

CLAIMS

What is claimed is:

1. A material handling system, comprising:
 - a plurality of destination areas;
 - a plurality of vehicles for delivering items to the destination areas or retrieving items from the destination areas, wherein the vehicles travel a path;
 - a controller for controlling movement of the plurality of vehicles;
 - means for detecting whether an item on one of the vehicles extends beyond a predetermined dimensional threshold relative to the vehicle, wherein the means for detecting is positioned adjacent the path on which the vehicles travel and the means for detecting is operable to create a depth data set representative of a three-dimensional representation of a target area;
 - wherein the controller controls operation of the vehicle in response to the means for detecting determining that an item projects beyond the dimensional threshold.
2. The system of claim 1 wherein the predetermined dimensional threshold is the height above the vehicle.
3. The system of claim 1 or 2 wherein in response to the means for detecting determining that an item projects beyond the dimensional threshold, the controller stops the vehicle from advancing until the item no longer projects above the dimensional threshold.
4. The system of any of claims 1-3 wherein the means for detecting comprises an emitter and a sensor wherein the sensor comprises a two-dimensional array of pixels.
5. The system of claim 4 wherein the emitter comprises an infrared or near infrared light source.
6. The system of claim 4 or 5 wherein each pixel comprises a photodetector.
7. The system of any of claims 1-6 wherein the means for detecting comprises a structured-light 3D scanner.
8. The system of claim 7 wherein the means for detecting comprises an emitter operable to project a light pattern and an imaging element spaced apart from the emitter, wherein the imaging element is operable to detect the light pattern emitted onto the target area.
9. The system of claim 8 wherein the means for detecting is operable to detect the distortion of the projected light pattern to determine the depth data set.

10. The system of claim 9 wherein the means for detecting uses triangulation to calculate the 3-dimensional position of surface points onto which the emitter projects the light pattern.
11. The system of claim 1 or 2 wherein the means for detecting comprises a time of flight camera.
12. The system of claim 11 wherein the time of flight camera comprises a light source and an image sensor comprising a plurality of pixels that detects the time light has taken to travel from the light source to objects in the target area and then back to the image sensor.
13. The system of claim 12 wherein the time of flight camera comprises a light source and an image element that measures the phase difference between light emitted from the light source and the light reflected back from objects in the target area to the imaging element.
14. The system of any of claims 1-13 wherein the means for detecting identifies three reference points that identify a plane generally parallel with an upper surface of the vehicle.
15. The system of claim 14 wherein the plane is at an angle to the horizon.
16. The system of claim 3-16 wherein the means for detecting is configured to use the identified plane to identify depth data representative of items that extend above the pre-determined height.
17. The system of any of claims 1-16 comprising an alarm that is actuated when the means for detecting detects an item that projects above the pre-determined height.
18. The system of claim 17 wherein the alarm is audible.
19. The system of claim 17 or 18 wherein the alarm is visual.
20. The system of any of claims 1-19 comprising a track that guides the vehicles, wherein the destination areas are disposed on either side of the track.
21. The system of claim 20 comprising a picking station located along the track, wherein the picking station is configured to allow an operator to retrieve items from the vehicles or place items onto the vehicles.
22. The system of claim 21 wherein the controller is configured to stop vehicles at the picking station.
23. The system of claim 22 wherein the track is configured to tilt the vehicles at the picking station to present items on the vehicles to the operator.

24. The system of claim any of claims 1-23 wherein the track comprises a front track and an opposing rear track with an aisle between the front track and the rear track.
25. The system of claim 24 wherein the picking station is positioned at the end of the aisle.
26. The system of claim 24 or 25 wherein the means for detecting is positioned between the front track and the rear track.
27. The system of claim 26 wherein the means for detecting is positioned adjacent the picking station so that the target area is a location in the picking area where the vehicles are stopped.
28. The system of claim 26 wherein the means for detecting is operable to detect whether a part of an operator extends into the path between the front track and the rear track.
29. A material handling system, comprising:
 - a plurality of destination areas;
 - a plurality of vehicles for delivering items to the destination areas or retrieving items from the destination areas, wherein the vehicles travel a path;
 - a detection assembly for detecting whether items on the vehicles extend beyond a pre-determined dimensional threshold relative to the vehicle, wherein the detection assembly is positioned adjacent the path on which the vehicles travel and the detection assembly comprises:
 - an emitter for projecting a light source onto one of the vehicles when the vehicle is at a location along the path; and
 - an imaging element configured to detect the light projected onto the vehicle;
 - an image processor configured to receive image data from the detection assembly to determine the distance that elements on the vehicle project from the vehicle;
 - wherein in response to the image processor determining that an item projects above the pre-determined dimensional threshold, movement of the vehicle along the path is altered.
30. The system of claim 29 wherein the dimensional threshold is the height above the vehicle.
31. The system of claim 29 or 30 wherein in response to the image processor determining that an item projects above the dimensional threshold, movement of the vehicle along the path is stopped until the item no longer projects beyond the dimensional threshold.

