Thirty Gallon Robot

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College of Engineering, Forestry, and Natural Sciences

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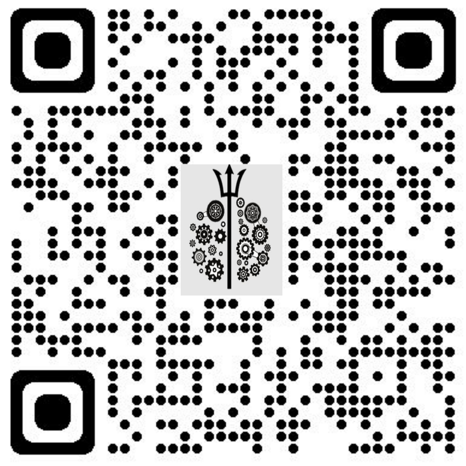


QR code for the team Poseidon Wayfinding web page

Motivation

Robotics is a diverse field and recently gained more popularity. However, the entryway to robotics in education can be expensive and may discourage many colleges from the field of robotics and thus hindering its educational expansion. Yet, as costs in technology have decreased, the client, Dr. Michael Leverington initiated the Thirty-Gallon Robot project in an attempt to create a cost-effective robot that will provide tours of the engineering college. The 30-gallon robot will bring more interest to the university, making it accessible to any engineering student as a learning opportunity of robotics. The robot in question has already been constructed from cheap materials such as a 30-gallon drum which holds components like motor drivers,a small raspberry pi, and batteries. Unfortunately, the robot is currently not capable of any autonomous movement. The team Poseidon Wayfinding seeks to build an autonomous navigation module that will incorporate obstacle avoidance.

Solution

The robot platform and hardware is already complete. We envision an autonomous moving robot that is able to avoid obstacles and determine when it has reached its destination. By implementing obstacle avoidance and autonomous movement, the Thirty Gallon Robot will be able to be used as a robotic platform. It could be programmed for any number of tasks and brings the project closer to the end goal of a tour-giving autonomous robot.

The key requirements of our system:

- Moves on the 2nd floor of the long hall in the NAU Engineering building.
- Able to go down the hallway, detect the end of the hall, turn around and do the same path going back.
- Stops the program upon detecting the final end of the hall
- Avoids obstacles by detecting and moving around them

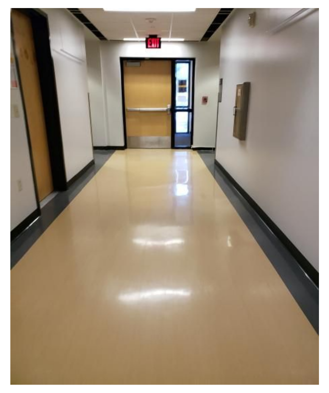


Figure 1 Exit Door (South End of the Hall)

Figure 2 Lobby (North End of the Hall)

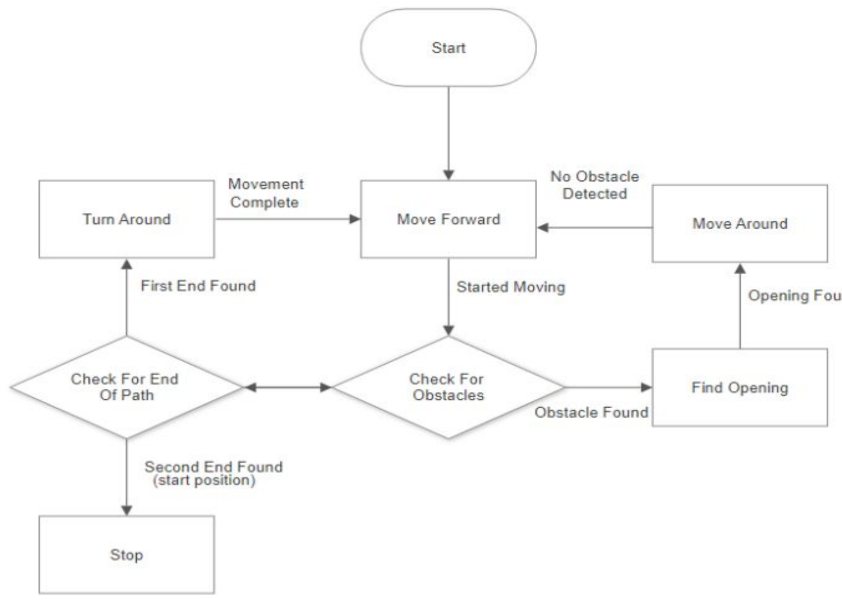


Figure 3 Obstacle Avoidance Loop

Technologies

- Raspberry Pi 4B - Serves as the main computer for the system. Sends the signals to the motor drivers to control the speed and direction of the motors
- Xbox 360 Kinect - Camera with a depth camera sensor that is used to capture the depth images for obstacle avoidance
- Raspberry Pi Camera - Captures images of the hallway and is used with computer vision to detect each end of the hallway
- Python - The programming language for computation and interacting between Raspberry Pi and other hardware
- OpenCV - Computer Vision library for manipulating images
- Tensorflow - Library for machine learning tools used to detect and determine the end of the hall

