameters 430 may include but are not limited to a current speed of the vehicle, a weight carried by the vehicle, an estimate time of arrival at a destination, an amount or charge remaining and the like.

Note that the display panel 400 may be configured to display additional data such as navigational directions in the case of the SA-vehicle. Note that for the SA-vehicle, the operator of the vehicle selects a destination, whereafter the WMC navigates the SA-vehicle based on a computed route. Accordingly, the directions pertaining to the navigation may be displayed on the display panel.

In certain embodiments, all or a portion of the information displayed on the display panel 400 may also, or alternatively, be displayed on a user device, such as a head mounted display, wearable display device (e.g., smart watch), or other portable device (e.g., a smart phone). All or a portion of the information displayed may also, or alternatively, be provided

to the operator in an audio format, for example using speaker mounted to the vehicle 300 or a ear piece being used by the operator.

By one embodiment, the WMC may transmit information pertaining to an item that is to be retrieved, to a vehicle that is scheduled to fulfill a pending order. For instance, the
5 WMC may transmit information (to a HD-vehicle and/or SA-vehicle) pertaining to the item to be retrieved. The information may include data such as, a location of the item in the warehouse, dimensions of the item, a weight of the item and the like. Such information may be displayed on the display panel as described previously with reference to Fig. 4A.

Furthermore, by one embodiment, the WMC may be configured to display a rack that
10 carries the item to be retrieved on the display panel of the vehicle. Moreover, the position of the item to be retrieved from the rack may also be displayed with a particular display effect e.g., a blinking effect, a brightness feature being greater than the brightness of the displayed rack, and the like to aid the user in determining the exact position of the item to be retrieved on the rack.

15 By one embodiment, the WMC and/or the vehicle may be configured to control a light emitter (e.g., a laser) that is attached to the vehicle to point to the article that is to be retrieved. In such a manner, the WMC provisions for the correct item to be retrieved from the racks by an operator of the vehicle.

Turning now to Fig. 4B is illustrated by an embodiment, an exemplary flowchart
20 depicting the steps performed in fulfilling an order.

As shown in Fig. 4B, the process commences in step S480, when the WMC transmits a predetermined position within a workspace at which an article is to be retrieved by the HD-driven or SA-vehicle. By one embodiment, if the particular vehicle is scheduled to pick up multiple items from the warehouse, the WMC may transmit the positions of the items in a
25 sequential manner. Specifically, the WMC may transmit a position of a first item to be

retrieved, and transmit the location of the second item to be retrieved only upon the completion of retrieval of the first item.

By one embodiment, the WMC may transmit the locations of all items that are to be retrieved in a single transmission, based on current vehicle traffic in the warehouse. For instance, if the vehicle under consideration is a HD-driven vehicle or a SA-vehicle, the WMC may transmit all the locations of the items to be retrieved to the vehicle and allow the vehicle operator to choose a specific location.

Moreover, it must be appreciated that if a certain order is a high priority order, (i.e., an order that may have stringent time requirement for order fulfillment), the WMC may transmit only a single location at a given time instant. In this manner, the WMC may control the sequence of items retrieved by the vehicle such that an overall time taken to retrieve the items is within a predetermined threshold time value.

Further, the process proceeds to step S485, wherein the WMC controls the navigational movements of the vehicle. Note that the vehicle (e.g. a HD-vehicle) may control its own navigation. Alternatively, for the SA-vehicle, the WMC may control the navigational movements of the vehicle. Accordingly, in step S485, the navigational movements of the vehicle may be controlled such that the vehicle is directed to the location of the item (article) that is to be retrieved.

Further, the process proceeds to step S490, wherein the WMC may transmit information of the item that is to be retrieved to be displayed on the panel of the vehicle. For instance, as stated previously, the WMC may transmit information such location of the item, weight of the item, dimensions of the item, and the like to the vehicle. Upon receiving such information, the vehicle, by one embodiment, may display the information on the display panel of the vehicle. It must be appreciated that such information may alternatively, or in addition, be displayed on a wearable display device of the user.

Further, in step S495, a query is made to determine whether another item is to be retrieved by the vehicle. If the response to the query is affirmative, the process loops back to step S480 and repeats the steps S480-S490. However, if the response to the query is negative, the process of fulfilling an order by the vehicle under consideration terminates. It must be appreciated that upon completion of the order fulfillment process by the vehicle under consideration, the WMC may navigate the vehicle, or instruct the vehicle to navigate itself to a predetermined position such that the vehicle does not obstruct other vehicles in operation.

