ENPM673 Perception for Autonomous Robots (Spring 2024)

Final Project – Turtlebot Challenge

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Submission guidelines:

- This homework is to be done and submitted individually.
- Your submission on ELMS/Canvas must be two files:
    a. Zip file containing all the files(both simulation and hardware interaction script)(.zip)
    b. Report (.pdf)

  following the naming convention ***YourDirectoryID_final_project***.
- If your email ID is **abc@umd.edu** or **abc@terpmail.umd.edu**, then your Directory ID is **abc**.
- Submit both the files in one attempt.
- Provide detailed explanations for each significant step in the Report
- Ensure the code is well-formatted for readability.
- Comment on each section (preferably every 2 lines) of the code to explain its purpose and functionality.
- Include relevant output images within the text cells where required.
- Include explanations to illustrate the results effectively.

Problem Statement:

In this final project option, you are going to implement a working intelligent robot using the Turtlebot Waffle-Pi hardware provided by the Robotic lab. By doing this project, you will gain a decent hardware experience and exposure to the Robotic lab capabilities.

The provided Turtlebot is equipped with a color camera and it is the primary vision sensor. The onboard lidar sensor should not be used. Since there are four subtasks in this project, each team should have four members.

Note: You have to use ROS2 Humble.

Perception (and Planner) Challenge

1. **Projective Geometry (25pt):**
    a. Sense: Two or more sets of parallel lines on the floor. Note, you only need to do this once at the starting location, since the horizon line does not change throughout.
    b. Act: None
    c. Grading: Overlay the vanishing points and the horizon line on the image display.
2. **Homography (25pt)**:
    a. Sense: Road lane markings (8.5”x11” papers) Note, you will need to do this periodically to update the path throughout to update the route of the planner.
    b. Act: Follow the curvature of the road
    c. Grading:
        i. Step 1: Use homography to obtain and show the top-down view of the road and use your planner from ENPM661 to follow the waypoints along the road.
        ii. Step 2: Follow the direction of the lane markings. The direction is defined by the longer edge of the paper.
3. **Object Detection (25pt)**:
    a. Sense: Stop Sign anywhere in the FOV
    b. Act: stop
    c. Grading: Overlay a bounding box around the stop sign in the image.
4. **Dynamic Obstacle / Optical Flow (25pt)**:

a. Sense: fast moving obstacle (note: fast means faster than the vehicle motion / ego motion)
b. Act: stop or keep going (must justify)
c. Grading: Show optical flow or overlay a bounding box around the moving object. Also indicate the object is above or below the horizon line.

The students will start working on this project during the final month of the semester, which is April 15 to May 14. A gazebo simulation github will be provided for the student to develop and test their code. The students will have access to the Robot lab and the Turtlebot hardware during this period to test the overall hardware integration.

The gazebo simulation github can be found at:
https://github.com/TommyChangUMD/ENPM673_turtlebot_perception_challenge