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Inventor(s)

Schafer; Ryan J. et al.

PALLET SKEW CORRECTION

Abstract

A cargo handling system is provided. The cargo handling system includes a set of first power drive units, a set of second power drive units, and a controller. Each of the set of first power drive units and the set of second power drive units includes a drive roller, a motor configured to rotate the drive roller; and an infrared sensor. The controller is configured to send a command to engage the drive roller of each of the set of first power drive units to drive a cargo in a first direction and, responsive to receiving a first signal from the infrared sensor from a first power drive unit in the set of second power drive units, send a command to disengage a drive roller of a paired first power drive unit in the set of first power drive units.

Inventors: Schafer; Ryan J. (Jamestown, ND), Olson; Mark L. (Jamestown, ND), Pfau; Ryan E. (Jamestown, ND), Brunner; Joseph E. (Jamestown, ND), Harms; Scott P. (Ypsilanti, ND), Samuelson; Louis C. (Jamestown, ND)

Applicant: GOODRICH CORPORATION (Charlotte, NC)

Family ID: 1000007697960

Assignee: GOODRICH CORPORATION (Charlotte, NC)

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Background/Summary

FIELD

[0001] The present disclosure relates generally to cargo handling systems and, more particularly, to pallet skew correction during loading of cargo.

BACKGROUND

[0002] Conventional aircraft cargo systems typically include various tracks and rollers that span the length of an aircraft. Cargo may be loaded from an aft position on an aircraft and conducted by the cargo system to a forward position and/or, depending upon aircraft configuration, cargo may be loaded from a forward position on an aircraft and conducted by the cargo system to an aft position. Cargo systems, such as those used by aircraft for transport of heavy containerized cargo or pallets, also referred to as unit load devices (ULDs), typically include roller trays containing transport rollers which support the cargo. Motor driven rollers are typically employed in these systems. Aircraft often employ a series of motor driven power drive units (PDUs) to propel cargo containers and pallets within the aircraft cargo compartment. This configuration may allow for the transportation of cargo pallets within the aircraft cargo compartment by one or more operators controlling the PDUs.

SUMMARY

[0003] A cargo handling system is disclosed herein. The cargo handling system includes a set of first power drive units and a set of second power drive units. Each of the set of first power drive units and the set of second power drive units includes a drive roller, a motor configured to rotate the drive roller, and an infrared sensor. Each power drive unit in the set of first power drive units is paired with a power drive in the set of second power drive units. The cargo handling system further includes a controller. The controller is configured to send a command to engage the drive roller of each of the set of first power drive units to drive a cargo in a first direction and, responsive to receiving a first signal from the infrared sensor from a first power drive unit in the set of second power drive units, send a command to disengage the drive roller of a paired first power drive unit in the set of first power drive units.

[0004] In various embodiments, each of the set of first power drive units and the set of second power drive units further includes a brake roller. In various embodiments, the controller is further configured to, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

[0005] In various embodiments, the controller is further configured to, responsive to receiving a second signal from the infrared sensor from a second power drive unit in the set of second power drive units, send a command to disengage the drive roller of a paired second power drive unit in the set of first power drive units and send a command to engage, if not already engaged, a brake roller associated with the second power drive unit in the set of second power drive units.

[0006] In various embodiments, the controller is further configured to, responsive to receiving a

signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units, and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0007] In various embodiments, the controller is further configured to send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction, and, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage the drive roller associated with the first power drive unit in the set of second power drive units.

[0008] In various embodiments, each of the set of first power drive units and the set of second power drive units further includes a brake roller. In various embodiments, the controller is further configured to, responsive to sending the command to disengage the drive roller associated with the first power drive unit in the set of second power drive units, sending a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

[0009] In various embodiments, the controller is further configured to, responsive to receiving a signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units, and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0010] In various embodiments, the controller is configured to send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction; responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage all drive rollers in the set of first power drive units and the set of second power drive units; and, responsive to receiving a signal from each infrared sensor of the set of second power drive units, send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0011] Also disclosed herein is an aircraft. The aircraft includes a cargo handling system includes a set of first power drive units and a set of second power drive units. Each of the set of first power drive units and the set of second power drive units includes a drive roller, a motor configured to rotate the drive roller, and an infrared sensor. Each power drive unit in the set of first power drive units is paired with a power drive in the set of second power drive units. The cargo handling system further includes a controller, The controller is configured to send a command to engage the drive roller of each of the set of first power drive units to drive a cargo in a first direction and, responsive to receiving a first signal from the infrared sensor from a first power drive unit in the set of second power drive units, send a command to disengage the drive roller of a paired first power drive unit in the set of first power drive units.