In what follows is described by one embodiment, a cooperative scheduling model implemented by the WMC of the warehouse. The scheduling model determines the number of transportation vehicles of each type that are assigned to perform the order fulfillment process of a particular order. The scheduling model as described below is posed as an optimization problem that is processed and computed by the WMC.

By one embodiment, the following notations are used to describe the parameters of the scheduling model:

$\mathbf{O} = \{O_1, O_2, O_3, \dots, O_K\}$ is the set of K orders to be fulfilled;

$\mathbf{S} = \{S_1, S_2, S_3, \dots, S_P\}$ is the set of P order fulfillment stations deployed in the warehouse;

$\mathbf{I} = \{I_1, I_2, I_3, \dots, I_M\}$ is the set of items stored in the warehouse, wherein M is a magnitude of the number of types of items included in the racks in the warehouse;

$\mathbf{HD} = \{HD_1, HD_2, HD_3, \dots, HD_{B1}\}$ is the set of human driven transportation vehicles in the warehouse;

$\mathbf{SA} = \{SA_1, SA_2, SA_3, \dots, SA_{B2}\}$ is the set of semi-automated transportation vehicles in the warehouse;

$\mathbf{FA} = \{FA_1, FA_2, FA_3, \dots, FA_{B3}\}$ is the set of fully-automated transportation vehicles in the warehouse;

Note that B1, B2, and B3 represent the number of transportation vehicles of each of the three types of transportation vehicles, respectively. The variables k_a , k_b , and k_c are used as indexing variables for the sets **HD**, **SA**, and **FA**, respectively. In other words, the parameter k_a can range from HD_1 to HD_{B1} . In a similar manner, the parameters k_b , and k_c can range from SA_1 to SA_{B2} , and FA_1 to FA_{B3} , respectively.

Further, by one embodiment, the variables **HD** (k_a), **SA** (k_b), and **FA** (k_c) are binary variables that are defined as follows:

$$\mathbf{HD}(k_a) = \begin{cases} 1, & \text{if assigned for a task} \\ 0, & \text{if not assigned} \end{cases} \quad (1)$$

$$\mathbf{SA}(k_b) = \begin{cases} 1, & \text{if assigned for a task} \\ 0, & \text{if not assigned} \end{cases} \quad (2)$$

$$\mathbf{FA}(k_c) = \begin{cases} 1, & \text{if assigned for a task} \\ 0, & \text{if not assigned} \end{cases} \quad (3)$$

By one embodiment, a preference parameter, denoted as $(\alpha)_{k_a}$, may be assigned for each of the transportation vehicles of the set **HD**. The preference parameter corresponds to an advantage incurred by the WMC in assigning a particular transportation vehicle for a task. For instance, consider the scenario wherein a particular transportation vehicle is scheduled to retrieve items from the storage area of the warehouse to fulfill a particular order. Based on the amount of bin space available in the transportation vehicle, it may be beneficial to schedule the same transportation vehicle to retrieve items for a subsequent order. In this manner, by one embodiment, the human driven transportation vehicles that are used to transport humans to a location of incidence (e.g., a location within the warehouse where maintenance like functionality is required) within the warehouse, may be used to fulfill orders upon the completion of the maintenance tasks.

Additionally, the warehouse may include different types of items, some of which may be delicate and/or expensive, and may thus require only a particular type of transportation vehicle for delivery. It must be appreciated that the equations (1) – (3) can be modified in order to accommodate this functionality. For instance, consider the case where item I_3 is delicate and thus may not be carried by any vehicle of type **FA**. Such a condition may be incorporated into the system by a constraint: $\mathbf{SA}(k_b) = 0$, for item I_3 , over the entire range of the indexing parameter k_b .

By one embodiment, the preference parameter of a particular vehicle may be assigned based on factors such as: whether the vehicle is already deployed in the warehouse to fulfill an order, an amount of bin space available in the transportation vehicle, an amount of remaining battery charge of the transportation vehicle, and the like. The preference parameters may be updated periodically at predetermined time intervals. In a manner similar to that described above, preference parameters denoted as $(\beta)_{k_b}$, and $(\gamma)_{k_c}$ respectively, may be assigned to each transportation vehicles of the set **SA** and **FA**.

