THE ROBOTICS INSTITUTE

MRSD Project Course

Team I – AIce

Autonomous Zamboni Convoy

Individual Lab Report 4

Team

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1. Individual Progress

Since the last Progress Review, I majorly worked in three domains:

a. Integrating Encoder on RC Car to validate localization
b. Implementation of Waypoint Following on RC Car
c. Validation of IMU (Bosch BMI055) on real sense in real world
d. PDS Layout and Schematic Design

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1.1. Hardware Installation on RC Car:

1.1.1. Wireless Communication on RC car

Implementing wireless communication on RC Car was an important step to validate the waypoint following algorithm on the RC Car. So, I integrated Bluetooth and Wi-Fi based communication with Arduino that can be used to send the steering angles and velocity commands through smartphone and laptop. Bluetooth is being used in the initial stage where latency is not an issue, but after integrating the complete subsystems, we might need Wi-Fi to have high-speed communication.

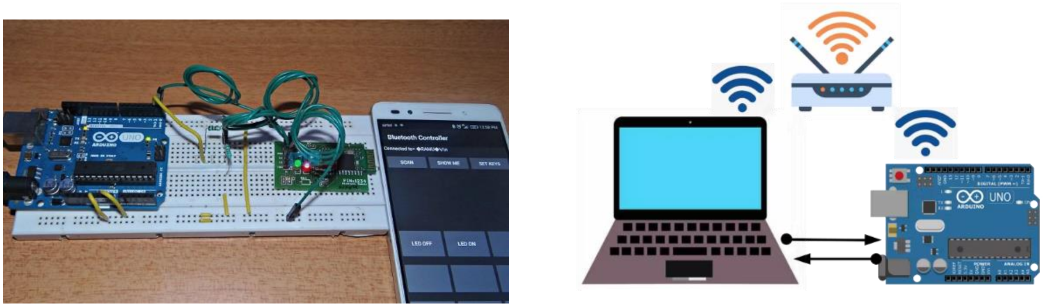

Figure 1. a. Bluetooth Communication b. Wi-Fi Communication

1.1.2. Encoder Installation

Another important upgrade I had to do on RC Car was installing an encoder so that we can get wheel odometry data. So, to install the encoder I had to design a gear that can mesh with the dc motor's gear and get the same gear ratio to get linear velocity. To do that I worked with Nick, to get the gear parameters necessary to design the gear. Based on the parameters obtained, I designed the gear which can be 3d printed (as shown in the figure below).

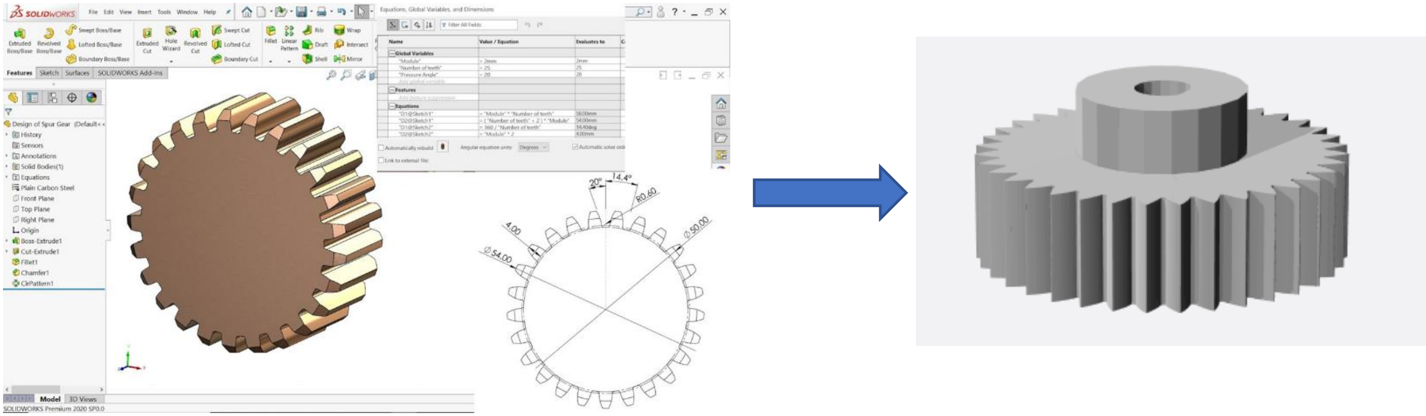

Figure 2. Gear Design in Solid works

The final installation of the gear and encoder is installed as shown in the figure below.