[0012] In various embodiments, each of the set of first power drive units and the set of second power drive units further includes a brake roller. In various embodiments, the controller is further configured to, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

[0013] In various embodiments, the controller is further configured to, responsive to receiving a second signal from the infrared sensor from a second power drive unit in the set of second power drive units, send a command to disengage the drive roller of a paired second power drive unit in the set of first power drive units and send a command to engage, if not already engaged, a brake roller associated with the second power drive unit in the set of second power drive units.

[0014] In various embodiments, the controller is further configured to, responsive to receiving a

signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units, and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0015] In various embodiments, the controller is further configured to send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction, and, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage the drive roller associated with the first power drive unit in the set of second power drive units.

[0016] In various embodiments, each of the set of first power drive units and the set of second power drive units further includes a brake roller. In various embodiments, the controller is further configured to, responsive to sending the command to disengage the drive roller associated with the first power drive unit in the set of second power drive units, sending a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

[0017] In various embodiments, the controller is further configured to, responsive to receiving a signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units, and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0018] In various embodiments, the controller is configured to send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction; responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage all drive rollers in the set of first power drive units and the set of second power drive units; and, responsive to receiving a signal from each infrared sensor of the set of second power drive units, send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0019] Additionally disclosed herein is a method for correcting skewed cargo. The method includes sending, by a controller, a command to engage a drive roller of each of a set of first power drive units to drive a cargo in a first direction, and, responsive to receiving a first signal from the infrared sensor from a first power drive unit in a set of second power drive units, sending, by the controller, a command to disengage the drive roller of a paired first power drive unit in the set of first power drive units.

[0020] In various embodiments, the method further includes, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, sending, by the controller, a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

[0021] In various embodiments, the method further includes, responsive to receiving a second signal from the infrared sensor from a second power drive unit in the set of second power drive units: sending, by the controller, a command to disengage the drive roller of a paired second power drive unit in the set of first power drive units and sending, by the controller, a command to engage, if not already engaged, a brake roller associated with the second power drive unit in the set of second power drive units.

[0022] In various embodiments, the method further includes, responsive to receiving a signal from each infrared sensor of the set of second power drive units: sending, by the controller, a command to disengage all brake rollers associated with the set of second power drive units, and sending, by the controller, a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

[0023] The foregoing features and elements may be combined in any combination, without exclusivity, unless expressly indicated herein otherwise. These features and elements as well as the operation of the disclosed embodiments will become more apparent in light of the following description and accompanying drawings.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The subject matter of the present disclosure is particularly pointed out and distinctly claimed in the concluding portion of the specification. A more complete understanding of the present disclosure, however, may best be obtained by referring to the detailed description and claims when considered in connection with the drawing figures, wherein like numerals denote like elements.

[0025] FIG. 1 illustrates an aircraft being loaded with cargo, in accordance with various embodiments.

[0026] FIG. 2 illustrates a portion of a cargo deck with a skewed pallet, in accordance with various embodiments.

[0027] FIG. 3 illustrates a method for controlling the skew of cargo during loading, in accordance with various embodiments.

[0028] FIG. 4 illustrates a method for controlling the skew of cargo during loading, in accordance with various embodiments.

[0029] FIG. 5 illustrates a method for controlling the skew of cargo during loading, in accordance with various embodiments.

DETAILED DESCRIPTION

[0030] The detailed description of embodiments herein makes reference to the accompanying drawings, which show embodiments by way of illustration. While these embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, it should be understood that other embodiments may be realized and that logical, chemical, and mechanical changes may be made without departing from the spirit and scope of the disclosure. Thus, the detailed description herein is presented for purposes of illustration only and not for limitation. For example, any reference to singular includes plural embodiments, and any reference to more than one component or step may include a singular embodiment or step. Also, any reference to attached, fixed, connected or the like may include permanent, removable, temporary, partial, full and/or any other possible attachment option. Further, any steps in a method discussed herein may be performed in any suitable order or combination.

[0031] Main deck cargo systems in cargo aircrafts commonly carry longer in length pallets, such as 16-foot-long pallets and 20-foot-long pallets, among others. These longer in length pallets utilize a load procedure that rotates these pallets 90 degrees due to a size of the cargo door of the cargo aircraft and a size of the loader utilized to load the cargo aircraft. If the pallets are of a weight that is greater than a typical pallet, the load procedure may require the pallets to be positioned in a centerline position instead of a side-by-side position. During the load procedure these pallets are translated from a port side of the cargo compartment to the centerline of the cargo compartment. During such loading procedures, the translation action may cause the pallet to skew, i.e. at least one edge of the pallet becoming not parallel or substantially parallel from a lateral side of the aircraft, as is illustrated in FIG. 2 described hereafter.

