

FREIGHT CONTAINER STORAGE AND RETRIEVAL SYSTEM AND METHOD

Technical Field

5 [0001] Embodiments relate generally to systems and methods for moving freight containers such as storing and/or retrieving of freight containers.

Background

10 [0002] Containerisation is a system of freight transportation based on the use of freight containers. The containers are built to standardised dimensions in order to provide cross-compatibility across the various transportation networks such as road, rail and sea, for example. An example of international standards that are applicable to freight containers can be found in the International Standards Organisation (ISO) Handbook - Freight Containers (ISO 668: 1995), which is hereby incorporated by reference.

15 [0003] The widespread use of ISO standards for freight containers has allowed freight containers to become the backbone of global supply chains. It is estimated that over 13 million freight containers are currently in service around the world and conform to ISO standards. In order to cope with the phenomenal growth of the use of freight containers in global trade, systems and methods of optimising the storage and transportation of such freight containers have also rapidly developed. Such systems and methods extend to, but are not limited to, the following:-

- a. Ship design;
- b. Transport methodologies; and
- c. Container loading, stacking and storage systems and facilities.

25 [0004] The ISO freight container is commonly twenty feet or forty feet in length. However, it is industry practice that the size of freight containers is often expressed in terms of twenty-foot equivalent units (TEU). One TEU container is generally 20 feet (6.1 m) x 8 feet (2.4m) x 8.5 feet (2.6m) (length x width x height) in size. Accordingly, a forty-foot container, or 2 TEUs has a length of 40 feet (12.2m) with
30 the width and height of the container remaining the same as that of a single TEU. It is this uniformity in the dimensions of the freight containers, insofar as the width and height are concerned, that allows the ISO freight container to be used widely across transportation networks as mentioned above. It is also this uniformity in dimensions

that allows the freight container to be stored in a relatively compact manner by employing the practice of stacking.

[0005] The freight containers are typically owned by a shipper, leasing lines, or a carrier. Often, after a freight container has been delivered to its destination and its contents unloaded, the freight container may not be required for further utilisation. In such instances, the freight container is sent to a container depot to be stored until required in the future. As container depots are shared facilities, i.e., several freight container owners share the storage facilities of the container depot, it is important that there is a proper management and tracking system in place to ensure that the location of each freight container is logged in order to facilitate any subsequent retrieval process in the event that the container is subsequently needed for use.

[0006] However, the main problems presently facing current container storage facilities are as follows:-

a. Freight containers are normally stored in open areas in a stacked fashion up to a limited height of 10 freight containers due to inaccuracies when stacking and exposure to external environment factors such as wind and rain;

b. Storage area for freight containers only occupies 60% of the space of the container storage facility with the remaining 40% being used for operational purposes such as for access ways, freight container stackers, prime movers and trailers;

c. A freight container stacker's cabin is situated at or around the 3rd or 4th freight container in a stack, which results in difficulty for the operator of the container stacker when stacking freight containers above the height of the container stacker's operator's cabin, which in turn results in inaccuracies in stacking and slower operations;

d. Stored location of the freight container may be entered wrongly into the management and tracking system; and

e. Freight containers may be placed in a wrong location due to operator's error when stacking of the freight containers.

[0007] Accordingly, example embodiments seek to provide systems and methods for moving the freight containers, such as storing and/or retrieving freight containers, at a container facility that addresses at least some of the issues identified above.

Summary

[0008] According to various embodiments, there is provided a system for moving a freight container at a container facility. The system may be automated or semi-automated. The system may include a structure enclosing a space. The structure may have a floor, vertical walls and a ceiling. The system may further include an automated container handling module configured to move the freight container within the space enclosed by the structure. The system may further include a processor module in communication with the automated container handling module. The processor module may be configured to control the automated container handling module to move the freight container within the space enclosed by the structure based on a movement plan generated in response to a movement request of the freight container as received by the processor module.

[0009] According to various embodiments, there is provided a method of moving a freight container using the system as described herein. The method may include receiving, by the processor module, a movement request of the freight container. The method may further include controlling the automated container handling module, by the processor module, to move the freight container within the space enclosed by the structure based on a movement plan generated in response to the movement request.

Brief description of the drawings

[0010] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments are described with reference to the following drawings, in which:

FIG. 1A shows a schematic diagram of a system for moving freight containers at a container facility according to various embodiments;

FIG. 1B shows a schematic diagram of a system for moving freight containers at a container facility according to various embodiments;

FIG. 2 shows a method of moving a freight container using the system according to various embodiments;

FIG. 3 shows a system for moving a freight container with a perspective view of a container facility showing a cut-out side portion according to various embodiments;

FIG. 4 shows the system of FIG. 3 with a back view of the container facility showing a cut-out back portion according to various embodiments;

FIG. 5 shows a perspective view of the container facility of the system of FIG. 3 according to various embodiments;

FIG. 6 shows a top perspective view of the container facility of the system of FIG. 3 according to various embodiments; and

FIG. 7 shows a cut-out side view of the container facility of the system of FIG. 3 according to various embodiments.

Detailed description

[0011] Embodiments described below in context of the apparatus are analogously valid for the respective methods, and vice versa. Furthermore, it will be understood that the embodiments described below may be combined, for example, a part of one embodiment may be combined with a part of another embodiment.

[0012] It should be understood that the terms “on”, “over”, “top”, “bottom”, “down”, “side”, “back”, “left”, “right”, “front”, “lateral”, “side”, “up”, “down” etc., when used in the following description are used for convenience and to aid understanding of relative positions or directions, and not intended to limit the orientation of any device, or structure or any part of any device or structure. In addition, the singular terms “a”, “an”, and “the” include plural referents unless context clearly indicates otherwise. Similarly, the word “or” is intended to include “and” unless the context clearly indicates otherwise.

