

2024-2025 UCSB Senior Capstone Project

Drone Based Ground Penetrating Radar for buried item/wire detection.

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Introduction: Scientists and engineers at HRL Laboratories, LLC (previously known as Hughes Research Laboratories, established in 1948) have been on the leading edge of technology, conducting pioneering research, providing real-world technology solutions, and advancing the state of the art. Our research collaborations with our LLC Member companies (General Motors and Boeing), government, commercial and academic institutions are realizing groundbreaking advances in ultra-high-performance circuitry, robust computing and communications, automated data extraction, and innovative architected materials. Our technologies operate in space, on aircraft, in automobiles, and in a variety of consumer products.

Background: Ground-penetrating radar (GPR) is a surveying method for subsurface features and structures based on scattering and refraction behaviors of radio waves interacting with materials beneath the ground. Typically, these systems operate at lower frequencies as longer wavelengths to penetrate further underground. As emerging and maturing markets such as 5G and automotive radar are driving down price for higher frequency electronics, HRL would like to explore the possibility of leveraging these low-cost devices to expand into new areas, such as GPR. These higher frequency devices are smaller and lighter, and open new possibilities such as drone mounted operation and higher resolution. Though higher frequency operation poses technical challenges, new techniques in data acquisition, processing algorithms, and novel system architectures may enable a useful product. A low-cost, mobile, and agile GPR system would have large implications for IED detection, wire surveying, and many other areas.

Project description:

The scope work for executing a fully functional system to accomplish this whole project is likely too large for a single team over the course of a year. HRL will work collaboratively with interested project groups to define subprojects that are more appropriate in scope for a Capstone development effort. HRL & interested students will develop:

- Project scope for an effort in this area
- Key metrics and requirements for development efforts
- Available resources & HRL mentorship/collaboration structure

If some part of this overall problem fits a team's interests and skillsets, please brainstorm a few potential focus areas and we can work together to curate a project in this area. A well-defined project in this area should seek to:

- Capture system design challenges from at least one engineering focus area. For this effort these include but are not limited to:
 - RF System Design & Prototyping
 - Radar System Design & Processing (SAR, FMCW, Bistatic operation)
 - Antenna Design
 - Spatial Navigation & Drone Control
 - Digital Signal Processing
- Have a project scope that addresses a key technical challenge, is separable from the larger effort, and that is easy to build upon in future works.
- Have a demonstratable output product.

Reference:

- https://www.researchgate.net/publication/252417436_Millimeter_wave_imaging_system_for_the_detection_of_nonmetallic_objects
- https://www.researchgate.net/publication/336225278_Bistatic_Landmine_and_IED_Detection_Combining_Vehicle_and_Drone_Mounted_GPR_Sensors