# TEAM 40: PROJECT SUBMISSION REPORT

## Program:

*Course Code: Design of Mechatronic Systems 2*

*Course Name: MCT382*

*Examination Committee*

*Dr. Shady Ahmed Maged*

*Dr. Maged ghoneim*

*Dr. Akram youssry*

**Ain Shams University**

**Faculty of Engineering**

**Credit Hours Engineering Programs (CHEP)**

**Spring Semester – 2020**

**Student Name :**

Menna Allah Muhammed
Muhammad Ahmed Ali
Ahmed Mohamed Mahmoud

**Student Code :**

15P3050
16P5015
16P8238

## Table of Contents

1 – Product Design

2 -Market Analysis

3 – Mechanical Design

4 – Electrical Design

5– Gazebo

# 1. Product design

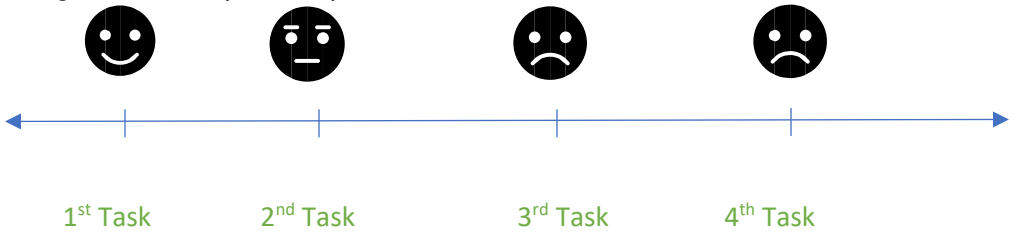
## 1.1 Theme and social circle

Our selected Design theme is represented in Hypermarkets and the selected Persona is represented in Storage & Exhibition areas inside the Hypermarkets.

We had interviews with the potential users and asked them about what they do, why the do it , how they feel about it and what is meaningful for them, to get an overview and a better understanding of the situation in order to figure out the problem they need a solution for.

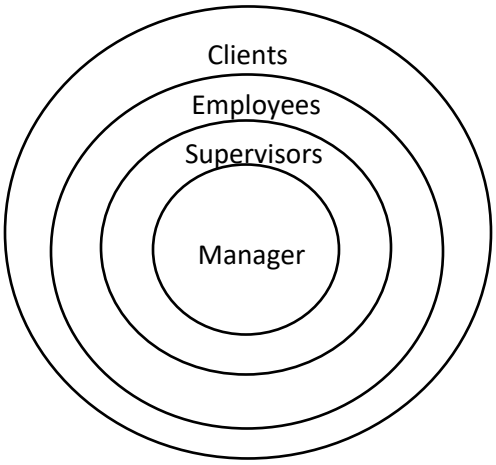
Our potential users are Hypermarkets managers representing Hypermarkets owners, we used two tools in interviewing; Timeline and social circle. Following is the interviews outcome

1 – Timeline: **First task** served by the manager is to assign and schedule tasks for specific employees. **Second task** is overseeing the receiving orders and stock control. **Third task** is reviewing the previous day sales activities report. **Fourth task** is dealing with all complaints, queries, and other related customer service issues.




**Analysis:** After analyzing timeline we concluded that the most exhausting parts of the job are reviewing the sales and expenses and dealing with customers complaints.

2 – Social Circle:




# 1.2 Problem definition, design challenges & list of requirements

## 1.2.1 Problem definition

- Who has the problem? ○ Malls managers.
- What is the problem?
  - Problem lies in the degradation of productivity, overhead unnecessary expenses and not achieving revenue goals.
- What is the effect we want the user to experience?
  - We want the manager to be reassured about the productivity and be satisfied about the working efficiency.
- What are the constraints?
  - Cost of the solution. ○ The ability of the solution to suit the situations in subject.
  - Usability.

## 1.2.2 Design challenge statement

We want the manager to be at ease and relieved about the retail revenue and productivity because we will multiply the workforce efficiency and reduce some running costs.

### 1.2.3 List of requirements

Below is a list of requirements that have be available in our solution.

1 – High payload.