[0013] FIG. 1A shows a schematic diagram of a system 100 for moving freight containers, such as storing or retrieving of freight containers, at a container facility according to various embodiments. The container facility may include a container depot, a container terminal, a container yard, or the like. The system 100 may be an automated system or a semi-automated system. The system 100 may include a structure 110 enclosing a space. The structure 110 may include a floor 112, vertical walls 114 and a ceiling 116. The structure 110 may be a building or part of a building. The system 100 may further include an automated container handling module 120

configured to move the freight container within the space enclosed by the structure 110. The automated container handling module 120 may include an equipment or apparatus suitable for handling, moving, carrying, transporting the freight container from a location to another location within the space enclosed by the structure 110.

5 The system 100 may further include a processor module 130 in communication with the automated container handling module 120. The processor module 130 may be configured to control the automated container handling module 120 to move the freight container within the space enclosed by the structure 110 based on a movement plan generated in response to a movement request of the freight container as received

10 by the processor module 130. The processor module 130 may include a processing unit capable of interpreting and executing instructions received by the processor module 130, and instructing the automated container handling module 120 to move via electronic communication links.

[0014] In other words, the system 100 for moving freight containers may include

15 an enclosed chamber defined by a base, a roof and a series of upright constructions extending between the base and the roof. The freight containers may be stored inside the enclosed chamber. The system 100 may include an automated equipment for handling the freight containers such that the freight container may be moved, carried or transported from point to point within the enclosed chamber. The system 100 may

20 also include a controller, such as a computing device or computer, connected to the automated equipment for handling the freight containers via a communication network. The controller may be configured to generate instructions to the automated equipment based on a movement scheme devised to perform a movement request of the freight container as received by the controller such that the automated equipment

25 may be controlled to move the freight container within the enclosed chamber according to the movement scheme.

[0015] According to various embodiments, the movement request may include a storage request, or a retrieval request, or a service request or an inspection request. A storage request may include a request to store a newly arrived freight container in the

30 container facility. A retrieval request may be a request to retrieve a previously stored freight container in the container facility. A service request may be a request to retrieve a previously stored freight container in the container facility so as to move the freight container to a service bay for repair, washing, servicing, modification, or any

other maintenance work. An inspection request may include a request to retrieve a previously stored freight container in the container facility so as to move the freight container to an inspection bay for inspecting the conditions of the freight container.

[0016] According to various embodiments, the processor module 130 of the system 100 may be configured to generate the movement plan, in response to the movement request such as a storage request, based on a storage position designated for the freight container. Accordingly, the processor module 130 may receive and process the storage request to compute and formulate the movement plan, containing a sequence of movements, to move the freight container to the storage position designated for the freight container. The sequence of movements may include movements of the freight container of the storage request as well as movements of other freight containers.

[0017] According to various embodiments, the processor module 130 may be configured to designate the storage position within the space enclosed by the structure 110 to store the freight container based on a classification of the freight container. The classification of the freight container may be based on dimensions or sizes of the freight container, type of the freight container, conditions of the freight container, status of the freight container, details of owner of the freight container, target timeframe for storage, or a combination thereof. Accordingly, the processor module 130 may classify the freight container and determine a storage position to store the freight container such that freight containers of the same classification may be stacked together. For example, freight containers of the same dimension may be stacked together, freight containers belonging to the same owner may be stacked together, freight containers to be stored for a longer target timeframe may be stored in positions lower in the stack while freight containers to be stored for a shorter target timeframe may be stored higher in the stack.

[0018] According to various embodiments, the processor module 130 may be configured to generate the movement plan, in response to the movement request such as a retrieval request, based on a position information of the freight container retrieved from a database. The database may contain position information of all the freight containers stored within the space enclosed by the structure 110. The position information of each freight containers may be input into the database by the processor module 130 when the processor module 130 is performing the storage request as

described above. Accordingly, the processor module 10 may receive and process the retrieval request to compute and formulate the movement plan, containing a sequence of movements, to retrieve and move the freight container from the storage position of the freight container, as recorded in the database during storage, in the retrieval request. The processor module 130 may search the database to retrieve the position information of the freight container in the retrieval request. The sequence of movements may include movements of the freight container of the retrieval request as well as movements of other freight containers such that the freight container of the retrieval request may be reached and moved.

10 **[0019]** According to various embodiments, the automated container handling module 120 may be configured to stack a plurality of freight containers in a single stack within the space enclosed by the structure 110. The single stack may refer to a single column of freight containers which is a plurality of freight containers being piled up one by one to form into a single column.

15 **[0020]** According to various embodiments, the automated container handling module 120 may be configured to stack a plurality of freight containers in a block stack within the space enclosed by the structure 110. The block stack may refer to the plurality of freight containers placed or laid one on another both sideways and top-bottom such that horizontal rows and vertical columns of freight containers are adjoining to form a block.

20 **[0021]** FIG. 1B shows a schematic diagram of a system 101 for moving freight containers, such as storing and/or retrieving freight containers, at a container facility according to various embodiments. The system 101 may be an automated system or a semi-automated system. The system 101 may, similar to the system 100 of FIG. 1A, include a structure 110 enclosing a space. The structure 110 may include a floor 112, vertical walls 114 and a ceiling 116. The system 101 may, similar to the system 100 of FIG. 1A, further include an automated container handling module 120 configured to move the freight container within the space enclosed by the structure 110. The system 101 may, similar to the system 100 of FIG. 1A, further include a processor module 130 in communication with the automated container handling module 120. The processor module 130 may be configured to control the automated container handling module 120 to move the freight container within the space enclosed by the

structure 110 based on a movement plan generated in response to a movement request of the freight container as received by the processor module 130.