[0032] Disclosed herein is a system for pallet skew correction for aerospace cargo systems.

Aircrafts often employ a series of motor driven power drive units (PDUs) located in the floor of the cargo handling system. These PDUs are configured to propel cargo containers and pallets within the aircraft cargo compartment. This configuration may allow for the transportation of cargo pallets

within the aircraft cargo compartment by one or more controllers or operators controlling the PDUs. Typically, these PDUs are configured with integrated infrared (IR) sensors. In various embodiments, responsive to a translation action of a pallet causes the pallet to skew within the cargo compartment, the control system coupled to the PDUs utilizes signals from the IR sensors in the PDUs to reduce pallet skew and limit abuse, i.e. load shifts or impacts, among others, to the cargo on the pallet or the aircraft, i.e. the pallet impacting guide surfaces within the cargo compartment and/or cargo moving while on the pallet with respect to the pallet.

[0033] In various embodiments, as a skewed pallet translates laterally from the port side of the cargo compartment to the centerline of the cargo compartment within the cargo compartment, the control system software may be configured to disengage specific ones of the PDUs in the drive system as well as engage brakes of the specific ones of the PDUs responsive to IR sensors of those specific ones of the PDUs are blocked. The disengagement of the drive of the specific ones of the PDUs and the application of braking may allow the other PDUs associated with the pallet to straighten the pallet from the skewed position and reduce abuse, i.e. load shifts or impacts, among others, to the cargo on the pallet or the aircraft, i.e. the pallet impacting guide surfaces within the cargo compartment and/or cargo moving while on the pallet with respect to the pallet.

[0034] Referring now to FIG. 1, an aircraft **10** having a cargo deck **12** is illustrated, in accordance with various embodiments. Aircraft **10** may include a cargo load door **14**, for example, at a side of the fuselage structure of the aircraft **10**. Cargo **20** may be loaded through cargo load door **14** and onto cargo deck **12** of aircraft **10** or unloaded from the cargo deck **12** of the aircraft **10**.

[0035] Items to be shipped by air, freight, and/or the like are typically loaded first onto specially configured pallets or into specially configured containers. In aviation, those various pallets and/or containers are commonly referred to as unit load devices (ULDs). ULDs are available in various sizes and capacities and are typically standardized in dimension and shape. In various embodiments, cargo **20** may be a ULD. Once loaded, the ULD is transferred to the aircraft, and is loaded onto the aircraft **10** through the cargo load door **14** using a conveyor ramp, scissor lift, or the like. Once inside the aircraft **10**, the ULD is moved within the cargo hold to its final stowage position. Multiple ULDs may be brought on-board the aircraft, with each ULD being placed in its respective stowage and transportation position in on cargo deck **12**. After the aircraft **10** has reached its destination, the ULDs are unloaded from the aircraft **10** similarly, but in reverse sequence to the loading procedure. To facilitate movement of cargo **20** along the cargo deck **12**, aircraft **10** may include a cargo handling system as described herein in accordance with various embodiments.

[0036] Referring now to FIG. 2, a portion of cargo deck **12** with a skewed pallet is illustrated with XYZ axes for case of illustration, in accordance with various embodiments. In various embodiments, the cargo deck **12** includes a cargo handling system **200** that may include one or more ball panels **202** and one or more roller trays **204**. Ball panels **202** may include a plurality of freely rotating conveyance balls **206** and roller trays **204** include a plurality of freely rotating conveyance rollers **208**. Roller trays **204** may be positioned longitudinally along cargo deck **12** in the z-direction. In various embodiments, a number of PDUs **210a-210e**, **212a-212e**, and **214** may be mounted along cargo deck **12**. For example, PDUs **210a-210e**, **212a-212e**, and **214** may be located in ball panels **202** and/or in roller trays **204**. More specifically, in various embodiments, PDUs **210a-210e** may be located in ball panels **202** and/or in roller trays **204** along a port side of the cargo deck, PDUs **212a-212e** may be located in ball panels **202** and/or in roller trays **204** along a starboard side of the cargo deck, and PDUs **214** may be located at the entrance of the cargo load door, such as cargo load door **14** of FIG. 1. In various embodiments, PDUs **210a-210e**, **212a-212e**, and **214** are configured to propel a pallet, hereinafter referred to as cargo **20**, over conveyance balls **206** and conveyance rollers **208** and across and along cargo deck **12**.