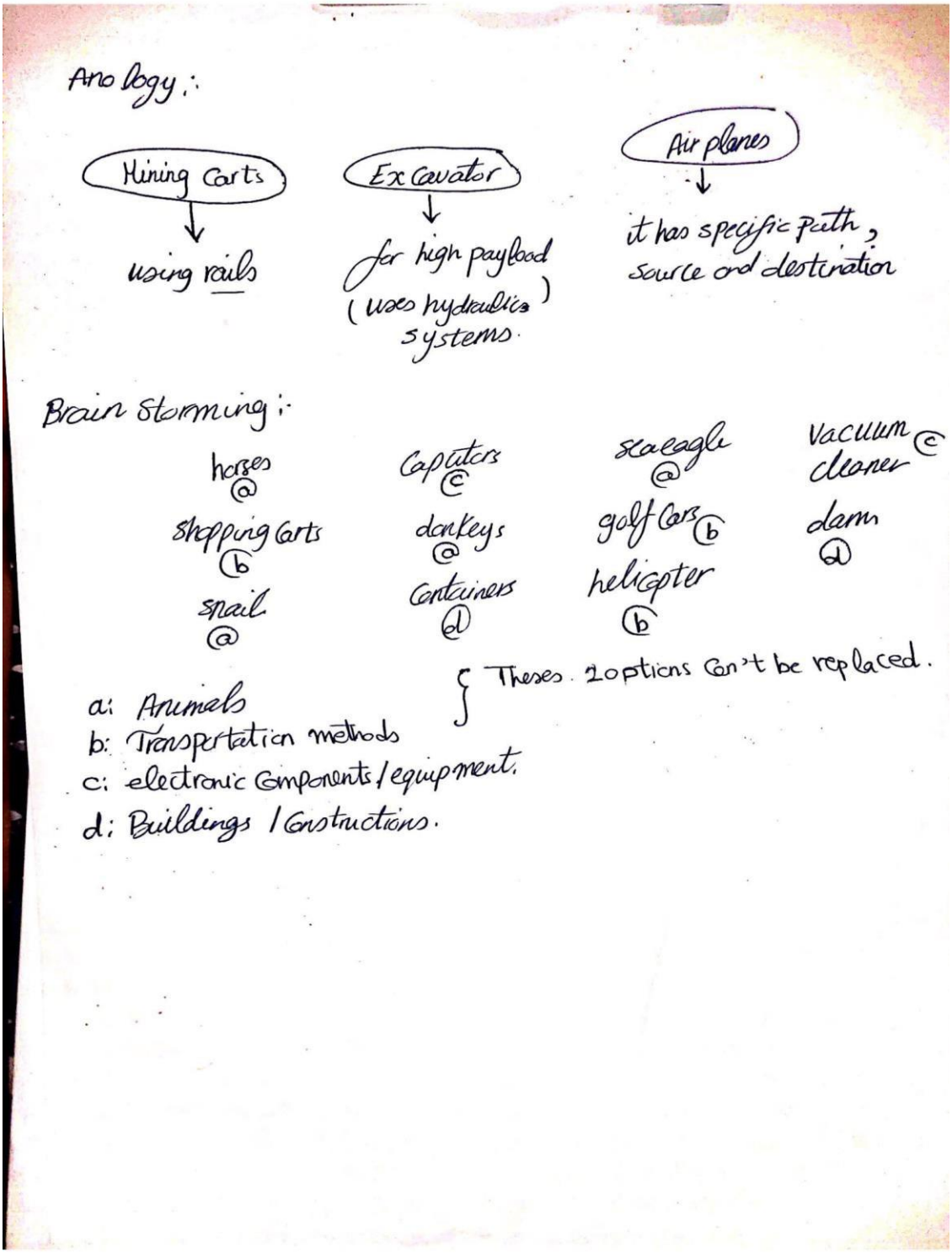
2 – Steady locomotion.

3 – Obstacle avoidance.

4 – Maneuverability.

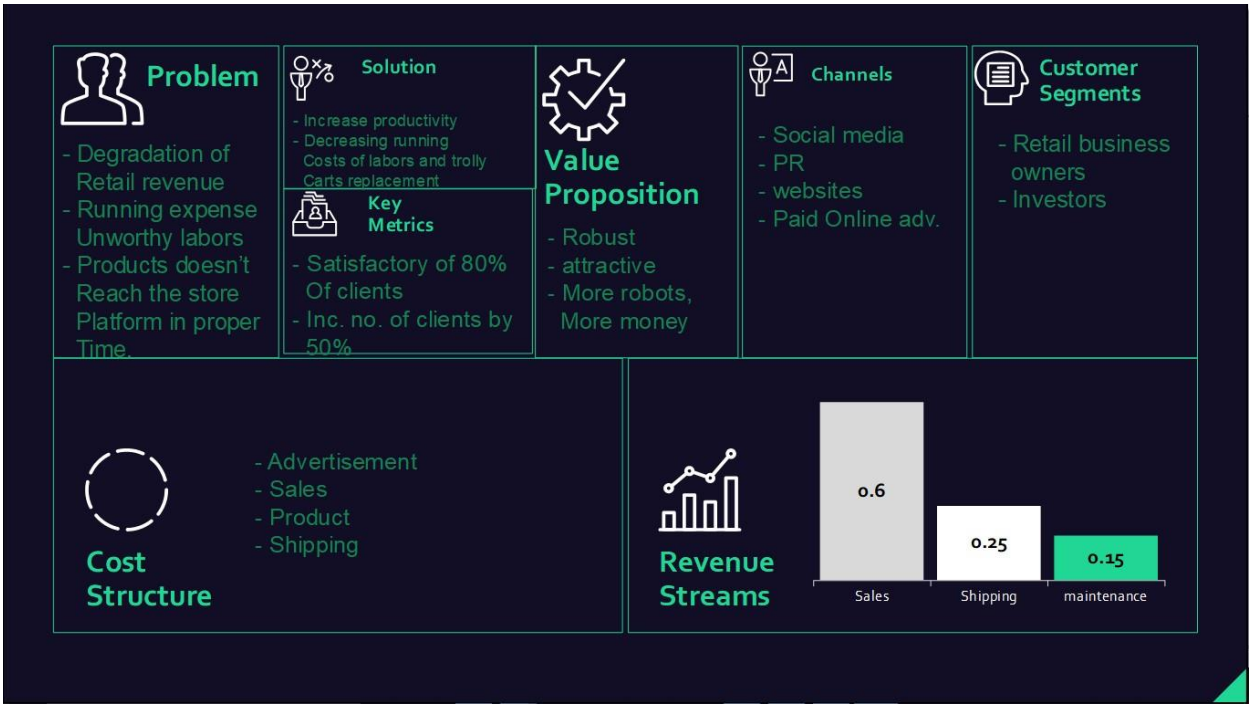
5 – Reduce products transportation time.