[0022] According to various embodiments, the system 101 may further include a positioning module 140 in communication with the automated container handling module 120. The positioning module 140 may be configured to guide the automated container handling module 120 for moving of the freight container. Accordingly, the positioning module 140 may include equipment and apparatus suitable for guiding or directing the motion of the automated container handling module 120 to place, move, dispose or arrange the freight container.

[0023] According to various embodiments, the positioning module 140 may be configured to detect real-time position information of the freight container for guiding the automated container handling module 120 to move the freight container. Accordingly, the positioning module 140 may provide real-time feedback of the position information of the freight container to the processor module 130 such that the processor module 130 may provide updated instructions to the automated container handling module 120 to accurately and precisely move and stack the freight container.

[0024] According to various embodiments, the positioning module 140 may include a plurality of sensors 142. Each sensor of the plurality of sensors 142 may measure a distance of the freight container from a predetermined reference point in the space enclosed by the structure 110 such that the position and orientation of the freight container within the space enclosed by the structure 110 may be determined. The plurality of sensors 142 may provide real-time measurement such that real-time feedback may be provided to the processor module 110.

[0025] According to various embodiments, the system 101 may further include a container transfer module 150 configured to move the freight container between a pre-determined position outside the space enclosed by the structure 110 and a pre-determined position inside the space enclosed by the structure 110 through an opening 118 in one of the vertical walls 114 of the structure 110. Accordingly, the container transfer module 150 may include a conveyor, such as a belt conveyor, or a roller conveyor, disposed between the pre-determined position outside the space enclosed by the structure 110 and the pre-determined position inside the space enclosed by the structure 110, and through the opening 118 of one of the vertical walls 114 of the structure 110 such that the freight container may be moved, carried or transported

between the pre-determined position outside the space enclosed by the structure 110 and the pre-determined position inside the space enclosed by the structure 110. The container transfer module 150 may also include a crane, or a top-side lifter, or a forklift, or a vehicle or an automated guided vehicle (AGV) configured to move
 5 between the pre-determined position outside the space enclosed by the structure 110 and the pre-determined position inside the space enclosed by the structure 110 such that the freight container may be moved, carried or transported between the pre-determined position outside the space enclosed by the structure 110 and the pre-determined position inside the space enclosed by the structure 110.

10 **[0026]** According to various embodiments, the automated container handling module 120 may be configured to pick up the freight container from the pre-determined position inside the space enclosed by the structure 110. According to various embodiments, the automated container handling module 120 may be configured to drop off the freight container at the pre-determined position inside the
 15 space enclosed by the structure 110.

[0027] According to various embodiments, the system 101 may further include an interface module 160 in communication with the processor module 120. The interface module 160 may be configured to receive an input from a user. The user may be a human user providing manual inputs. Accordingly, the interface module 160
 20 may include a computer interface, a touch screen interface, or other suitable user interface. According to various embodiments, the user may also be a processor or processor-based device, such as an external computing device.

[0028] According to various embodiments, the structure 110 and the automated container handling module 120 may be configured to accommodate at least ten
 25 containers stacked in a single column. Accordingly, the ceiling 116 and the floor 112 of the structure 110 together with the automated container handling module 120 may be arranged or disposed such that there is provided a space sufficient to accommodate at least ten containers stacked in a single column and the space is also sufficient for the operation of the automated container handling module 120.

30 **[0029]** According to various embodiments, the floor 112 of the structure 110 may be configured to maintain leveled with a pre-determined horizontal plane under any internal or external loading conditions. The pre-determined horizontal plane may be substantially perpendicular to a direction of the gravity. The internal loading

conditions may include the weight of the freight containers stacked on the floor 112. The external loading conditions may include seismic activity or other ground vibration. Accordingly, the floor 112 may be substantially flat regardless of the load acting on the floor such that the floor 112 may maintain the stability of the stacked freight containers and minimize internal or external load's influence on the stacked freight containers. According to various embodiments, the floor 112 of the structure 110 may include a floating concrete slab or a rigid floor configuration.

[0030] According to various embodiments, the structure 110 may be configured to limit lateral sway of the structure 110 caused by a lateral load applied on the structure 110. Accordingly, the structure 110 may be built with sufficient rigidity such that the sway of the structure 110 caused by a lateral wind load may be significantly reduced so as to reduce the impact of the swaying of the structure 110 on the stacking accuracy of the automated container handling module 120 during stacking of the freight containers.

[0031] According to various embodiments, the structure 110 may be configured to minimize interference from external environmental forces such as wind or rain into the space enclosed by the structure 110. For example, the structure 110 may be configured to be substantially watertight and/or windtight. Accordingly, penetration of wind and/or rain into the space enclosed by the structure 110 may be reduced or minimized, and the space enclosed by the structure 110 may be substantially isolated from the external environmental forces.

[0032] According to various embodiments, the automated container handling module 120 may include an automated overhead crane 122 with a container spreader 124. Accordingly, the automated overhead crane 122 may move the container spreader 124 for picking up and dropping off of freight container.

[0033] According to various embodiments, the automated overhead crane 122 may include a pair of parallel runways suspended across two opposing vertical walls 114 of the structure 110. The automated overhead crane 122 may further include a bridge spanning across the pair of parallel runway. The bridge may be movable along the pair of parallel runway. The automated overhead crane 122 may further include a hoist coupled to the bridge and movable along the bridge. The container spreader 124 may be coupled to the hoist.