[0037] in various embodiments, PDUs **210a-210e**, **212a-212e**, and **214** may include one or more drive rollers, which may be actively controlled by a motor via a command from a controller. PDUs

210a-210e, **212a-212e**, and **214**, including drive rollers, provide a mechanism upon which cargo **20** is propelled over the conveyance rollers **208**. The cargo **20** may contact the drive rollers of PDUs **210a-210e**, **212a-212e**, and **214** located within the ball panels **202** and the roller trays **204** to provide motive force for the cargo **20**. Each of PDUs **210a-210e**, **212a-212e**, and **214** may include an actuator, such as an electrically operated motor, which drives one or more drive rollers via a command from a controller. In various embodiments, a drive roller may be raised from a lowered position beneath the conveyance surface to an elevated position above conveyance surface. As used with respect to cargo deck **12**, the term “beneath” may refer to the negative y-direction, and the term “above” may refer to the positive y-direction with respect to the provided XYZ axes. In the elevated position, a drive roller contacts and drives the overlying the cargo **20** that rides on the conveyance rollers **208**. In accordance with various embodiments, the drive roller may be held or biased in a position above the conveyance surface by a spring.

[0038] In various embodiments, a number of brake rollers may be located along cargo deck **12** within or adjacent to PDUs **210a-210e**, **212a-212e**, and **214**. In addition to drive rollers and the brake rollers, each of PDUs **210a-210e**, **212a-212e**, and **214** may be configured with one or more IR sensors **216**. In various embodiments, the IR sensors **216** are configured to detect the presence of cargo **20** above the PDUs **210a-210e**, **212a-212e**, and **214**.

[0039] In various embodiments, the cargo handling system **200** may include a controller **230** in communication with the PDUs **210a-210e**, **212a-212e**, and **214** via a plurality of channels **232**. Channels **232** may be a data bus, such as a controller area network (CAN) bus and may include one or more CAN busses or multi-CANs. An operator may selectively control operation of PDUs **210a-210e**, **212a-212e**, and **214** using controller **230**. Controller **230** may be configured to engage and/or disengage various ones of the PDUs **210a-210e**, **212a-212e**, and **214** of the cargo deck **12**. Thus, cargo handling system **200** may receive operator input through controller **230** to control the PDUs **210a-210e**, **212a-212e**, and **214** to manipulate the cargo **20** into a desired position on cargo deck **12**. Controller **230** may include a general-purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof.

[0040] System program instructions and/or controller instructions may be loaded onto a tangible, non-transitory, computer-readable medium (also referred to herein as a tangible, non-transitory, memory) having instructions stored thereon that, in response to execution by a controller, cause the controller to perform various operations. The term “non-transitory” is to be understood to remove only propagating transitory signals per se from the claim scope and does not relinquish rights to all standard computer-readable media that are not only propagating transitory signals per se. Stated another way, the meaning of the term “non-transitory computer-readable medium” and “non-transitory computer-readable storage medium” should be construed to exclude only those types of transitory computer-readable media which were found in *In Re Nuijten* to fall outside the scope of patentable subject matter under 35 U.S.C. § 101.

[0041] The cargo handling system **200** may also include a power source **234** configured to supply power to the PDUs **210a-210e**, **212a-212e**, and **214** and/or other components of cargo handling system **200** via one or more power busses **236**. As described below, in various embodiments, the controller **230** may be complimented by or substituted with one or more local controllers, whereby control of each PDU or groups of PDUs is performed by individual local controllers configured to communicate with one another.

[0042] In various embodiments, cargo **20** may be become skewed for any number of reasons, such as responsive to a heavy bias in the mast towards one side or the other. In that regard, one side of the cargo **20**, in response to being propelled by one or more of PDUs **210a-210e** and **212a-212e**, may translate faster than another side. In various embodiments, the controller **230** may be configured to send commands to engage or disengage driver rollers associated with various ones of

PDUs, while engaging or disengaging other PDUs based on an IR sensor signal from the PDU itself or another PDU. In that regard, in various embodiments, in an attempt to move cargo **20** against the starboard side buttock line **218**, the drive rollers of PDUs **210b-210e** may be engaged and PDUs **212b-212e** may be disengaged. Responsive to cargo **20** becoming skewed, as soon as an IR sensor **216** associated with PDU **212b** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212c-212e** failing to detect the presence of the cargo **20**, then the controller **230** may be configured to send a command to disengage the drive roller of PDU **210b** while continuing to drive the drive rollers of PDUs **210c-210e** in order to correct the skew. Furthermore, in various embodiments, in order to prevent movement of the cargo **20** associated with PDU **212b**, controller **230** may be configured to send a command to engage, if not already engaged, the brake roller associated with PDU **212b**.

