Multi-Modal Sensor Platform for Low-Cost Detection of Landmines

clearfield robotics

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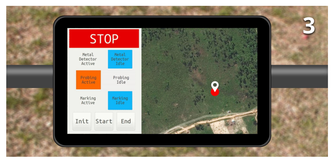
Problem Statement

- 100 million+ landmines are currently buried around the world. The rate of clearance is lagging behind the rate of burial
- Current humanitarian mine clearance methods are dangerous and the investigation of false positives is time-consuming
- Repurposed military equipment is often too complex or costly for the limited budgets and resources of humanitarian demining organizations

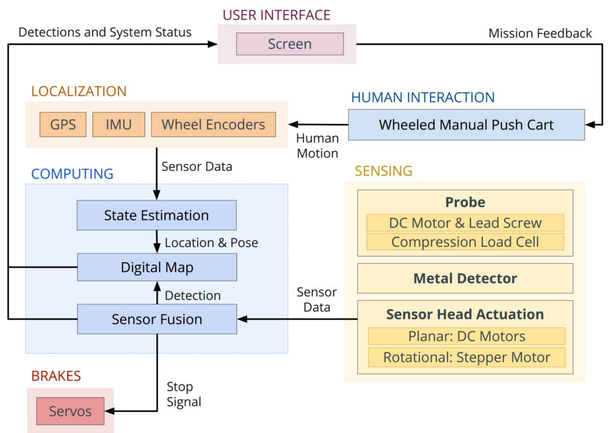
Use Case

How would a team of deminers use our platform in the field?



System Architecture

A description of the flow of data between system components



Vehicle Design

✓ Installed a custom sensor head onto field-proven Scorpion push-cart used on humanitarian demining missions

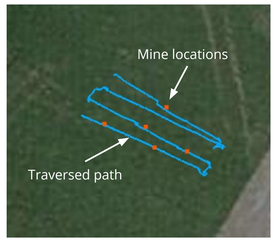
✓ 3 DOF gantry permits inspection coverage of 1m lanes

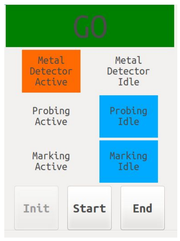
✓ Brakes activate within 0.25s of initial target detection to prevent operator advancing into danger

✓ Sensor head and electronics cost <$5000

✓ Components weigh <50kg and are able to be lifted by two people

Localization & User Interface

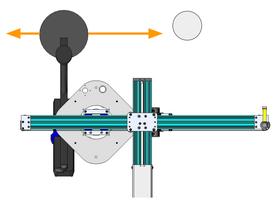




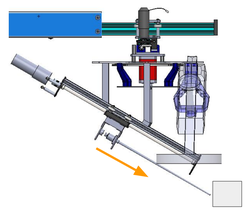
✓ Extended Kalman Filter fuses data from GPS, IMU and wheel encoders to provide localization of vehicle and detected targets within 1m accuracy

✓ Touch-screen Graphical User Interface presents system status, command interface and warning signals to user

Sensing & Classification



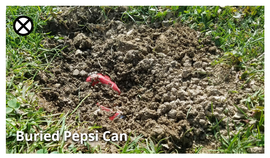
A Minelab F3 metal detector is swept laterally at 1m/s and two slow passes are made in the longitudinal and lateral axes to pinpoint the mine

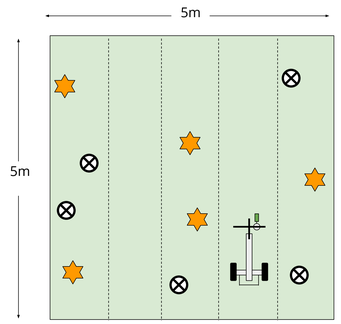


Custom-designed assembly probes ground at 30° to avoid contacting the trigger plate and contact points are fit with RANSAC to determine mine shape

Validation Experiment

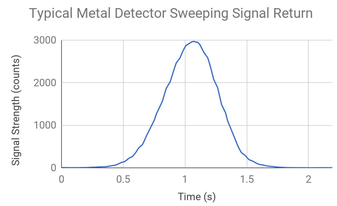
An overview of the setup of the Spring Validation Experiment

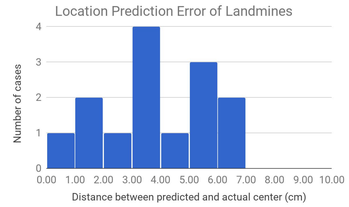




Results

An overview of the results of the Spring Validation Experiment

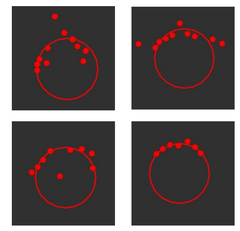




✓ In test field, correctly classified 100% of mine targets correctly and 90% of non-mine targets correctly

✓ Located mine targets to within 10cm

✓ Did not 'detonate' any mines during probing



Conclusions

- High variability in soil type and weather conditions are the primary challenges for subsurface probing
- Modular software architecture and hardware-in-loop simulations were vital to successful system integration
- Building custom hardware was necessary but was very time-consuming
- Low-cost sensing solutions for humanitarian demining warrant further research
- *Future work*: Expand database of probe contact data in a variety of soil types and objects for data-driven object classification