[0034] According to various embodiments, the automated container handling module 120 may further include a plurality of sensors configured to detect the orientation and position of the container spreader 124. Accordingly, the plurality of sensors may provide orientation and position feedback to the automated container handling module 120 such that the automated container handling module 120 may accurately and precisely control the container spreader for moving the freight container.

[0035] According to various embodiments, the system 101 may further include a container loading module 170 outside the space enclosed by the structure 110. The container loading module 170 may be configured to load the freight container from a trailer of a prime mover onto the container transfer module 150, for example when the container transfer module 150 is a belt conveyor or a roller conveyor. Accordingly, the container loading module 170 may be configured such that the freight container on the trailer with the prime mover parked in a loading/unloading bay may be picked up and moved onto the belt conveyor or the roller conveyor. The container transfer module 150 in the form of the belt conveyor or the roller conveyor may then move, carry or transport the freight container to the predetermined position inside the space enclosed by the structure 110. The container loading module 170 may include an overhead crane, a gantry crane, a forklift or other suitable apparatus. According to various embodiments, the container loading module 170 may be configured to be automated or driverless.

[0036] According to various embodiments, the structure 110 may include a multi-storeys building. Accordingly, the structure 110 may include more than one storey for storing of freight containers. The structure 110 may also include one or more storeys for other functional use other than storing of freight containers.

[0037] According to various embodiments, the system 101 may include at least one vehicular transit portion 180 configured to allow vehicles to travel between various storeys of the multi-storeys building. The at least one vehicular transit portion 180 may include a vehicular lift or a vehicular ramp.

[0038] According to various embodiments, the system 101 may include an inspection bay 190 configured for inspecting of the condition of the freight container before storing the freight container in the space enclosed by the structure 110. According to various embodiments, the system 101 may include a service bay 192 for

performing maintenance and/or repair works on the freight container before storing the freight container in the space enclosed by the structure 110.

[0039] FIG. 2 shows a method 200 of moving a freight container at a container facility using the system according to various embodiments. The method include, at 202, receiving, by the processor module, a movement request of the freight container. The method may further include, at 204, controlling the automated container handling module, by the processor module, to move the freight container within the space enclosed by the structure based on a movement plan generated in response to the movement request.

[0040] According to various embodiments of the method, the movement request may include a storage request, or a retrieval request, or a service request, or an inspection request.

[0041] According to various embodiments, for example when the movement request is a storage request, the method may further include generating, by the processor module, the movement plan based on a storage position designated for the freight container.

[0042] According to various embodiments, the method may further include designating, by the processor module, the storage position within the space enclosed by the structure based on a classification of the freight container.

[0043] According to various embodiments, classification of the freight container may be based on dimensions or sizes of the freight container, type of the freight container, status of the freight container, conditions of the freight container, details of owner of the freight container, target timeframe for storage, or a combination thereof.

[0044] According to various embodiments, for example when the movement request is a retrieval request, the method may further include generating, by the processor module, the movement plan based on a position information of the freight container.

[0045] According to various embodiments, the method may further include retrieving, by the processor module, the position information of the freight container from a database.

[0046] FIG. 3 shows a system 400 for moving a freight container, such as storing and/or retrieving the freight container, with a perspective view of a container facility 401 showing a cut-out side portion according to various embodiments. FIG. 4 shows

the system 400 for moving a freight container with a back view of the container facility 401 showing a cut-out back portion according to various embodiments. FIG. 5 shows a perspective view of the container facility 401 with the system 400 for moving a freight container according to various embodiments. FIG. 6 shows a top perspective view of the container facility 401 with the system 400 for moving a freight container according to various embodiments. FIG. 7 shows a cut-out side view of the container facility 401 with the system 400 for moving a freight container according to various embodiments.

[0047] According to various embodiments, the system 400 may be an automated system or a semi-automated system. As shown in FIG. 3 to FIG. 7, the system 400 may include a structure 410 enclosing a space 411. The structure 410 may include a floor 412, vertical walls 414 and a ceiling 416. As shown, the vertical walls 414 of the structure 410 may include a ledge to form a step portion 415. The space 411 enclosed by the structure 410 may be used to store freight containers 402. The structure 410 may also include partitioning walls 413.

[0048] Referring to FIG. 3, the structure 410 of the system 400 may include a multi-storeys building. As shown, the structure 410 may include at least two storeys for storing of freight containers 402. Further, the structure 410 may also include one or more storeys for other functional use other than storing of freight containers 402. The structure 410 of the system 400 may include a storey having an inspection bay 490 configured for inspecting of the condition of the freight container 402 before storing the freight container 402 in the space 411 enclosed by the structure 410. The structure 410 of the system 400 may also include a storey having a service bay (not shown) for performing maintenance and/or repair works on the freight container 402 before storing the freight container 402 in the space enclosed by the structure 410. According to various embodiments, the inspection bay 490 and the service bay may be on the same storey.

[0049] According to various embodiments, when the structure 410 of the system 400 is a multi-storeys building, at least one of the upper storeys may be configured and shaped into a rectangular trough portion 417. As shown in FIG. 3, the structure 410 of the system 400 may include a storey having a step portion 415 and a rectangular trough portion 417. The freight container 402 may be delivered to the storey of the structure 410 on which the step portion 415 may be located. The step

portion 415 may be at a top edge or rim of the rectangular trough portion 417 of the structure 410. Accordingly, the rectangular trough portion 417 may be recessed downward from the step portion 415. The freight container 402 may then be moved from the step portion 415 and lowered into the rectangular trough portion 417 such that the freight container 402 may be stacked and stored inside the rectangular trough portion 417. Accordingly, access to the rectangular trough portion 417 may be via the step portion 415 and through a top opening of the rectangular trough portion.

