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GANTRY ROBOT FOR CHARGING MULTIPLE ELECTRIC VEHICLES

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ABSTRACT

An overhead gantry robotic system moves a Wireless Power Transfer (WPT) coil across a row of parking spaces in a parking structure. The system detects a vehicle to be charged, adjusts the position of the primary coil over the vehicle, and lowers the primary coil into proximity of a receiver coil in the top of the vehicle.

DETAILED DESCRIPTION

The market for full electric vehicles (EVs) continues to grow very rapidly. Some jurisdictions and vehicle manufacturers plan to convert their entire fleet into full electric vehicles. Significant additions to the roadside infrastructure are needed to support this changing market. In particular, a massive infrastructure build-out is needed to ensure that a sufficient number of charging stations are available for EVs.

However, installing charging stations incurs high cost, making it prohibitive for each parking spot to have permanent charge facilities. Currently, if there are more EVs that need to be charged than available charging stations, the EVs must wait until a charging station is available, which can be a great inconvenience. Self-driving cars may be able to autonomously move into parking spots with charging stations to receive charge (and move into a normal parking space once charging is completed). However, this remains a problem for non-autonomous cars.

WPT is an important emerging technology for charging EVs. In this technology, a primary coil, usually embedded in the road surface, obtains energy from the power grid, and inductively couples the energy (through a small air gap) to a receiver coil beneath the EV. The EV collects the transferred energy, and uses this energy to charge its batteries. The primary coils typically contain many kilograms of copper and sophisticated power electronics, and therefore are expensive, making the complete deployment of a primary coil per spot in a large parking lot or structure cost prohibitive.

Also, a limited number of today's vehicles have WPT receiver coils, which further impacts development of infrastructure. Parking structures and roadways will not install WPT infrastructure until a critical mass of vehicles can use them, and vehicle manufacturers will not offer the receiver coils until there is a critical mass of infrastructure to make them valuable.

The present techniques and systems provide an alternate strategy, wherein the charging capability moves to the location of the EV, and also manages to retrofit an existing EV for WPT charging. This system transports a WPT charging coil on an overhead gantry robot that moves over a row of parked cars in a parking structure or parking lot. As shown in *Figure 1*, multiple parking spaces can be serviced by a single gantry, with two or more robots traveling on it.

