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TELESCOPING CONVEYOR

Abstract

Extendable conveyor system and operating processes for the same. An extendable conveyor system that includes a plurality of conveyor segments, a conveyor extension/retraction system, and a control system. The plurality of conveyor segments are interlocked in a telescoping configuration with individual conveyor segments at least partially overlapping one another. The conveyor extension/retraction system is operatively coupled to at least one of the conveyor segments and configured to control the extension and retraction of the extendable conveyor system by controlling movement of the conveyor segments relative to one another. The control system is in electrical communication with the conveyor extension/retraction system and configured to perform operations that include adjusting a position of one or more conveyor segments responsive to data received from a package handling robot in electronic communication with the control system.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation of U.S. application Ser. No. 18/444,442, filed on Feb. 16, 2024, which claims the benefit of the filing date of U.S. Provisional Application No. 63/448,038, filed on Feb. 24, 2023. The contents of U.S. Application No. 63/448,038 and Ser. No. 18/444,442 are incorporated herein by reference in their entirety.

BACKGROUND
[0002] Conveyor systems are used in many different industries to move objects through a facility efficiently. For instance, conveyor systems are used in manufacturing to move individual components around a manufacturing facility. Conveyor systems are also used in distribution facilities to move packages throughout the facility. Conveyor systems are used in shipping and receiving facilities to route packages through sorting facilities and to shipping container or vehicles. Improvements in such conveyance systems are sought to continually improve efficient routing of objects within such industries.
SUMMARY
[0003] This specification relates an extendable conveyor system and the operations of such a system.
[0004] In general, innovative aspects of the subject matter described in this specification can be embodied in methods that include the operations of obtaining a first distance between a front end of a conveyor system and at least one object positioned in front of the conveyor system from a sensor system. The operations include determining that the first distance is less than a first predefined distance. And, the operations include controlling the conveyor system to move to increase a distance from the at least one object in response to the first distance being less than the first predefined distance. Other implementations of this aspect include corresponding systems, apparatus, and computer programs, configured to perform the actions of the methods, encoded on computer storage devices. These and other implementations can each optionally include one or more of the following features.
[0005] In some implementations, determining that the first distance is less than the first predefined distance includes comparing a measured value of the first distance to the first predefined distance.
[0006] In some implementations, the first predefined distance includes a user selected value.
[0007] In some implementations, controlling the conveyor system includes sending instructions to one or more motor controllers that cause the conveyor system to retract until the first distance is equal to or greater than the first predefined distance.
[0008] In some implementations, the conveyor system is an extendable conveyor system that comprises a first conveyor segment and a second conveyor segment configured to nest underneath the first conveyor segment, and wherein the one or more motor controllers control relative movement between the first conveyor segment and the second conveyor segment.
[0009] In some implementations, the first distance is the shortest distance between the front end of

the conveyor system and a plurality of objects.
[0010] In some implementations, the operations include controlling the front end of the conveyor system to move laterally relative to a length of the conveyor system.
[0011] In some implementations, controlling the front end of the conveyor system to move laterally includes moving the front end in response to measurement data from the sensor system.
[0012] In some implementations, controlling the front end of the conveyor system to move laterally includes sending instructions to one or more motor controllers that control lateral movement of the conveyor system in response to measurement data from the sensor system.
[0013] In some implementations, the operations include: obtaining, from at least a first side mounted sensor of the sensor system, a second distance between a first side of the conveyor system and a second object; obtaining, from a second side mounted sensor of the sensor system, a third distance between the second side of the conveyor system and a third object; determining that a difference between the second distance and the third distance exceeds a threshold difference value; and in response, controlling the conveyor system to move such that the difference is within the threshold difference value.
[0014] In some implementations, the conveyor system includes an interface for connecting a robot to the conveyor system and the operation of obtaining the first distance includes obtaining the first distance from the robot through the interface.
[0015] In some implementations, the operations include obtaining package flow data indicating a rate package flow along the conveyor system; and controlling, based on the package flow data, operation of independent indexing sections of the conveyor system.
[0016] In some implementations, controlling the operation of the independent indexing sections includes controlling at least one independent indexing section to adjust buffering distances between packages by varying the speed of the at least one independent indexing section.
[0017] Another general aspect can be embodied in an extendable conveyor system that includes a plurality of conveyor segments, a conveyor extension/retraction system, and a control system. The plurality of conveyor segments are interlocked in a telescoping configuration with individual conveyor segments at least partially overlapping one another. The conveyor extension/retraction system is operatively coupled to at least one of the conveyor segments and configured to control the extension and retraction of the extendable conveyor system by controlling movement of the conveyor segments relative to one another. The control system is in electrical communication with the conveyor extension/retraction system and configured to perform operations that include adjusting a position of one or more conveyor segments responsive to data received from a package handling robot in electronic communication with the control system. In some implementations, the control system can be configured to perform any one or more of the operations discussed above.
[0018] In some implementations, each conveyor segment includes one or more indexing sections, and the operations of the control system include controlling a speed of one indexing section independent from other indexing sections responsive to second data received from the package handling robot.
[0019] In some implementations, a forward most conveyor segment of the plurality of conveyor segments includes an articulating end configured to pivot relative to the forward most conveyor segment.
[0020] In some implementations, a base conveyor segment of the plurality of conveyor segments includes a package stop configured to raise and lower responsive to control signals from the control system.
[0021] In some implementations, the plurality of conveyor segments include a base conveyor segment configured to receive packages from a gravity chute, an end conveyor segment, and one or more middle conveyor segments arranged between the base conveyor segment and the end conveyor segment.
[0022] In some implementations, the base conveyor segment of the plurality of conveyor segments

