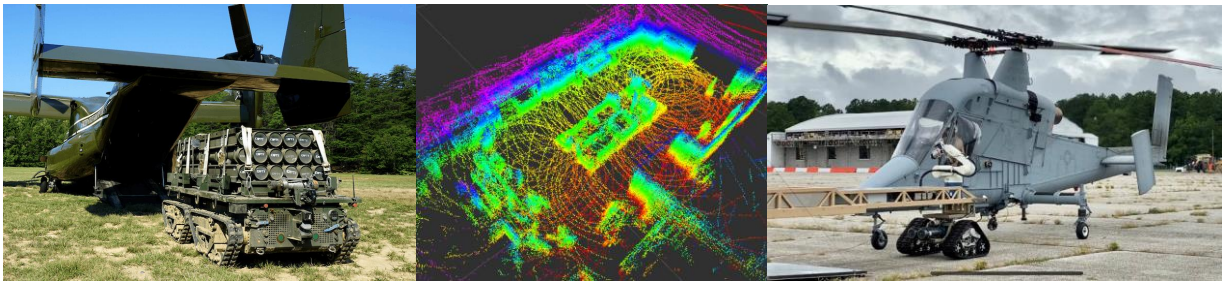
Robust 3D Template Matching Algorithm for Autonomous Perception



Company Background:

At Stratom, we are driving the future of automation by developing unmanned ground vehicles and autonomous robotic systems for commercial and defense applications — whether in safe, controlled settings or dynamic and challenging terrain.

Specializing in unmanned cargo movement, autonomous mobile robots (AMR) and robotic refueling, our proven tools, methods, technologies and strategic services continuously meet our customers' unique and evolving needs in logistics and operations. Our solutions enable them to reduce monotonous, difficult or dangerous tasks to optimize uptime and efficiencies, address labor shortages, increase profitability, and keep people safe.

Project Description:

In many robotics applications, including those at Stratom, accurate processing of 3D data such as point clouds is essential for precise object recognition and spatial awareness. Template matching is one of many widely used algorithm for achieving this goal. The practical use of template matching in real world scenarios, however, often requires extensive preprocessing to achieve consistent and timely results, which can be highly situation-dependent. The challenge is to develop an algorithm that can autonomously match a template to a part of a large point cloud with minimal preprocessing, making it robust and adaptable to varied environments.

This project focuses on creating a robust 3D template matching algorithm for use in real world robotics applications. This algorithm will be capable of taking a large point cloud of the world around a robot and accurately matching a template within that cloud. For example, imagine scanning an entire car, having a 3D model of a tire, and having the algorithm identify and segment just the tires from the larger scene without intensive and context-specific preprocessing. Although template alignment algorithms exist, achieving reliable performance in diverse and dynamic settings remains a significant challenge and will be a large focus for this success criteria of this algorithm.

Students will develop an algorithm that accepts a template (either a point cloud, a 3D CAD file, or some other data type that students deem useful) and a scene point cloud, then matches the template to the scene. They will work with real-world and/or simulated data provided to students in ROS2 bags. The algorithm will be implemented within a ROS2 node and will be benchmarked on an Nvidia Jetson provided to the students for the duration of the project. Students will need to build practical unit tests for their algorithm, report on the accuracy of their algorithm, the processing time required to handle point cloud scenes, and the algorithm's ability to work in dynamic and varied environments.

Project Objectives:

- Research existing algorithms and tools for 3D template matching
- Develop an algorithm for template matching in point clouds that requires minimal preprocessing
- Implement the algorithm in a ROS2 node and deploy onto an Nvidia Jetson.
- Test the algorithm on data provided in ROS bags, write practical unit tests, and report on algorithm accuracy and processing times
- Ensure the algorithm works consistently in varied and dynamic environments

Desired Skillset:

- Point cloud processing, computer vision, and/or machine learning techniques
- Applied math for point cloud analysis, such as linear algebra, the implementation of RANSAC, etc.
- C++, Python
- ROS2
- Linux
- Docker

This project provides an excellent opportunity for students to leverage their foundation in C++ or Python to develop skills in computer vision, object localization, and applied mathematics. Students will gain hands-on experience in integrating perception algorithms into a robotics-focused software stack and acquire practical skills needed to translate theoretical algorithms into functional applications in the context of autonomous robotics. While experience in all of these skills is not strictly required, students should be up for the task of fast-paced learning in these areas.

Team Size: 3-4 Students

Location:

Meetings will primarily be held remotely using Teams or Zoom. Our office is located in Louisville at 331 South 104th Street, Suite 235. Students are welcome to visit to see the autonomous robots that algorithms such as theirs may be deployed on.

Note: All intellectual property developed as part of this project will be owned by Stratom.