

Project Overview

Utility companies need to mark the location of buried utilities before the start of construction projects. Detecting and marking electrical cables is time consuming, monotonous, and can be dangerous for utility workers.

To solve these problems, a prototype semi-autonomous robot was created. The robot's operation was split into three main functions:

- Detect and follow a buried cable
- Mark the position of a buried cable
- Avoid static obstacles while localizing the robot in its environment

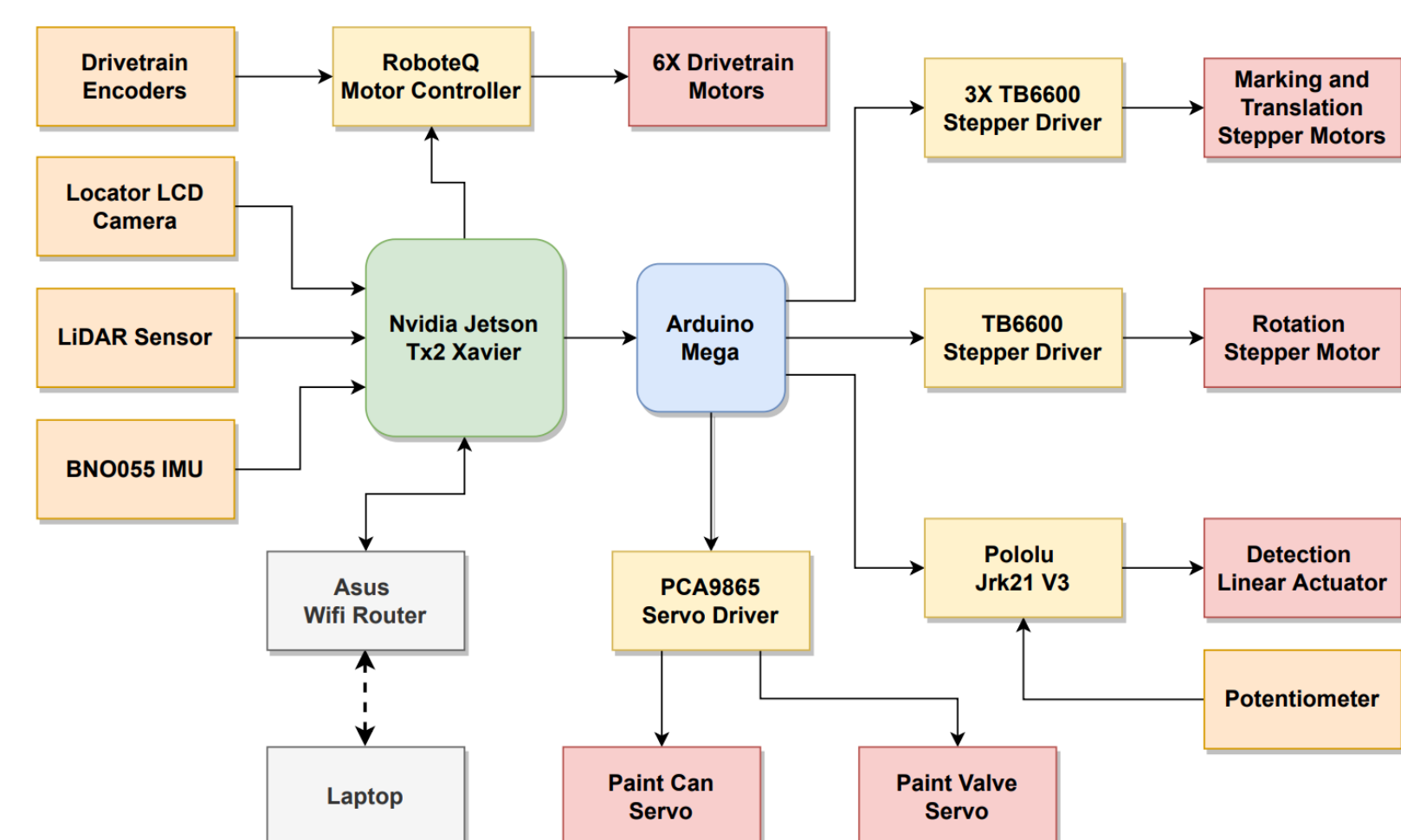
Chassis

The SuperDroid Robots HK1500 chassis features:

- The ability to handle rough and uneven terrain
- Off the shelf ROS integration
- External mounting options
- Large internal and external payload capacity
- Various internal voltage sources (5, 12, 24VDC)



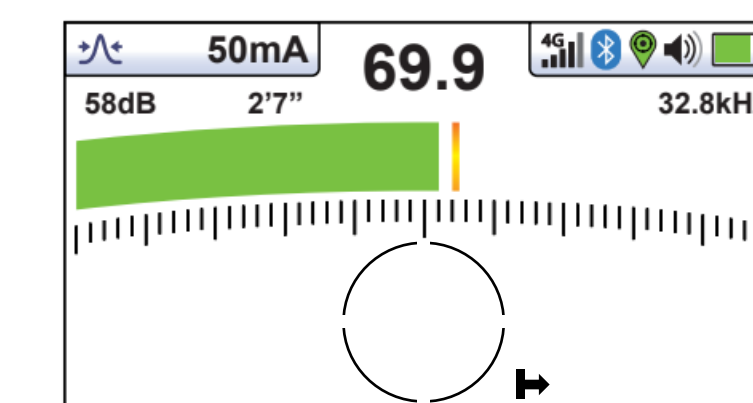
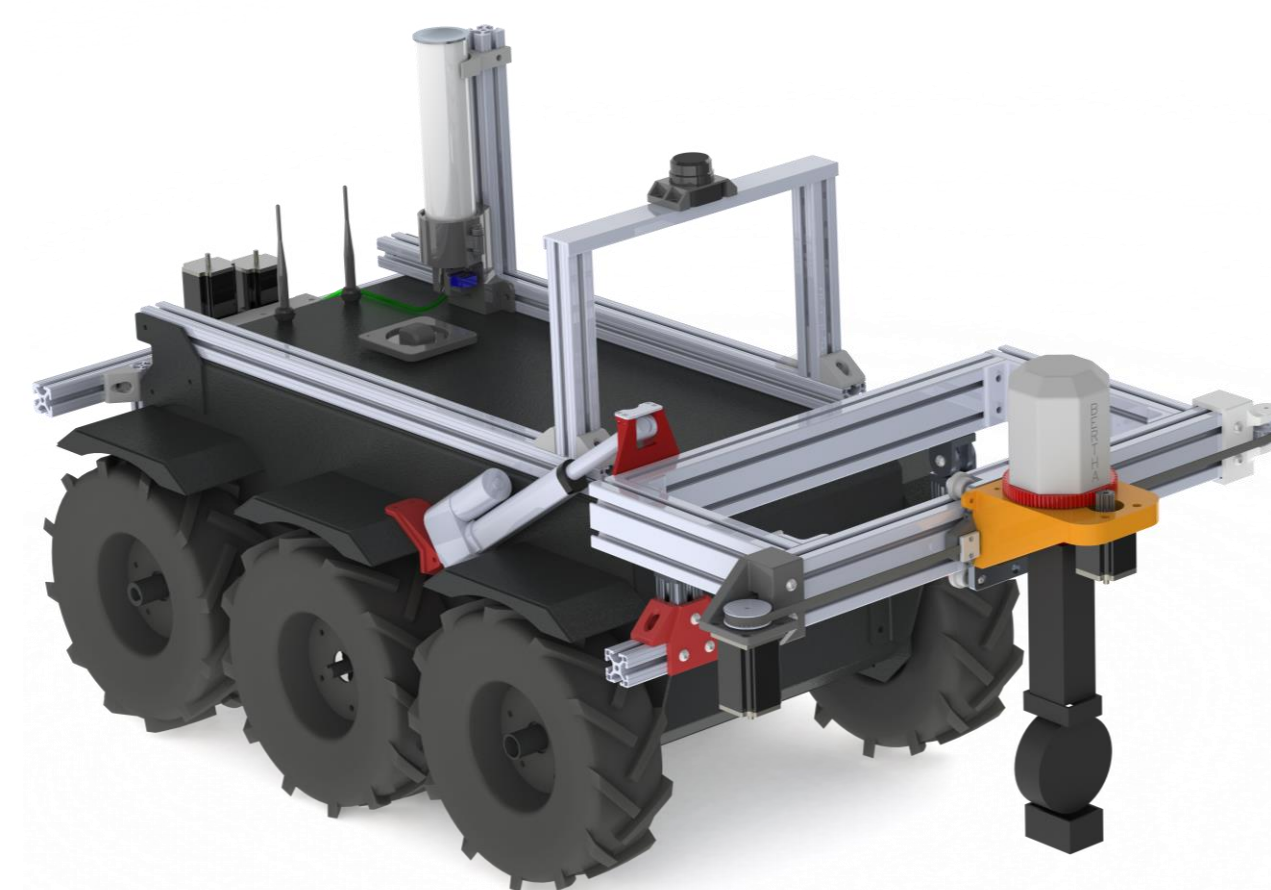
System Architecture