[0043] While not illustrated, in various embodiments, since the controller **230** is continuing to send commands to drive the drive rollers of PDUs **210c-210e** in order to correct the skew, as soon as an IR sensor **216** associated with PDU **212c** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212d-212e** fail to detect the presence of the cargo **20**, then the controller **230** is configured to send a command to disengage the drive roller of PDU **210c** while continuing to drive the drive roller of PDUs **210d-210e** in order to correct the skew. In various embodiments, in order to prevent movement of the cargo **20** associated with PDU **212c**, controller **230** may be configured to send a command to engage, if not already engaged, the brake roller associated with PDU **212c**. Further, since the controller **230** is continuing to send commands to drive the drive rollers of PDUs **210d-210e** in order to correct the skew, as soon as an IR sensor **216** associated with PDU **212d** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212e** fails to detect the presence of the cargo **20**, then the controller **230** is configured to send a command to disengage the drive roller of PDU **210d** while continuing to drive the drive roller of PDU **210e** in order to correct the skew. In various embodiments, in order to prevent movement of the cargo **20** associated with PDU **212d**, controller **230** may be configured to send a command to engage, if not already engaged, the brake roller associated with PDU **212d**. Finally, in various embodiments, since the controller **230** is continuing to send commands to drive the drive roller of PDU **210e** in order to correct the skew, as soon as an IR sensor **216** associated with PDU **212e** detects the presence of the cargo **20**, then the controller **230** may be configured to send commands to disengage all brake rollers of each of PDUs **210a-210e** and **212a-212e** and to engage the drive rollers of each of PDUs **210a-210e** and **212a-212e** to move the cargo in the x-direction against the starboard side buttock line **218** in order to reduce abuse to the cargo **20** associated with the cargo **20** running into the starboard side buttock line **218** at an angle within the cargo compartment.

[0044] In other various embodiments, in an attempt to move cargo **20** against the starboard side buttock line **218**, the drive rollers of PDUs **210b-210e** and PDUs **212b-212e** may be engaged. Responsive to cargo **20** becoming skewed, as soon as an IR sensor **216** associated with PDU **212b** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212c-212e** failing to detect the presence of the cargo **20**, then the controller **230** may be configured to send a command to disengage the drive rollers of PDUs **210b** and **212b** while continuing to drive the drive rollers of PDUs **210c-210e** and **212c-212e** in order to correct the skew. Furthermore, in various embodiments, in order to prevent movement of the cargo **20** associated with PDU **212b**, controller **230** may be configured to send a command to engage, if not already engaged, the brake roller associated with PDU **212b**.

[0045] In various embodiments, since the controller **230** is continuing to send commands to drive the drive rollers of PDUs **210c-210e** and PDUs **212c-212e** in order to correct the skew, as soon as an IR sensor **216** associated with PDU **212c** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212d-212e** fail to detect the presence of the cargo **20**, then the controller **230** is configured to send a command to disengage the drive rollers of PDUs **210c** and **212c** while continuing to drive the drive roller of PDUs **210d-210e** and **212d-212e** in order to correct the skew.

In various embodiments, in order to prevent movement of the cargo **20** associated with PDU **212c**, controller **230** may be configured to send a command to engage, if not already engaged, the brake roller associated with PDU **212c**. Further, since the controller **230** is continuing send commands to drive the drive rollers of PDUs **210d-210e** and **212d-212e** in order to correct the skew, as soon as an IR sensor **216** associated with PDU **212d** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212e** fails to detect the presence of the cargo **20**, then the controller **230** is configured to send a command to disengage the drive rollers of PDUs **210d** and **212d** while continuing to drive the drive rollers of PDU **210e** and **212e** in order to correct the skew. In various embodiments, in order to prevent movement of the cargo **20** associated with PDU **212d**, controller **230** may be configured to send a command to engage, if not already engaged, the brake roller associated with PDU **212d**. Finally, in various embodiments, since the controller **230** is continuing to send commands to drive the drive roller of PDU **210e** and **212e** in order to correct the skew, as soon as an IR sensor **216** associated with PDU **212e** detects the presence of the cargo **20**, then the controller **230** may be configured to send commands to disengage all brake rollers of each of PDUs **210a-210e** and **212a-212e** and to engage the drive rollers of each of PDUs **210a-210e** and **212a-212e** to move the cargo in the x-direction against the starboard side buttock line **218** in order to reduce abuse to the cargo **20** associated with the cargo **20** running into the starboard side buttock line **218** at an angle within the cargo compartment.

