MagGrid: Non-Levitative Electromagnet Robot Propulsion Method for 2-D Material Handling

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Autonomous mobile robot (AMR) fleets are widely used in smart warehouses, distribution centers and manufacturing to bring operational efficiency, with their market projected reaching up to $18.9 billion by 2032. However, the cost of AMR fleets grows fast with more robots, since every robot requires complex onboard subsystems including navigation, communication, battery, etc. Their productivity also goes down due to the required intensive computing, slow avoidance, and downtime for the battery charging. The use of batteries is not environmentally friendly either. My goal is to develop a robot propulsion method for robot fleet with the robots themselves passive, thereby removing redundant onboard subsystems and improving fleet operation throughput, cost-effectiveness, and reliability. In this project, the propulsion mechanism and system architect were studied, resulting in a novel method of using radial magnetic forces of an electromagnet coil grid underneath to drive the wheeled robot platforms with embedded bar magnets. I custom-modelled the magnetic field and dynamics equation of the robot for use with the developed PD-based motion control algorithm and Hall-effect sensor-based localization method. The propulsion and motion control method were verified through the prototype and various tests to demonstrate the concept and application viability, including maximum speed, peak power draw, positioning accuracy carrying capacity, and stability in different motion configurations. Overall, this research for the first time presents a wheel-based non-levitative electromagnet robot propulsion method for robot fleets for large-volume material handling applications. Furthermore, this method can extend to other applications like assistive propulsion for cars.