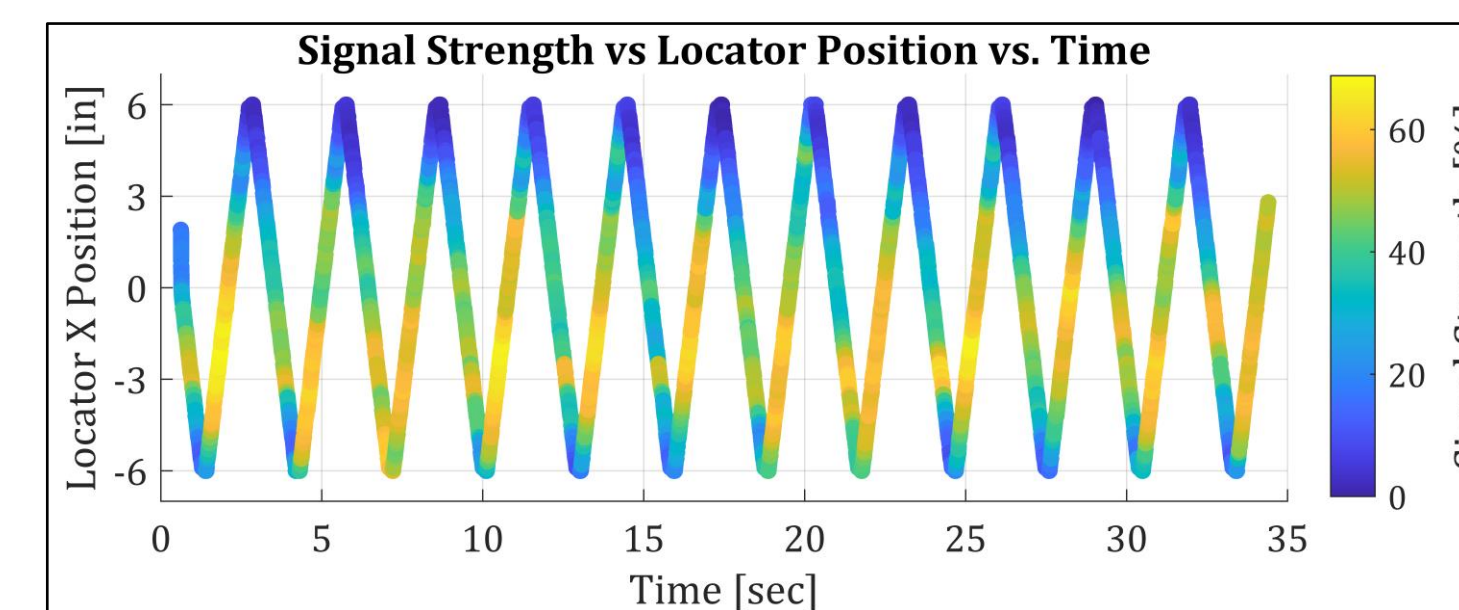
The system is centered around an NVIDIA Jetson AGX Xavier. Rosserial is used to communicate with an Arduino Mega.