[0050] Referring to FIG. 3, the structure 410 of the system 400 may include at least one vehicular transit portion 480 configured to allow vehicles to travel between various storeys of the multi-storeys building. As shown, the vehicular transit portion 480 may include a vehicular ramp 482. According to various embodiments, the vehicular transit portion may include a vehicular lift. With the vehicular transit portion 480, prime movers with trailers carrying freight containers 402 may move between the various storeys of the building.

[0051] According to various embodiments, the space 411 enclosed by the structure 410 may be configured to be sufficient to accommodate at least ten freight containers 402 stacked in a single column. For example, the ceiling 416 and the floor 412 of the structure 410 may be configured such that a distance apart between a lowest point of any equipment attached to the ceiling 416 and the floor 412 may accommodate at least ten freight containers 402.

[0052] According to various embodiments, the floor 412 of the structure 410 may be configured to maintain leveled with a pre-determined horizontal plane under any internal or external loading conditions. The pre-determined horizontal plane may be substantially perpendicular to the direction of gravity. The internal loading conditions may include the weight of the freight containers stacked on the floor 412. The external loading conditions may include seismic activity or other ground vibration. Accordingly, the floor 412 may be substantially flat regardless of the load acting on the floor such that the floor 412 may maintain the stability of the stacked freight containers and minimize internal or external load influence on the stacked freight containers. According to various embodiments, the floor 412 of the structure 410 may include a floating concrete slab or a rigid floor configuration. The floating concrete slab or the rigid floor configuration may provide stability to the freight containers 402 stacked inside the space 411 enclosed by the structure 410.

[0053] According to various embodiments, the structure 410 may be configured to limit lateral sway of the structure 410 caused by a lateral load applied on the structure 410. Accordingly, the structure 410 may be built with sufficient rigidity such that the sway of the structure 410 caused by a lateral wind load may be significantly reduced so as to reduce the impact of the swaying of the structure 410 on the accuracy of the stacking of the freight containers 402 inside the space 411 enclosed by the structure 410.

[0054] According to various embodiments, the structure 410 may be configured to minimize interference from external environmental forces such as wind or rain into the space enclosed by the structure 410. For example, the structure 410 may be configured to be substantially watertight and windtight. Accordingly, penetration of wind or rain into the space enclosed by the structure 110 may be reduced or minimized, and the space 411 enclosed by the structure 410 may be substantially isolated from the external environmental forces.

[0055] Referring to FIG. 3, the system 400 may further include an automated container handling module 420 configured to move the freight container 402 within the space 411 enclosed by the structure 410. The automated container handling module 420 may be configured to pick up a freight container 402 for storage from a pre-determined designated position 419 within the space 411 enclosed by the structure 410. Accordingly, a prime mover with a trailer carrying the freight container 402 for storage may be directed to the pre-determined designated position 419 inside the space 411 enclosed by the structure 410 such that the automated container handling module 420 may pick up the freight container 402 for storage. The automated container handling module 420 may also be configured to drop off a retrieved freight container at the pre-determined designated position 419 within the space 411 enclosed by the structure 410. Accordingly, a prime move with an empty trailer may be directed to the pre-determined designated position 419 inside the space 411 enclosed by the structure 410 such that the automated container handling module 420 may drop off the retrieved freight container 402 on the empty trailer of the prime mover.

[0056] According to various embodiments, the automated container handling module 420 may be configured to stack a plurality of freight containers 402 in a single stack within the space 411 enclosed by the structure 410. The single stack may be a single column of freight containers 402, which may be a plurality of freight

containers 402 being piled up one on top of another to form into a single column. The automated container handling module 420 may also be configured to stack a plurality of freight containers 402 in a block stack within the space 411 enclosed by the structure 410. The block stack may be a plurality of freight containers 402 placed or
5 laid one on another both sideways and top-bottom such that horizontal rows and vertical columns of freight containers 402 may be adjoining to form a block.

[0057] As shown, the automated container handling module 420 may include an automated overhead crane 422 with a container spreader 424. Accordingly, the automated overhead crane 422 may move the container spreader 424 for picking up
10 and dropping off of freight container.

[0058] Further, as shown, the automated overhead crane 422 may include a pair of parallel runways 426 suspended across two opposing vertical walls 414 of the structure 410. The automated overhead crane 422 may further include a bridge 428 spanning across the pair of parallel runway 426. The bridge 428 may be movable
15 along the pair of parallel runway 426. The automated overhead crane 422 may further include a hoist 429 coupled to the bridge 428 and movable along the bridge 428. The container spreader 424 may be coupled to the hoist 429.

[0059] According to various embodiments, the automated container handling module 420 may further include a plurality of sensors configured to detect the
20 orientation and position of the container spreader 424. Accordingly, the plurality of sensors may provide orientation and position feedback to the automated container handling module 420 such that the automated container handling module 420 may accurately and precisely control the container spreader 424 for moving the freight container 402.

[0060] Referring to FIG. 3, the system 400 may further include a container transfer module 450 configured to move the freight container 402 between a pre-determined position 452 outside the space 411 enclosed by the structure 410 and a pre-determined position 454 inside the space 411 enclosed by the structure 410 through an opening 418 in one of the vertical walls 414 of the structure 410. The
30 opening 418 may include a shutter or other suitable door mechanism to close the opening 418 when not in use. As shown, the container transfer module 450 may include a belt conveyor, or a roller conveyor disposed between the pre-determined position 452 outside the space 411 enclosed by the structure 410 and the pre-

determined position 454 inside the space 411 enclosed by the structure 410, and through the opening 418 of one of the vertical walls 414 of the structure 410 such that the freight container 402 may be moved, carried or transported between the pre-determined position 452 outside the space 411 enclosed by the structure 110 and the pre-determined position 454 inside the space 411 enclosed by the structure 110. According to various embodiments, other than a belt conveyor or roller conveyor, the container transfer module 450 may also include a crane, or a top-side lifter, or a forklift, or a vehicle configured to move between the pre-determined position 452 outside the space 411 enclosed by the structure 410 and the pre-determined position 454 inside the space 411 enclosed by the structure 410 such that the freight container 402 may be moved, carried or transported between the pre-determined position 452 outside the space 411 enclosed by the structure 410 and the pre-determined position 454 inside the space 411 enclosed by the structure 410.