# 1.3 Analogy & Brain storming

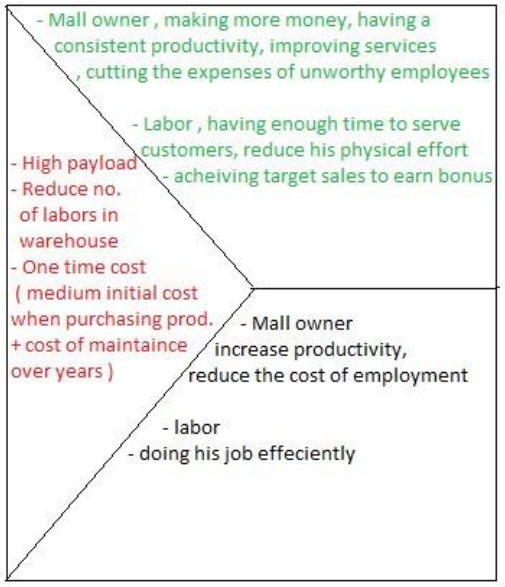


# 2. Market analysis

## 2.1 Lean business canvas



# 2.2 Value proposition





# 3.1 Description

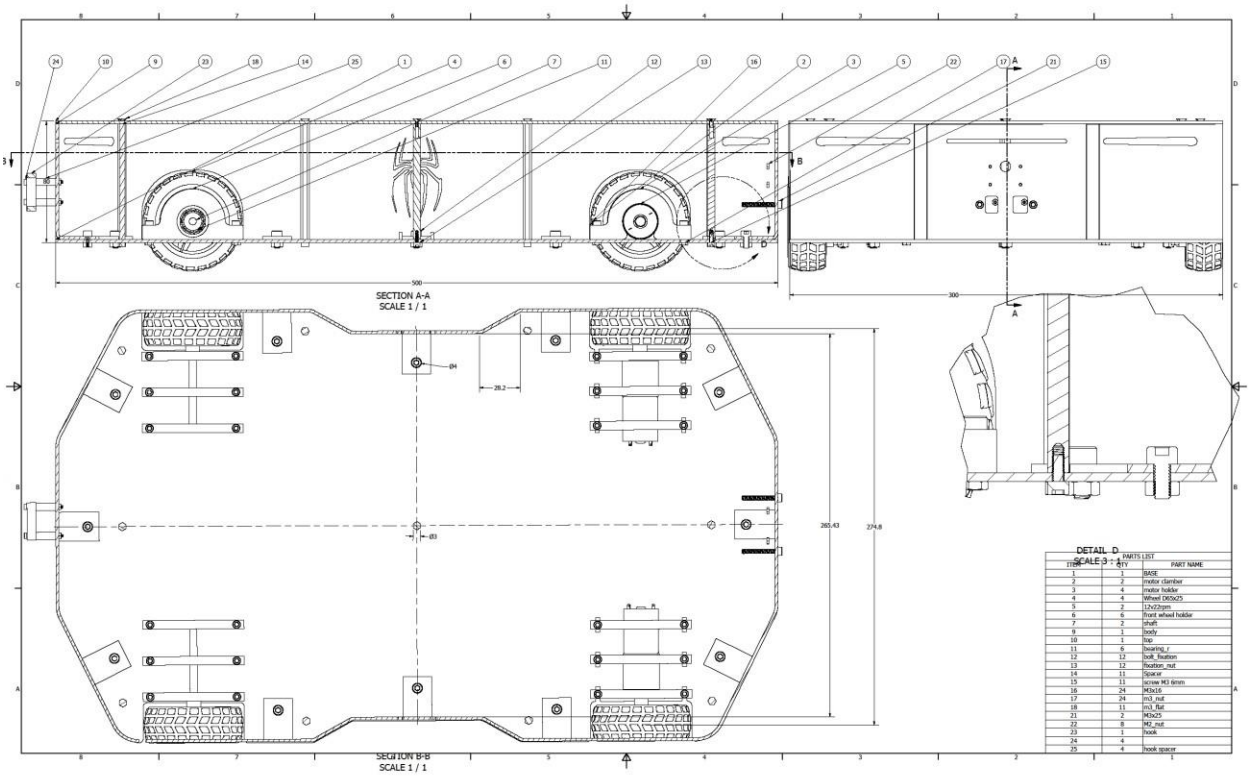
Warehouse Spyder body is made of aluminum sheets, the side of the body is formed using bending machine and thus, we will not cut multiple plates and weld them to form the shape of the sides.

