Edge Computing on GPUs for Ground Robotics

ELECOMP Capstone Design Project 2025-2026

Sponsoring Company:

The Charles Stark Draper Laboratory, Inc.
555 Technology Sq
Cambridge, MA 02139
https://www.draper.com/

Company Overview:

As a nonprofit engineering innovation company, Draper serves our nation's interests and security needs; advances technologies at the intersection of government, academia, and industry; cultivates the next generation of innovators; and solves the most complex challenges. Multidisciplinary teams drawn from a broad and deep pool of 1,300 engineers and scientists collaborate to develop first-of-a-kind solutions. Our unbiased approach enables us to focus on our customers' needs and to deliver new capabilities to them.

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Technical Director(s):

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Project Motivation:

We are a leader in the design, development, integration, and testing of algorithms and software for autonomous systems. We have developed reusable autonomy architectures that enable full mission autonomy for single- and multi-agent applications across many complex domains: underwater, terrestrial, aerial, and space. We are looking for a motivated student team to support the development of a swarm of compact ground robots to collaboratively explore and map a cluttered indoor/office environment.

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Anticipated Best Outcome:

The goal is to create an edge compute infrastructure and demonstrate swarm autonomy.

Milestones:

    a. Baseline:
         i. 2D SLAM
         ii. centralized map fusion
         iii. visual mark detection

    b. Advanced:
         i. Robot teaming with shared navigation logic (2+ robots)

    c. Stretch:
         i. 3D map generation via stereo/monocular camera
         ii. CUDA acceleration for image/depth tasks

Draper will provide system level requirements and provide hardware resources needed to create the prototype system. The student team will have weekly correspondence (i.e., email, phone calls) with the Sponsor's Project POCs at a time that is mutually agreed upon. In addition to the technical directors, students will have access to additional subject matter experts from Draper as needed.

Project Details:

This project introduces modular, stretch goals as following:

1. Centralized or semi-centralized swarm coordination, where each robot navigates locally but contributes to a shared global map
2. Stereo vision or monocular depth estimation to construct 3D representations of indoor environments
3. CUDA acceleration for real time visual perception, depth estimation, or map merging on each robot.

The robots will be equipped with IMU, wheel encoders, and camera modules, and will send sensor and mapping data to a central server. The system will support exploration tasks such as:

- Searching for localizing visual marks or objects
- Annotating the environment with semantic tags (Ex. obstacle vs passage)
- Reconstructing a scene with 2D/3D spatial layout useful

Hardware:

- Open-Source robot with Nvidia Jetson Nano: https://jetbot.org/master/index.html

Hardware/Electrical Tasks:

- Assemble bill of materials
- Create schematics of components
- Assemble robots and perform integration testing

Firmware/Software/Computer Tasks:
- Create drivers for hardware interfaces
- Design network between robot nodes and central servers
- Architect and develop autonomy software
- Create application to process image data
- Benchmark performance and optimize

Composition of Team:

1 Electrical Engineer (Preference will be given to an ELE who can ALSO do the Firmware/Software/Computer Tasks above.

1 Computer Engineer

US Citizenship Required

Skills Required:

Computer Engineering Skills Required:
- Embedded software
- Autonomy topics (SLAM, path planning)
- Edge Computing
- C/C++
- DSP
- CUDA
- OpenCV
- Electronics

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Anticipated Best Outcome's Impact on Company's Business, and Economic Impact

Successful demonstration of edge computing with an autonomous system will increase Draper's edge computing capability which will enable Draper to pursue additional contracts for novel solutions in the area of national security.

Broader Implications of the Best Outcome on the Company's Industry:

Autonomy platforms and the ability to collaborate effectively help remove humans from harm. Autonomous systems scale at a fraction of the cost of a human and provide better situational awareness by collecting data at larger scales.

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