CLAIMS

What is claimed is:

1. A method for detecting a suspended load by an autonomous vehicle maneuvering about an environment, the method comprising:

receiving, from a scanning device mounted on and perpendicular to a top surface of the autonomous vehicle, a plurality of data points surrounding the autonomous vehicle;

filtering the plurality of data points to remove any data points that fall within a predetermined region of the environment so as to exclude load stacks;

detecting, using a point detection module, whether an object is present within a detection range of the autonomous vehicle by:

clustering subsets of the plurality of data points; and

determining whether at least one clustered subset of the plurality of data points is within the detection range;

based on the object being present within the detection range, extracting, by a suspended load detection module, at least three features including one or more of a height-related feature, a distance-related feature, and a relative positional feature from the object to detect whether the object is a suspended load; and

controlling maneuvering of the autonomous vehicle based on detection of the suspended load.

2. The method of claim 1, wherein the controlling comprises halting maneuvering of the autonomous vehicle when (i) the object is detected as the suspended load and (ii) the autonomous vehicle is within a predetermined range of the suspended load.

3. The method of claim 1 or claim 2, wherein the extracting comprises:

identifying a first portion of the plurality of data points that are present to either the left or the right of a center line of the autonomous vehicle;

determining whether any of data points in the first portion are within (i) a first predetermined distance in front of the autonomous vehicle and (ii) a first predetermined height range,

wherein a first feature of the at least three features is identified based on presence of any data point of the first portion within the first predetermined distance and the predetermined height range, and

wherein the determining is repeated for a second portion of the plurality of data points that are present on an opposite side of the center line than the first portion based on none of the data points in the first portion being within the first predetermined distance and the first predetermined height range.

4. The method of claim 3, wherein based on the first feature being detected the extracting further comprises:

determining whether any of data points in the first portion are within a second predetermined distance in front of the autonomous vehicle that is behind the first feature,

wherein a second feature of the object is identified based on presence of any data point of the first portion within the second predetermined distance.

5. The method of claim 4, wherein based on the second feature being detected the extracting further comprises:

determining whether any of data points in the first portion are within a second predetermined height range,

wherein the object is identified as the suspended load positioned between the first feature and the second feature based on presence of any data point of the first portion within the second predetermined height range.

6. The method of claim 5, wherein based on none of the data points in the first portion being within the second predetermined distance or the second predetermined height range, the detecting presence of the object further comprises:

determining whether any of data points in a second portion are within (i) the first predetermined distance in front of the autonomous vehicle and (ii) the first predetermined height range,

wherein the first feature of the object is identified based on presence of any data point of the second portion within the first predetermined distance and the predetermined height range, and

wherein the second portion of the plurality of data points comprises data points that are present on an opposite side of the center line than the first portion.

7. The method of any of the preceding claims, wherein when the plurality of data points are not within the detection range, the controlling comprises maintaining the maneuvering of the autonomous vehicle.

8. The method of any of the preceding claims, wherein the scanning device is a light and detection ranging (LiDAR) device and the plurality of data points comprises a plurality of LiDAR data points.

9. The method of any of the preceding claims, wherein the clustering further comprises:

identifying a subset of the plurality of data points located within a designated region;

determining whether the subset is greater than a threshold value; and

based on the subset being greater than the threshold value, generating a plurality of clusters among the subset based on distances between each data point.

10. The method of claim 9, wherein coordinates of the plurality of clusters are provided by the point detection modules to the suspended load detection module.

11. The method of any of the preceding claims, wherein the autonomous vehicle is an autonomous prime mover and the environment is a shipping port environment.

12. A system detecting a suspended load by an autonomous vehicle maneuvering about an environment, the system comprising:

at least one data processor; and

memory storing instructions, which when executed by at least one data processor, result in operations for implementing operations comprising:

receiving, from a scanning device mounted on and perpendicular to a top surface of the autonomous vehicle, a plurality of data points surrounding the autonomous vehicle;

filtering the plurality of data points to remove any data points that fall within a predetermined region of the environment so as to exclude load stacks;

detecting, using a point detection module, whether an object is present within a detection range of the autonomous vehicle by:

clustering subsets of the plurality of data points;

determining whether at least one clustered subset of the plurality of data points is within the detection range;

based on the object being present within the detection range, extracting, by a suspended load detection module, at least three features including one or more of a height-related feature, a distance-related feature, and a relative positional feature from the object to detect whether the object is a suspended load; and

controlling maneuvering of the autonomous vehicle based on detection of the suspended load.