[0046] In other various embodiments, in an attempt to move cargo **20** against the starboard side buttock line **218**, the drive rollers of PDUs **210a-210e** and PDUs **212a-212e** may be engaged. Responsive to cargo **20** becoming skewed, as soon as an IR sensor **216** associated with PDU **212b** detects the presence of the cargo **20** and the IR sensors **216** associated with PDUs **212a** and **212c-212e** failing to detect the presence of the cargo **20**, then the controller **230** may be configured to send a command to disengage all the drive rollers of PDUs **210a-210e** and PDUs **212a-212e** until the skew of the cargo is manually corrected. Responsive to the skew being manually corrected and the IR sensors **216** associated with PDUs **212b-212e** detecting the presence of the cargo **20**, then the controller **230** may be configured to send commands to disengage all brake rollers of each of PDUs **210a-210e** and **212a-212e** and to engage the drive rollers of each of PDUs **210a-210e** and **212a-212e** to move the cargo in the x-direction against the starboard side buttock line **218** in order to reduce abuse to the cargo **20** associated with the cargo **20** running into the starboard side buttock line **218** at an angle within the cargo compartment.

[0047] Referring now to FIG. **3**, in accordance with various embodiments, a method for controlling the skew of cargo during loading is illustrated. The method **300** may be performed by a controller, such as controller **230** of FIG. **2**. In various embodiments, the cargo compartment includes a starboard side set of PDUs along a port side of the cargo compartment and a port side set of PDUs along a second side of the cargo compartment, where PDUs from the starboard side set of PDU and from the port side set of PDUs operate in pairs. At block **302**, the controller sends commands to drives rollers of the port side set of PDUs on a port side of a cargo compartment to move the cargo against a buttock line on the starboard side of the cargo compartment. At block **304**, responsive to the controller determining that an IR sensor associated with a PDU in the starboard side set of PDUs on the starboard side of the cargo compartment has indicated a presence of the cargo while IR sensors associated with other PDUs in the starboard side set of PDUs fail to detect the presence of the cargo, the controller sends a command to disengage a drive roller of paired PDU in the port side set of PDUs and, at block **306**, the controller sends commands to continue to drive the drive rollers of other PDUs in the port side set of PDUs in order to correct the skew. At block **308**, the controller determines whether each IR sensor of each PDU in the starboard side set of PDUs is detecting the cargo. If at block **308** the controller determines that at least one IR sensor of the starboard side set of PDUs is not detecting the cargo, then the operation returns to block **304**. If at block **308** the controller determines that all the IR sensors in the starboard side set of PDUs is detecting the cargo, at block **310**, the controller is configured to send commands to disengage all

brake rollers of each of the starboard side set of PDUs and the port side set of PDUs and to engage the drive rollers of each of the starboard side set of PDUs and the port side set of PDUs to move the cargo against the starboard side buttock line in order to reduce abuse to the cargo associated with the cargo running into a guide rail at an angle within the cargo compartment.

[0048] Referring now to FIG. 4, in accordance with various embodiments, a method for controlling the skew of cargo during loading is illustrated. The method **400** may be performed by a controller, such as controller **230** of FIG. 2. In various embodiments, the cargo compartment includes a starboard side set of PDUs along the starboard side of the cargo compartment and a port side set of PDUs along the port side of the cargo compartment, where PDUs from the starboard side set of PDU and from the port side set of PDUs operate in pairs. At block **402**, the controller sends commands to drives rollers of the starboard side set of PDUs and the port side set of PDUs of a cargo compartment to move the cargo against a buttock line on a starboard side of the cargo compartment. At block **404**, responsive to the controller determining that an IR sensor associated with a PDU in the starboard side set of PDUs on the starboard side of the cargo compartment has indicated a presence of the cargo while IR sensors associated with other PDUs in the starboard side set of PDUs fail to detect the presence of the cargo, the controller sends commands to disengage a drive roller of paired PDUs in the starboard side set of PDUs and the port side set of PDUs associated with the PDU in the starboard side set of PDUs on the starboard side of the cargo compartment that indicated the presence of the cargo and, at block **406**, the controller sends commands to continue to drive the drive rollers of other PDUs in the starboard side set of PDUS and the port side set of PDUs in order to correct the skew. At block **408** controller determines whether each IR sensor of each PDU in the starboard side set of PDUs is detecting the cargo. If at block **408** the controller determines that at least one IR sensor of the starboard side set of PDUs is not detecting the cargo, then the operation returns to block **404**. If at block **408** the controller determines that all the IR sensors in the starboard side set of PDUs is detecting the cargo, at block **410**, the controller is configured to send commands to disengage all brake rollers of each of the starboard side set of PDUs and the port side set of PDUs and to engage the drive rollers of each of starboard side set of PDUs and the port side set of PDUs to move the cargo against the starboard side buttock line in order to reduce abuse to the cargo associated with the cargo running into a guide rail at an angle within the cargo compartment.