There are multiple rods with counter sink holes at both ends used to make the connection between top and base of the robot and also to reduce vibrations as there are a lot of fixed points.

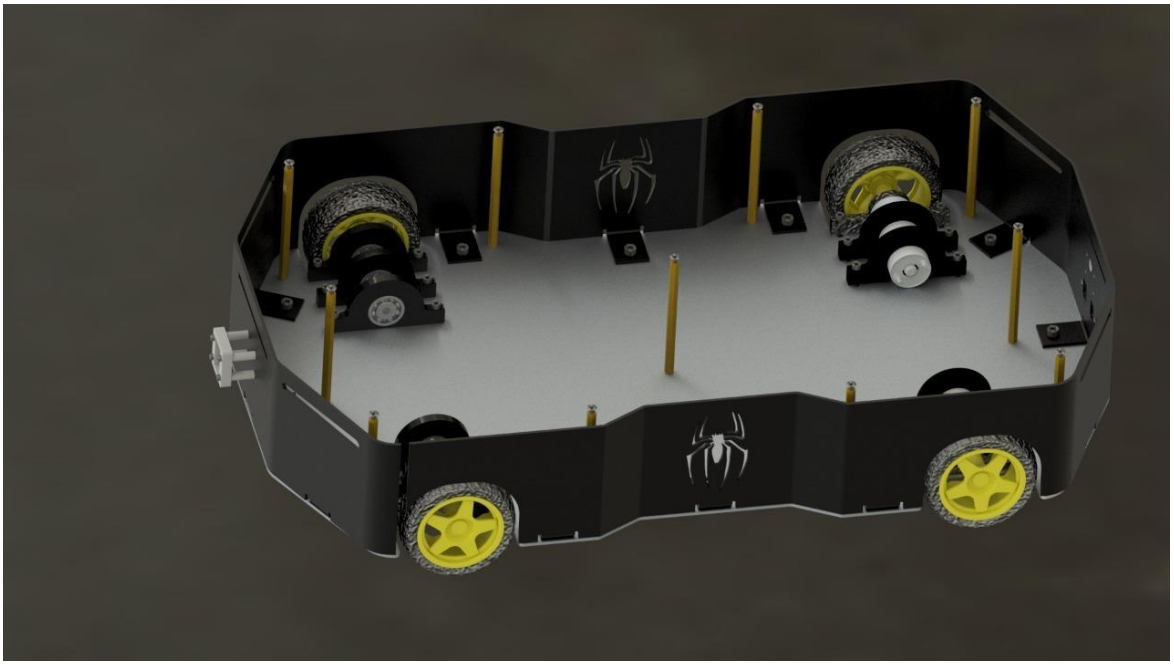
The sides will be connected to the bottom using L-shape connectors.

There's a female hook in the rear of the robot at which the hook of the shelf that's being transported will be attached to.

# 3.2 Construction drawing



## 3.3 CAD model



## 3.4 Stress analysis

Stress analysis was performed using Inventor, it was performed on the hook female at the rear as it is the most critical part of the robot that is most likely to experience stresses.

### 3.4.1 Physical parameters of Spyder

| | |
|---|---|
| Mass | 2.82759 kg |
| Area | 989346 mm^2 |
| Volume | 998856 mm^3 |
| Center of Gravity | x=-52.3211 mm<br>y=-83.9121 mm<br>z=1360.61 mm |

