

CLAIMS

- 2 1. A system for automatically connecting at least one service line on a truck to a trailer
3 comprising:
4 a receiver on the trailer that is permanently or temporarily affixed thereto, the receiver
5 interconnected with at least one of a pneumatic line and an electrical line;
6 a coupling that is manipulated by an end effector of a robotic manipulator to find and
7 engage the receiver when the trailer is brought into proximity with, or hitched to, the truck; and
8 a processor that, in response to a position of the receiver, moves the manipulator to align
9 and engage the coupling with the receiver so as to complete a circuit between the truck and the
10 trailer.
- 1 2. The system as set forth in claim 1, wherein the end effector is mounted on at least one of
2 (a) a framework moving along at least two orthogonal axes and having a rearwardly extending
3 arm, (b) a multi-degree-of-freedom robot arm, and (c) a linear-actuator-driven arm with pivoting
4 joints to allow for concurrent rearward extension and height adjustment.
- 1 3. The system as set forth in claim 2, wherein the linear-actuator-driven arm is mounted on
2 a laterally moving base on the truck chassis.
- 1 4. The system as set forth in claim 3, wherein a pivoting joint attached to the end effector
2 includes a rotary actuator to maintain a predetermined angle in the coupling.
- 1 5. The system as set forth in claim 1, wherein the coupling includes an actuated, quick-
2 disconnect-style fitting adapted to selectively and sealingly secure to a connector in the
3 receptacle.
- 1 6. The system as set forth in claim 5, wherein the actuated, quick-disconnect-style fitting
2 comprises a magnetic solenoid assembly that selectively and slidably opens and allows closure
3 of the quick-disconnect-style fitting in response, to application of electrical current thereto.
- 1 7. The system as set forth in claim 1, further comprising a tensioned cable attached to the
2 coupling and a pneumatic line attached to the truck brake system.
- 1 8. The system as set forth in claim 7, wherein the brake system comprises at least one of a
2 service brake and an emergency brake.

- 1 9. The system as set forth in claim 8, further comprising an electrical connection on the
2 coupling attached to the truck electrical system.
- 1 10. The system as set forth in claim 9, wherein the receptacle is removably attached to a
2 front face of the trailer by at least one of an interengaging fabric material, fasteners, clamps and
3 magnets.
- 1 11. The system as set forth in claim 10, further comprising a retrofit kit for the trailer
2 defining a Y-connector for at least one of a trailer pneumatic line and a trailer electrical line, the
3 Y-connector connecting to both a conventional service connector and the receiver.
- 1 12. The system as set forth in claim 11, wherein the Y-connector is operatively connected to
2 a venting mechanism that selectively allows one of the coupling and the conventional service
3 connector to vent.
- 1 13. The system as set forth in claim 12, wherein the conventional service connector
2 comprises a glad hand.
- 1 14. A system for operating an autonomous truck with respect to a trailer comprising:
2 a processor that communicates with a tug-test process that, when the truck is hitched to
3 the trailer, automatically determines whether the trailer is hitched by applying motive power to
4 the truck and determining load on the truck thereby.
- 1 15. A system for handling a trailer with a truck, free of service connections between a
2 pneumatic brake system of the truck and a brake system of the trailer, comprising:
3 a pressurized air canister removably secured to the trailer and connected to the brake
4 system thereof having a valve that is actuated based upon a signal from the truck to release the
5 brake system.
- 1 16. The system as set forth in claim 15, wherein the truck is an autonomous truck and the
2 signal is transmitted wirelessly from a controller of the truck.
- 1 17. The system as set forth in claim 16, wherein the truck is an AV yard truck and the
2 canister is adapted to be attached upon delivery of the trailer to a yard.

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1 18. A system for locating a glad hand connector on a front face of a trailer comprising:
2 a gross sensing system that acquires at least one of a 2D and a 3D image of the front face
3 and searches for glad hand-related image features.

1 19. The system as set forth in claim 18 wherein the gross sensing system locates features
2 having a differing texture or color from the surrounding image features after identifying edges of
3 the trailer front face in the image.