In order to ensure that at least one transportation vehicle is assigned to fulfill a particular order, the WMC may ensure that the following condition is valid:

$$\sum_{k_a \in \mathbf{HD}} \sum_{k_b \in \mathbf{SA}} \sum_{k_c \in \mathbf{FA}} (\mathbf{HD}(k_a) + \mathbf{SA}(k_b) + \mathbf{FA}(k_c)) \geq 1 \quad (4)$$

Furthermore, by one embodiment, the WMC may assign transportation vehicles from the set **HD**, **SA**, and **FA** in order to minimize the amount of time required in fulfilling the order. For instance, for each transportation vehicle assigned to fulfill an order, the WMC may compute the amount of time required by the transportation vehicle(s) in retrieving the items (belonging to the order) from the storage space to the processing station where the order is being fulfilled. Note that the processing station where the order is to be processed may be based on factors such as a queuing delay of the processing station. In other words, if a

particular station is currently processing an order, and a subsequent order is assigned to the same processing station, then the processing of the subsequent order will only commence upon the completion of the previous order. Alternatively, the processing station for a particular order may be assigned based on the type of items included in the order.

- 5 Specifically, a particular processing station that is in close proximity to the racks carrying a majority of the items include in the order may be preferred as compared to a processing station that is located far away from the racks. In doing so, the WMC may ensure that that the traffic (i.e., a number of moving transportation vehicles) is minimized.

With a goal of minimizing the amount of time required to process the order, the WMC
 10 may compute a pair of time instances ($t_{\text{start-location}}$, $t_{\text{end-location}}$), based on a system clock, corresponding to each transportation vehicle that is assigned to fulfill a particular order. The parameter $t_{\text{start-location}}$ corresponds to a system time recorded at the time instant (and location) when the transportation vehicle commences the order fulfillment process. In a similar manner, the parameter $t_{\text{end-location}}$ corresponds to the system time that is recorded when the
 15 transportation vehicle has delivered the respective item(s) belonging to the order at the predetermined processing station. Thus, the WMC computes, for each item delivered by an assigned transportation vehicle of the set **HD**, the parameter $t_{k_a} = t_{k_a(\text{end-location})} - t_{k_a(\text{start-location})}$. In a similar manner, the WMC may compute the parameters $t_{k_b} = t_{k_b(\text{end-location})} - t_{k_b(\text{start-location})}$ and $t_{k_c} = t_{k_c(\text{end-location})} - t_{k_c(\text{start-location})}$ for
 20 each of the transportation vehicles of the set **SA** and **FA** that are assigned for the particular order fulfillment process.

By one embodiment, the WMC may minimize the total time required to fulfill the set of orders **O**, by minimizing the following objective function:

$$\text{minimize } \sum_{\text{all } o} [\sum_{k_a \in \text{HD}} (\text{HD}(k_a) \cdot t_{k_a}) + \sum_{k_b \in \text{SA}} (\text{SA}(k_b) \cdot t_{k_b}) + \sum_{k_c \in \text{FA}} (\text{FA}(k_c) \cdot t_{k_c})]$$

25 (5)

Furthermore, it must be appreciated that the WMC may incorporate additional constraints within the above model to ensure that a particular order is fulfilled only when all the items belonging to the order are transported to the respective processing station where the order is being processed. Moreover, in determining whether a vehicle can be scheduled to fulfill a pending order, the WMC may incorporate additional constraints such as a current space available in the bin of the HD-vehicle being sufficient enough to hold/store an item that is to be retrieved.

Additionally, by one embodiment, in place of (or in addition to) minimizing only the total time required to fulfil the orders, the WMC may incorporate the preference parameters of each transportation vehicle within the objective function to minimize the total time to fulfill the orders, as well as the total number of vehicles deployed to complete the orders. For instance, the WMC may choose to minimize the following objective function:

$$\begin{aligned} \text{minimize } \sum_{all} o [& \sum_{k_a \in HD} (HD(k_a) \cdot t_{k_a}) \cdot (1 - (\alpha)_{k_a}) + \sum_{k_b \in SA} (SA(k_b) \cdot t_{k_b}) \cdot (1 - \\ & (\beta)_{k_b}) + \sum_{k_c \in FA} (FA(k_c) \cdot t_{k_c}) \cdot (1 - (\gamma)_{k_c})] \end{aligned} \quad (6)$$

It must be appreciated that the WMC may implement the above optimization process at predetermined time intervals that correspond to, for example, the time instant when the warehouse system receives a particular order. Moreover, by one embodiment, the circuitry included in the WMC may implement the above described optimization process by utilizing one of a plurality of optimization tools such as CPLEX and Matlab, that are widely available.

