Lab 6
Leader-Follower using Computer Vision in ROS

March 31, 2022

Learning Objectives

1. Program a single-board Linux computer for an embedded application.
2. Utilize the Linux operating system, including its command line interface (CLI).
3. Leverage the usability of ROS and its libraries for the rapid development and prototyping of embedded systems.
4. Learn the fundamentals of computer vision through the use of an application programming interface (API) for image processing.
5. Learn how to interact and control a small, mobile robot such as the Turtlebot.
6. Network a remote workstation to a mobile robot within the ROS environment so that messages can be wirelessly exchanged between nodes on either computer.
7. Leverage pre-existing hardware drivers and other nodes in the ROS repository and integrate them together with custom-written nodes as part of a robot application.

Overview

For this lab, you will use the Pi Camera or similar USB camera to detect path boundaries and perform leader-follower behaviors for 2 mobile robots.

The term *leader-follower* refers to a type of movement formation where robots autonomously follow the path set by a leader. Recent advancements in leader-follower technology reduces the resources necessary for navigating a team of vehicles to a destination. For example, the U.S. Army is interested in employing the capability for autonomously moving logistical supplies in hazardous areas[1]. For a robot to exhibit a follow-the-leader behavior, it requires the integration of various sensors and a control algorithm that responds to these sensor inputs.

Lab Requirements

Program a leader robot to follow a lane using computer vision and simple controller. Program a second robot to follow the leader using computer vision and a simple controller. The robot should

[1]South, Todd, *Robot truck convoys? The Army's been doing that for years.* `https://www.armytimes.com/news/your-army/2021/10/06/robot-truck-convoys-the-armys-been-doing-that-for-years/`

follow the leader, while attempting to maintain a nominal separation distance of 3 feet.

- The Turtlebot3 will be used as the robotic platforms.
- A Pi camera will perform the image processing for detecting the position and size of the leader's signature. The leader robot will have a colored rectangular plate attached to its rear for the purpose of assisting the follower in detecting its movement.
- Design a simple method for controlling the steering and throttle of your robot.
- The robot must be able to detect and follow a leader's movements, including curves and turns of nearly 90 degrees.

Deliverables

- Demonstrate the leader successfully navigating the configured path setup by your instructor and the follower successfully following the leader.
- All code should be included in the appendix section of your lab report.
- Record a video of your leader-follower robots following the designed path.

Scoring Matrix

To receive maximum credit on the group demo portion, the follower robot must meet the specifications listed above and summarized below.

- **10 pts:** Controller systems didn't work, but some level of effort was apparent.
- **20 pts:** Moved toward the leader at times, but exhibited significant or repeated separation and detection problems.
- **30 pts:** Demonstrated speed and steering control functionality while robot was on a stand by moving a signature object in front of the camera. However, the robot failed to reliably track a leader robot.
- **40 pts:** Mostly followed the leader near the specified distance, but exhibited one or more of the following issues: failed to respond to changes in leader speed, failed to follow the leader around turns, or struck the leader during testing.
- **50 pts:** Robot did not exhibit any follower issues during instructor testing to include turns and changes in speed. Additionally, controllers seemed to have a rapid response to leader changes in movement.