32. The system of any of claims 29-31 wherein the emitter comprises an infrared or near infrared light source.
33. The system of claim 32 wherein the imaging element comprises an imaging sensor having a two-dimensional array of pixels.
34. The system of claim 33 wherein each pixel comprises a photodetector.
35. The system of 33 or 34 wherein the detection assembly comprises a structured-light 3D scanner.
36. The system of claim 35 wherein the emitter projects a light pattern and the imaging element is spaced apart from the emitter.
37. The system of claim 36 wherein the image processor detects the distortion of the projected light pattern to determine the distance between the detection assembly and items onto which the light pattern is projected.
38. The system of claim 37 wherein the image processor calculates the 3-dimensional position of surface points onto which the emitter projects the light pattern using triangulation.
39. The system of claim 29 wherein the imaging element comprises a time of flight camera.
40. The system of claim 39 wherein the time of flight camera comprises an image sensor comprising a plurality of pixels that detects the time light has taken to travel from the emitter to objects and then back to image sensor.
41. The system of claim 39 wherein image sensor measure a phase difference between the light projected by the emitter onto objects and the light reflected back from the objects to the imaging element.
42. The system of any of claims 29-41 wherein the image processor identifies three reference points that identify a plane generally parallel with an upper surface of the vehicle.
43. The system of claim 42 wherein the plane is at an angle to the horizon.
44. The system of claim 43 wherein the image processor is configured to use the identified plane to identify image data representing items that extend above a threshold height above the vehicle.
45. The system of any of claims 29-44 comprising an alarm that is actuated when the image processor detects an item that projects above the height threshold.
46. The system of claim 45 wherein the alarm is audible.
47. The system of claim 45 or 46 wherein the alarm is visual.

48. The system of any of claims 29-47 comprising a track that guides the vehicles, wherein the destination areas are disposed on either side of the track.
49. The system of claim 48 comprising a picking station located along the track, wherein the picking station is configured to allow an operator to retrieve items from the vehicles or place items onto the vehicles.
50. The system of claim 49 comprising a controller configured to stop vehicles at the picking station.
51. The system of claim 29 wherein the track is configured to tilt the vehicles at the picking station to present items on the vehicles to the operator.
52. The system of claim any of claims 48-51 wherein the track comprises a front track and an opposing rear track with an aisle between the front track and the rear track.
53. The system of claim 52 wherein the picking station is positioned at the end of the aisle.
54. The system of claim 52 or 53 wherein the detection assembly is positioned between the front track and the rear track.
55. The system of claim 53 wherein the detection assembly is positioned adjacent the picking station so that the detection assembly is directed toward a target area located in the picking area where the vehicles are stopped.
56. The system of claim 55 wherein the detection assembly is operable to detect whether a part of an operator extends into the path between the front track and the rear track.
57. A method for handling materials to store items in a plurality of destination areas and/or retrieve items from the plurality of destination areas, wherein the method comprises the steps of:
 - controlling movement of a plurality of vehicles along a path to deliver items to the destination areas or retrieve items from the destination areas;
 - detecting whether an item on one of the vehicles extends beyond a pre-determined dimensional threshold relative to the vehicle, wherein the step of detecting comprises creating a depth data set representative of a three-dimensional representation of a target area;
 - wherein the vehicles are controlled in response to detecting that an item projects beyond the dimensional threshold.
58. The method of claim 57 wherein the dimensional threshold is the height above the vehicle.

