Claims

1. A method for guiding a probe inside a constrained space (16), wherein the probe is a hyper-redundant manipulator (30) comprising a plurality of independently-orientable connected segments (33) extendable between a proximal end and a distal end inside the constrained space, the method including the steps of:

determining: an initial point (p_1) where the probe intersects a predetermined curve (C) which defines a circle or part circle within said space; and an initial bend for the probe between an entry point (40) on a surface of the constrained space and the initial point;

and, repeatedly:

determining a new orientation of said segments which results in an advancement of the distal end to a new position which is on said curve, the new orientation being determined so as to minimise each of: a) the deviation between the point (p_1) on the probe where the probe starts to follow said curve and the initial point (p_2), and b) the deviation between a point (p_1) on the probe closer to the distal end than the point where the probe starts to follow said curve and said curve (p_2); and

adjusting the orientation of said segments to said new orientation and advancing the probe so that the distal end is located at the new position.

2. A method according to claim 1, wherein the constrained space is toroidal.

3. A method according to claim1 or claim 2 wherein the curve defines a mid point of the space.

4. A probe system for accessing a constrained space (16), the probe system comprising:

a hyper-redundant manipulator (30) having a plurality of independently-orientable connected segments (33) extendable between a proximal end and a distal end; and

a controller,

wherein the controller is arranged to control the orientation of said segments so as to position the distal end in a desired position by:

determining: an initial point (p_1) where the probe intersects a predetermined curve (C) which defines a circle or part circle within said space, and an initial bend for the probe between an entry point (40) on a surface of the constrained space and the initial point;

and, repeatedly:

determining a new orientation of said segments which results in an advancement of the distal end to a new position which is on said curve, the new orientation being determined so as to minimise each of a) the deviation between the point (p_1) on the probe where the probe starts to follow said curve and the initial point (p_2), and b) the deviation between a point (p_1) on the probe closer to the distal end than the point where the probe starts to follow said curve and said curve (p_2); and

sending actuation signals to the manipulator so to as to cause adjustment of the orientation of said segments to said new orientation and advance the probe so that the distal end is located at the new position.

5. A probe system according to claim 4 further including an end-effector (34) at the distal end of the manipulator.

6. A probe system according to claim 4 or claim 5 wherein the constrained space is toroidal.

7. A probe system according to any one of claims 4 to 6 wherein the curve defines a mid point of the space.

8. A probe system according to any one of claims 4 to 7 further including a feed-in mechanism (38) for advancing the probe.

9. A probe system according to any one of claims 4 to 8 further including an actuation mechanism located at or near the proximal end, the actuation mechanism either being linked to actuators on each segment or arranged to directly drive the motion of each segment.