CLAIMS

1. A method for determining orientation of a vehicle relative to a surface, the steps comprising:

providing a vehicle having:

a first chassis section;

a second chassis section;

a hinge joint connecting the first and second chassis sections such that the first and second chassis sections are capable of rotation with respect to each other in at least a first direction;

a first wheel mounted to one of the first and second chassis sections;

a second wheel mounted to the other of the first and second chassis sections, in which the first and second wheels are configured to contact the surface;

providing vehicle geometric data defining at least a distance between the hinge joint and a center of the first and second wheels, respectively, and a diameter of each of the wheels;

providing surface geometric data defining a curvature of the surface;

measuring an angle of rotation about the hinge joint by measuring the angle between the first and second chassis sections;

determining an orientation of the vehicle relative to the surface based on the vehicle geometric data, the surface geometric data, and the measured angle of rotation.

2. A method according to Claim1, in which the first wheel is a magnetic drive wheel.

3. A method according to Claim 1, in which the second wheel is a magnetic drive wheel.

4. A method according to Claim1, in which the vehicle is capable of traversing a curved surface in a helical path.

5. A system for determining orientation of a vehicle relative to a surface having defined geometric data that represents a curvature of the surface, comprising:

a vehicle having:

a first chassis section;

a second chassis section;

a hinge joint connecting the first and second chassis sections such that the first and second chassis sections are capable of rotation with respect to each other in at least a first direction;

a first wheel mounted to one of the first and second chassis sections;

a second wheel mounted to the other of the first and second chassis sections, in which the first and second wheels are configured to contact the surface;

a sensor configured to measure an angle of rotation about the hinge joint; and

a processor configured to determine an orientation of the vehicle relative to the surface based on defined vehicle geometric data, the surface geometric data, and the measured angle of rotation about the hinge joint.

6. A system according to Claim 5, in which the defined vehicle geometric data includes at least a distance between the hinge joint and a center of the first and second wheels, respectively, and a diameter of the wheels.

7. A system according to Claim 5, in which the first wheel is a magnetic drive wheel.

8. A system according to Claim 5, in which the second wheel is a magnetic drive wheel.

9. A system according to Claim 5, in which the vehicle is capable of traversing a curved surface in a helical path.

10. A method for determining orientation of a device relative to an object having a surface, the steps comprising:

providing a device having:

at least first and second elements configured to contact the surface of the object;

a third element capable of measuring at least one variable that is dependent on the orientation of the device with respect to the surface of the object;

providing geometric data defining the geometry of the device;

providing surface geometric data defining a curvature of the surface;

measuring the variable;

determining an orientation of the device relative to the surface of the object based on the device geometric data, the surface geometric data, and the measured variable.

11. A method according to Claim 10, in which the first and second elements are first and second legs.

12. A method according to Claim 11, in which the first and second legs include gripper elements that are configured to adhere to the surface of the object.

13. A method according to Claim 12, in which the third element includes a third leg connected to the device via a pivot and a sensor configured to measure the rotation of the third leg about the pivot.

14. A method according to Claim 13, in which the third leg includes a third gripper element that is configured to adhere to the surface of the object.

15. A method according to Claim 14, in which the variable is the degree of rotation of the third leg about the pivot.

16. A method according to Claim 12, in which the third element includes first and second pivots that connect the first and second legs to the device and first and second sensors that are configured to measure the rotation of the of the first and second legs, respectively.

17. A method according to Claim 16, in which the variable includes the degree of rotation of the first and second legs about their respective pivots.

18. A method according to Claim 12, in which the third element is configured to linearly translate with respect to the device and further includes a sensor configured to measure translation with respect to the device.

19. A method according to Claim 18, in which the third element includes a third gripper element that is configured to adhere to the surface of the object.

20. A method according to Claim 19, in which the variable is the amount of linear translation of the third element.

21. A method according to Claim 12, in which the third element is a non-contact distance sensor supported by the device and configured measure the distance between the device and the surface of the object.

22. A method according to Claim 21, in which the variable is the distance between the sensor and the surface.

23. A system for determining orientation of a device relative to an object having surface having defined geometric data that represents a curvature of the surface, comprising:

the device having:

at least first and second elements configured to contact the surface of the object;

a third element capable of measuring at least one variable that is dependent on the orientation of the device with respect to the surface of the object;

a processor configured to determine an orientation of the device relative to surface, based on defined device geometric data, the surface geometric data, and the measured variable.

24. A system according to Claim 23, in which the first and second elements are first and second legs.

25. A system according to Claim 24, in which the first and second legs include gripper elements that are configured to adhere to the surface of the object.

26. A system according to Claim 25, in which the third element includes a third leg connected to the device via a pivot and a sensor configured to measure the rotation of the third leg about the pivot.

27. A system according to Claim 26, in which the third leg includes a third gripper element that is configured to adhere to the surface of the object.

28. A system according to Claim 27, in which the variable is the degree of rotation of the third leg about the pivot.

29. A system according to Claim 25, in which the third element includes first and second pivots that connect the first and second legs to the device and first and second sensors that are configured to measure the rotation of the of the first and second legs, respectively.

30. A system according to Claim 29, in which the variable includes the degree of rotation of the first and second legs about their respective pivots.

31. A system according to Claim 25, in which the third element is configured to linearly translate with respect to the device and further includes a sensor configured to measure translation with respect to the device.

32. A system according to Claim 31, in which the third element includes a third gripper element that is configured to adhere to the surface of the object.

33. A system according to Claim 32, in which the variable is the amount of linear translation of the third element.

34. A system according to Claim 25, in which the third element is a non-contact distance sensor supported by the device and configured measure the distance between the device and the surface of the object.

35. A system according to Claim 34, in which the variable is the distance between the sensor and the surface.

36. A method according to Claim 1, in which the step of measuring the angle of rotation about the hinge joint comprises providing a sensor in the vehicle, the sensor being configured to measure the angle of rotation about the hinge joint.

37. A method according to Claim 4, further including the step of determining when every loop of the helical path ends and a next loop starts by analyzing a plurality of sensor readings including wheel encoders and inertial measurement unit (IMU) data.

38. A method according to Claim 37, in which the IMU data includes data obtained from accelerometers, gyroscopes and magnetometers.

39. A method according to Claim 1, in which the surface comprises a cylindrical pipe and the step of determining the orientation of the vehicle corresponds to determining four possible orientations relative to a centerline of the cylindrical pipe and the method further includes the step of recording previous measurements of the hinge angle and determining which of the four possible orientations is a true orientation of the vehicle based on a start orientation and previous orientation changes of the vehicle.

40. A method according to Claim 4, in which the vehicle includes a processor that operates to control a helical pitch and ensure that loops of the helix are spaced a constant distance from one another.

41. A method according to Claim 1, in which the first wheel is a magnetic drive wheel that rotates about a first axis and the second wheel is a magnetic omni-wheel that rotates about a second axis that is perpendicular to the first axis, the omni-wheel including a plurality of rollers that are located about a periphery of the omni-wheel, each roller rotating in a same direction as rotation of the magnetic drive wheel.

42. A method according to Claim 1, in which the hinge joint includes first and second rotation stops that are configured to prevent unintentional rotation about the hinge joint.

43. A method according to Claim 42, in which the hinge joint is disposed between the first chassis section and the second chassis section such that the first and second chassis sections are capable of rotation with respect to each other in at least one direction, in which the first and second rotation stops are mating surfaces on each of first and second chassis section.