includes a package stop configured to raise and lower responsive to control signals from the control system.
[0023] In some implementations, the one or more middle conveyor segments each comprise an independently controllable conveyor belt.
[0024] In some implementations, the forward most conveyor segment includes a plurality of rollers including at least a first set of powered rollers and a second set of powered rollers with the first set of powered rollers separated from the second set of powered rollers by a set of unpowered rollers.
[0025] In some implementations, the forward most conveyor segment includes an articulating end configured to pivot relative to a forward end of the end conveyor segment.
[0026] Another general aspect can be embodied in an extendable conveyor system that includes a plurality of conveyor segments, a conveyor extension/retraction system, a sensor system, and a control system. The plurality of conveyor segments are interlocked in a telescoping configuration with individual conveyor segments at least partially overlapping one another. The conveyor extension/retraction system is operatively coupled to at least one of the conveyor segments and configured to control the extension and retraction of the extendable conveyor system by controlling movement of the conveyor segments relative to one another. The control system is in electrical communication with the conveyor extension/retraction system and with the sensor system, the control system configured to perform operations that include: obtaining, from the sensor system, a first distance between a front end of the conveyor system and at least one object positioned in front of the conveyor system; determining that the first distance is less than a first predefined distance; and in response to the first distance being less than the first predefined distance, controlling the conveyor extension/retraction system to move the conveyor segments to increase a distance from the at least one object. In some implementations, the control system of can be configured to perform any one or more of the operations discussed above.
[0027] In some implementations, the plurality of conveyor segments include a base conveyor segment configured to receive packages from a gravity chute, an end conveyor segment, and one or more middle conveyor segments arranged between the base conveyor segment and the end conveyor segment.
[0028] In some implementations, the base conveyor segment of the plurality of conveyor segments includes a package stop configured to raise and lower responsive to control signals from the control system.
[0029] In some implementations, the one or more middle conveyor segments includes each comprise an independently controllable conveyor belt.
[0030] In some implementations, the forward most conveyor segment includes a plurality of rollers including at least a first set of powered rollers and a second set of powered rollers with the first set of powered rollers separated from the second set of powered rollers by a set of unpowered rollers.
[0031] In some implementations, the forward most conveyor segment includes an articulating end configured to pivot relative to a forward end of the end conveyor segment.
[0032] Particular implementations of the subject matter described in this specification can be implemented so as to realize one or more of the following advantages. Implementations may improve the efficiency of performing package loading operations. Implementations may reduce worker fatigue by maintaining a proper distance between the end of a conveyor and a package loading site.
[0033] The details of one or more implementations of the subject matter described in this specification are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages of the subject matter will become apparent from the description, the drawings, and the claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0034] FIG. **1** is an elevation view of an exemplary extendable conveyor system in a transport configuration for shipping vehicle according to an implementation of the disclosure;

[0035] FIG. **2** is an elevation view of the extendable conveyor system of FIG. **1** in an extended configuration according to an implementation of the disclosure;

[0036] FIGS. **3-6** are elevation views of various configurations for adjustable height at a delivery end of the extendable conveyor system of FIG. **1**;

[0037] FIG. **7** is a perspective view of an exemplary implementation of the extendable conveyor system in a retracted configuration and configured to interface with a package handling robot;

[0038] FIG. **8** is an elevation view of the exemplary implementation of the extendable conveyor system in a retracted configuration and interfacing with a package handling robot;

[0039] FIG. **9** is a detail view of a side edge of an implementation of the extendable conveyor system;

[0040] FIG. **10** is a block diagram of an exemplary control system for the extendable conveyor system;

[0041] FIG. **11** depicts flow charts of alignment processes for an extendable conveyor system that can be performed by the control system of FIG. **10**;

[0042] FIGS. **12**A-**12**D depict a series of diagrams illustrating alignment operations of an extendable conveyor system within a shipping vehicle;

[0043] FIG. **13**A is a perspective view of another implementation of an extendable conveyor system in an extended configuration;

[0044] FIGS. **13**B and **13**C are perspective views of the extendable conveyor system implementation of FIG. **13**A in a retracted configuration; and

[0045] FIG. **14** is a detailed view of an articulating end of the extendable conveyor system implementation of FIG. **13**A.

[0046] Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

[0047] Implementations of the present disclosure generally relate to an extendable conveyor system. The conveyor system can be configured to extend and retract automatically, under user control, or by interaction with a robot. The extendable conveyor system will be described within the exemplary use context of loading shipping trailers. However, such a system may be used in various other contexts and/or industries, e.g., in warehousing operations, manufacturing operations, agricultural operations, etc.

[0048] Referring to FIGS. **1** and **2**, an extendable conveyor system **30** is depicted according to an embodiment of the disclosure. As shown, the extendable conveyor system **30** is configured for loading shipping vehicles such as flatbed trailers. The extendable conveyor system **30** includes an assembly of conveyor segments **32** supported by a frame **34**. The frame **34** forms a support structure from which the conveyor segments **32** are extended and into which they are retracted. The assembly of conveyor segments **32** can include a base conveyor segment **36** and one or more extension conveyor segments **38** nested below the base conveyor segment **36**. The conveyor segments **36**, **38** of the conveyor segment assembly **32** are slidingly coupled to each other for arrangement in a transport or stowed configuration **42** (FIG. **1**) or an operating or extended configuration **44** (FIG. **2**). The base conveyor segment **36** and each extension conveyor segment **38** can include a transfer ramp **46** that extends in a distal (forward) direction **48** from the respective conveyor segment **38** to provide an inclined transition between successive conveyor segments **36**, **38**. The assembly of conveyor segments **32** can be laterally dimensioned for extension onto a flatbed trailer **50** or other shipping vehicle. In some implementations, the conveyor system **30** is configured to extend from a truck dock the full length of a 53-foot trailer to allow access by a robot in and out of the door, and to retract to a footprint that creates a small footprint inside the building.

For example, the number of conveyor segments **32** and/or the length of individual segments **32** can be configured to achieve a small retracted footprint yet extend to over 53 feet.

[0049] In some implementations, the frame **34** can be configured as a mobile transport cart. In such implementations, the frame **34** may include casters **62**. In some embodiments, each of the extension conveyor segments **38** is supported at a distal end with a support frame **66** that are mounted to casters **68**. In some embodiments, the extendable conveyor system **30** includes one or more stabilizers **72** that are selectively extendible from the frame **34**. In some implementations, the extendable conveyor system **30** includes a drive unit **74** mounted to the support frame **66** of a lead (forward most) conveyor segment **76** of the conveyor segment assembly **32**. The drive unit **74** includes a drive wheel **78** that contacts the flatbed trailer **50** and is driven, for example, with a motor (not depicted). The drive unit **74** can be rotatable about a vertical steering axis **80**. In some implementations the frame **34** is a stationary frame.

[0050] Functionally, the extendable conveyor system **30** facilitates the loading of packages onto a shipping vehicle, e.g., flatbed trailer **50**. The nested arrangement of the assembly of conveyor segments **32** enables the extension conveyor segments **38** to be extended in the distal direction **48** relative to the base conveyor segment **36**. For embodiments where the assembly of conveyor segments **32** are appropriately dimensioned, the extension conveyor segments **38** as well as the base conveyor segment **36** and frame **34** can be positioned at a rear end **92** of the flatbed trailer **50**.

[0051] The stabilizers **72** act to selectively anchor the frame **34**. The drive unit **74** acts to motivate the lead conveyor segment **76** in the distal direction **48**, thereby extending the extension conveyor segments **38** as the lead conveyor segment **76** progresses distally. In some embodiments, the drive unit **74** is rotated about the vertical steering axis **80** to steer a forward end **94** of the lead conveyor segment **76** relative to the frame **34**. In some embodiments, the drive unit **74** can also motivate the lead conveyor segment **76** in a proximal direction **96** for repositioning of the forward end **94** as loading of the flatbed trailer **50** progresses.

[0052] In operation, the extendable conveyor system **30** is positioned proximate the rear end **92** of the flatbed trailer **50** in the transport configuration **42**. In some embodiments, one of the stabilizers **72** is grounded, enabling the frame **34** to pivot thereabout as the drive unit **74** extends and steers the assembly of conveyor segments **32** onto the flatbed trailer **50**. Upon reaching the desired extension of the assembly of conveyor segments **32**, any ungrounded stabilizers **72** may be grounded to secure the extendable conveyor system **30** proximate the rear end **92** of the flatbed trailer **50**.

