CLAIMS

1. A method for minimizing deviations between a target pose and an actual pose of a moving part of an autonomous charging device (ACD) manipulator, the manipulator adapted to connect a charging connector to an electric vehicle socket, comprising:

    a. obtaining a compensation function covering at least a part of a workspace of the manipulator, wherein the compensation function utilizes a relationship between at least one motion command and a corresponding actual pose, and

    b. operating the manipulator based on the obtained compensation function such that the resulting actual pose minimally deviates from the target pose,

wherein the relationship between at least one motion command and a corresponding actual pose is obtained by a method comprising at least the following steps:

- having an image acquisition device attached to a moving part of the manipulator, the device disposed to acquire an image containing a visible fiducial marker placed at a referential pose;
- instructing the manipulator to move using at least one motion command and acquiring an image of the fiducial marker;
- using a computer-vision unit and the image for determining the relative pose of the fiducial marker with respect to the image acquisition device;
- computing the actual pose of the moving part of the manipulator using the referential pose of the fiducial marker and the determined relative pose of the fiducial marker with respect to the image acquisition device; and
- fitting a template function that relates the at least one motion command to the computed actual pose.

2. The method according to any one of the preceding claims wherein the vehicle socket is used as the fiducial marker.

3. The method according to any one of the preceding claims wherein the method comprises establishing the relationship between a plurality of motion commands and their

corresponding computed actual poses, encompassing a substantial portion of the workspace of the manipulator.

4. The method according to any one of the preceding claims wherein the method comprises using an existing function of the workspace comprising representations of major features and existing data relationships between motion commands and actual poses for a plurality of motion commands.

5. The method according to any one of the preceding claims wherein the compensation function comprises a lookup table representing the relationship between at least one motion command and a corresponding actual pose to determine a motion command to be given to a target pose.

6. The method according to claim 5 wherein the compensation function comprises an optimization algorithm to refine and optimize the parameter values of the lookup table, thereby minimizing deviations between actual and target poses.

7. The method according to claim 6 wherein the optimization algorithm comprises an interpolation procedure to estimate values between data points in the lookup table, wherein data points include at least one of translation and rotation values for each motion command.

8. The method according to any one of the preceding claims further comprises dynamically assessing the deviation between the resulting actual pose and the target pose during operation of the manipulator, and adjusting at least one boundary of the workspace if the deviation exceeds a predetermined threshold, wherein the adjusting of the at least one boundary of the workspace preferably includes adjusting the motion limits of the manipulator to a narrower range so that that the resulting actual pose minimally deviates from the target pose.

9. The method according to any one of the preceding claims wherein the motion command includes at least one of a predefined waypoint and a set of coordinates, and wherein the predefined waypoints for a plurality of motion commands is substantially the same.

10. The method according to any one of the preceding claims wherein the motion command comprises a sequence of waypoints that serve as intermediate positions for the moving part of the manipulator and for the image acquisition device to record subsequent images of the fiducial marker.

11. The method according to any one of the preceding claims wherein the referential pose is determined by acquiring an image of the fiducial marker when the manipulator is in a state

where the difference between an actual pose and target pose are minimal, determining the pose of the fiducial marker with respect to the camera, and calculating the absolute pose of the fiducial marker.

12. The method according to any one of the preceding claims wherein when the referential pose is a substantially static pose, the referential pose is unknown, or when the referential pose is a substantially non-static pose, the referential pose is a known pose, and wherein the referential pose is preferably known with a confidence interval.

13. The method according to any one of the preceding claims wherein the method comprises utilizing a plurality of fiducial markers, each placed at different poses.

14. The method according to any one of the preceding claims wherein the method comprises using a socket having a fiducial marker to validate the compensation function, wherein the manipulator is instructed to manipulate the socket to a target pose, and the actual pose of the socket is compared to the predicted pose based on the compensation function.

15. An autonomous charging device (ACD) system comprising;

- A manipulator adapted to connect a charging connector to an electric vehicle socket
- An image acquisition device attached to a moving part of the manipulator
- A computer vision module
- A motion control unit,

wherein the motion control unit device is configured to carry out a method in accordance with anyone of the claims 1-14.

16. A method for obtaining a function representing a relationship between at least one motion command and a corresponding actual pose of the moving part of an ACD manipulator, the method comprising:

a) having an image acquisition device attached to the moving part of the manipulator, the device disposed to acquire an image containing a visible fiducial marker placed at a referential pose;

b) instructing the manipulator to move using at least one motion command and acquiring an image of the fiducial marker;

c) using a computer-vision unit and the image for determining the relative pose of the fiducial marker with respect to the image acquisition device;

d) computing the actual pose of the moving part of the manipulator using the referential pose of the fiducial marker and the determined relative pose of the fiducial marker with respect to the image acquisition device; and

e) fitting a template function that relates the at least one motion command to the computed actual pose.