Each of the functions of the described embodiments may be implemented by one or more processing circuits. Each of the types of vehicles described above as well the WMC of the warehouse may be equipped with circuitry to execute the features of the above described embodiments. A processing circuit includes a programmed processor (for example, processor 503 in Fig. 5), as a processor includes circuitry. A processing circuit also includes devices

such as an application-specific integrated circuit (ASIC) and circuit components that are arranged to perform the recited functions.

The various features discussed above may be implemented by a computer system (or programmable logic). Fig. 5 illustrates such a computer system 501. In one embodiment, the computer system 501 is a particular, special-purpose machine when the processor 503 is programmed to perform the estimate computations and other functions described above.

The computer system 501 includes a disk controller 506 coupled to the bus 502 to control one or more storage devices for storing information and instructions, such as a magnetic hard disk 507, and a removable media drive 508 (e.g., floppy disk drive, read-only compact disc drive, read/write compact disc drive, compact disc jukebox, tape drive, and removable magneto-optical drive). The storage devices may be added to the computer system 501 using an appropriate device interface (e.g., small computer system interface (SCSI), integrated device electronics (IDE), enhanced-IDE (E-IDE), direct memory access (DMA), or ultra-DMA).

The computer system 501 may also include special purpose logic devices (e.g., application specific integrated circuits (ASICs)) or configurable logic devices (e.g., simple programmable logic devices (SPLDs), complex programmable logic devices (CPLDs), and field programmable gate arrays (FPGAs)).

The computer system 501 may also include a display controller 509 coupled to the bus 502 to control a display 510, for displaying information to a computer user. The computer system includes input devices, such as a keyboard 511 and a pointing device 512, for interacting with a computer user and providing information to the processor 503. The pointing device 512, for example, may be a mouse, a trackball, a finger for a touch screen sensor, or a pointing stick for communicating direction information and command selections to the processor 503 and for controlling cursor movement on the display 510.

The processor 503 executes one or more sequences of one or more instructions contained in a memory, such as the main memory 504. Such instructions may be read into the main memory 504 from another computer readable medium, such as a hard disk 507 or a removable media drive 508. One or more processors in a multi-processing arrangement may
5 also be employed to execute the sequences of instructions contained in the main memory 504. In alternative embodiments, hard-wired circuitry may be used in place of or in combination with software instructions. Thus, embodiments are not limited to any specific combination of hardware circuitry and software.

As stated above, the computer system 501 includes at least one computer readable
10 medium or memory for holding instructions programmed according to any of the teachings of the present disclosure and for containing data structures, tables, records, or other data described herein. Examples of computer readable media are compact discs, hard disks, floppy disks, tape, magneto-optical disks, PROMs (EPROM, EEPROM, flash EPROM), DRAM, SRAM, SDRAM, or any other magnetic medium, compact discs (e.g., CD-ROM), or
15 any other optical medium, punch cards, paper tape, or other physical medium with patterns of holes.

Stored on any one or on a combination of computer readable media, the present disclosure includes software for controlling the computer system 501, for driving a device or devices for implementing the features of the present disclosure, and for enabling the
20 computer system 501 to interact with a human user. Such software may include, but is not limited to, device drivers, operating systems, and applications software. Such computer readable media further includes the computer program product of the present disclosure for performing all or a portion (if processing is distributed) of the processing performed in implementing any portion of the present disclosure.

The computer code devices of the present embodiments may be any interpretable or executable code mechanism, including but not limited to scripts, interpretable programs, dynamic link libraries (DLLs), Java classes, and complete executable programs. Moreover, parts of the processing of the present embodiments may be distributed for better performance, reliability, and/or cost.

The term “computer readable medium” as used herein refers to any non-transitory medium that participates in providing instructions to the processor 503 for execution. A computer readable medium may take many forms, including but not limited to, non-volatile media or volatile media. Non-volatile media includes, for example, optical, magnetic disks, and magneto-optical disks, such as the hard disk 507 or the removable media drive 508. Volatile media includes dynamic memory, such as the main memory 504. Transmission media, on the contrary, includes coaxial cables, copper wire and fiber optics, including the wires that make up the bus 502. Transmission media also may also take the form of acoustic or light waves, such as those generated during radio wave and infrared data communications.