[0053] Referring to FIGS. **3** through **6**, configurations for vertically positioning the forward end **94** of the lead conveyor segment **76** to a desired height **112** are depicted according to implementations of the disclosure. In some implementations, all of the conveyor segments **36**, **38** of the assembly **32** are, when in the extended configuration **44**, rotated vertically about a pivot **114** located on or proximate a rearward upright **116** of the frame **34** to effect the desired height **112** (FIG. **3**). In some implementations, only the conveyor segments **36**, **38** of the assembly **32** are rotated vertically about the pivot **114**, with the pivot **114** being located at or proximate a forward upright **118** of the frame **34** (FIG. **4**). In some embodiments, the pivot **114** is disposed at or proximate the support frame **66** of one of the extension conveyor segments **38** so that any of the extension conveyor segments **38** distal thereto can be inclined to effect the desired height **112** (FIG. **5**). In some embodiments, the pivot **114** is disposed along the lead conveyor segment **76** for articulation thereof to the desired height **112** (FIG. **6**).

[0054] In some implementations, the forward end **94** of the lead conveyor segment **76** is vertically positioned with a jack (not depicted) mounted to the support frame **66** of the lead conveyor segment **76**. The jack can be manual or power driven. In some implementations, the support frames **66**, as well as the forward upright **118** of the frame **34**, are configured to vertically adjust as necessary to accommodate the changing height of the respective conveyor segment **36**, **38** during adjustment of the desired height **112** of the forward end **94**. The height adjustment of the support frames **66** may be passive, with support provided by pneumatic or hydraulic cylinders.

[0055] In some implementations, the extendable conveyor system **30** is configured to automatically align the forward end **94** within a confined region, such as within a flatbed trailer **50**. For example, a trailer may be misaligned with a loading dock due to parking variations and such embodiments allow the conveyor system **30** to adjust for such variations while maintaining alignment with the trailer walls as it extends into the trailer. In such implementations, the extendable conveyor system **30** can automatically adjust its alignment within the trailer **50** as packages **122** are loaded into the trailer **50**. For example, the extendable conveyor system **30** can include a system of alignment sensors **124** arranged at the forward end **94**. The alignment sensors **124** can include distance measurement sensors, e.g., laser sensors, IR sensors, ultrasonic sensors, imaging sensors, stereoscopic sensors, or a combination thereof. The alignment sensor system **124** is configured to measure distances **128** between the front end **94** of the extendable conveyor system **30** and objects in front of the extendable conveyor system **30**, e.g., the package wall **120** being formed within a flatbed trailer **50**, the back wall of the trailer **50**, or a package handling robot. In a manual loading configuration, the extendable conveyor system **30** can be configured to adjust is position within the flatbed trailer **50** in response to measurements from the alignment sensor system **124**. For example, as the distance **128** decreases while a worker adds packages **122** from the extendable conveyor system **30** onto the package wall **120**, the extendable conveyor system **30** can automatically retract to provide the worker with additional space between the forward end **94** and the package wall **120**. Additionally, as discussed in more detail below, some implementations are also configured to use measurement data from the alignment sensor system **124** to align the extendable conveyor system **30** forward end **94** laterally within a trailer **50**.

[0056] In some implementations, the extendable conveyor system **30** is configured to automatically buffer packages **122** as they are conveyed along the conveyor. For example, the extendable conveyor system **30** can include a package sensor system c. In an exemplary implementation, the package senor system **126** can be configured with a set of sensors **126** arranged along the extendable conveyor system **30**. The package sensor system **126** can include gating sensors and/or vision sensors. For example, gating sensors can include line-break, e.g., optical sensors arranged along the extendable conveyor system **30** that detect the passage of packages moving along the extendable conveyor system **30**. A control system (discussed below) can calculate package flow rate and adjust the speed of independently controlled conveyors along the extendable conveyor system **30** to maintain a manageable spacing between packages for a worker or a robot staking packages **122** at the forward end **94**. As another example, the package sensor system **126** can be configured with vision sensors and employ an object identification processes, e.g., a machine learning network to detect package spacing and flow rate along the extendable conveyor system **30**. The package buffering can be used to slow the rate of package flow or increase the rate depending on the rate that a package stacking robot, or a worker, is removing the packages from the conveyor system **30**. In some instance, the conveyor system can shut down one or more conveyors to save energy, e.g., if the flow rate of packages from elsewhere in a distribution system is slow or sporadic due to arrival frequency of incoming deliveries.

[0057] FIG. **7** is a perspective view of an exemplary implementation of the extendable conveyor system **30** in a retracted configuration and FIG. **8** is an elevation view of the extendable conveyor system **30** in a retracted configuration. The extendable conveyor system **30** is shown with the base conveyor segment **36** aligned below a gravity feed **134**, e.g., in a sorting facility. The gravity feed **134** can be, e.g., a sheet metal chute, a chute with a package stop, or a chute with a powered conveyor and/or a package stop. Each conveyor segment **32** of the extendable conveyor system **30** can include an impact surface **140** and one or more independently controlled conveyor indexing sections **138**. For example, the depicted implementation, the base segment **36** includes an impact surface **140** and two conveyor indexing sections **138**. Other extension segments **38** can be configured the similarly to the base conveyor segment **36**. The impact surface **140** is configured with a set of free spinning rollers. In some implementations, the rollers can be mounted on bearing supported by rubber or another type of shock absorber to absorb the impact of packages dropping to the impact surface **140**. The conveyor indexing sections **138** are independently controllable sections of motorized conveyors. For example, each conveyor indexing section **138** can be an individual conveyor belt driven by motors that can be configured to operate independently of other conveyor indexing sections **138**. In some implementations, the conveyor indexing sections **138** can be motorized rollers that that can be configured to operate independently of other conveyor indexing sections **138**. In some implementations, the conveyor indexing sections can be configured with a combination of motorized and free spinning rollers. The motorized rollers can be configured to operate independently of other conveyor indexing sections **138**.

[0058] The front end **94** is configured as a cantilevered end **132** to permit access underneath the forward end **94**. For example, the cantilevered end **132** can be configured to permit a package handling robot **130** to fit underneath. For example, the cantilevered end **132** can permit a package loading platform of a robot **130** to fit underneath the forward end **94** so that packages fall from the extendable conveyor system **30** to the robot's platform. The robot **130** can be programed to remove packages from the conveyor or the robot **130** may have a presentation conveyor or platform that the package fall onto before they are stacked by the robot **130**.

[0059] In some implementations, the extendable conveyor system **30** is configured to interface with a package handling robot **130**. For example, in some implementations, the extendable conveyor system **30** can include an interface that couples a robot **130** to the extendable conveyor system **30**. The interface can be configured for communications between the extendable conveyor system's **30** control system and the robot **130** (e.g., a wired or wireless communication interface) or can include a mechanical connection that allows the robot **130** to maneuver the forward end **94** of the extendable conveyor system **30**. When used with a robot **130**, the robot sends operating commands to the extendable conveyor system **30** to control movement of the conveyor system **30** and, e.g., to maintain a spacing interface between the robot **130** and the end of the conveyor system **30** as they both traverse in/out of a trailer.