59. The method of claim 57 or 58 wherein in response to detecting that an item projects beyond the dimensional threshold, the vehicle is stopped along the path until the item no longer projects beyond the dimensional threshold.
60. The method of any of claims 57-59 wherein the step of detecting comprises the steps of emitting light and detecting the light at a plurality of points in a two-dimensional array of pixels.
61. The method of claim 60 wherein the step of emitting light comprises emitting an infrared or near infrared light.
62. The method of claim 60 or 61 wherein the step of emitting light comprises emitting structured light onto the target area.
63. The method of claim 62 wherein the step of detecting comprises detecting the structured emitted onto the target area.
64. The method of claim 63 wherein the step of detecting detects distortions of the structured light to determine the depth data set.
65. The method of claim 64 wherein the step of detecting uses triangulation to calculate the 3-dimensional position of surface points onto which the emitter projects the structured light.
66. The method of claim 60 wherein the step of detecting comprises using a time of flight camera.
67. The method of claim 66 wherein the step of detecting comprises detecting the time light has taken to travel from a light source to objects in the target area and then back to an image sensor.
68. The method of claim 66 wherein the step of detecting comprises emitting a light source and measuring the phase difference between the emitted light source and the light reflected back from objects in the target area to an image sensor.
69. The method of any of claims 58-68 wherein the step of detecting comprises identifying three reference points that identify a plane generally parallel with an upper surface of the vehicle.
70. The method of claim 69 wherein the plane is at an angle to the horizon.
71. The method of claim 69 or 70 wherein the step of detecting comprises using the identified plane to identify depth data representative of items that extend above the pre-determined height.

72. The method of any of claims 58-71 comprising the step of actuating an alarm when the step of detecting detects an item that projects above the pre-determined height.
73. The method of claim 72 wherein the step of actuating an alarm comprises actuating an audible alarm.
74. The method of claim 72 or 73 wherein the step of actuating an alarm comprises actuating a visual alarm.
75. The method of any of claims 58-74 wherein the step of controlling movement of the vehicles along the track comprises guiding the vehicles along a track between destination areas disposed on either side of the track.
76. The method of claim 75 wherein the step of controlling movement of the vehicles comprises directing the vehicles to a picking station located along the track to allow an operator to retrieve items from the vehicles or place items onto the vehicles.
77. The method of claim 76 wherein the step of controlling movement of the vehicles comprises stopping vehicles at the picking station.
78. The method of claim 77 comprising the step of tilting the vehicles at the picking station to present items on the vehicles to the operator.
79. The method of any of claims 58-78 wherein the step of detecting detects whether a part of an operator extends into the path.
80. A material handling system, comprising:
 - a plurality of destination areas;
 - a plurality of vehicles for delivering items to the destination areas or retrieving items from the destination areas, wherein the vehicles travel a path;
 - a controller for controlling movement of the plurality of vehicles;
 - means for detecting whether an item extends into the path of the vehicle wherein the means for detecting is positioned adjacent the path on which the vehicles travel and the means for detecting is operable to create a depth data set representative of a three-dimensional representation of a target area;
 - wherein the controller controls operation of the vehicle in response to the means for detecting determining that an item projects into the path.
81. The system of claim 80 wherein in response to the means for detecting determining that an item projects into the path of one of the vehicles, the controller stops the vehicle from advancing until the item no longer projects into the path of the vehicle.

82. The system of claim 80 or 81 wherein the means for detecting comprises an emitter and a sensor wherein the sensor comprises a two-dimensional array of pixels.
83. The system of claim 82 wherein the emitter comprises an infrared or near infrared light source.
84. The system of claim 82 or 83 wherein each pixel comprises a photodetector.
85. The system of any of claims 80-84 wherein the means for detecting is a structured-light 3D scanner.
86. The system of claim 85 wherein the means for detecting comprises an emitter operable to project a light pattern and an imaging element spaced apart from the emitter, wherein the imaging element is operable to detect the light pattern emitted onto the target area.
87. The system of claim 86 wherein the means for detecting is operable to detect the distortion of the projected light pattern to determine the depth data set.
88. The system of claim 87 wherein the means for detecting uses triangulation to calculate the 3-dimensional position of surface points onto which the emitter projects the light pattern.
89. The system of claim 80 wherein the means for detecting comprises a time of flight camera.
90. The system of claim 89 wherein the time of flight camera comprises a light source and an image sensor comprising a plurality of pixels that detects the time light has taken to travel from the light source to objects in the target area and then back to the image sensor.
91. The system of claim 90 wherein the time of flight camera comprises a light source and an image element that measures the phase difference between light emitted from the light source and the light reflected back from objects in the target area to the imaging element.
92. The system of any of claims 80-91 wherein the means for detecting identifies three reference points that identify a plane generally parallel with an upper surface of the vehicle.
93. The system of claim 92 wherein the plane is at an angle to the horizon.
94. The system of claim 93 wherein the means for detecting is configured to use the identified plane to identify depth data representative of items that extend into the path of the vehicle.