1 20. The system as set forth in claim 19 wherein the gross sensing system includes a sensor
2 located on a cab or chassis of an autonomous yard truck.

1 21. The system as set forth in claim 20, further comprising a fine sensing system, located on
2 an end effector of a fine manipulator, that is moved in a gross motion operation to a location
3 adjacent to a location on the front face containing candidate glad hand features.

1 22. The system as set forth in claim 21 wherein the fine sensing system includes a plurality
2 of 2D and 3D imaging sensors.

1 23. The system as set forth in claim 22 wherein the fine manipulator comprises a multi-axis
2 robotic arm mounted on a multi-axis gross motion mechanism.

1 24. The system as set forth in claim 23 wherein the gross motion mechanism comprises a
2 plurality of linear actuators mounted on the autonomous yard truck that move the fine
3 manipulator from a neutral location to the location adjacent to the glad hand candidate features.

1 25. The system as set forth in claim 23 wherein the gross motion mechanism comprises a
2 piston driven, hinged platform mounted on the autonomous yard truck that moves the fine
3 manipulator from a neutral location to the location adjacent to the glad hand candidate features.

1 26. The system as set forth in claim 23 wherein the fine manipulator is servoed based upon
2 feedback received from the fine sensing system relative to the glad hand imaged thereby.

1 27. The system as set forth in claim 26 wherein the fine sensing system locates a trained
2 feature on the glad hand to determine pose thereof.

1 28. The system as set forth in claim 27 wherein the feature is at least one of the annular glad
2 hand seal, an outline edge of a flange for securing the glad hand, and a tag attached to the glad
3 hand.

1 29. The system as set forth in claim 28 wherein the tag includes a fiducial matrix that assists
2 in determining the pose.

1 30. The system as set forth in claim 28 wherein the tag is located on a clip attached to a
2 raised element on the glad hand.

1 31. The system as set forth in claim 27, wherein the feature includes a plurality of
2 identification regions on a gasket seal of the glad hand.
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1 32. A system for attaching a truck-based pneumatic line connector to a glad hand on a trailer
2 using a manipulator with an end effector that selectively engages and releases the connector
3 comprising:
4 a clamping assembly that selectively overlies an annular seal of the glad hand and that
5 sealingly clamps the connector to the annular seal.

1 33. The system as set forth in claim 32 wherein the clamping assembly is at least one of an
2 actuated clamp and a spring-loaded clamp.

1 34. The system as set forth in claim 33 wherein the spring-loaded clamp is normally closed
2 and is opened by a gripping action of the end effector.

1 35. The system as set forth claim 33 wherein the actuated clamp includes one of (a) a
2 pivoting pair of clamping members and (b) a sliding clamping member.

- 1 36. A system for attaching a truck-based pneumatic line connector to a glad hand on a
2 trailer using a manipulator with an end effector that selectively engages and releases the
3 connector comprising:
4 a probe member, containing a pressure port, that inserts into and becomes lodged in an
5 annular seal of the glad hand based upon a placement motion of the end effector.
- 1 37. The system as set forth in claim 36 wherein the probe member comprises one of (a) a
2 frustoconical plug that is releasable press fit into the annual seal and (b) an inflatable plug that
3 selectively engages a cavity in the glad hand beneath the annular seal and is inflated to become
4 secured therein.
- 1 38. The system as set forth in claim 37 wherein the frustoconical plug includes a
2 circumferential barb to assist in retaining against the annular seal.
- 1 39. A system for attaching a truck-based pneumatic line connector to a trailer glad hand on a
2 trailer using a manipulator with an end effector that selectively engages and releases the
3 connector comprising:
4 another glad hand secured to the trailer glad hand in a substantially conventional manner,
5 the other glad hand including a quick-disconnect fitting that receives the selectively connector
6 from the end effector.
- 1 40. A system for determining a relative angle of a trailer with respect to a truck in a
2 confronting relationship in which the truck is attempting to move in reverse to hitch to the trailer
3 comprising:
4 a spatial sensing device located to face rearward on the truck, the sensing device oriented
5 to sense space beneath an underside of the trailer; and
6 a processor that identifies and analyzes data points generated by the sensing device with
7 respect to at least one of landing gear legs of the trailer and wheel sets of the trailer and that
8 thereby determines the relative angle.
- 1 41. The system as set forth in claim 40 wherein the sensing device is a high-resolution
2 LIDAR device that generates points using projected rings of structured light.
- 1 42. The system as set forth in claim 41 wherein the processor identifies point groups and
2 compares the point groups to expected shapes and locations of the landing gear legs.