[0060] In some implementations the extendable conveyor system **30** is configured to interface with the gravity feed **134** in a manner that forms a smooth transition between the gravity feed **134** and the base conveyor segment **36** of the extendable conveyor system **30**. For example, the base conveyor segment **36**, the gravity feed **134**, or both can be oriented at angles with respect to one another that form a smooth transition between the two.

[0061] FIG. **9** depicts a detail view of a side edge of the extendable conveyor system **30**. Each segment **32** of the extendable conveyor system **30** can include edging **202** that extends at an angle upward from the top surface of a conveyor belt **204** and/or rollers **200**.

[0062] FIG. **10** shows a block diagram of an exemplary control system **300** for the extendable conveyor system **30**. The control system **300** includes a controller **302** in communication with various input and output systems. The controller **302** includes one or more processors **304** and computer memory **306**. The computer memory can store instructions that are executed by the processor(s) **304** in order to perform control system operations described below.

[0063] Each of the input and output system can be configured as one or more computer executable software modules, hardware modules, or a combination thereof. For example, one or more of the input and output systems can be implemented as blocks of software code with instructions that cause one or more processors of the control system **300** to execute operations described herein. In addition or alternatively, one or more of the input and output systems can be implemented in electronic circuitry such as, e.g., programmable logic circuits, field programmable logic arrays (FPGA), or application specific integrated circuits (ASIC). The input systems can include a conveyor alignment sensor system **308**, a package flow sensors system **310**, a user control interface **312**, and, optionally, a robot communication interface **314**. The output systems can include a conveyor extension/retraction system **31**, a conveyor alignment system **318**, and a package buffering system **320**.

[0064] The conveyor alignment sensor system **308** can include the conveyor alignment sensors **124** discussed above. In addition, the conveyor alignment sensor system **308** can include sensors directed outward from the sides of the extendable conveyor system **30** forward end **94** and arranged to obtain measurement data indicating distances between the sides of the extendable conveyor system **30** and side walls of a trailer **50** (see FIGS. **12**A-**12**D). The conveyor alignment sensor system **308** sensors can be arranged to aid in maintaining alignment of the forward end **94** laterally within a confined space and to manage distances from a package wall **120**.

[0065] The package flow sensor system **310** can include the package sensor system **126** described above. In some implementations, where the package sensor system **126** includes imaging sensors, the package flow sensor system **310** can execute an image processing algorithm to identify packages within the images and preprocess the images before sending package flow data to the controller **302**. For example, the package flow sensor system **310** can employ the image processing algorithm to determine package flow rate and package spacing along the extendable conveyor system **30**. The package flow sensor system **310** can send the package flow rate and package spacing data to the controller **302**. In some implementations, the package flow sensor system **310** includes a machine learning model trained to receive imagery data (e.g., a series of images or video) along the extendable conveyor system **30** as input and output package flow and spacing data. In some implementations, the package flow sensor system **310** can be configured to use a series of line break sensors to determine package flow and spacing. For example, package flow sensor system **310** can determine package flow rate and spacing based on the operating speed of individual conveyor indexing sections **138** adjacent to respective sensors and the timing between detected line breaks. Likewise, the package flow sensor system **310** can determine the sizes of each package based on the operating speed of individual conveyor indexing sections **138** adjacent to respective sensors and the duration of a line break. For example, a line break refers to the obstruction of an optical signal between two sensors positioned on opposite sides of the extendable conveyor system **30**.

[0066] In response, the controller **302** can use the package flow rate and spacing data to adjust the speeds of individual conveyor indexing sections **138** to manage proper package spacing. For example, proper package spacing is a spacing between packages that conforms to the rate at which a worker or robot removes packages from the extendable conveyor system **30** and stacks them in the trailer **50**. The control system **300** can be configured to adjust the proper package spacing to accommodate changes in the rate at which the worker or robot is working. For example, the package flow sensor system **310** can include a sensor at the forward end **94** that measures the time between a packages being removed from the extendable conveyor system **30** by the worker or robot. The controller **300** can determine the speeds at which to operate the conveyor indexing sections **138** so that packages arrive at approximately the same rate that the worker or robot is stacking them.

[0067] The user control interface **312** allows a user to manually control operations of the control system **300** and calibrate system operations. For example, the user control interface **312** can permit a user to maneuver the extendable conveyor system **30** to manually extend/retract and/or align the front end **94**. In some implementations, the user control interface **312** can be permit a user to calibrate automated operations of the extendable conveyor system **30** by, e.g., adding or adjusting default values for a distance to maintain between the forward end **94** and a package wall **120**, a lateral position for the extendable conveyor system **30** within a trailer **50**, a package flow rate to maintain, etc. The user control interface **312** can be hardwired to the extendable conveyor system **30** or configured to interface with the control system **300** wirelessly. For example, the user control interface **312** can be a touch screen display or a mobile computing device (e.g., a tablet computer or laptop computer). In some implementations, the user control interface **312** can include a joystick to maneuver the extendable conveyor system **30**.

[0068] The robot communication interface **314** is an electrical communication interface that permits a package handling robot **130** to communicate with the controller **302**. For example, in some implementations, operations of the extendable conveyor system **30** can be controlled or directed by a robot **130**. For example, the controller **302** can receive commands from a robot **130** through the robot communication interface **314** and operate the extendable conveyor system **30** responsive to such commands.

[0069] The conveyor extension/retraction system **316** is configured to control extension and retraction operations of the extendable conveyor system **30**. For example, the conveyor extension/retraction system **316** includes one or more motors **324** coupled to one or more conveyor segments **36** and arranged to extend and retract the extendable conveyor system **30** conveyor segments **36**. In addition, the conveyor extension/retraction system **316** includes one or more motor controllers **322** to control operation of the motors **324**. For example, a motor controller **322** can be configured to receive digital commands from the controller **302** and operate the motors **324** in accordance with the commands. The conveyor extension/retraction system **316** can include two independent drive motors coupled to the drive wheels **78** discussed above. In some implementations, the motors are coupled to the drive wheels through a set of reduction gears. The extendable conveyor system **30** can be extended or retracted by controlling the drive motors. In some implementations, the conveyor extension/retraction system **316** can include drive wheels **78** and drive motors on each extension segment **36** so that each extensions segment **36** can be independently extended or retracted relative to neighboring segments. In general, the conveyor extension/retraction system **316** receives commands from the controller **302** and operates the drive wheels **78** in accordance with such commands to maneuver the extend and retract the extendable conveyor system **30**.

[0070] In some implementations, the conveyor extension/retraction system **316** can include other mechanisms to extend and retract the extendable conveyor system **30**. For example, the conveyor extension/retraction system **316** can employ motor driven worm gear or gear and rack configurations mounted between neighboring conveyor segments **36** to extend and retract the segments relative to one another.