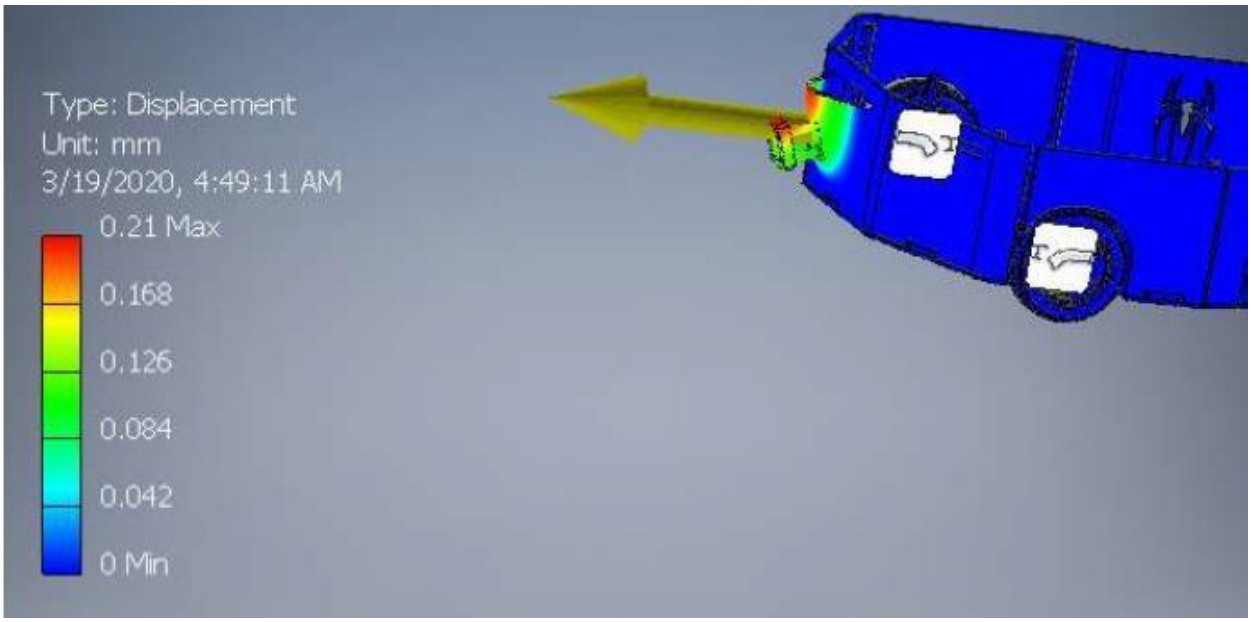
### 3.4.2 Material properties

| Name | Aluminum 6061 | |
|---|---|---|
| General | Mass Density | 2.7 g/cm^3 |
| | Yield Strength | 275 MPa |
| | Ultimate Tensile Strength | 310 MPa |
| Stress | Young's Modulus | 68.9 GPa |
| | Poisson's Ratio | 0.33 ul |
| | Shear Modulus | 25.9023 GPa |

### 3.4.3 Results

| Name | Minimum | Maximum |
|---|---|---|
| Volume | 998848 mm^3 | |
| Mass | 2.82758 kg | |
| Von Mises Stress | 0.00000000126713 MPa | 73.1301 MPa |
| 1st Principal Stress | -4.55265 MPa | 69.8243 MPa |
| 3rd Principal Stress | -64.0171 MPa | 7.69456 MPa |
| Displacement | 0 mm | 0.209954 mm |
| Safety Factor | 3.43532 ul | 15 ul |

### 3.4.4 Visualization of the result



# 4. Electrical design

## 4.1 Motherboard

### 4.1.1 Components

SPYDER'S Motherboard comprises ATMEGA328P based low level Micro-controller that operates at Clock Rate 16Mhz, L298N based modified DC Motor driver that is capable of Providing 7 Amperes output, also we are using the branded 7404 not gate IC, branded LM350K voltage regulator is also used to supply the circuit with Logical voltage (+5V) as we will use 12V Li-Ion Battery as main power source. An HC-05 Bluetooth module is also used and finally an IMU (MPU – 6050).

### 4.1.2 Explanation of motherboard's components

#### 4.1.2.1 ATMEGA328P based microcontroller

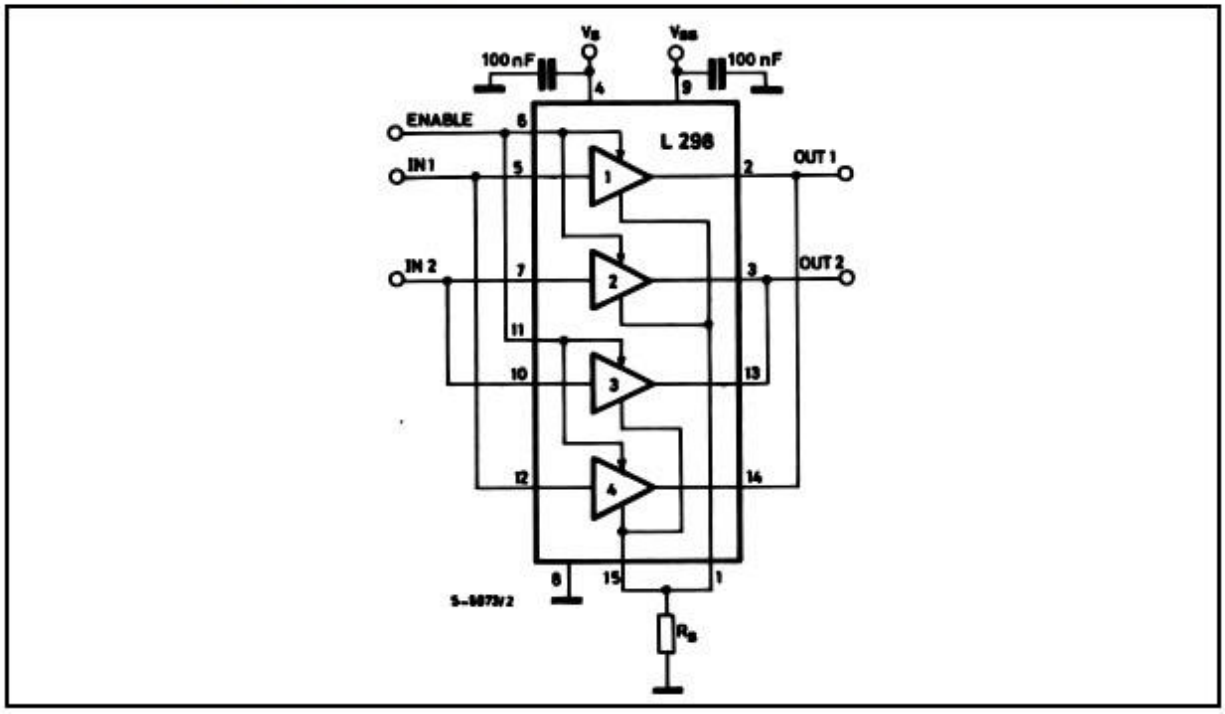
As we previously mentioned, the low-level Micro-controller is operated at Clock rate of 16Mhz to give an extremely high rate of instructions execution to obtain stable and better performance.

