Lab Report of EEE 187L Labs 4-6.

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Abstract **- In the Robotics Lab, our goal is to create a robot that is able to specific tasks. Each lab, new sensors or features are added to make the robot capable of doing the objectives that are given.**

I. INTRODUCTION

One of the best ways to learn the basics of robotics is to build a robot, and the aim of the EEE 187 Lab class is to learn these through the process of doing the labs.

In each lab the objective was to build up the robot while adding new functions to the robot, and the topic of the lab report is discussing labs 4, 5 and 6 of the EEE 187 class. In the fourth lab, the objective was to have multiple groups to work together to build a convoy robot, one robot that leads the follower robot, follows the leader. In the fifth lab, the objective was to have the robot navigate through the maze. The final and sixth lab was the race - in a tournament bracket with the other robots in the class, the class had a drag race to see which robot was the fastest.

II. COMPONENTS USED

TABLE I
COMPONENTS USED IN LAB 4-6

Component	Purpose	Used in Labs
Raspberry Pi 3B+	Control Systems	All
L298 Motor Driver	Locomotion Control	All
2x 6V DC Motors W/ Encoders	Locomotion	All
Caster Wheel	Stability	All
AA Battery Holder	Power	All
Phone Battery Bank	Power	All
TCRT5000 (QTI) IR Sensor	Detect Line for Following	Lab 4
Ultrasonic Ping Sensors	Sensor for detection	Lab 4 & 5 Lab 4 & 5
LM2596s Voltage Regulator/Buck Converter	Battery Manager	Lab 6

III. LAB IV

A. Experimental Details

In the fourth lab, the goal of this lab activity was several teams (between 2 and 5) work together to create a convoy of robot. There were two roles in the lab - leader and follower:

Role of the leader - The leader follows a line to reach the destination. It has to stop completely when it reaches the final destination. The role of leader is as follows:

- Follow the line.
- Slow down for a few seconds then accelerate. The change in motion should be noticeable.
- There will be at least one obstacle on the convoy's path. The leader should be able to detect the obstacle and fully stop. The obstacle will be removed so the convoy can complete the course.
- Stop at the destination point.

Role of the follower - The role of the follower is

- Follow the leader at a constant distance. The distance should be set to any specific value between 20 cm and 40 cm.
- Implement a proportional controller where the speed is proportional to the error between the desired value and the actual value of the distance. This is an important requirement for this lab that will be verified in the code.
- The follower cannot use line detection sensors.

For this lab it was decided to do leader role, and as the leader, the robot needed to have ultrasonic sensors to be added at the front so the robot can stop at the block, and that needed to be integrated with line following code so the robot can go in a path.

Fig 1. Circuit of Robot for Lab I

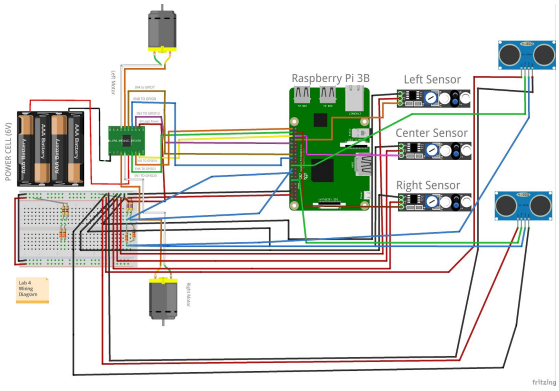


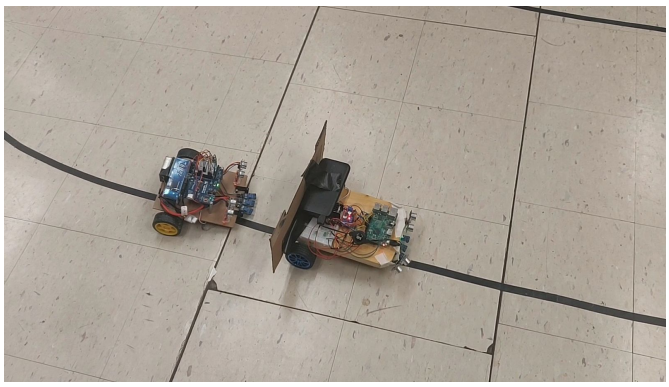
TABLE II
NEW GPIO PINS ON THE RASPBERRY PI FOR LAB IV

Name in Code	Function	Pin
R_TRIGGER	Trigger Pin of Side Right sensor	5
R_ECHO	Echo Pin of Side Right	6
L_ECHO	Echo Pin of Side Left Sensor	11
L_TRIGGER	Trigger Pin of Side Left Sensor	9

The robot was wired up according to the Figure I, with the Pi GPIO Pins organized as according to the Table II. The code and calibration work was then done to get the robot working, following the path and then stopping at the point with the block. The cardboard box part in Figure II to the robot rear so the other group's robot could sense the robot.