Detection

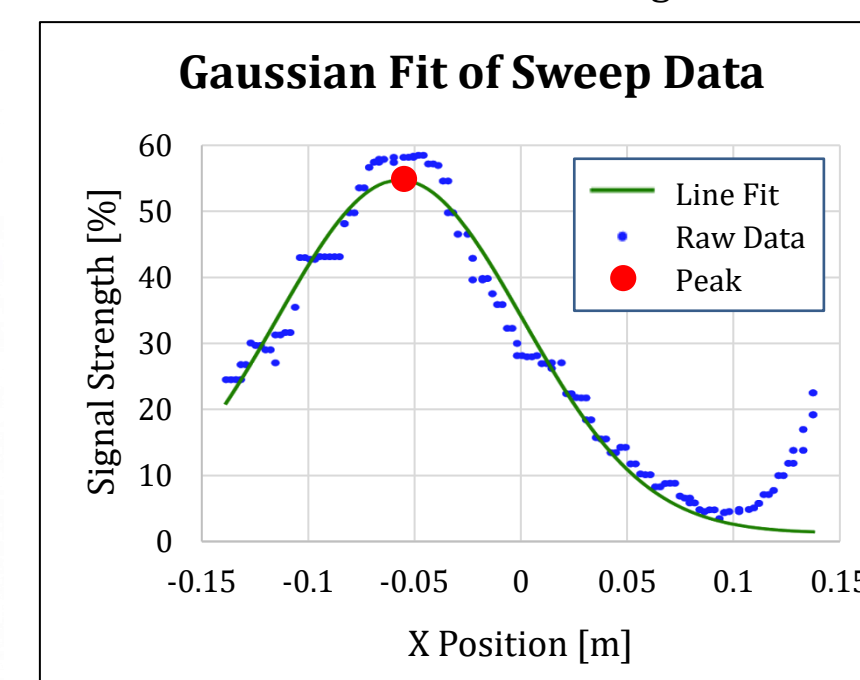
- Industry standard cable locator detects electromagnetic frequencies from AC cables
- Locator is mounted to a belt-driven carriage
- NEMA 23 motors translate and rotate locator
- Translation system range of motion: 17.5 in
- Translation system max speed: 13.2 in/s
- Rotation range of motion: 180 degrees
- Locator's induction coils distanced from chassis to reduce EMI from drivetrain motors
- Algorithm fits Gaussian curve to locator readings to determine signal peak