[0071] The conveyor alignment system **318** is configured to control lateral motion of extendable conveyor system **30** forward end **94**. The conveyor alignment system **318** includes one or more motors **328** coupled to the extendable conveyor system in order to move the forward end **94** laterally (or in an arc in the case that the extendable conveyor system **30** is mounted on a pivot point at the rearward end). In addition, the conveyor alignment system **318** includes one or more motor controllers **326** to control operation of the motors **328**. As noted above, a motor controller **326** can be configured to receive digital commands from the controller **302** and operate the motors **328** in accordance with the commands. The conveyor alignment system **318** can also operate the drive wheels **78**. For example, the conveyor alignment system **318** can include motors (e.g., servo motors) coupled to a support of the drive motors to pivot the drive wheel **78** ninety degrees so the forward end **94** can be maneuvered side-to-side. In some implementations, the conveyor alignment system **318** may be subsumed within or may be a sub-system to the conveyor extension/retraction system **316**. In general, the conveyor alignment system **318** receives commands from the controller **302** and operates the drive wheels **78** in accordance with such commands to maneuver the forward end **94** of the extendable conveyor system **30**.

[0072] The package buffering system **320** is configured to control the operation of the conveyor indexing sections **138** to maintain a buffer distance between packages conveyed along the extendable conveyor system **30**. The buffering system **320** includes motors **332** coupled to drive units of each indexing section **138**. The drive units can include one or more drive rollers in a belt conveyor or one or more drive rollers in a set of rollers in each indexing section **138**. As noted above, motor controllers **330** can be configured to receive digital commands from the controller **302** and operate the motors **332** in accordance with the commands. The individual indexing sections **138** can be independently controlled by the controller **302** in response to input from the package flow sensor system **310** (e.g., a vision system), or by a robot **130** communicating with the controller **302**. The controller **302** can control independently vary the speeds of the indexing sections **138** to maintain a package spacing and flow rate commensurate with the rate that packages are being removed from the front end of the conveyor system. Each indexing section **132** can be stopped or reversed, independent of the others, in order to maintain a desired package flow. In some examples, the indexing sections **138** can be stopped when a package is not present on them, e.g., to reduce power usage.

[0073] The package buffering system **320** can also control a series of one or more package stops **602** along the length of the conveyor system **30**. The package stops **602** can be controlled to allow packages to enter the conveyor system (e.g., from the gravity feed **134**) automatically and at a controlled rate. For example, the controller **302** can raise and lower the package stops **602** as a gate the flow of packages along with controlling the speed that the packages travel along the indexing sections **138**. The controller **302** can control operation of the package stops **602** based on input from the package flow sensor system **310** (e.g., a vision system), or based on input commands from a robot **130** with a vision system.

[0074] In general, the package buffering system **320** receives commands from the controller **302** and adjusts the individual speed of appropriate indexing section(s) **138** in response to the commands. For example, the controller **302** receives package flow and spacing data from the package flow sensor system **310** and/or from the robot **130**. The controller **302** can then determine whether the package flow rate is too fast or too slow for compared to the rate at which a worker or robot is removing the packages from the forward end **94**. For example, using data from the package flow sensor system **310**, the controller **302** can determine a package dwell time to track how long a package sits at the forward end **94** before a worker removes the package and stacks it in the trailer **50**. For example, the package dwell time can be determined from an imaging sensor at the front end that detects a package arrival and tracks how long the package remains at the forward end **94** before the worker or robot removes it. As another example, the package dwell time can be determined based on a duration that a package triggers a line break sensor at the forward end **94**. If the package dwell time is too long, e.g., it exceeds a threshold time, the controller **302** can operate the indexing sections **138** to slow the package flow rate. Alternatively, if a package dwell time is too short (e.g., indicating that packages are removed immediately when they arrive), the controller **302** can operate the indexing sections **138** to increase the package flow rate.

[0075] In some situations, packages may arrive at varying intervals. The controller can control upstream indexing sections **138** to adjust the package spacing. For example, if data from the package flow sensor system **310** indicates that two packages arrived one right after the other, the controller **302** can temporarily slow or stop the first indexing section **138** as soon as the first package passes from the first indexing section to the next subsequent indexing section on the extendable conveyor system **30**. That way the two packages can be appropriately spaced. In implementations, that employ imaging sensors (e.g., computer vision), the controller **302** can monitor spacing between all packages along the extendable conveyor system **30** and adjust individual conveyor indexing sections **138** independently to maintain proper package spacing with real-time feedback provided by the imaging sensors.

[0076] In some implementations, the package buffering system **320** includes package stops (e.g., package stop **604** discussed below). The control system **300** can control operation of the package stops to aid in buffering packages. For example, the control system **300** can operate motors and/or hydraulic actuators to raise and lower a package stop **604** to moderate the flow of packages onto the extendable conveyor system **30**.

[0077] FIGS. **13**A-**13**C depict another implementation of an extendable conveyor system **30**. The implementation shown in FIGS. **13**A-**13**C is generally similar to that described above with a few optional variations. The extendable conveyor system **30** is configured for mounting underneath the gravity feed **134**. For example, the base conveyor segment **36** is shortened, which permits the fame to be positioned beneath the gravity feed **134**. The base conveyor segment **35** also includes a package stop **602**. The control system **300** can control operation of the package stop **602** to assist in buffering packages that transit the extendable conveyor system **30**. For example, the package stop **602** can be controlled to selectively raise and lower to control the flow of packages **122** to the extendable conveyor system **30**. For example, the control system **300** can operate the package stop **602** to permit packages **122** to pass individually or in groups.

[0078] The base conveyor segment **36** and each extensions conveyor segment **38** have a transition ramps **606** between segments. The transition ramps **606** can be a flat, low friction surface or can have free spinning rollers. In some implementations, the transition ramps **606** can have powered rollers, e.g., to assist moving packages in a reverse direction, up the extendable conveyor system **30** to assist with unloading a trailer.

[0079] The base conveyor segment **36** and each extensions conveyor segment **38**, as shown, each have only one conveyor indexing section **138***a* implemented as conveyor belts. The last extension segment **638** has a different configuration from the three middle segments **38**. Extension segment **638** employs all rollers with three conveyor indexing sections **138***b* using powered rollers, e.g., to assist with package buffering at the end of the extendable conveyor system **30**. The control system **300** can control the direction and speed of each indexing section **138***b* independently to buffer packages, as discussed above.

[0080] Shown in FIG. **13**C, the extension segment **638** can have an interface for attaching a purge cart **610**. The purge cart **610** may be used to sort packages **122** that cannot be handled by the robot **130**, e.g., damaged or oddly shaped packages **122**. The purge cart **610** can be releasable coupled to extension segment **638** using a latch assembly and/or a pair of magnets. For example, the purge cart interface can be coupled to a sidewall or frame of extension segment **638**. The purge cart connection interface allows the purge cart **610** to be moved alongside the extendable conveyor system **30** as the extendable conveyor system **30** is extended and retracted. In some examples, the purge cart is lower than the articulating end **604** so that non-pickable packages can be pushed in.

