To: Professor Pisano

Team: 10

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Subject: Customer Installation Report

Customer Installation Report

Draper Convoy

By

Team 10

Team Members

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Details of Customer Installation

Our customer installation included the presentation and attendance of the Draper Labs Capstone Symposium on April 17th, 2025, where our mentor for the project joined us as we presented our project and our project poster before a panel of judges from the company. Our entire team was present during the symposium, and each person had a role to play during the presentation. Overall, our presentation went well as we gave a comprehensive report on our success in delivering the system requested.

Requirements

Original Expected Solution from client:
Included in Final Product:
Skipped/Eliminated:
Modified: (see *footnote))

- **Sensor Characterization:** Well-calibrated sensors (cameras, IMU, lidar, etc) are essential for target recognition, tracking, and obstacle avoidance.
- **Automated Target Recognition (ATR):** Recognize fellow convoy members (including the leader) with transfer learning from an existing deep network such as ResNet18 *4, vision-based filtering of ATR false positives and overlapping detections, and (optionally) image segmentation. The ATR system should output a bounding box and confidence level for each detection.
- **Tracking:** The tracking system should output an estimate of the position and velocities of each ATR detected object's center of mass, using computer vision (optionally fused with other sensor information). *1
- **Obstacle Detection:** vision, lidar, or a combination of the two should be used to determine the system's distance from obstacles. *2
- **Control:** The visual servoing & path planning systems should integrate motion primitives that govern the wheels with target tracking and obstacle detections in order to achieve safe, robust, and preferably energy-efficient autonomous follow-the-leader driving behaviors.
- **Integration & Testing (I&T):** All systems must work together in order for this convoy to work. ROS 2 provides a framework for sharing information and commands among the systems within a robot and potentially across members of the convoy. Each system must also be rigorously tested before and after integration into the working whole in order to identify failure points, improve fault tolerance, ensure usability, and measure performance.

- **Miscellaneous:** Depending on the team's interests, their focus could shift to emphasize any subset of these objectives. Time allowing, this project could also be extended to integrate an open-source simultaneous localization and mapping (SLAM) system, state estimation, or additional swarm/teaming behaviors *3.

*1: Our tracking system outputs an estimate of *distance* and *angle* to each ATR-detected object instead.
*2: We utilize the Nav2 ROS Stack to perform obstacle detection and avoidance. Intrinsically, this uses LIDAR data.
*3: Although we didn't achieve full swarm behavior due to our constraint of 2 turtlebots, we did achieve teaming/following behavior where one will follow the other.
*4: We used a YOLO architecture instead.
Added features developed (not asked by client):

- Dynamic motor control mode switching based on distance to target
- Follow-around-corner relocation behavior
- Tracking incorporates a flexible tracking object that can be utilized by any human (vest)

Overall assessment of product installation testing

Our product was installed successfully, with every mandatory feature implemented and with some stretch goals like implementing SLAM into our system. At the symposium we presented our client with a video of the full functionality of our product in action and she was thrilled that we had managed to complete all the objectives. Our client was most impressed that we had managed to hit every goal and had the product operational because of the product including so many parts like navigation, obstacle avoidance, target recognition, and SLAM. She had previously worked with a team on a similar project that only included the navigation aspect of our project which made our proof of functionality all the more impressive. During the symposium at Draper we presented not only how we accomplished all our goals but how our product could be used, in hospitals to follow patients and monitor them, in a warehouse for helping distribute items, and as lab assistants carrying items for researchers, just to name a few. We discussed with our client the next steps this project could take and agreed that expanding the convoy functionality by having more Turtlebots and increasing the number of convoy shapes. Currently we have a single file line convoy behavior but a triangular or rectangular behavior could be added for different uses of the product. She thought these were great ideas and may have other teams build on this work for future products.

Customer Acceptance:

We attended a symposium at the client headquarters (Draper) and showcased our final product through a poster presentation. Although we didn't receive a written email of our client's acceptance, we got their verbal approval of our project during this symposium.