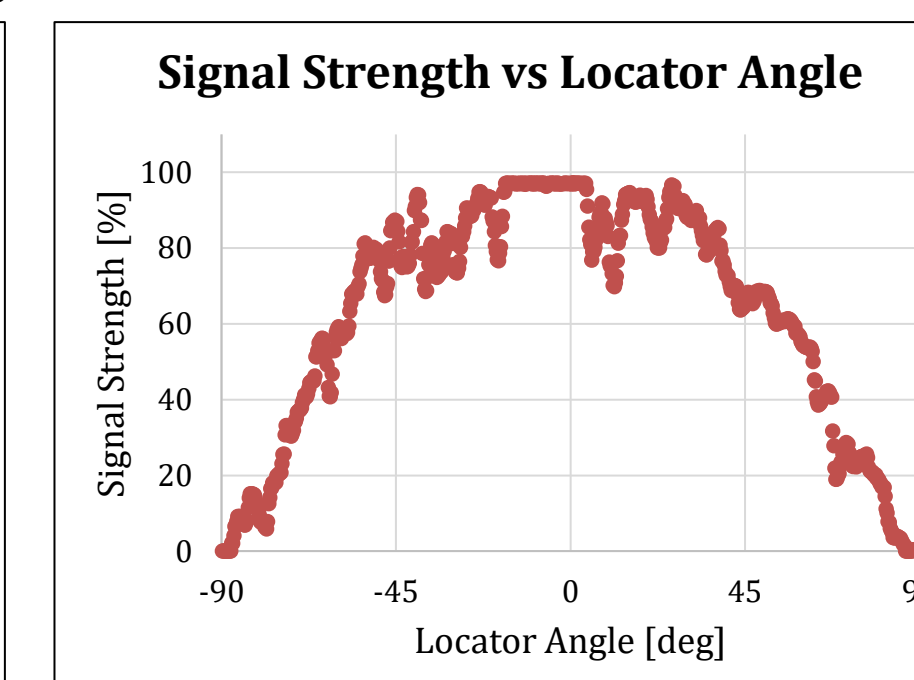
Internal webcam monitors signal strength bar on locator's LCD screen



Plot showing the cable signal as the robot drives forward



Gaussian curve and peak being fit to a single locator sweep



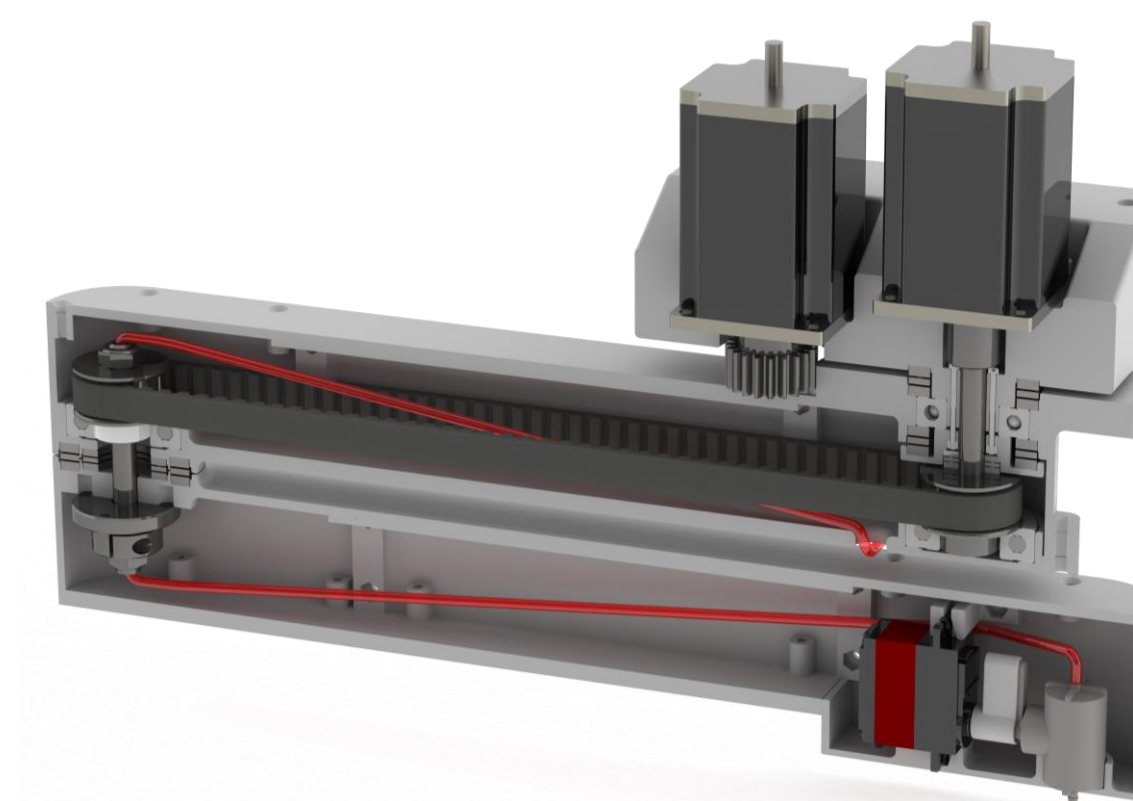
Orientation relative to a cable affects the locator's signal strength

