AI-Powered Magnetic Inspection Robot for Advanced Structural Health Monitoring of Ferromagnetic Structures

Tseng, Angelina (School: Santa Catalina School)

Over 130,000 aging steel bridges in the United States are at risk from corrosion and structural issues. More efficient and thorough inspection methods are necessary to avoid future disasters like the Silver Bridge collapse, which resulted in 46 fatalities due to an overlooked defect. Current conventional human inspections are prone to human error, and robotic inspection methods using drones and clamp-based robots have limitations including the inability to navigate in small spaces, and unadaptability to different surfaces. To address this, I engineered a robot utilizing magnetic ring wheels that allow for robust adherence to ferromagnetic surfaces of all configurations and created a deep learning image analysis model based on MobileNetV2 to automate the search for structural fissures. The robot achieved reliable omnidirectional mobility on diverse structural elements including internal and external corners, cylindrical surfaces, inclines and wedges. An Arduino Nano board controlling six servo motors enables it to adjust its steering angle, alter its center of gravity, and actuate two magnetic ring wheels. An ESP32-CAM with WiFi sends visual data to a central unit for analysis and receives movement commands from a mobile app through WiFi. The final machine learning model consists of 53 layers implemented with Pytorch based on Google's MobileNetV2 architecture to optimize the model for processing on mobile or weaker processors. The model was trained with 1600 images from the North Eastern University Steel Surface Defects Database and can visually identify six types of metal deficiencies with an 85.71% accuracy.