[0081] Also shown in FIG. **13**C, a power supply **612** is be mounted to the frame **34**. Flexible wire ways **614** are used to supply power to the conveyor segments **32**.

[0082] The forward end of extension segment **638** includes an articulating end **604**. The articulating end can be controlled manually or by the control system **300** to make height adjustments and/or lateral adjustments. FIG. **14** is a detailed view of the articulating end **604** extension segment **638**. As shown in FIG. **14**, the articulating end **604** can be configured to articulate vertically to adjust the height of the extendable conveyor system **30** at the forward end **94**. For example, the articulating end **604** can be mounted to extension segment **638** at a hinge joint **616** allowing the articulating end **604** to be pivoted automatically (through control system **300**) or manually. articulating end **604** is shown in three positions. Position A is substantially horizontal and extends at the same height as the extension segment **638**. This position may be used for interfacing with a package handling robot **130**. In position B, the articulating end **604** is pivoted downward. This position may be used for manual unloading/loading packages from/to the extendable conveyor system **30**. Position C is a storage positon. In some implementations, the articulating end **604** can be mounted on a vertical pivot that permits it to pivot laterally side-to-side. The articulating end **604** can include motors or hydraulics controlled by the control system **300** arranged to permit automated movement of the articulating end **604** relative to rest of extension segment **638**.

[0083] Articulating end **604** includes a package stop **622**, e.g., to prevent packages from falling off the end. The package stop **622** can be fixed. In some implementations, the package stop **622** is movable and can be raised/lowered, similar to package stop **602**. The articulating end **604** can have a package indexing section **138** (e.g., a power conveyor belt or powered rollers) similar to the other conveyor segments **32**.

[0084] Articulating end **604** can include a bumper **618** on the end. in some implementations, the bumper has a pressure sensor to detect if/when the articulating end **604** bumps against and object.

The pressure sensor can serve to alert the control system **300**, which can in turn, retract or stop motion of the extendable conveyor system **30** upon sensing a bump. In some examples, the articulating end **604** includes lights and/or reflectors on the forward end **94** and/or the sides.

[0085] Operation of the articulating end **604** can be controlled by the controller **302** independently or through commands from a robot **130**. That is, controller **302** operating independently or through commands from a robot **130** can control the pivoting of the articulating end **604** (e.g., up/down or side to side), the operation of the conveyors or powered rollers on the indexing section **138** of the articulating end, and the operation of the package stop **602**. In some implementations, the articulating end **604** serves as a package pick zone for a robot **130** or a worker. For example, when operating with a robot **130**, multiple packages may be present on the articulating end **604** at a time (e.g., three packages in a row). If the robot **130** picks a package that is not in the middle or the back of the articulating end **604** (e.g., the second package in a row), it can command the controller **302** to advance the indexing section **138**. This will move the packages at the back of the articulating end **604** forward while the front most package is prevented from falling off the edge by the package stop **602**. In some implementations, the controller **302** can automatically sense where packages are located on the articulating end **604** and advance the indexing section **138** appropriately without control from a robot **130**. For example, the controller **302** can control operation of the indexing section **138** on the articulating end **604** in a manner similar to that described, but in response to input from the package flow sensor system **310** (e.g., vision system) or from an array of pressure sensors under the indexing section **138** indicating package locations on the indexing section **138**.

[0086] FIG. **11** depicts flow charts of alignment processes **400**, **420** for operating an extendable conveyor system. Process **400** and **420** can be executed by one or more computing systems including, but not limited to, control system **300**, described above, to control an extendable conveyor system **30**. Processes **400** and **420** will be described with reference to FIGS. **11** and **12**A-**12**D. FIGS. **12**A-**12**D depict a series of overhead diagrams illustrating the operations of processes **400** and **420**.

[0087] Process **400** is a process for automatically controlling the retraction of an extendable conveyor system **30** as packages are loaded into a trailer **50**. The control system **300** obtains a first distance measurement between the forward end of the conveyor system and at least one object positioned in front of the conveyor system (**402**). For example, the control system can obtain one or more distance measurements (e.g., d.sub.1 and d.sub.2) from alignment sensors **124**. In some implementations, a robot **130** can perform the measurements and transmit them to the control system **300**. The object may be, e.g., a package wall **120**, a front wall of a trailer **50**, or a package handling robot **130**. For example, when the extendable conveyor system **30** is used with a package handling robot **130**, the control system **300** can maintain a desired distance to the robot **130** so that the end of the extendable conveyor system **30** is within reach of the robot **130**. In such implementations, the control system **300** can store different distance settings. For example, a desired distance from a package wall under manual operations may be different than a desired distance from a robot **130** (e.g., since the forward end **94** can be cantilevered over part of the robot, the desired distance from the robot may be less than the desired distance from a package wall in manual operations).

[0088] The control system **300** determines that the first distance is less than a first predefined distance (**404**). For example, the control system **300** can compare the measured distance(s) to a predefined spacing (e.g., working distance) between the front end **94** and the back of the trailer or the package wall **120**. If the measured spacing is less than the predefined spacing, then the control system **300** can retract the extendable conveyor system **30** (**406**). If the measured distance is greater than the predefined spacing, then the control system **300** can extend the extendable conveyor system **30**. In some implementations, a variance distance can be used to avoid excessive movement of the extendable conveyor system **30**. For instance, the variance distance may define a permissible variance (e.g., 6 inches) from the predefined spacing. If the difference between the measured distance and the predefined distance is within the variance, the control system **300** does not extend or retract the extendable conveyor system **30**. The control system **300** can control retraction/extension of the extendable conveyor system **30** by sending instructions to one or more motor controllers that cause the conveyor system to retract/extend until the measured distance is equal to or greater than the predefined spacing.

[0089] The predefined spacing can be a user set value, e.g., in the case of a manual trailer loading process. In some implementations, the user can adjust the predefined spacing value during operations.

[0090] In some implementations, the control system **300** can employ a time delay to account for temporary obstruction of one or more alignment sensors **124** by loading operations. For example, the control system **300** may require that any change in measurement distance persist for a period of time (e.g., 1-2 seconds) before any action is taken to retract the extendable conveyor system **30**.

[0091] In some implementations, the control system **300** can use multiple distance measurements, as shown in FIGS. **12**A-**12**C. For example, the control system may require multiple distance measurements to be less than the predefined spacing before initiating an action to retract the extendable conveyor system **30**. As depicted in FIG. **12**A, distance d**1** is less than the predefined spacing because a package has been placed in front of the leftmost sensor. However, distance d**2** is still within the predefined spacing, so the control system **300** will not yet retract the extendable conveyor system **30**. When a package is placed in front of the right most sensor (as shown in FIG. **12**B), then both d**1** and d**2** are less than the predefined spacing, so the control system **300** retracts the extendable conveyor system **30** (FIG. **12**C), until the average, or mean value of all forward distance measurements (d.sub.1 & d.sub.2) are within the permitted variance of the predefined spacing. The control system can wait to retract the extendable conveyor system until all distance measurements are less than the predefined distance or it can use a majority rule process and retract when a majority of the forward facing sensors measure a distance less than the predefined spacing.