13. The system of claim 12, wherein the controlling comprises halting maneuvering of the autonomous vehicle when (i) the object is detected as the suspended load and (ii) the autonomous vehicle is within a predetermined range of the suspended load.

14. The system of claim 12 or claim 13, wherein the extracting comprises:

identifying a first portion of the plurality of data points that are present to either the left or the right of a center line of the autonomous vehicle;

determining whether any of data points in the first portion are within (i) a first predetermined distance in front of the autonomous vehicle and (ii) a first predetermined height range,

wherein a first feature of the object is identified based on presence of any data point of the first portion within the first predetermined distance and the predetermined height range, and

wherein the determining is repeated for a second portion of the plurality of data points that are present on an opposite side of the center line than the first portion based on none of the data points in the first portion being within the first predetermined distance and the first predetermined height range.

15. The system of claim 14, wherein based on the first feature being detected the extracting further comprises:

determining whether any of data points in the first portion are within a second predetermined distance in front of the autonomous vehicle that is behind the first feature,

wherein a second feature of the object is identified based on presence of any data point of the first portion within the second predetermined distance.

16. The system of claim 15, wherein based on the second feature detected the extracting further comprises:

determining whether any of data points in the first portion are within a second predetermined height range,

wherein the object is identified as the suspended load positioned between the first feature and the second feature based on presence of any data point of the first portion within the second predetermined height range.

17. The system of claim 16, wherein based on none of the data points in the first portion being within the second predetermined distance or the second predetermined height range, the detecting presence of the object further comprises:

determining whether any of data points in a second portion are within (i) the first predetermined distance in front of the autonomous vehicle and (ii) the first predetermined height range,

wherein the first feature of the object is identified based on presence of any data point of the second portion within the first predetermined distance and the predetermined height range, and

wherein the second portion of the plurality of data points comprises data points that are present on an opposite side of the center line than the first portion.

18. The system of any of claim 12 to claim 17, wherein when the plurality of data points are not within the detection range, the controlling comprises maintaining the maneuvering of the autonomous vehicle.

19. The system of any of claim 12 to claim 18, wherein the scanning device is a light and detection ranging (LiDAR) device and the plurality of data points comprises a plurality of LiDAR data points.

20. The system of any of claim 12 to claim 19, wherein the clustering further comprises:

identifying a subset of the plurality of data points located within a designated region; determining whether the subset is greater than a threshold value; and

based on the subset being greater than the threshold value, generating a plurality of clusters among the subset based on distances between each data point.

21. The system of claim 20, wherein coordinates of the plurality of clusters are provided by the point detection modules to the suspended load detection module.

22. The system of any of claim 12 to claim 21, wherein the autonomous vehicle is an autonomous prime mover and the environment is a shipping port environment.

23. A non-transitory computer program product detecting a suspended load by an autonomous vehicle maneuvering about an environment, the non-transitory computer program product storing instructions which, when executed by at least one data processor forming part of at least one computing device, implement operations comprising:

receiving, from a scanning device mounted on and perpendicular to a top surface of the autonomous vehicle, a plurality of data points surrounding the autonomous vehicle;

filtering the plurality of data points to remove any data points that fall within a predetermined region of the environment so as to exclude load stacks;

detecting, using a point detection module, whether an object is present within a detection range of the autonomous vehicle by:

clustering subsets of the plurality of data points;

determining whether at least one clustered subset of the plurality of data points is within the detection range;

based on the object being present within the detection range, extracting at least three features including one or more of a height-related feature, a distance-related feature, and a relative positional feature from the object to detect whether the object is a suspended load; and

controlling maneuvering of the autonomous vehicle based on detection of the suspended load.