[0049] Referring now to FIG. 5, in accordance with various embodiments, a method for controlling the skew of cargo during loading is illustrated. The method **500** may be performed by a controller, such as controller **230** of FIG. s. In various embodiments, the cargo compartment includes a starboard side set of PDUs along a starboard side of the cargo compartment and a port side set of PDUs along a port side of the cargo compartment, where PDUs from the starboard side set of PDU and from the port side set of PDUs operate in pairs. At block **502**, the controller sends commands to drives rollers of the starboard side set of PDUs and the port side set of PDUs of a cargo compartment to move the cargo against a buttock line on a starboard side of the cargo compartment. At block **504**, responsive to the controller determining that an IR sensor associated with a PDU in the starboard side set of PDUs on the starboard side of the cargo compartment has indicated a presence of the cargo while IR sensors associated with other PDUs in the set of first PDUs fail to detect the presence of the cargo, the controller sends commands to disengage all of the drive rollers of the starboard side set of PDUs and the port side set of PDUs until the skew of the cargo is manually corrected. At block **506**, responsive to the controller receiving an indication that the skew has been manually corrected, the controller send commands to disengage all brake rollers of each of the starboard side set of PDUs and the port side set of PDUs and to engage the drive rollers of each of starboard side set of PDUs and the port side set of PDUs to move the cargo against the starboard side buttock line in order to reduce abuse to the cargo associated with the cargo running into a guide rail at an angle within the cargo compartment.

[0050] Benefits and other advantages have been described herein with regard to specific

embodiments. Furthermore, the connecting lines shown in the various figures contained herein are intended to represent exemplary functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in a practical system. However, the benefits, advantages, solutions to problems, and any elements that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as critical, required, or essential features or elements of the disclosure. The scope of the disclosure is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean “one and only one” unless explicitly so stated, but rather “one or more.” Moreover, where a phrase similar to “at least one of A, B, or C” is used in the claims, it is intended that the phrase be interpreted to mean that A alone may be present in an embodiment, B alone may be present in an embodiment, C alone may be present in an embodiment, or that any combination of the elements A, B and C may be present in a single embodiment; for example, A and B, A and C, B and C, or A and B and C.

[0051] Systems, methods, and apparatus are provided herein. In the detailed description herein, references to “one embodiment,” “an embodiment,” “an example embodiment,” etc., indicate that the embodiment described may include a particular feature, structure, or characteristic, but every embodiment may not necessarily include the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to affect such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described. After reading the description, it will be apparent to one skilled in the relevant art(s) how to implement the disclosure in alternative embodiments.

[0052] Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims. No claim element herein is intended to invoke 35 U.S.C. 112(f) unless the element is expressly recited using the phrase “means for.” As used herein, the terms “comprises,” “comprising,” or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

Claims

1. A cargo handling system, comprising: a set of first power drive units; and a set of second power drive units, wherein each of the set of first power drive units and the set of second power drive units comprising: a drive roller; a motor configured to rotate the drive roller; and an infrared sensor, wherein each power drive unit in the set of first power drive units is paired with a power drive in the set of second power drive units; and a controller, the controller is configured to: send a command to engage the drive roller of each of the set of first power drive units to drive a cargo in a first direction; and responsive to receiving a first signal from the infrared sensor from a first power drive unit in the set of second power drive units, send a command to disengage the drive roller of a paired first power drive unit in the set of first power drive units.
2. The cargo handling system of claim 1, wherein each of the set of first power drive units and the set of second power drive units further comprises: a brake roller, wherein the controller is further configured to, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

3. The cargo handling system of claim 2, wherein the controller is further configured to: responsive to receiving a second signal from the infrared sensor from a second power drive unit in the set of second power drive units: send a command to disengage the drive roller of a paired second power drive unit in the set of first power drive units; and send a command to engage, if not already engaged, a brake roller associated with the second power drive unit in the set of second power drive units.