[0061] According to various embodiments, the pre-determined position 452 outside the space 411 enclosed by the structure 410 may be adjacent to a loading/unloading bay. The pre-determined position 454 inside the space 411 enclosed by the structure may be on the step portion 415 of the wall 414.

[0062] According to various embodiments, when the container transfer module 450 is a belt conveyor or a roller conveyor, the system 400 may further include a container loading module outside the space 411 enclosed by the structure 410. The container loading module may be configured to move the freight container 402 between a trailer of a prime mover and the belt conveyor or the roller conveyor. Accordingly, the container loading module may be configured such that the freight container 402 on the trailer of the prime mover parked in a loading/unloading bay may be picked up and moved to the predetermined position 452 outside the space 411 enclosed by the structure 410 and onto the belt conveyor or the roller conveyor. The belt conveyor or the roller conveyor may then move, carry or transport the freight container 402 to the predetermined position 454 inside the space 411 enclosed by the structure 410. According to various embodiments, the container loading module may include a forklift or other suitable apparatus. According to various embodiments, the container loading module may be configured to be automated or driverless.

[0063] According to various embodiments, the system 400 may include a processor module 430 in communication with the automated container handling

module 420. The processor module 430 may be configured to control the automated container handling module 420 to move the freight container 402 within the space 411 enclosed by the structure 410 based on a movement plan generated in response to a movement request of the freight container 402 as received by the processor module 430. The processor module 430 may include a processing unit capable of interpreting and executing instructions received by the processor module 430, and capable of instructing the automated container handling module 420 to move via electronic communication links.

[0064] According to various embodiments, the movement request may include a storage request, or a retrieval request, or a service request or an inspection request. A storage request may include a request to store a newly arrived freight container in the container facility. A retrieval request may be a request to retrieve a previously stored freight container in the container facility. A service request may be a request to retrieve a previously stored freight container in the container facility so as to move the freight container to a service bay for either repair, washing, servicing, modification, or any other maintenance work. An inspection request may include a request to retrieve a previously stored freight container in the container facility so as to move the freight container to an inspection bay for inspecting the conditions of the freight container.

[0065] According to various embodiments, when the movement request is a storage request, the processor module 430 of the system 400 may be configured to generate the movement plan, in response to the storage request, based on a storage position designated for the freight container 402. Accordingly, the processor module 430 may receive and process the storage request to compute and formulate the movement plan, containing a sequence of movements, to move the freight container 402 to the storage position designated for the freight container 402. The sequence of movements may include movements of the freight container 402 of the storage request as well as movements of other freight containers 402.

[0066] According to various embodiments, the processor module 430 may be configured to designate the storage position within the space 411 enclosed by the structure 410 to store the freight container 402 based on a classification of the freight container 402. The classification of the freight container 402 may be based on dimensions of the freight container 402, type of the freight container 402, conditions of the freight container 402, details of owner of the freight container 402, target

timeframe for storage, or a combination thereof. Accordingly, the processor module 430 may classify the freight container 402 and determine a storage position to store the freight container 402 such that freight containers 402 of the same classification may be stacked together. For example, freight containers 402 of the same dimension may be stacked together, freight containers 402 belonging to the same owner may be stacked together, freight containers 402 to be stored for a longer target timeframe may be stored in positions lower in the stack while freight containers 402 to be stored for a shorter target timeframe may be stored higher in the stack.

[0067] According to various embodiments, when the movement request is a retrieval request, the processor module 430 may be configured to generate the movement plan, in response to the retrieval request, based on a position information of the freight container 402 retrieved from a database. The database may contain position information of all the freight containers 402 stored within the space enclosed by the structure 410. The position information of each freight containers 402 may be input into the database by the processor module 430 when the processor module 430 is performing the storage request as described above. Accordingly, the processor module 430 may receive and process the retrieval request to compute and formulate the movement plan, containing a sequence of movements, to retrieve and move the freight container 402 from the storage position of the freight container 402, as recorded in the database during storage, in the retrieval request. The processor module 430 may search the database to retrieve the position information of the freight container 402 in the retrieval request. The sequence of movements may include movements of the freight container 402 of the retrieval request as well as movements of other freight containers 402 such that the freight container 402 of the retrieval request may be reached and moved.

[0068] According to various embodiments, the system 400 may further include a positioning module 440 in communication with the automated container handling module 420. The positioning module 440 may be configured to guide the automated container handling module 420 for moving of the freight container 402. Accordingly, the positioning module 440 may include equipment and apparatus suitable for guiding or directing the motion of the automated container handling module 420 to place, dispose or arrange the freight container 402.

[0069] According to various embodiments, the positioning module 440 may be configured to detect real-time position information of the freight container 402 for guiding the automated container handling module 420 to move the freight container 402. Accordingly, the positioning module 440 may provide real-time feedback of the position information of the freight container 402 to the processor module 430 such that the processor module 430 may provide updated instructions to the automated container handling module 420 to accurately and precisely move and stack the freight container 402.