We also provided a reset push button to ensure that when pressed all registers are set to their reset values, which includes setting the Stack Pointer and Program Counter to their start addresses, allowing the MCU to execute code at the beginning.

#### 4.1.2.2 L298N based motor driver

SPYDER is propelled using Two DC motors, each motor draws approx. 3.3 Amps, Therefore we needed a Driver that is capable of providing such output current, the L298N H-Bridge IC can only provide 2 Amps for each motor, But according to L298N Datasheet; when paralleling two L298N H-Bridge ICs by paralleling each 2 input channels and same with each 2 output channels, Current that can be drawn per motor is doubled meaning that each motor can draw current up to 4 Amps. Please refer to the snapshot below from L298N Datasheet.

**Figure 7 :** For higher currents, outputs can be paralleled. Take care to parallel channel 1 with channel 4 and channel 2 with channel 3.




### 4.1.2.3 7404 NOT gate

The NOT Gate at each two paralleled Input channels are used to fuse or merge each Two channels at one pin of the Micro-controller to reduce the number of used Pins in the Microcontroller.

### 4.1.2.4 LM350K voltage regulator

This is an adjustable voltage regulator with guaranteed output voltage can obtained from the following relation $V_O = 1.25V_i(1 + R_2/R_1)$ and output current reaches to 3 Amps, It's safer and more stable more than the 78xx family because of the higher guaranteed output current.

The LM350K has a capacitor connected to its output terminal to ensure stability and improve the transient response, there is also another capacitor at the input terminal in case if it is going to be located an appreciable distance from power supply.

There are also protection diodes to prevent the capacitors from discharging through low current points into the regulator.

