An autonomous system that can reach charge mobile robots without interrupting their missions

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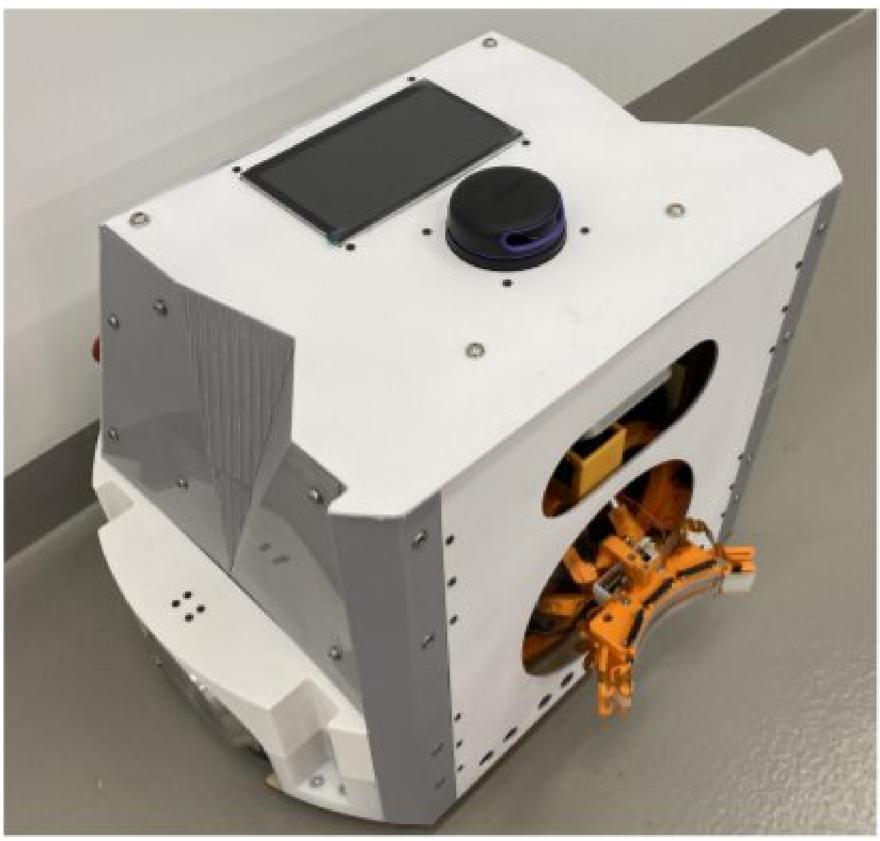

The prototype of MobileCharger. Credit: arXiv:2107.10585v2 [cs.RO]

Researchers at Skolkovo Institute of Science and Technology in Russia have recently developed MobileCharger, an autonomous robotic system designed to charge other robots as they complete their missions. This system, presented in a paper pre-published on arXiv, can transfer energy to mobile robots without forcing them to fly back to designated charging stations when their power is depleted.

"In a nutshell, MobileCharger is a mobile power bank for autonomous robots," Dzmitry Tsetserukou, Professor and Head of the Intelligent Space Robotics Laboratory, told TechXplore. "Can you imagine that soon thousands of delivery robots will travel through the city next to us? If one or several such robots are discharged, it will be the serious obstacle for pedestrian and traffic."

The general idea behind the recent study by Tsetserukou and his colleagues was to devise a system that can reach faulty robots or robots with a depleted battery power and assist them. The system they developed, dubbed MobileCharger, can charge robots as they are operating and trying to complete a mission, such as delivering a parcel or collecting data in a specific location.

"A delivery robot and MobileCharger can run as one unit until the target robot is fully charged," Tsetserukou explained. "Subsequently, MobileCharger detaches and goes to a new robot or charging station."

Aerial refueling (i.e., the provision of fuel during flight operation) allows aircraft to remain in the air longer and can lead to 35–40 percent fuel savings during long-range missions. The system devised by Tsetserukou and his colleagues may thus be highly valuable, as the deployment of several of these systems as a swarm could decrease the costs of robot missions and shorten the time a delivery robot takes to deliver items to a given location.

"Instead of losing time for traveling to the charging station, delivery robots can always be engaged in the mission," Tsetserukou said. "In the future, it will be also possible to create a MobileCharger energy harvester with integrated solar panel. This would mean that when the battery is near exhausted, a robot can simply move to a sunny spot and position solar panel towards sun light."

MobileCharger is the first robot that can directly charge other autonomous robots on the go. Its most characterizing component is the DeltaCharger, a system that can position electrodes in three-dimensions (3D) to sustain charging in situations where a target robot is not horizontally or vertically aligned to the charger. This could happen, for instance, when a robot is running over stones and other objects or when a robot's configuration does not allow it to be favorably positioned for charging.

"Computer vision systems are not as effective as tactile ones in detecting the electrode misalignment in close proximity," Tsetserukou said. "DeltaCharger has an advanced tactile perception, as it based on high-density pressure sensors provided by Professor Hiroyuki Kajimoto from University of Electro-Communications in Tokyo, Japan."

Tsetserukou and his colleagues also developed a convolutional neural network (CNN) that can evaluate the angle of misalignment between the electrodes on MobileCharger and those on a robot that requires charging. This algorithm was trained on a series of tactile patterns comprised of 100 points.

The team evaluated the CNN in a series of tests and found that it could measure the angle, vertical and horizontal values of electrode misalignment by analyzing pressure data with remarkable accuracies of 95.46 percent, 98.2 percent, and 86.9 percent, respectively. This means that the robot charging system they developed should be able to attach itself to a variety of robots with different configurations, irrespective of the environment they are in when they need charging.

"Besides the charging of mobile robots, a future application of the technology may be the charging of drones in midair, with a charging drone based on the DeltaCharger mechanism wired to the ground power station and a target UAV being recharged without landing," Tsetserukou said. "Innovative autonomous ships and tankers with electric motors could also be charged during sailing with the proposed concept, as this would prevent them from having to enter ports for refueling. Additionally, any types of robots such as robot dog, outdoor cleaning robots, and even self-driving cars can be charged in the similar way."

In the future, the innovative robot charging system developed by this team of researchers could be adapted to charge countless different robotic systems, ranging from autonomous vehicles to mobile robots. Meanwhile, Tsetserukou and his colleagues plan to continue working on the initial prototype they created to further improve its performance and generalizability.

"To increase the power of the electric source, swarm of MobileCharger robots can form parallel connection with increased capacity to charge powerful vehicles or series connection to adjust output voltage to the target vehicle," Tsetserukou said. "In the future, we can imagine that robots with cloud AI will not only charge but also repair the autonomous robots to make Roboverse (Robot Metaverse) self-sustainable."

More information: Iaroslav Okunevich et al, MobileCharger: an autonomous mobile robot with inverted delta actuator for robust and safe robot charging (2021). arXiv:2107.10585v2 [cs.RO], arxiv.org/abs/2107.10585

Iaroslav Okunevich et al, Delta Charger: Charging robot with inverted delta mechanism and CNN-driven high fidelity tactile perception for precise 3D positioning. *IEEE Robotics and Automation Letters*(2021). DOI: 10.1109/LRA.2021.3098838.