B. Results

Fig 2. Robot acting as a leader



https://www.dropbox.com/s/h8uj0a42hnhzyl4/VID_20191104_172357_01.mp4?dl=0

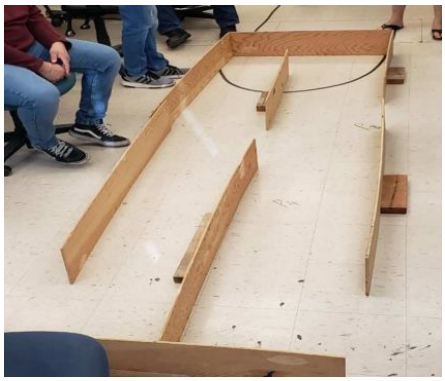
During the demo of the lab, the robot successfully followed the path and the follower successfully followed the robot even during a turn. The robot had no issues during operation. The dropbox link above is the video link above, and the lab was demonstrated to the Lab Instructor without problems.

IV. LAB V

A. Experimental Details

In the fifth lab, the objective of this lab was to program the robot to navigate a complex maze. The robot was not allowed to hit any of the walls, and to do that sensors needed to be added but the type of sensors that was used did not matter. There was an optional part of the lab in which the robot would cross a bridge similar to the bridge from Lab II but our group decided not to do this component of the lab.

Fig 3. Maze for Lab V



For this lab, 2 more ultrasonic sensors were added to the robot. From Lab IV, 2 ultrasonic sensors were wired up in the front and in Lab V sensors on the left and right sides were added. The way that the robot handled the maze was that it detected the walls to move and could theoretically do any maze as long as it doesn't have to go backwards. If 2 of the 3 sensors detected a wall, the robot would turn the other way, if any one of the sensors got too close to the side ones, it would go away from that and if the robot detected walls on the sides it would go straight.

Fig 4. Circuit of Robot for Lab V

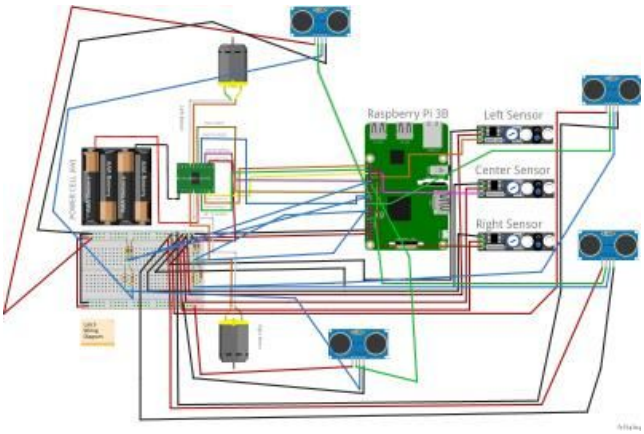


TABLE III
NEW GPIO PINS ON THE RASPBERRY PI FOR LAB V

Name in Code	Function	Pin
FR_TRIGGER	Trigger Pin of Front Right PING Sensor	18
FR_ECHO	Echo Pin of Front Right sensor	23
FL_ECHO	Echo Pin of Front Left sensor	24
FL_TRIGGER	Trigger Pin of Front Left sensor	25

B. Results

Fig 5. Robot Running through the Maze

https://drive.google.com/file/d/19FkPNCYSo-98Qe3u3Lz9Uypw3zpZYG9_/view?usp=sharing

After a few runs with calibration fixes in between each run, the robot was capable of detecting all most of the walls and was able to follow the path, recorded it which is the video link above, and demonstrated to the Lab Instructor without problems.

V. LAB VI

A. Experimental Details

In the 6th lab, the goal of this lab was a EEE187 grand prix race. There are only two requirements for the race:

- The robot should be able to move in a straight line for at least 20 meters.
- The robot should be able to detect an obstacle placed about 20cm in front of it. The race starts when the obstacle is removed. Your robot does not have to stop at the finish line.

All robots that do not complete the race (reach finish line) will be destroyed. The robots have to run in a fairly straight line.

The code that was used for the robot during the race was code from Lab 1, just going straight without line following. Calibration work was done to make sure that the robot goes straight.