Various forms of computer readable media may be involved in carrying out one or more sequences of one or more instructions to processor 503 for execution. For example, the instructions may initially be carried on a magnetic disk of a remote computer. The remote computer can load the instructions for implementing all or a portion of the present disclosure remotely into a dynamic memory and send the instructions over a telephone line using a modem. A modem local to the computer system 501 may receive the data on the telephone line and place the data on the bus 502. The bus 502 carries the data to the main memory 504, from which the processor 503 retrieves and executes the instructions. The instructions received by the main memory 504 may optionally be stored on storage device 507 or 508 either before or after execution by processor 503.

The computer system 501 also includes a communication interface 513 coupled to the bus 502. The communication interface 513 provides a two-way data communication coupling to a network link 514 that is connected to, for example, a local area network (LAN) 515, or to another communications network 516 such as the Internet. For example, the communication interface 513 may be a network interface card to attach to any packet switched LAN. As another example, the communication interface 513 may be an integrated services digital network (ISDN) card. Wireless links may also be implemented. In any such implementation, the communication interface 513 sends and receives electrical, electromagnetic or optical signals that carry digital data streams representing various types of information.

The network link 514 typically provides data communication through one or more networks to other data devices. For example, the network link 514 may provide a connection to another computer through a local network 515 (e.g., a LAN) or through equipment operated by a service provider, which provides communication services through a communications network 516. The local network 514 and the communications network 516 use, for example, electrical, electromagnetic, or optical signals that carry digital data streams, and the associated physical layer (e.g., CAT 5 cable, coaxial cable, optical fiber, etc.). The signals through the various networks and the signals on the network link 514 and through the communication interface 513, which carry the digital data to and from the computer system 501 may be implemented in baseband signals, or carrier wave based signals.

The baseband signals convey the digital data as unmodulated electrical pulses that are descriptive of a stream of digital data bits, where the term “bits” is to be construed broadly to mean symbol, where each symbol conveys at least one or more information bits. The digital data may also be used to modulate a carrier wave, such as with amplitude, phase and/or frequency shift keyed signals that are propagated over a conductive media, or transmitted as

electromagnetic waves through a propagation medium. Thus, the digital data may be sent as unmodulated baseband data through a “wired” communication channel and/or sent within a predetermined frequency band, different than baseband, by modulating a carrier wave. The computer system 501 can transmit and receive data, including program code, through the network(s) 515 and 516, the network link 514 and the communication interface 513.

Moreover, the network link 514 may provide a connection through a LAN 515 to a mobile device 517 such as a personal digital assistant (PDA) laptop computer, or cellular telephone.

It must be appreciated that embodiments are described herein for a vehicle, such as a transportation vehicle or a transportation robot. However, embodiments described herein can be applied to other automatically guided vehicles. Examples include, but are not limited to a four-wheel drive vehicle, or a vehicle using an Ackerman steering system in which the front inside wheel turns into a curve at a greater radius than the front outside wheel.

While aspects of the present disclosure have been described in conjunction with the specific embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. It should be noted that, as used in the specification and the appended claims, the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise.

CLAIMS:

1. A vehicle for transporting a user within a workspace, the vehicle comprising:

a platform to support the user;

a bin configured to hold an article to be retrieved from, or stored, within the workspace;

circuitry configured to

receive a predetermined position within the workspace at which one of the article is to be retrieved or stored,

control the vehicle to move to the predetermined position within the workspace, and

output an indication of the article to be retrieved or stored by the user.
2. The vehicle according to claim 1, wherein the circuitry is configured to

receive a user input that identifies the predetermined position, and

move the vehicle to the predetermined position based on a path that is generated automatically in response to the user input that identifies the predetermined position.
3. The vehicle according to claim 1, further comprising:

a sensor to detect any obstacles along a movement path of the vehicle, and

a position sensor to periodically or continuously provide a position of the vehicle to a server.

4. The vehicle according to claim 1, wherein the circuitry is configured to receive information regarding articles to be retrieved from, or stored, within the workspace from a server, wherein the information regarding at least two of the articles are received at different times.