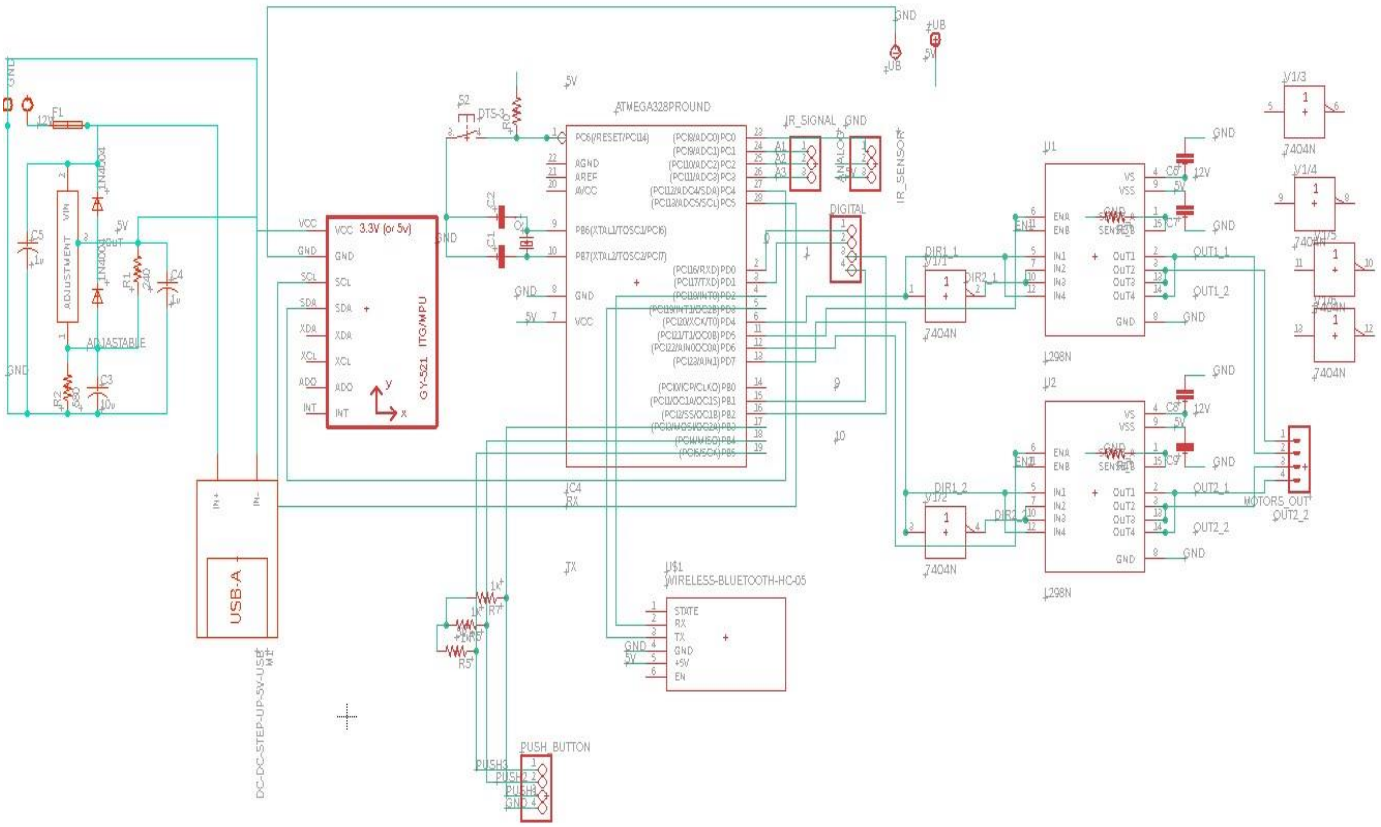
### 4.1.2.5 HC-05 Bluetooth module

It's used to establish communication link between the micro-controller and the android application that is to be used when controlling SPYDER manually.