Fig 6. Picture of Robot Fully Wired Up in Lab VI

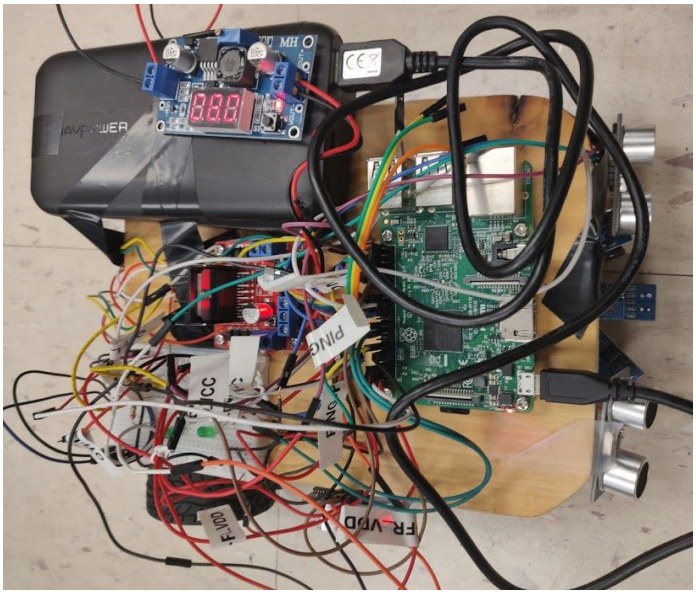
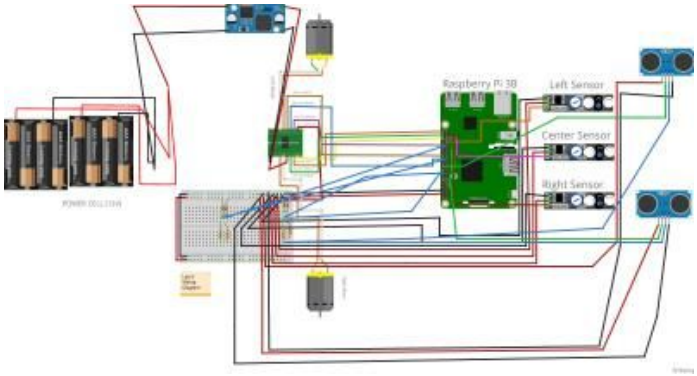


Fig 7. Circuit of Robot for Lab V



During Labs IV and V the robot was running into issues because as the batteries drained the power output dropped, so the decision was made to wire according to Figure 7, swapping a 6v battery pack to a 12v power and a LM2596s Voltage Regulator/Buck Converter. As a result, the robot's runs were more consistent, and ran at peak voltage for longer. To make the robot go faster, the voltage was tweaked to go higher, and during the runs for the race the robot was putting 8v to the robot.

B. Results

Fig 8. Picture of Robot in Race

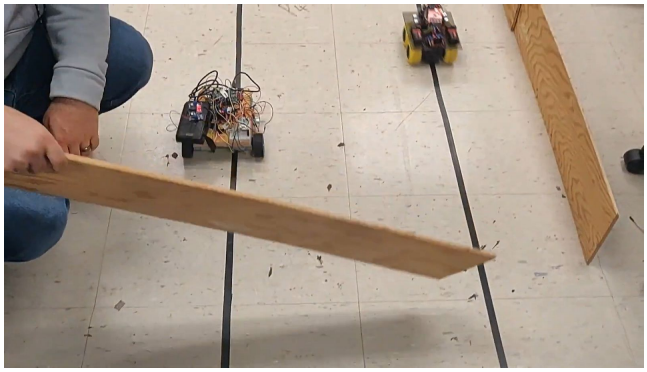
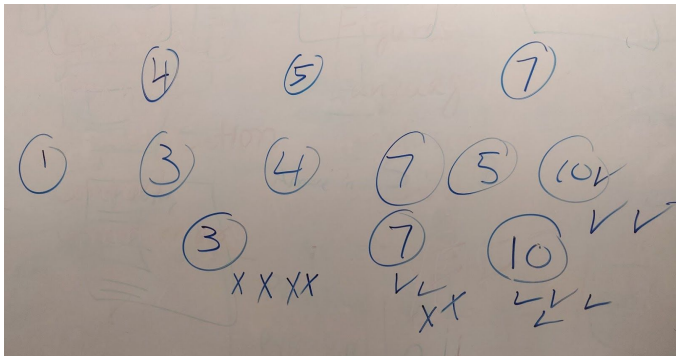


Fig 9. Results of the Race



The robot made it to the 2nd round with Figure 8 showing a part of the lab, beating out a robot before being outperformed by group 10, that ultimately won the tournament. Group 5 was our group, group 10 was the Victors.

VI. CONCLUSION

Throughout these labs we have built a robot that has been a part of a robot convoy, was able to leave a maze, and participated in a race . The completion of these labs were very informative and through implementation more was learned about the concepts of robotics themselves. These labs were mostly smooth sailing, but we had some issues getting Lab 4 done on time. For Lab 5, the challenge was to make sure that our logic was consistent so that the robot would not run into a wall, but this was easily overcome. Lab 6 was smooth sailing with power supply upgrade from 6V to 12 V.. Overall, the lab was a great learning experience and went well.

VII. REFERENCES

[1] Fethi Belkhouche, EEE 187 Lab: Activity 4, Oct 2019

[2] Fethi Belkhouche, EEE 187 Lab: Activity 5, Oct 2019

[3] Fethi Belkhouche, EEE 187 Lab: Activity 6, Nov 2019

[4] "How to use the TCRT5000 IR line follower sensor with the Raspberry Pi" thepihut, Accessed October 10, 2019 [Online]. Available: https://thepihut.com/blogs/raspberry-pi-tutorials/how-to-use-the-tcrt5000-ir-line-follower-sensor-with-the-raspberry-pi

[5] "Using a Raspberry Pi Distance Sensor (ultrasonic sensor HR-SR04) " tutorials-raspberrypi, Accessed on October 21, 2019 [Online]. Available: https://tutorials-raspberrypi.com/raspberry-pi-ultrasonic-sensor-hc-sr04/