[0092] The control system **300** can control retraction of the extendable conveyor system **30** by sending instructions to one or more motor controllers that cause the conveyor system to retract until the measured distance is equal to or greater than the predefined spacing.

[0093] In some implementations, a package handling robot **130** can perform the process **400**. In such implementations, the robot **130** can control operations of the extendable conveyor system **30** by sending comments to the control system **300**. For example, the robot **130** can employ its own sensor and determine when to extend or retract the extendable conveyor system **30**, then issue appropriate commands to the control system **300** that cause the control system **300** to operate the extendable conveyor system **30** accordingly.

[0094] With reference to FIGS. **11** and **12**D, process **420** is a process for automatically aligning an extendable conveyor system **30** within a confined space (e.g., a trailer **50**). The control system **300** obtains first and second distance measurements from either side of the conveyor at the forward end **95** (**422**). One measurement is a distance between the right side of the conveyor and a right side wall **550** of the trailer (e.g., d.sub.4) and the other measurement is a distance between the left side of the conveyor and a left sidewall **552** of the trailer (e.g., d.sub.3). For example, the measurements can be obtained from alignment sensors **124** positioned to take distance measurements from the sides of the extendable conveyor system **30**.

[0095] The control system determines a difference between first and second distance measurements (**424**). If the measurements are different the extendable conveyor system **30** is misaligned within the trailer. The control system **300** can compare the difference to a threshold value (e.g., 6 inches). If the difference is greater than the threshold value then the control system **300** can control the extendable conveyor system **30** to adjust its lateral position within the trailer (**426**). For example, the control system **300** can control the extendable conveyor system **30** to move in the direction of the sensor that measured the greater distance so as to reduce the difference between the two measurements. For example, the control system **300** can send instructions to one or more motor controllers to pivot the drive wheels and move the forward end **94** to the left (as show in FIG. **12**D).

[0096] Although the extendable conveyor system **30** has been described as performing trailer loading operations, it could also be used in an unload configuration. For example, the conveyor can be operated in the reverse direction and the process **400** can be performed in a similar manner to incrementally extend the extendable conveyor system **30** into a trailer as packages are removed from the trailer. As the measured distances become greater than the predefined spacing, the extendable conveyor system **30** is incrementally extended to maintain the spacing. Furthermore, in an implementation capable of performing both loading and unloading operations the transition ramps **606** can be designed with a low-profile and/or can include powered rollers to assist in moving packages up the conveyor.

[0097] Implementations of the subject matter and the functional operations described in this specification can be implemented in digital electronic circuitry, in tangibly-implemented computer software or firmware, in computer hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them. Implementations of the subject matter described in this specification can be implemented as one or more computer programs, i.e., one or more modules of computer program instructions encoded on a tangible non transitory program carrier for execution by, or to control the operation of, data processing apparatus. The computer storage medium can be a machine-readable storage device, a machine-readable storage substrate, a random or serial access memory device, or a combination of one or more of them.

[0098] The term “controller” refers to data processing hardware and encompasses all kinds of apparatus, devices, and machines for processing data, including, by way of example, a programmable processor, a computer, or multiple processors or computers. The apparatus can also be or further include special purpose logic circuitry, e.g., a central processing unit (CPU), a FPGA (field programmable gate array), or an ASIC (application specific integrated circuit). In some implementations, the data processing apparatus and/or special purpose logic circuitry may be hardware-based and/or software-based. The apparatus can optionally include code that creates an execution environment for computer programs, e.g., code that constitutes processor firmware, a protocol stack, a database management system, an operating system, or a combination of one or more of them. The present disclosure contemplates the use of data processing apparatuses with or without conventional operating systems, for example Linux, UNIX, Windows, Mac OS, Android, iOS or any other suitable conventional operating system

[0099] A computer program, which may also be referred to or described as a program, software, a software application, a module, a software module, a script, or code, can be written in any form of programming language, including compiled or interpreted languages, or declarative or procedural languages, and it can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer program may, but need not, correspond to a file in a file system. A program can be stored in a portion of a file that holds other programs or data, e.g., one or more scripts stored in a markup language document, in a single file dedicated to the program in question, or in multiple coordinated files, e.g., files that store one or more modules, sub programs, or portions of code. A computer program can be deployed to be executed on one computer or on multiple computers that are located at one site or distributed across multiple sites and interconnected by a communication network. While portions of the programs illustrated in the various figures are shown as individual modules that implement the various features and functionality through various objects, methods, or other processes, the programs may instead include a number of submodules, third party services, components, libraries, and such, as appropriate. Conversely, the features and functionality of various components can be combined into single components as appropriate

[0100] The processes and logic flows described in this specification can be performed by one or more programmable computers executing one or more computer programs to perform functions by operating on input data and generating output. The processes and logic flows can also be performed by, and apparatus can also be implemented as, special purpose logic circuitry, e.g., a central processing unit (CPU), a FPGA (field programmable gate array), or an ASIC (application specific integrated circuit

[0101] Computers suitable for the execution of a computer program include, by way of example, can be based on general or special purpose microprocessors or both, or any other kind of central processing unit. Generally, a central processing unit will receive instructions and data from a read only memory or a random access memory or both. The essential elements of a computer are a central processing unit for performing or executing instructions and one or more memory devices for storing instructions and data. Generally, a computer will also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Moreover, a computer can be embedded in another device, e.g., a mobile telephone, a personal digital assistant (PDA), a mobile audio or video player, a game console, a Global Positioning System (GPS) receiver, or a portable storage device, e.g., a universal serial bus (USB) flash drive, to name just a few

[0102] Computer readable media (transitory or non-transitory, as appropriate) suitable for storing computer program instructions and data include all forms of non-volatile memory, media and memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD-ROM disks. The memory may store various objects or data, including caches, classes, frameworks, applications, backup data, jobs, web pages, web page templates, database tables, repositories storing business and/or dynamic information, and any other appropriate information including any parameters, variables, algorithms, instructions, rules, constraints, or references thereto. Additionally, the memory may include any other appropriate data, such as logs, policies, security or access data, reporting files, as well as others. The processor and the memory can be supplemented by, or incorporated in, special purpose logic circuitry

[0103] To provide for interaction with a user, implementations of the subject matter described in this specification can be implemented on a computer having a display device, e.g., a CRT (cathode ray tube), LCD (liquid crystal display), or plasma monitor, for displaying information to the user and a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well; for example, feedback provided to the user can be any form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user can be received in any form, including acoustic, speech, or tactile input. In addition, a computer can interact with a user by sending documents to and receiving documents from a device that is used by the user; for example, by sending web pages to a web browser on a user's client device in response to requests received from the web browser.