95. The system of any of claims 80-94 comprising an alarm that is actuated when the means for detecting detects an item that projects into the path of the vehicle.
96. The system of claim 95 wherein the alarm is audible.
97. The system of claim 95 or 96 wherein the alarm is visual.
98. The system of any of claims 80-97 comprising a track that guides the vehicles, wherein the destination areas are disposed on either side of the track.
99. The system of claim 98 comprising a picking station located along the track, wherein the picking station is configured to allow an operator to retrieve items from the vehicles or place items onto the vehicles.
100. The system of claim 99 wherein the controller is configured to stop vehicles at the picking station.
101. The system of claim 100 wherein the track is configured to tilt the vehicles at the picking station to present items on the vehicles to the operator.
102. The system of claim any of claims 80-101 wherein the track comprises a front track and an opposing rear track with an aisle between the front track and the rear track.
103. The system of claim 102 wherein the picking station is positioned at the end of the aisle.
104. The system of claim 102 or 103 wherein the means for detecting is positioned between the front track and the rear track.
105. The system of claim 104 wherein the means for detecting is positioned adjacent the picking station so that the target area is a location in the picking area where the vehicles are stopped.
106. The system of claim 104 wherein the means for detecting is operable to detect whether a part of an operator extends into the path between the front track and the rear track.
107. A material handling system, comprising:
 - a conveyor dimensioned and arranged to move items along a conveying path extending between a first location and a second location;
 - a sensing arrangement dimensioned and arranged to determine whether an item surface extends beyond a reference plane; and
 - a controller for operating the conveyor according to a first mode of operation if the item surface is determined not to extend beyond the reference plane.
108. The material handling system of claim 107, wherein the controller operates the conveyor according to a second mode of operation if the item surface is determined to extend beyond the reference plane by the first distance.

109. The material handling system of claim 107, wherein the conveyor comprises a plurality of independently movable vehicles.
110. The material handling system of claim 109, wherein a first independently movable vehicle, of the plurality of independently movable vehicles, is operative according to the first mode of operation to deliver the item to a selectable destination along the conveying path.
111. The material handling system of claim 110, wherein the first independently movable vehicle, of the plurality of independently movable vehicles, is operative according to the second mode of operation to deliver the item to an alternate destination along the conveying path.
112. The material handling system of claim 111, wherein the first independently movable vehicle is operative, according to the second mode of operation, to transfer a receptacle carrying the item from the alternate destination to a holding area dimensioned and arranged to receive items not complying with a dimensional constraint.
113. The material handling system of claim 111, wherein the controller is operative to redirect the first independently movable vehicle from a selected destination to the alternate destination based on the distance determined by the sensing arrangement.
114. The material handling system of claim 110, wherein the controller is operative according to the second mode of operation to delay movement of the first independently movable vehicle to allow modifying an item.
115. The material handling system of claim 114, wherein modifying includes at least one of removal of an item from a receptacle, repositioning of one or more items within a receptacle, or repositioning an item on an item supporting surface of the conveyor.
116. The material handling system of claim 107, further including an alert generator operatively associated with the sensing arrangement for alerting an operator of a need to remove or reposition an item.
117. The material handling system of claim 109, wherein the first independently movable vehicle is operative, according to the first mode of operation, to transfer a receptacle carrying the item into a storage area for subsequent retrieval.
118. The material handling system of claim 107, wherein the sensing arrangement generates a depth data set representative of a three-dimensional representation of a target area disposed along the conveying path, wherein the three dimensional representation includes the reference plane and item surface.

119. The material handling system of claim 118, wherein the sensing arrangement includes an emitter and at least one sensor for generating a two-dimensional array of pixels.
120. The material handling system of claim 118, wherein the emitter comprises an infrared or a near infrared light source.
121. The material handling system of claim 118, wherein each sensor comprises a photodetector.
122. The material handling system of claim 118, wherein the sensing arrangement includes a time of flight scanner.
123. The material handling system of claim 118, wherein the sensing arrangement comprises an emitter operable to project a light pattern and an imaging element spaced apart from the emitter, and wherein the imaging element is operable to detect the light pattern emitted onto the target area.
124. The material handling system of claim 123, wherein the sensing arrangement is operable to detect distortion of the projected light pattern to determine the depth data set.
125. The material handling system of claim 123, wherein the sensing arrangement is operative to calculate, by triangulation, a 3-dimensional position of surface points onto which the emitter projects the light pattern.
126. The material handling system of claim 107, wherein the sensing arrangement includes a time of flight camera.