Marking

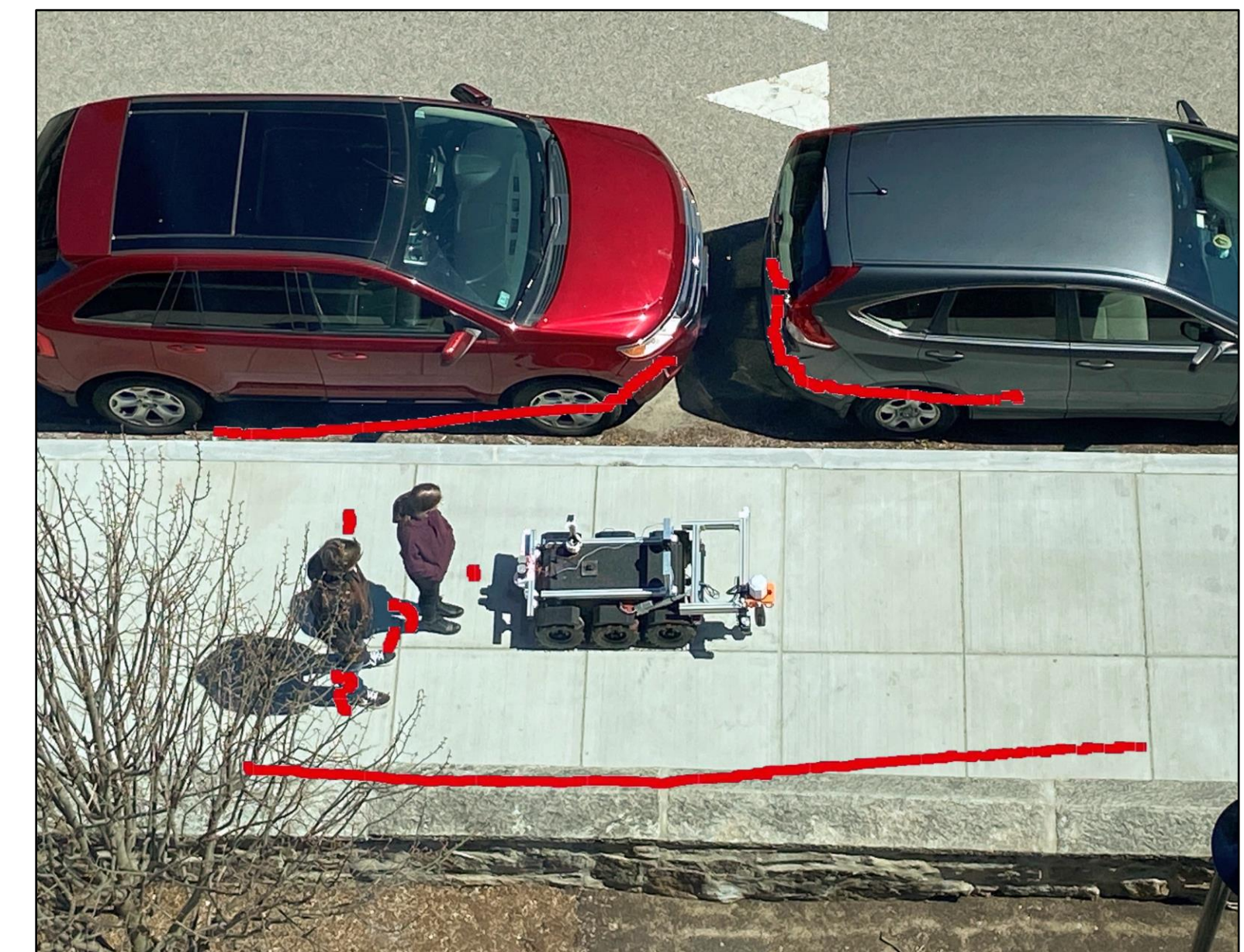


An 8-inch diameter circle is drawn over the detected cable. Next, two 18-inch-long lines are drawn 15 inches from the center of the circle parallel to the cable. This marking is created every 20 feet along the cable's route.

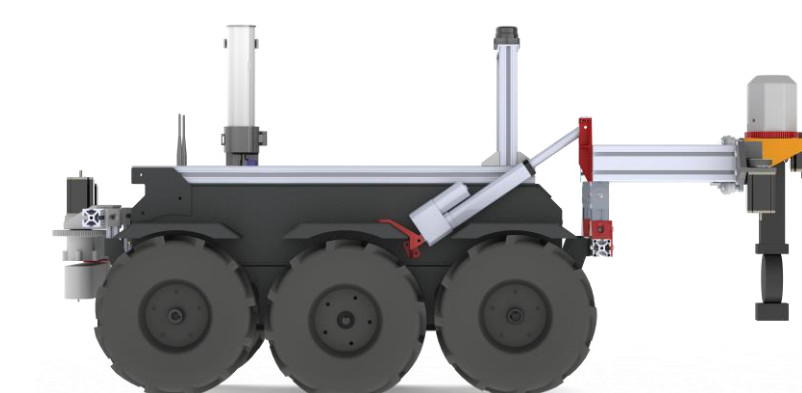
- NEMA 23 motors actuate 2 Degree of Freedom (2DoF) linkage
- First link is gear driven (1:4 gear ratio)
- Second link is belt driven (1:1 pulley ratio)
- Spray paint can is mounted inside holder on top of the robot
- Servo depresses can nozzle to pressurize paint tube
- Paint released by servo operated valve at end-effector
- Nozzle of spray paint can is connected to PVC valve using pneumatic tubing to transport the paint to the end effector



