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Developing a Self-Navigating Robot to Map Disaster Regions

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RCEU 2022 Project Proposal

Project Title

Developing a self-navigating robot to map disaster regions

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Instructions are on the last page.

I. Project Description

Figure 2: robot with LIDAR

Figure 2: Sample LIDAR scan s

First responders usually have a difficult task of searching for survivors after a natural disaster, such as an earthquake. A robot or better yet, a group of robots can autonomously navigate the region and cooperate in building a map of the region and locate survivors. This is similar to an on-demand "Google maps" for first responders to quickly plan out their rescue operations to reach the survivors. To this end, the goal of this research project is to develop a self-navigating autonomous robot that can build a 3D virtual map of the environment. Figure 2 shows an example of the robot that will be built by the students along with a mounted Light Detection and Ranging (LIDAR) sensor, that scans the surroundings and produces an image as in Figure 1. Students will then use the robot to create a 3D map of some UAH buildings.

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties

Our research group will purchase the basic robot base that contains the batteries, wheels, and a platform to mount any required computing hardware and sensors. We will also purchase the LIDAR sensor, a mini-computer, connecting cables and mounting hardware. The specific student duties are: (1) Assembly: Students will have to follow the instructions to mount the LIDAR sensor, connect cables, power up the robot, test and validate the proper functioning of the robot. (2) LIDAR setup: The LIDAR sensor will have to be connected to the computer and the onboard power source. The sensor will also require calibration. (3) Control: Students will have to setup an Xbox wireless controller or a simple RF controller. Students will control the robot with the wireless controller. (4) Data recording and animation: Students will have to navigate the robot at UAH buildings, record data and display the results as an animation. (5) Theory and Programming: Students will have to study some basics of mathematics, engineering, and programming, as required for the project. Students will meet and work closely with the me and my graduate students to gain required skills to accomplish the above duties.

b. Tangible Contributions by the Student to the Project

Student contributions are very much an integral part of this research project. The students will assemble the real-world working robot and use it to record LIDAR scan data around UAH buildings. This is crucial to the project as my graduate students, and I will simultaneously be working on this collected data. Students will calibrate the sensors on the robot, thus ensuring that the gathered data is consistent. All the data will be hosted on my website and will be shared for researchers around the world. Students will be appropriately acknowledged here for generating this research data. Students will also develop visualizations of the 3D LIDAR points, a precursor to the development of the final user interface for first responders.

c. Specific Outcomes Provided by the Project to the Student

1. Hands-on experience with LIDAR sensor: Students will learn the theoretical working principles of LIDAR sensors. They will learn to read the LIDAR scan data and visualize it.
2. Students will learn processing algorithms to remove outliers and noise in 3D points and store large sets of point data for easy retrieval.
3. Students will also learn sensor data acquisition from other sensors such as IMU and GPS.
4. Students will learn the basics of robot design, power requirement calculations, basic electronics, python programming and overall, how to put all the systems together into a working robot.
5. Students will be acquainted with the latest self-driving technologies used by the industry.

III. Student Selection Criteria

Robotics is a multidisciplinary field, requiring skills from mechanical engineering, electrical engineering, and computer science. It is also a field that requires fair amount of trial-and-error, intuition, and a healthy tinkering attitude. Students who are hands-on and enjoy learning new technologies will excel in this project. The selection criteria in *decreasing* order of priority are:

1. Previous robotic projects. Can be at home DIY projects on Arduino or Raspberry pi too.
2. Experience with programming languages such as Python. This skill is easily learned if you have some experience in MATLAB or C programming
3. GPA >2.5. This is not a strict requirement.
4. Course work: Any courses on Instrumentation (like MAE 311), Programming (like CS 104, CS 121, CS 221), Circuits (like EE213) and Mathematics (like MAE 284). Any courses along these lines will also be helpful.

IV. Project Mentorship

Given that 3D LIDAR sensors are some of the more advanced sensors used in the industry, especially by self-driving cars (like Google's WAYMO), students need mentoring in all aspects of theory and practice of using a LIDAR sensor. Students will be guided at every step along the way, with quantifiable milestones. To this end, students will begin with the setup and running of a simple Arduino based 2D LIDAR sensor. This is their hands-on opportunity for hardware tinkering, trial-and-error setup, software debugging and importantly*, building strong engineering intuition*. Lessons learned from this task will be used by the students to work on the advanced 3D LIDAR. I will divide the overall project into individual tasks of mechanical design, electrical and electronic setup, and finally software programming. Students are encouraged to team-up with each other or even with my graduate students. I will host weekly informal lectures at my Lab to go over the details of each task. I will also include real-world examples and the current state-of-the-art technologies used by the industry. This hands-on training in multiple fields will help students become well-rounded engineers, ready for the next generation jobs of the industry.