1 43. The system as set forth in claim 42 wherein, if one of the landing gear legs is occluded,
2 the processor estimates a location of the occluded landing gear leg to determine the relative
3 angle.

1 44. The system as set forth in claim 42 wherein the processor locates and analyzes a shape
2 and position of the wheel sets to at least one of (a) confirm a determination of the relative angle
3 based on the landing gear legs and (b) determine the relative angle independently where analysis
4 the landing gear legs is unavailable or inconclusive.

1 45. The system as set forth in claim 44 wherein the processor is arranged to determine a
2 location of a kingpin of the trailer.

1 46. A system for determining a relative location of a kingpin of a trailer with respect to a
2 truck in a confronting relationship in which the truck is attempting to move in reverse to hitch to
3 the trailer comprising:

4 a spatial sensing device located to face rearward on the truck, the sensing device oriented
5 to sense space beneath an underside of the trailer; and

6 a processor that identifies and analyzes data points generated by the sensing device with
7 respect to at least one of the kingpin, landing gear legs of the trailer and wheel sets of the trailer
8 and that thereby determines the relative location of the kingpin.

1 47. The system as set forth in claim 46 wherein the sensing device is a high-resolution
2 LIDAR device that generates points using projected rings of structured light.

1 48. The system as set forth in claim 47 wherein the processor identifies point groups and
2 compares the point groups to expected shapes and locations of the kingpin and landing gear legs.

1 49. The system as set forth in claim 48 wherein the processor is arranged to iteratively image
2 with the LIDAR device, and locate, groups of points that represent the expected locations and to
3 provide the relative location of the kingpin in response to a confidence value above a
4 predetermined threshold.

1 50. A system for interconnecting an airline between an autonomous truck and a trailer
2 comprising:

3 an adapter that is mounted with respect to a trailer-side airline and directs pressurized air
4 therethrough, the adapter having at least one glad hand connection thereon; and

5 a manipulator that carries and moves a connection tool into and out of engagement with
6 the adapter, the connection tool being interconnected with a truck-side airline for delivering the
7 pressurized air to the adapter when engaged therewith and the manipulator being arranged to
8 selectively release from the tool when the tool is engaged to the adapter.

1 51. The system as set forth in claim 50 wherein the adapter includes a glad hand connection
2 that engages a glad hand connection attached to the trailer-side airline and the adapter includes a
3 quick-disconnect fitting that engages an actuatable quick disconnect on the tool.

1 52. The system as set forth in claim 51 wherein the quick disconnect is actuated by at least
2 one of a pulling motion and a powered actuator assembly.

1 53. The system as set forth in claim 51 wherein the adapter further includes a truck-side glad
2 hand connection and a shuttle valve that selectively routes the pressurized air from either the
3 truck-side glad hand connection or the quick disconnect fitting.

1 54. The system as set forth in claim 50 wherein the tool includes guide structures to enable
2 alignment with the adapter during engagement therebetween.

1 55. The system as set forth in claim 54 wherein the guide structures include at least one of
2 guide pins, vanes, slots and keyways.

1 56. The system as set forth in claim 50 wherein the tool includes a screw-driven clamp that
2 selectively engages a truck-side glad hand connection and a guide pin that is arranged to engage
3 one of a plurality of keyways at different rotational orientations about an axis of the truck-side
4 glad hand connection.

1 57. The system as set forth in claim 50 wherein the adapter includes a fiducial that identifies
2 and assists in orienting the manipulator, based upon an operatively connected vision system.