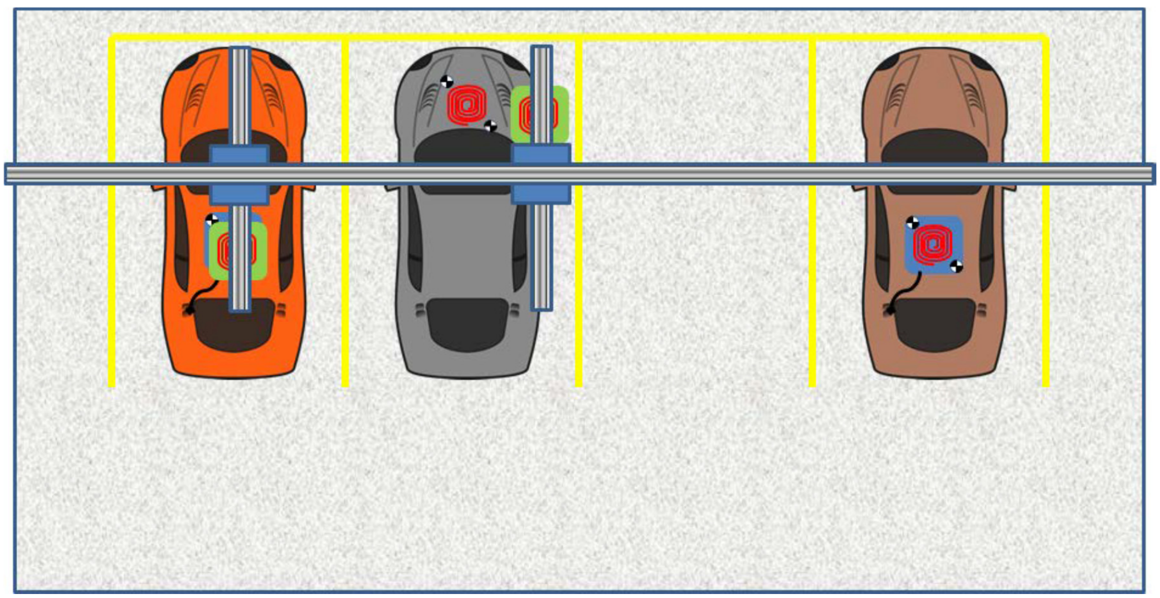

Figure 1

The horizontal bar shown over the parking spaces is a main track suspended from an overhead structure that supports the robots. The overhead structure could span hundreds of feet, cover tens or hundreds of parking spaces (although for simplicity, only four are shown here), and include curved sections, permitting the robots to serve multiple rows in large parking lots. The main track contains heavy power bus bars to supply energy to power the robots, and also supplies tens of kWs to parked EVs. Robots move left and right on the track using motorized wheels, rack-and pinion drives, etc. Two robots are shown as blue boxes with short orthogonal tracks attached. The short tracks permit the robot to move over the length of the vehicle (bumper-to-bumper) to adapt to different receiver coil locations. A trolley moves on the short track, which carries the wireless charging coil and charger electronics. The coil can be lowered from the trolley to a height that creates optimal coupling between the robot's WPT primary coil and the receiver coil on the vehicle.

In *Figure 1*, the red car on the left is currently being charged by the left robot. Note that there is a WPT receiver coil (shown by the blue outline) on that car's roof. The WPT primary coil (shown in green) is moved into alignment and lowered into close proximity of the receiver coil. The left robot has three degrees of freedom (e.g., left-right on the rail across the spaces, front-back along the length of the car, and up-down to lower the coil into place). Once in place, high power transfer (up to 100 kW) draws energy from the grid. Power flows through bus bars in the main rail, through sliding contacts into the robot, and down short cables to the primary coil, where the power is inductively coupled to the car's receiver coil to charge the vehicle. The right robot is shown as being in motion, slewing to the left to align with a charging coil molded into the hood of the gray car.

There are cameras positioned in the robot to align the primary coils with the receiver coils in the EVs. The cameras may use a fiduciary mark (in this illustration, the black / white circular targets, or alternatively, a bar code or QR code) to locate the exact position of the coil. Alternate alignment strategies are possible. Additional cameras on the robots and around the parking structure may take pictures of the vehicles to determine if a driver is present, or to detect vehicles in motion to avoid collisions between the system and moving vehicles.

The brown car, which does not originally have a WPT receiver built into its top surfaces, may be modified to fit an aftermarket receiver coil (shown in blue). The aftermarket receiver coil may be magnetically attached to the roof of the car, with a short power cable plugged into the EV's primary charging port. In places like airports or hotel garages, aftermarket receiver coils may be loaned or rented to allow almost any EV with a standard charging port enabling it to use the overhead robot charging system described herein.

Alternatively, instead of the main track being attached to the ceiling, the main track may be bolted to a side wall of the parking garage, and may extend the primary coil horizontally to meet a receiver coil in the front grill of the car. This configuration may be easier to install and maintain than a fully overhead system.

Another alternate embodiment may position the robot/robot arm near or at ground level, wherein the robot/robot arm rolls underneath the vehicle to charge the vehicles, which have coils underneath (not limited to top or side). In some aspects, this arrangement may leverage the gantry system of *Figure 1* to position the robot next to the vehicle, and may then allow the robot to roll underneath the vehicle. This arrangement has several advantages over other arrangements, including shorter cables which provide improved safety, and also reduce the likelihood of a cable or robot damaging a vehicle or a vehicle damaging the cable or robot.

In summary, the system converts parking spaces in a large parking lot into a structure capable of charging EVs without the need to equip all spaces with expensive charging stations or WPT coils. The system can charge a row of 20-100 vehicle spaces for the cost of about six standard charging stations using an overhead gantry system comprising a robot for charging EVs. Further, the system can balance the charging capabilities across a row of cars, optimizing energy transfer based on their needs. Additionally, a novel way to retrofit cars with WPT coils is also provided.