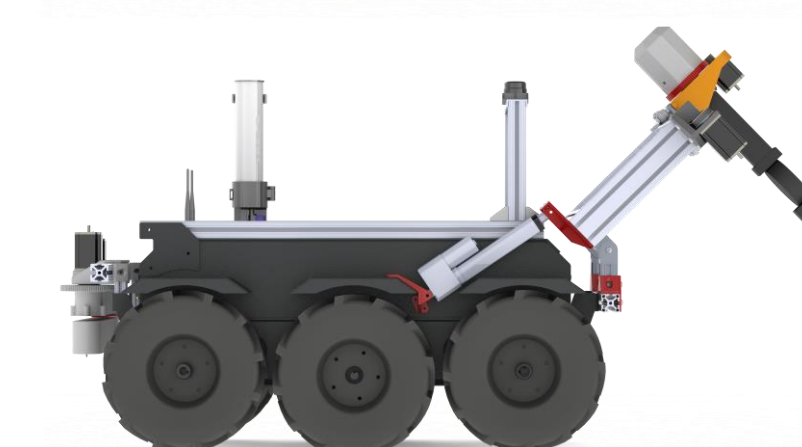
Navigation



A 2D LiDAR detects large obstacles in the robot's path. A GPS, an IMU, and encoders are used to localize the robot.



Detection system tilted downward to detect cables (5.75 inches of ground clearance)



Detection system tilted upward to avoid collision with obstacles (20 inches of ground clearance)

Future Work

Further work includes increasing the speed and reliability of cable following and navigation algorithms, software development to manage GIS mapping and aid in human-robot interactions, replacing the current cable locator with a more robot-friendly one, and the addition of sensors to allow for detection of low-profile obstacles.

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