Outcome

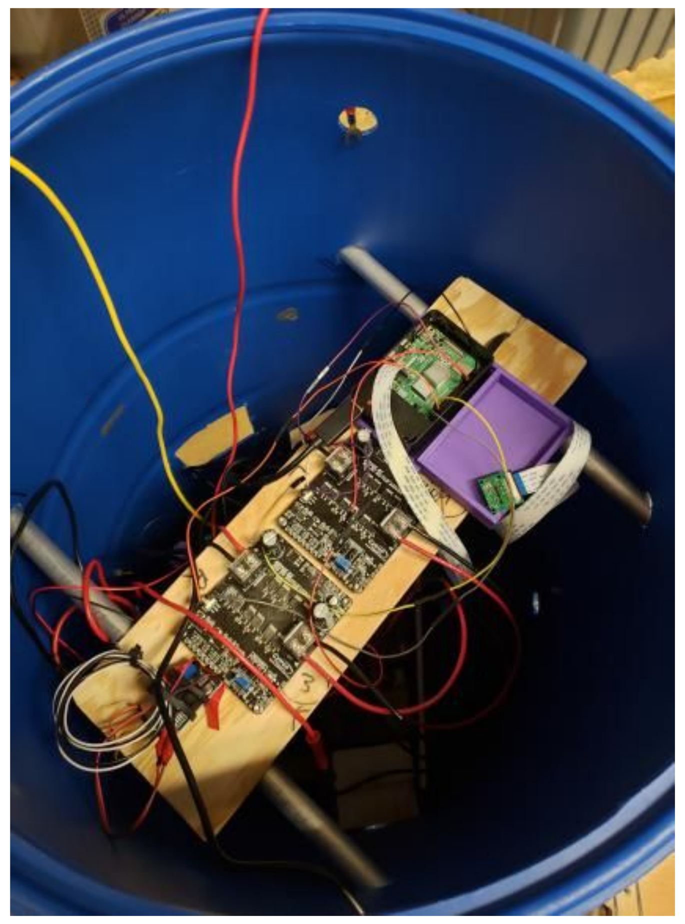


Figure 4 and Figure 5 Current Thirty Gallon Robot Platform

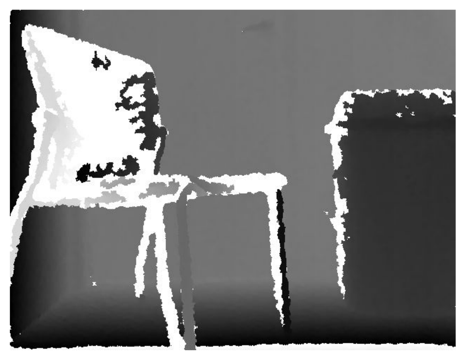
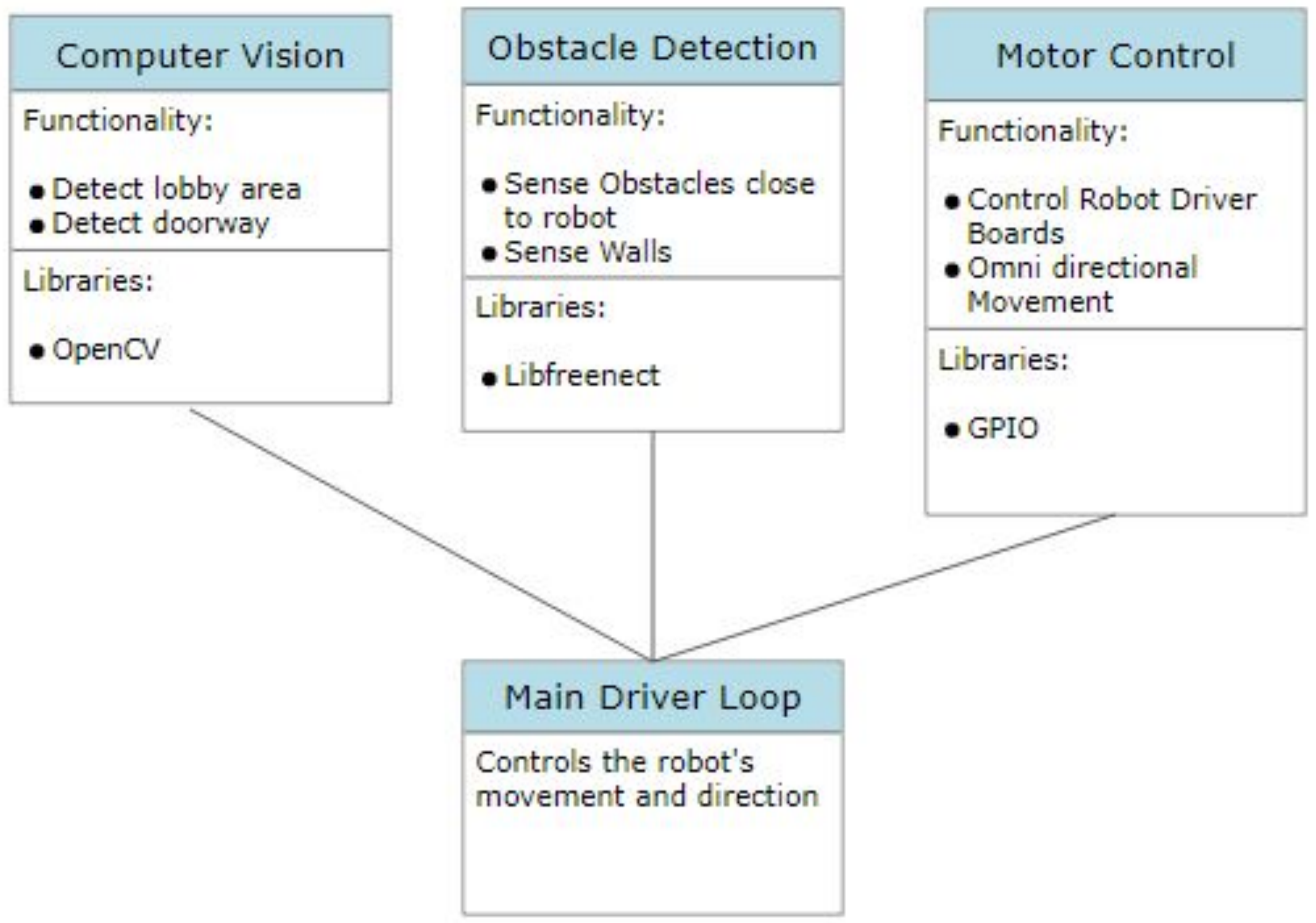


Figure 6 Raw Depth Image from Kinect Sensor

Figure 7 Processed Depth Image

The robot detects obstacles using the Xbox 360 Kinect's built-in depth sensor camera. For each frame, we gather the depth image and process it into a binary image where black pixels represent an object that is too close to the camera. To identify whether than obstacle is in the way, we count the area or amount of black pixels detected. If the amount of pixels detected is above a certain threshold, it detects an obstacle. To route around the obstacle, we rotate the robot in the direction opposite of where the object is. The same approach as detecting an obstacle is used for openings, except with the amount of white, undetected pixels. When an opening is detected, the robot will move forwards and pass the obstacle.

Architecture



The system is made of up three submodules that control different aspects of the robot, and one main module that implements these submodules to control the robot. The first submodule is the motor control. This allows the main function to control the motors in the robot, allowing it to turn and move forward. The second submodule is the obstacle detection. This allows the robot to detect any object that it may encounter in its path, as well as any walls it might accidentally run into. The final submodule is computer vision. This allows the robot to detect both ends of the hallway, one being the lobby area and the other being the doorway. All of these submodules come together to safely and autonomously move the robot down the hallway

Challenges and Testing

While integrating the software into the robot was successful throughout the project, we faced few electrical and performance challenges during our implementation phase. As specified in the requirements given from our client, we were highly discouraged using RFC or NFC tag scanning system to detect end of the hallway. To ensure the future usability of the robot, we needed to implement a software that relies on AI or machine learning to detect each ends of the hallway. We used model matching system using a mini raspberry pi camera to analyze images to detect end of the hallway and know when to stop and when to turn around.

The current structure of the robot has been modified to withstand the performance issues presented early on by decreasing the power of motor drivers to 30%. We have modified our software architecture so the robot can fully run through the hallway autonomously while avoiding objects. We have extensively tested our software to detect potential bugs that could malfunction the hardware of the robot. Specifically, our team focused testing the potential of the software around future implementations so that essentially, the robot will be able to give tours in the engineering building.

Future Work

This project will be continued by future capstone teams. Our work will serve as a part of their foundation and allow them to implement future modules such as localization and navigation. These modules will be integrated with our obstacle avoidance module to create a fully autonomous robot. Finally this robot can be programmed to give autonomous tours around the Engineering building, marking the completion of the project