[0070] According to various embodiments, the positioning module 440 may include a plurality of sensors. Each sensor of the plurality of sensors may measure a distance of the freight container 402 from a predetermined reference point in the space 411 enclosed by the structure 410 such that the position and orientation of the freight container 402 within the space 411 enclosed by the structure 410 may be determined. The plurality of sensors may provide real-time measurement such that real-time feedback may be provided to the processor module 410.

[0071] According to various embodiments, the system 400 may further include an interface module 460 in communication with the processor module 420. The interface module 460 may be configured to receive an input from a user. Accordingly, the interface module 460 may include a computer interface, a touch screen interface, or other suitable user interface.

[0072] According to various embodiments, the work flow of storing a freight container using the system according to various embodiments may include the following. A customer of the container facility may provide an advance storing order or storing notification that the customer intends to deposit a freight container for storage at the container facility. The advance storing order or storing notification may include any description or particulars of the freight container, such as its dimensions, serial or registration number and/or particulars of the customer's representative who is authorized to deposit the freight container with the container facility. The container facility may provide a confirmation of receipt of the advance storing order or storing notification with a specific reference identification number to the customer.

[0073] Subsequently, the authorized representative of the customer may arrive at the container facility with a prime mover with a trailer carrying the freight container for storage. The reference identification number may be verified against the advance

storing order and the storing notification. After verification, the prime mover with the trailer carrying the freight container for storage may be directed to undergo an inspection at the inspection bay of the system according to the various embodiments. The inspection may determine whether the freight container has any defects that may affect the stacking process of the system. In particular, the integrity of the dimensions of the freight container may be inspected so as to determine whether the freight container may cause instability of the stacked freight containers.

[0074] If the freight container is determined to require repair before it can be stored, the freight container may be directed to the service bay for repairs. After repair is completed, the freight container may be re-directed for inspection.

[0075] If the freight container is determined that it is suitable to be stored, the prime mover with the trailer carrying the freight container for storage may be directed to a pre-determined position inside the space enclosed by the structure of the system, for example the pre-determined position 419 shown in FIG. 3. According to various embodiments, the prime mover with the trailer carrying the freight container for storage may also be directed to the loading/unloading bay of the system. At the loading/unloading bay, the container loading module of the system may move the freight container from the trailer of the prime mover to the container transfer module of the system, for example the container transfer module 450 in the form of a conveyor as shown in FIG. 3. The container transfer module 450 may then move the freight container to the pre-determined position inside the space enclosed by the structure of the system.

[0076] A storage request may be input into the processor module of the system. Upon receiving the storage request, the processor module may control the automated container handling module of the system to pick up the freight container from the pre-determined position inside the space enclosed by the structure of the system. The processor module may then control the automated container handling module to move and store the freight container within the space enclosed by the structure based on a movement plan generated in response to the storage request.

[0077] According to various embodiments, the processor module may generate the movement plan based on a storage position designated for the freight container. The processor module may also designate the storage position within the space enclosed by the structure based on a classification of the freight container. The

classification of the freight container may be based on dimensions of the freight container, type of the freight container, conditions of the freight container, details of owner of the freight container, target timeframe for storage, or a combination thereof.

5 [0078] According to various embodiments, the work flow of retrieving a freight container using the system according to various embodiments may include the following. A customer of the container facility may provide an advance retrieval order or retrieval notification that the customer intends to retrieve a freight container from the container facility. The advance retrieval order or retrieval notification may include any description or particulars of the freight container, such as its dimensions, serial or
10 registration number and/or particulars of the customer's representative who is authorized to retrieve the freight container with the container facility. The container facility may provide a confirmation of receipt of the advance retrieval order or retrieval notification with a specific reference identification number to the customer.

[0079] Subsequently, the authorized representative of the customer may arrive at
15 the container facility with a prime mover with an empty trailer. The reference identification number may be verified against the advance retrieval order and the retrieval notification.

[0080] According to various embodiments, after verification, the prime mover with the trailer may be directed to the pre-determined position inside the space enclosed by the structure, for example the pre-determined position 419 shown in FIG.
20 3. According to various embodiments, after verification, the prime mover with the trailer may be directed to the loading/unloading bay of the system.

[0081] A retrieval request may be input into the processor module of the system. Upon receiving the retrieval request, the processor module may control the automated
25 container handling module to retrieve and move the freight container within the space enclosed by the structure based on a movement plan generated in response to the retrieval request. The processor module may also control the automated container handling module to move and drop off the freight container at the pre-determined position inside the space enclosed by the structure of the system.

30 [0082] According to various embodiments, the processor may generate the movement plan based on a position information of the freight container. The processor module may retrieve the position information of the freight container from a database.

[0083] According to various embodiments, the freight container may be dropped off, for example, at the pre-determined position 419 (see FIG. 3) inside the space enclosed by the structure such that the freight container may be directly loaded onto the trailer of the prime mover which was previously directed to the pre-determined position 419 inside the space enclosed by the structure.

[0084] According to various embodiments, the freight container may be dropped off, for example, at the pre-determined position 454 (see. FIG. 3) inside the space enclosed by the structure of the system onto the container transfer module in the form of the conveyor to move the freight container to the pre-determined position 452 outside the space enclosed by the structure of the system. The freight container may then be moved, by the container loading module, from the the pre-determined position 452 outside the space enclosed by the structure onto the trailer of the prime mover which was previously directed to the loading/unloading bay.

[0085] Various embodiments have provided a system and a method for storing and retrieving freight containers at a container facility that allows stacking of ten or more freight containers, stacking of containers in an environment isolated from external environment factors such as wind or rain, maximize use of land area for storage of freight containers, enhance the accuracies of stacking and faster operations, reduce or eliminate erroneous entry of storage position into management and tracking system, and reduce or eliminate erroneous storage of freight containers due to operator's error.

