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Robot-based automation of charging process for electric vehicle*

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Along with the recent increase of electric vehicles, the rapid chargers are become popular. This has resulted in thicker and heavier charging cables, making it difficult for users to handle them. Thus the demand for unmanned automatic charging systems using robot is increasing to imporve the convenience of operation and to secure the safety of users. Several researches on a robot-based automatic charging systems have been conducted to solve this problem [1], [2], [3]. Since a robot should be added to the existing EV charger, the unit price may be increased. In addition, once the charging coupler is attached to EV and charging process starts, the robot has nothing to do until charging is completed. To solve such problems, we propose a novel concept of charging system which provides charging service for multiple vehicles with one robot. The robot is attached at the ceiling of the bridge structure and moves along the rail to provide charging services for vehicles parked inside the charging station. Charging dispensers are installed as many as the number of parking site. Figure 1 shows the concept design of the proposed robotic charging system, in which one robot can charge up to 8 vehicles as an example. The merits of the proposed system is that the cost can be reduced and the contamination from the external environment can be prevented.

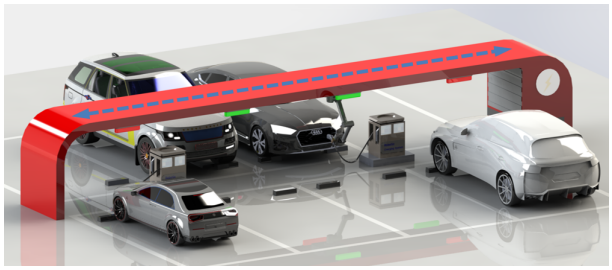

Fig. 1. Concept of the proposed robotic charging system

This paper focuses on a rapid charger system with a capacity of 400kW, which has a charging coupler weight of 0.9 kg, a charging cable weight of 1.6 kg/m, and a cable length of 5 m. The payload of the robot was desiged as 15 kg considering the required connecting force of the charging coupler into the charging inlet. Also, to meet the requirements of the height of the bridge structure and the distance from the vehicle and the dispenser, the maximum reach of the robot was designed to be 1.5 m. An analysis of the workspace and the load were conducted to calculate the required torque. The horizontal distance D and vertical distance H between the charging inlet of the vehicle and the center of the robot's 2nd axis was set as variables in the analysis. The result of the workspace analysis was shown in Figure 2.

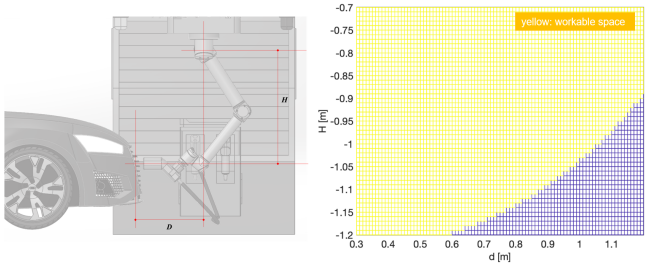

Fig. 2. Workspace analysis

The prototype is implemented according to the design parameters. The system is composed of the bridge structure with the rail and the rack-pinion gear and the collaborative robot with the payload 15kg. The end-effector is also desiged to handle the charging coupler using tool changer. Figure 3 shows the implemented system.

Fig. 3. Prototype of the EV charging robot system

REFERENCES

[1] B. Walzel, C. Sturm, J. Fabian and M. Hirz, Automated robot-based charging system for electric vehicles, Internationales Stuttgarter Symposium, Proceedings. Springer, Wiesbaden (2016).
[2] J. Miseikis, M. Rther, B. Walzel, M. Hirz, and H. Brunner, 3D Vision Guided Robotic Charging Station for Electric and Plug-in Hybrid Vehicles, Proceedings of the OAGM & ARW Joint Workshop (2017).
[3] Y. Lou and S. Di, Design of a Cable-Driven Auto-Charging Robot for Electric Vehicles, IEEE Access, vol. 8, pp. 15640-15655 (2020)

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