[0104] Implementations of the subject matter described in this specification can be implemented in a computing system that includes a back end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front end component, e.g., a client computer having a graphical user interface or a Web browser through which a user can interact with an implementation of the subject matter described in this specification, or any combination of one or more such back end, middleware, or front end components. The components of the system can be interconnected by any form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network (LAN), a wide area network (WAN), e.g., the Internet, and a wireless local area network (WLAN).

[0105] The computing system can include clients and servers. A client and server are generally remote from each other and typically interact through a communication network. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other

[0106] While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any invention or on the scope of what may be claimed, but rather as descriptions of features that may be specific to particular implementations of particular inventions. Certain features that are described in this specification in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a sub combination or variation of a sub-combination.

[0107] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be helpful. Moreover, the separation of various system modules and components in the implementations described above should not be understood as requiring such separation in all implementations, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

[0108] While this document contains many specific implementation details, these should not be construed as limitations on the scope of what may be claimed, but rather as descriptions of features that may be specific to particular implementations or embodiments. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable sub combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can, in some cases, be excised from the combination, and the claimed combination may be directed to a sub combination or variation of a sub combination.

Claims

1. A conveyor system operating method executed by one or more processors, the method comprising: obtaining, from a sensor system of a conveyor system, a first distance between a front end of the conveyor system and at least one object positioned in front of the conveyor system; determining that the first distance is less than a first predefined distance; and in response to the first distance being less than the first predefined distance, controlling the conveyor system to move to increase a distance from the at least one object.

2. The method of claim 1, wherein determining that the first distance is less than the first predefined distance comprises comparing a measured value of the first distance to the first predefined distance.

3. The method of claim 1, wherein the first predefined distance comprises a user selected value.

4. The method of claim 1, wherein controlling the conveyor system comprises sending instructions to one or more motor controllers that cause the conveyor system to retract until the first distance is equal to or greater than the first predefined distance.

5. The method of claim 4, wherein the conveyor system is an extendable conveyor system that comprises a first conveyor segment and a second conveyor segment configured to nest underneath the first conveyor segment, and wherein the one or more motor controllers control relative movement between the first conveyor segment and the second conveyor segment.

6. The method of claim 1, wherein the first distance is the shortest distance between the front end of the conveyor system and a plurality of objects.

7. The method of claim 1 further comprising controlling the front end of the conveyor system to move laterally relative to a length of the conveyor system.

8. The method of claim 7, wherein controlling the front end of the conveyor system to move laterally comprises moving the front end in response to measurement data from the sensor system.

9. The method of claim 7, wherein controlling the front end of the conveyor system to move laterally comprises sending instructions to one or more motor controllers that control lateral movement of the conveyor system in response to measurement data from the sensor system.

10. The method of claim 1, further comprising obtaining, from at least a first side mounted sensor of the sensor system, a second distance between a first side of the conveyor system and a second object; obtaining, from a second side mounted sensor of the sensor system, a third distance between the second side of the conveyor system and a third object; determining that a difference between the second distance and the third distance exceeds a threshold difference value; and in response, controlling the conveyor system to move such that the difference is within the threshold difference value.

11. The method of claim 1, wherein the conveyor system comprises an interface for connecting a robot to the conveyor system; wherein obtaining the first distance comprises obtaining the first distance from the robot through the interface.

12. The method of claim 1, further comprising: obtaining package flow data indicating a rate package flow along the conveyor system; and controlling, based on the package flow data, operation of independent indexing sections of the conveyor system.

13. The method of claim 12, wherein controlling the operation of the independent indexing sections comprises controlling at least one independent indexing section to adjust buffering distances between packages by varying the speed of the at least one independent indexing section.

14. A extendable conveyor system comprising: a plurality of conveyor segments interlocked in a telescoping configuration with individual conveyor segments at least partially overlapping one another; a conveyor extension/retraction system operatively coupled to at least one of the conveyor segments and configured to control the extension and retraction of the extendable conveyor system by controlling movement of the conveyor segments relative to one another; and a control system in electrical communication with the conveyor extension/retraction system and configured to perform operations comprising adjusting a position of one or more conveyor segments responsive to data received from a package handling robot in electronic communication with the control system.

15. The extendable conveyor system of claim 14, wherein each conveyor segment comprises one or more indexing sections, and wherein the operations comprise controlling a speed of one indexing section independent from other indexing sections responsive to second data received from the package handling robot.

16. The extendable conveyor system of claim 14, wherein a forward most conveyor segment of the plurality of conveyor segments comprises an articulating end configured to pivot relative to the forward most conveyor segment.

17. The extendable conveyor system of claim 14, wherein a base conveyor segment of the plurality of conveyor segments comprises a package stop configured to raise and lower responsive to control signals from the control system.

18. The extendable conveyor system of claim 14, wherein the plurality of conveyor segments comprise a base conveyor segment configured to receive packages from a gravity chute, an end conveyor segment, and one or more middle conveyor segments arranged between the base conveyor segment and the end conveyor segment, wherein the base conveyor segment of the plurality of conveyor segments comprises a package stop configured to raise and lower responsive to control signals from the control system, wherein the one or more middle conveyor segments each comprise an independently controllable conveyor belt, and wherein the forward most conveyor segment comprises: a plurality of rollers including at least a first set of powered rollers and a second set of powered rollers with the first set of powered rollers separated from the second set of powered rollers by a set of unpowered rollers, and an articulating end configured to pivot relative to a forward end of the end conveyor segment.

19. A extendable conveyor system comprising: a plurality of conveyor segments interlocked in a telescoping configuration with individual conveyor segments at least partially overlapping one another; a conveyor extension/retraction system operatively coupled to at least one of the conveyor segments and configured to control the extension and retraction of the extendable conveyor system by controlling movement of the conveyor segments relative to one another; a sensor system; and a control system in electrical communication with the conveyor extension/retraction system and with the sensor system, the control system configured to perform operations comprising: obtaining, from the sensor system, a first distance between a front end of the conveyor system and at least one object positioned in front of the conveyor system; determining that the first distance is less than a first predefined distance; and in response to the first distance being less than the first predefined distance, controlling the conveyor extension/retraction system to move the conveyor segments to increase a distance from the at least one object.

20. The extendable conveyor system of claim 19, wherein the plurality of conveyor segments comprise a base conveyor segment configured to receive packages from a gravity chute, an end conveyor segment, and one or more middle conveyor segments arranged between the base conveyor segment and the end conveyor segment, wherein the base conveyor segment of the plurality of conveyor segments comprises a package stop configured to raise and lower responsive to control signals from the control system, wherein the one or more middle conveyor segments comprise each comprise an independently controllable conveyor belt, and wherein the forward most conveyor segment comprises: a plurality of rollers including at least a first set of powered rollers and a second set of powered rollers with the first set of powered rollers separated from the second set of powered rollers by a set of unpowered rollers, and an articulating end configured to pivot relative to a forward end of the end conveyor segment.