[0086] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

1. A system for moving a freight container at a container facility comprising:
a structure enclosing a space, the structure having a floor, vertical walls and a ceiling;
an automated container handling module configured to move the freight container within the space enclosed by the structure; and
a processor module in communication with the automated container handling module, the processor module configured to control the automated container handling module to move the freight container within the space enclosed by the structure based on a movement plan generated in response to a movement request of the freight container as received by the processor module.
2. The system as claimed in claim 1, wherein the movement request comprises a storage request, or a retrieval request, or a service request or an inspection request.
3. The system as claimed in claim 1 or 2, wherein the processor module is configured to generate the movement plan, in response to the movement request, based on a storage position designated for the freight container.
4. The system as claimed in claim 3, wherein the processor module is configured to designate the storage position within the space enclosed by the structure to store the freight container based on a classification of the freight container.
5. The system as claimed in any one of claims 1 to 4, wherein the processor module is configured to generate the movement plan, in response to the movement request, based on a position information of the freight container retrieved from a database.
6. The system as claimed in any one of claims 1 to 5, wherein the automated container handling module is configured to stack a plurality of freight containers in a single stack within the space enclosed by the structure.

7. The system as claimed in any one of claims 1 to 6, wherein the automated container handling module is configured to stack a plurality of freight containers in a block stack within the space enclosed by the structure.
8. The system as claimed in any one of claims 1 to 7, further comprising a positioning module in communication with the automated container handling module, the positioning module configured to guide the automated container handling module for moving of the freight container.
9. The system as claimed in claim 8, wherein the positioning module is configured to detect real-time position information of the freight container for guiding the automated container handling module to move the freight container.
10. The system as claimed in claim 8 or 9, wherein the positioning module comprises a plurality of sensors.
11. The system as claimed in any one of claims 1 to 9, further comprising a container transfer module configured to move the freight container between a pre-determined position outside the space enclosed by the structure and a pre-determined position inside the space enclosed by the structure through an opening in one of the vertical walls of the structure.
12. The system as claimed in claim 11, wherein the container transfer module comprises a belt conveyor, or a roller conveyor, or a crane, or a top-side lifter, or a forklift, or a vehicle.
13. The system as claimed in claim 11 or 12, wherein the automated container handling module is configured to pick up the freight container from the pre-determined position inside the space enclosed by the structure.
14. The system as claimed in any one of claims 11 to 13, wherein the automated container handling module is configured to drop off the freight container at the pre-determined position inside the space enclosed by the structure.

15. The system as claimed in any one of claims 1 to 14, further comprising an interface module in communication with the processor module, the interface module configured to receive an input from a user.
16. The system as claimed in any one of claims 1 to 14, wherein the structure and the automated container handling module are configured to accommodate at least ten containers stacked in a single column.
17. The system as claimed in any one of claims 1 to 16, wherein the floor of the structure is configured to maintain leveled with a pre-determined horizontal plane under any internal or external loading conditions.
18. The system as claimed in claim 17 wherein the floor of the structure comprises a floating concrete slab or a rigid floor configuration.
19. The system as claimed in any of claims 1 to 18, wherein the structure is configured to limit lateral sway of the structure caused by a lateral load applied on the structure.
20. The system as claimed in any one of claims 1 to 19, wherein the structure is configured to minimize interference from external environmental forces such as wind or rain into the space enclosed by the structure.
21. The system as claimed in any one of claims 1 to 20, wherein the automated container handling module comprises an automated overhead crane with a container spreader.
22. The system as claimed in claim 21, wherein the automated overhead crane comprises
a pair of parallel runways suspended across two opposing vertical walls of the structure;

a bridge spanning across the pair of parallel runway, the bridge movable along the pair of parallel runway; and

a hoist coupled to the bridge and movable along the bridge,

wherein the container spreader is coupled to the hoist.

23. The system as claimed in claim 21 or 22, wherein the automated container handling module further comprises a plurality of sensors configured to detect the orientation and position of the container spreader.

24. The system as claimed in any one of claims 1 to 23, wherein the structure comprises a multi-storeys building.

25. The system as claimed in claim 24, further comprising at least one vehicular transit portion configured to allow vehicles to travel between various storeys of the multi-storeys building.

26. The system as claimed in claim 25, wherein the at least one vehicular transit portion comprises a vehicular lift or a vehicular ramp.

27. The system as claimed in any one of claims 1 to 26, further comprising an inspection bay.

28. The system as claimed in any one of claims 1 to 27, further comprising a service bay.

29. A method of moving a freight container using the system according to any one of claims 1 to 28, the method comprising:

receiving, by the processor module, a movement request of the freight container;

controlling the automated container handling module, by the processor module, to move the freight container within the space enclosed by the structure based on a movement plan generated in response to the movement request.

30. The method as claimed in claim 29, wherein the movement request comprises a storage request, or a retrieval request, or a service request, or an inspection request.

31. The method as claimed in claim 29 or 30, further comprising generating, by the processor module, the movement plan based on a storage position designated for the freight container.

32. The method as claimed in claim 30, further comprising designating, by the processor module, the storage position within the space enclosed by the structure based on a classification of the freight container.

33. The method as claimed in claim 32, wherein the classification of the freight container is based on dimensions of the freight container, type of the freight container, conditions of the freight container, details of owner of the freight container, target timeframe for storage, or a combination thereof.

34. The method as claimed in claim 29 or 30, further comprising generating, by the processor module, the movement plan based on a position information of the freight container.

35. The method as claimed in claim 34, further comprising retrieving, by the processor module, the position information of the freight container from a database.