5. The vehicle according to claim 1, wherein the circuitry is configured to output the indication of the article to be retrieved or stored by the user to a head mounted display, a wearable display device, or a display panel mounted on the vehicle.

6. The vehicle according to claim 1, wherein the circuitry is configured to output the indication of the one of the articles to be retrieved or stored by the user to an earpiece or speaker.

7. The vehicle according to claim 1, wherein the circuitry is configured to cause a light emitter to point to the article to be picked or a placement location of the article to be stored.

8. The vehicle according to claim 1, further comprising:
a lift to adjust a height of the user according to a position of the article to be retrieved or stored.

9. A method for fulfilling an order, the method comprising:

receiving by circuitry, a predetermined position within a workspace at which an article is to be retrieved, the retrieved article to be stored in a bin included in a vehicle that transports a user to the predetermined position, the vehicle including a platform to support the user;

controlling the vehicle to move to the predetermined position within the workspace;
and

outputting an indication of the article to be retrieved by the user.

10. The method of Claim 9, further comprising:

receiving a user input that identifies the predetermined position, and

moving the vehicle to the predetermined position based on a path that is generated automatically in response to the user input that identifies the predetermined position.

11. The method of Claim 9, further comprising:

detecting by a sensor, any obstacles along a movement path of the vehicle; and

transmitting to a server, a position of the vehicle that is detected by a position sensor, the transmission being performed in one of a periodic manner and a continuous manner.

12. The method according to Claim 9, further comprising:

receiving from a server, information regarding articles to be retrieved from the workspace, wherein the information regarding at least two of the articles are received at different times.

13. The method according to Claim 9, further comprising:
outputting the indication of the article to be retrieved by the user to a head mounted display, a wearable display device, or a display panel mounted on the vehicle.

14. The method according to Claim 9, further comprising:
outputting the indication of the one of the articles to be retrieved or stored by the user to an earpiece or speaker.

15. The method according to Claim 9, further comprising:
controlling a light emitter to point to the article that is to be retrieved.

16. A non-transitory computer readable medium including executable instructions, which when executed by a computer cause the computer to execute a method for fulfilling an order, the method comprising:

receiving by circuitry, a predetermined position within a workspace at which an article is to be retrieved, the retrieved article to be stored in a bin included in a vehicle that transports a user to the predetermined position, the vehicle including a platform to support the user;

controlling the vehicle to move to the predetermined position within the workspace;
and

outputting an indication of the article to be retrieved by the user.

17. The non-transitory computer readable medium of Claim 16, further comprising:
receiving a user input that identifies the predetermined position, and
moving the vehicle to the predetermined position based on a path that is generated
automatically in response to the user input that identifies the predetermined position.

18. The non-transitory computer readable medium of Claim 16, further comprising:
detecting by a sensor, any obstacles along a movement path of the vehicle; and
transmitting to a server, a position of the vehicle that is detected by a position sensor,
the transmission being performed in one of a periodic manner and a continuous manner.

19. The non-transitory computer readable medium of Claim 16, further comprising:
receiving from a server, information regarding articles to be retrieved from the
workspace, wherein the information regarding at least two of the articles are received at
different times.

20. The non-transitory computer readable medium of Claim 16, further comprising:
outputting the indication of the article to be retrieved by the user to a head mounted
display, a wearable display device, or a display panel mounted on the vehicle.

21. The non-transitory computer readable medium of Claim 16, further comprising:
outputting the indication of the one of the articles to be retrieved or stored by the user
to an earpiece or speaker.

22. The non-transitory computer readable medium of Claim 16, further comprising:
controlling a light emitter to point to the article that is to be retrieved.

23. A warehouse system comprising:

a plurality of distinct vehicles, the plurality of distinct vehicles including at least a first type of vehicle, a second type of vehicle, and a third type of vehicle; and

circuitry configured to

receive, via a network interface, an order to be fulfilled, the order including a set of items,

determine a processing station wherein the order is to be processed, and

select a number of vehicles to complete the order, each selected vehicle being one of the first type of vehicle, the second type of vehicle, or the third type of vehicle, wherein a first destination location and a first navigation path corresponding to the first type of vehicle is computed by the circuitry, a second destination location and a second navigation path corresponding to the second type of vehicle is determined by a first operator of the second type of vehicle, and a third destination location corresponding to the third type of vehicle is determined by a second operator of the third type of vehicle, and a third navigation path corresponding to the third type of vehicle is computed by the circuitry.