4. The cargo handling system of claim 3, wherein the controller is further configured to: responsive to receiving a signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units; and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

5. The cargo handling system of claim 1, wherein the controller is further configured to: send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction; and responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage the drive roller associated with the first power drive unit in the set of second power drive units.

6. The cargo handling system of claim 5, wherein each of the set of first power drive units and the set of second power drive units further comprises: a brake roller, wherein the controller is further configured to, responsive to sending the command to disengage the drive roller associated with the first power drive unit in the set of second power drive units, sending a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

7. The cargo handling system of claim 6, wherein the controller is further configured to: responsive to receiving a signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units; and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

8. The cargo handling system of claim 1, wherein the controller is configured to: send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction; responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage all drive rollers in the set of first power drive units and the set of second power drive units; and responsive to receiving a signal from each infrared sensor of the set of second power drive units, send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.

9. An aircraft, the aircraft comprising: cargo handling system, the cargo handling system comprising: a set of first power drive units; and a set of second power drive units, wherein each of the set of first power drive units and the set of second power drive units comprising: a drive roller; a motor configured to rotate the drive roller; and an infrared sensor, wherein each power drive unit in the set of first power drive units is paired with a power drive in the set of second power drive units; and a controller, the controller is configured to: send a command to engage the drive roller of each of the set of first power drive units to drive a cargo in a first direction; and responsive to receiving a first signal from the infrared sensor from a first power drive unit in the set of second power drive units, send a command to disengage the drive roller of a paired first power drive unit in the set of first power drive units.

10. The aircraft of claim 9, wherein each of the set of first power drive units and the set of second power drive units further comprises: a brake roller, wherein the controller is further configured to, responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.

- 11.** The aircraft of claim 10, wherein the controller is further configured to: responsive to receiving a second signal from the infrared sensor from a second power drive unit in the set of second power drive units: send a command to disengage the drive roller of a paired second power drive unit in the set of first power drive units; and send a command to engage, if not already engaged, a brake roller associated with the second power drive unit in the set of second power drive units.
- 12.** The aircraft of claim 11, wherein the controller is further configured to: responsive to receiving a signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units; and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.
- 13.** The aircraft of claim 9, wherein the controller is further configured to: send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction; and responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage the drive roller associated with the first power drive unit in the set of second power drive units.
- 14.** The aircraft of claim 13, wherein each of the set of first power drive units and the set of second power drive units further comprises: a brake roller, wherein the controller is further configured to, responsive to sending the command to disengage the drive roller associated with the first power drive unit in the set of second power drive units, sending a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.
- 15.** The aircraft of claim 14, wherein the controller is further configured to: responsive to receiving a signal from each infrared sensor of the set of second power drive units: send a command to disengage all brake rollers associated with the set of second power drive units; and send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.
- 16.** The aircraft of claim 9, wherein the controller is configured to: send a command to engage the drive roller of each of the set of second power drive units to drive the cargo in the first direction; responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, send a command to disengage all drive rollers in the set of first power drive units and the set of second power drive units; and responsive to receiving a signal from each infrared sensor of the set of second power drive units, send a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.
- 17.** A method for correcting skewed cargo, the method comprising: sending, by a controller, a command to engage a drive roller of each of a set of first power drive units to drive a cargo in a first direction; and responsive to receiving a first signal from the infrared sensor from a first power drive unit in a set of second power drive units, sending, by the controller, a command to disengage the drive roller of a paired first power drive unit in the set of first power drive units.
- 18.** The method of claim 17, further comprising: responsive to receiving the first signal from the infrared sensor from the first power drive unit in the set of second power drive units, sending, by the controller, a command to engage, if not already engaged, a brake roller associated with the first power drive unit in the set of second power drive units.
- 19.** The method of claim 18, further comprising: responsive to receiving a second signal from the infrared sensor from a second power drive unit in the set of second power drive units: sending, by the controller, a command to disengage the drive roller of a paired second power drive unit in the set of first power drive units; and sending, by the controller, a command to engage, if not already engaged, a brake roller associated with the second power drive unit in the set of second power drive units.
- 20.** The method of claim 19, further comprising: responsive to receiving a signal from each infrared

sensor of the set of second power drive units: sending, by the controller, a command to disengage all brake rollers associated with the set of second power drive units; and sending, by the controller, a command to engage the drive roller of each of the set of first power drive units and the drive roller of each of the set of second power drive units to drive the cargo in the first direction.