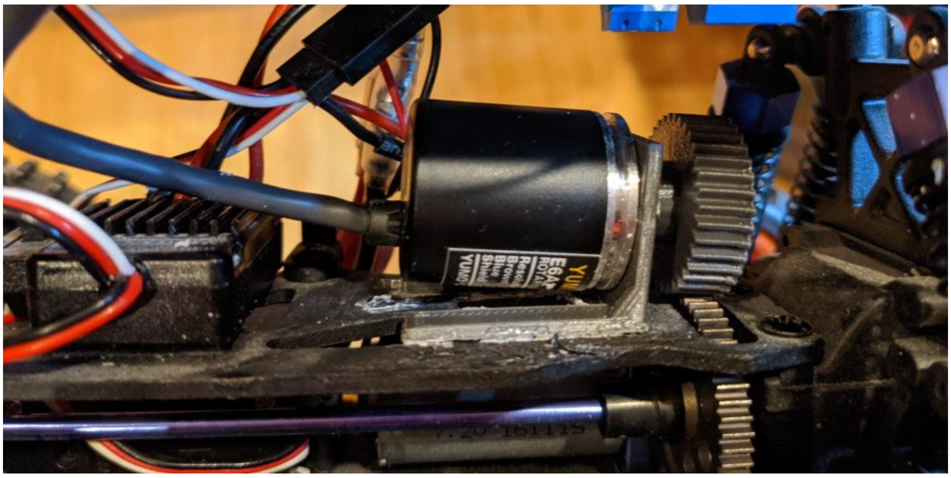

Figure 3. Encoder mount on RC Car with gear mesh

1.2. Implementation of Waypoint Following on RC Car

The most important update after the last PR was the implementation of waypoint following on RC Car. The Stanley controller developed earlier was used to get the correct angles based on the waypoint that the RC Car should follow. The kinematic characteristics of the RC Car and the mapping between the servo motor and steering angle of the RC Car were modelled in the Stanley Controller. Based on the coordinates, the Stanley controller computed the steering angle command, in degrees, that adjusts the current pose of a vehicle to match a reference pose, given the vehicle's current velocity and direction.

I had to carry out multiple trials and errors to get the right waypoint following as I had to find the scaling between the angle given by the controller and the angle the wheel of RC car needs as the geometry of the RC car is not perfect (has non-linear caster and camber), which made it difficult to get the mapping.

1.3. Calibration of IMU (Bosch BMI055) on real-sense D435i

The IMU on the D435i device is not calibrated at the factory. To obtain the best performance, we had to calibrate the device through a custom calibration process. The IMU calibration parameters include intrinsic and extrinsic parameters, some of which we focused on was for the accelerometer: Scale factor (sensitivity), Bias (zero offsets)

For Gyroscope: Bias (zero offsets)

I worked with Kelvin to calibrate the imu, where A calibration python script, rs-imu-calibration.py, is included in the Intel® RealSense™.

The general process to calibrate a device with the Python Calibration Script starts the script to capture IMU data in 6 different positions, then computing the parameters and writing the results to the camera.

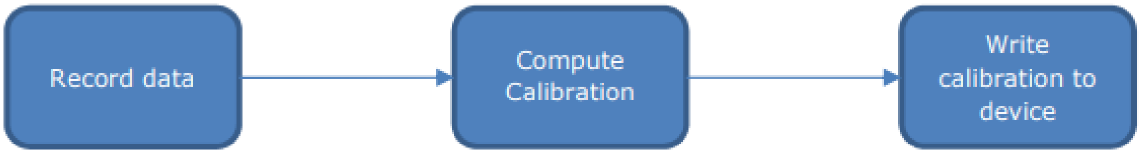

Figure 4. IMU Calibration Process

We carried out this process successfully and were able to get calibrated data, which was validated on the SDK software provided.

Figure 5. IMU Calibration results

1.4. PDS PCB design for the RC Car

Our project has a RC Car platform equipped with sensors and motors. We aim to develop a Power Distribution Board that can be used to power the motors, motor controllers, and sensors that go on this RC Car.

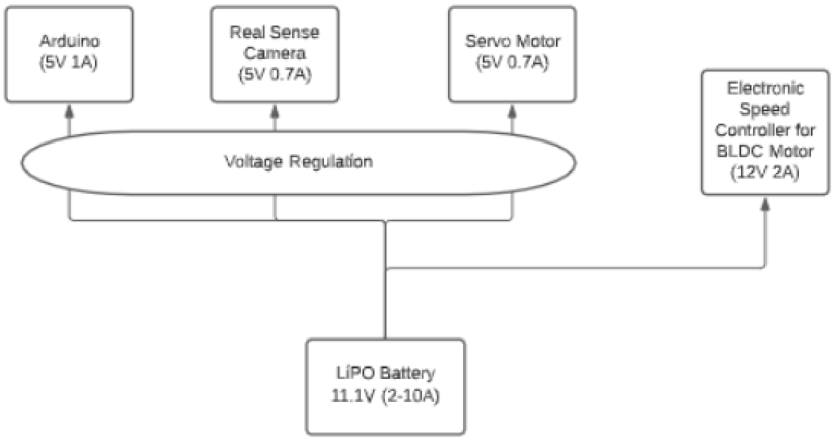

Figure 6. PCB Concept

I designed the PCB schematic and board layout for the same. The schematic and layout design are attached in the appendix.

2. Challenges

The main challenge was faced when validating the waypoint following on the RC Car. The major challenges are highlighted as follows:

- LiPo discharges very quickly
- Mapping of Ackermann steering angle on RC Car and the Simulation model (not linear)- Had to do many trials to get the mapping

Another challenge was making the encoder fit on the RC. The RC Car had limited space so getting the encoder fit with good mesh between gear.

