Modular Magnetic-Tracked Robot for Ferromagnetic Surface Traversal

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Between 2020 and 2024, fatal occupational falls averaged 782 annually, peaking at 865 in 2022, according to Bureau of Labor Statistics data. Many occurred in high risk environments like skyscraper exteriors or large storage tanks. These tragedies could be prevented by using robots capable of navigating complex surfaces where traditional systems fail. Wall climbing robot technology is now being pioneered to replace human workers with programmable robotic systems for dangerous tasks. This project aims to design, build, and test a compact magnetic tracked wall climbing robot featuring modular plug and play payloads for environmental sensing, distance measurement, and visual inspection. Following a review of adhesion strategies and experiments with magnetic wheel designs, a specialized magnetic track was developed. To ensure the robot supports itself on vertical surfaces, kinematic static and dynamic force analyses were performed using Newton's 2nd Law of Motion, modeling magnetic force across varying weights, incline angles, and friction coefficients to identify the optimal weight where track adhesion matches the required magnetic force. The robot features a lightweight, cost effective body designed in Fusion 360 and 3D printed. It utilizes off the shelf components, including lithium polymer batteries, microcontroller, DC motors, sensors, and a solar panel. A fully functional prototype was successfully tested on metal surfaces at various angles and transitions while simultaneously performing measurements. The robot's small footprint enables access to large ferrous structures and confined spaces unreachable by existing industrial robots, making it ideal for inspection and diagnostic tasks on ferromagnetic structures such as pipelines, bridges, ship hulls, and wind turbines.

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