There were some challenges concerning the PCB Design. Availability of a dc-dc converter, so designing the circuit based on available components was a little difficult.

3. Teamwork

a. Kelvin Shen

Kelvin Set up Velodyne's Puck in simulation and converted the published PointCloud2 message into PCL format. He also worked with me on the calibration of the IMU sensor.

b. Nick Carcione

Nick designed for the encoder and helped me with encoder gear design. He also worked on mounting the encoder and getting it running. He also worked with me to test waypoint following on RC Car.

c. Yilin Cai

Yilin majorly worked on simulation and visualization setup for autonomous convoy demo. He also integrated perception, estimation, and localization to generate the leader path and successfully implemented leader-follower convoy simulation.

d. Jiayi Qui

Jiayi majorly implemented real-time follower desired velocity estimation using EKF and implemented ROS node to publish the follower's desired trajectory.

She also generated followers' local trajectory for low-level control. She also contributed to a simulated leader-follower convoy using pure pursuit control with Yilin.

4. Future Work/Plans

Following is the plan for the coming weeks:

1. Integrate Jetson with sensors and Arduino in RC Car
2. Validate localization on RC Car
3. Validate the Leader Detection with actual size ArUco marker on Leader and moving RC Car
4. Validate velocity estimation algorithm on RC Car and Moving Leader
5. Demonstrate Basic Leader following with RC Car

5. Appendix

PDS schematic

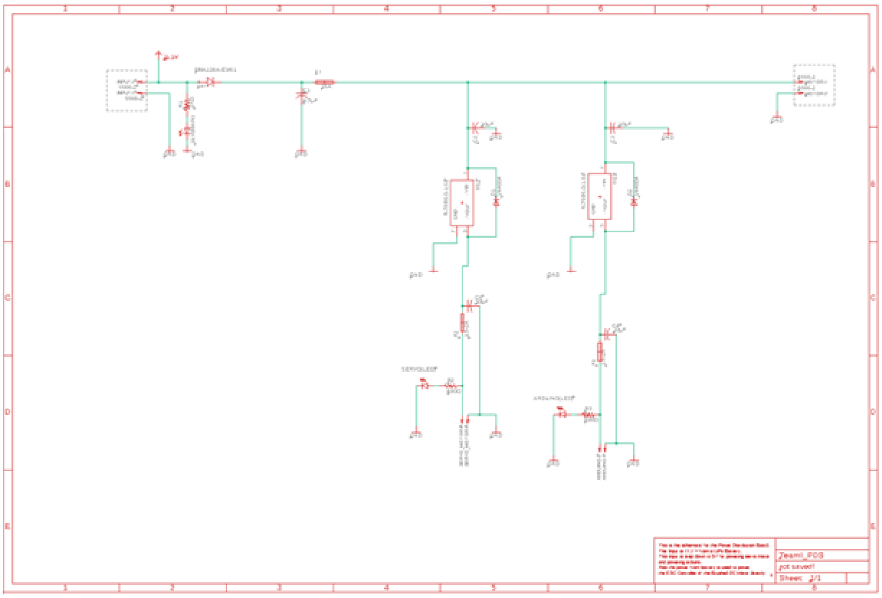

Figure 7. PCB Schematic

PDS layout

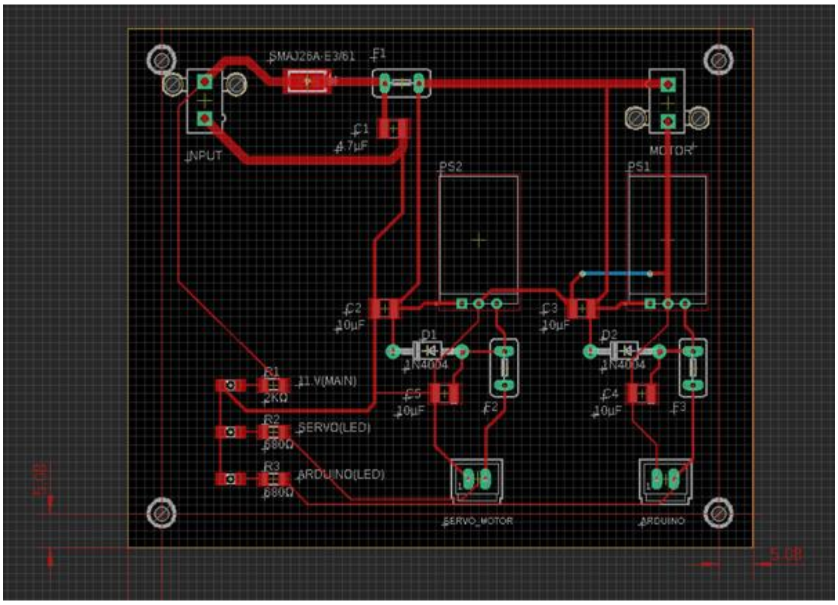

Figure 8. PCB Layout