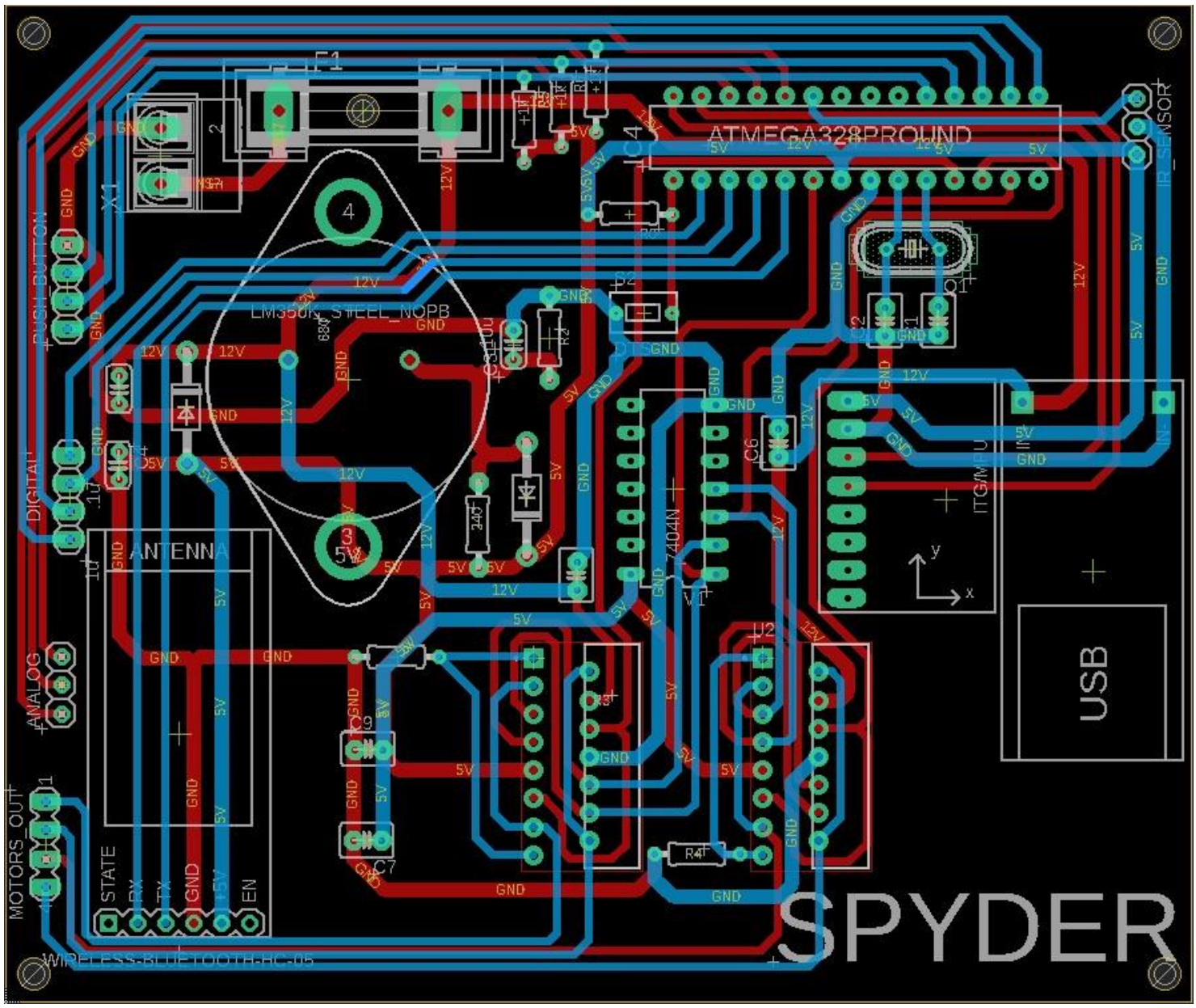
### 4.1.2.6 MPU-6050

This is a 6 D.O.F IMU and is used to give us YAW angle readings during operation as our robot is going to be steered by adjusting the YAW angle.

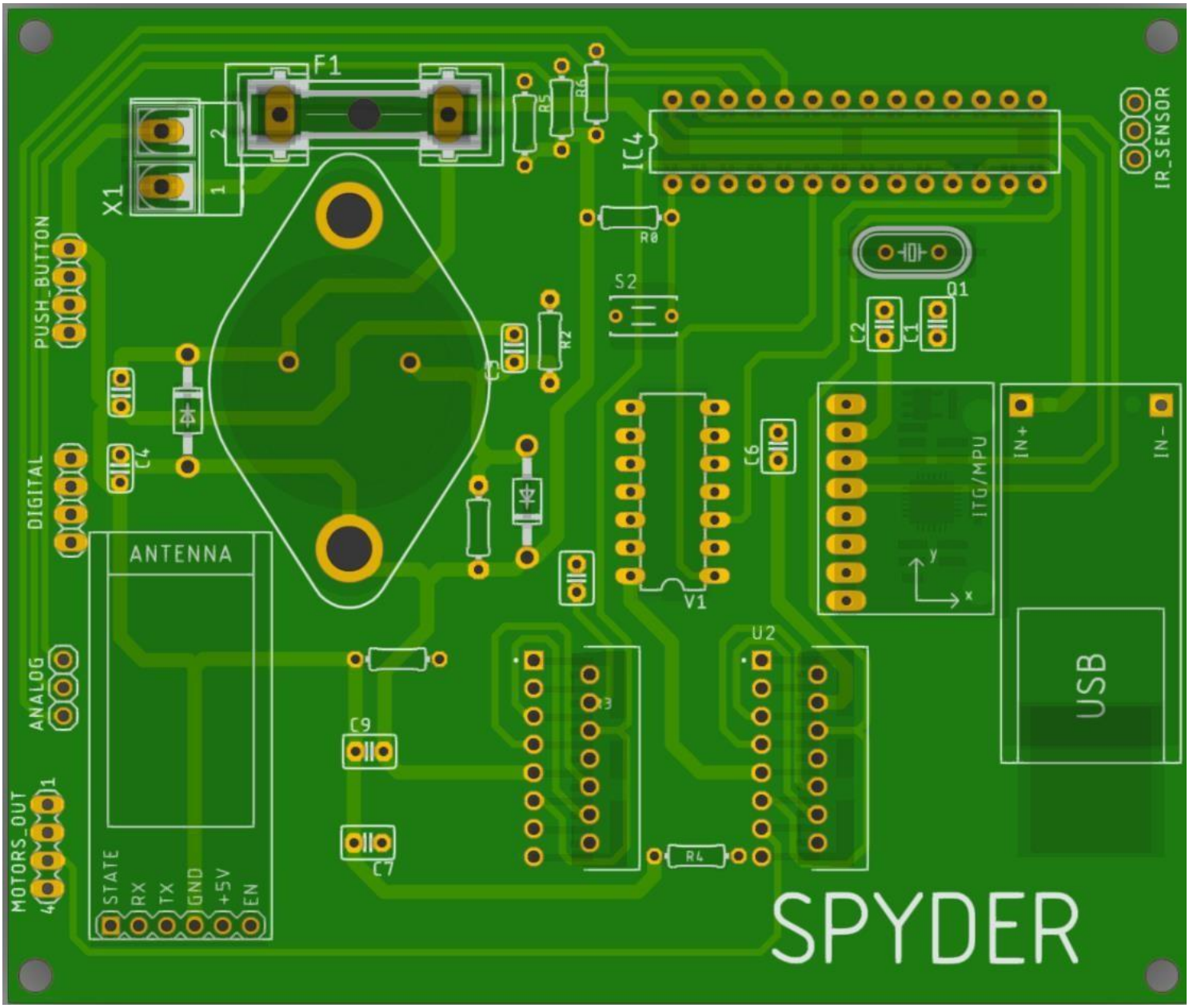
## 4.1.3 Motherboard circuit schematic



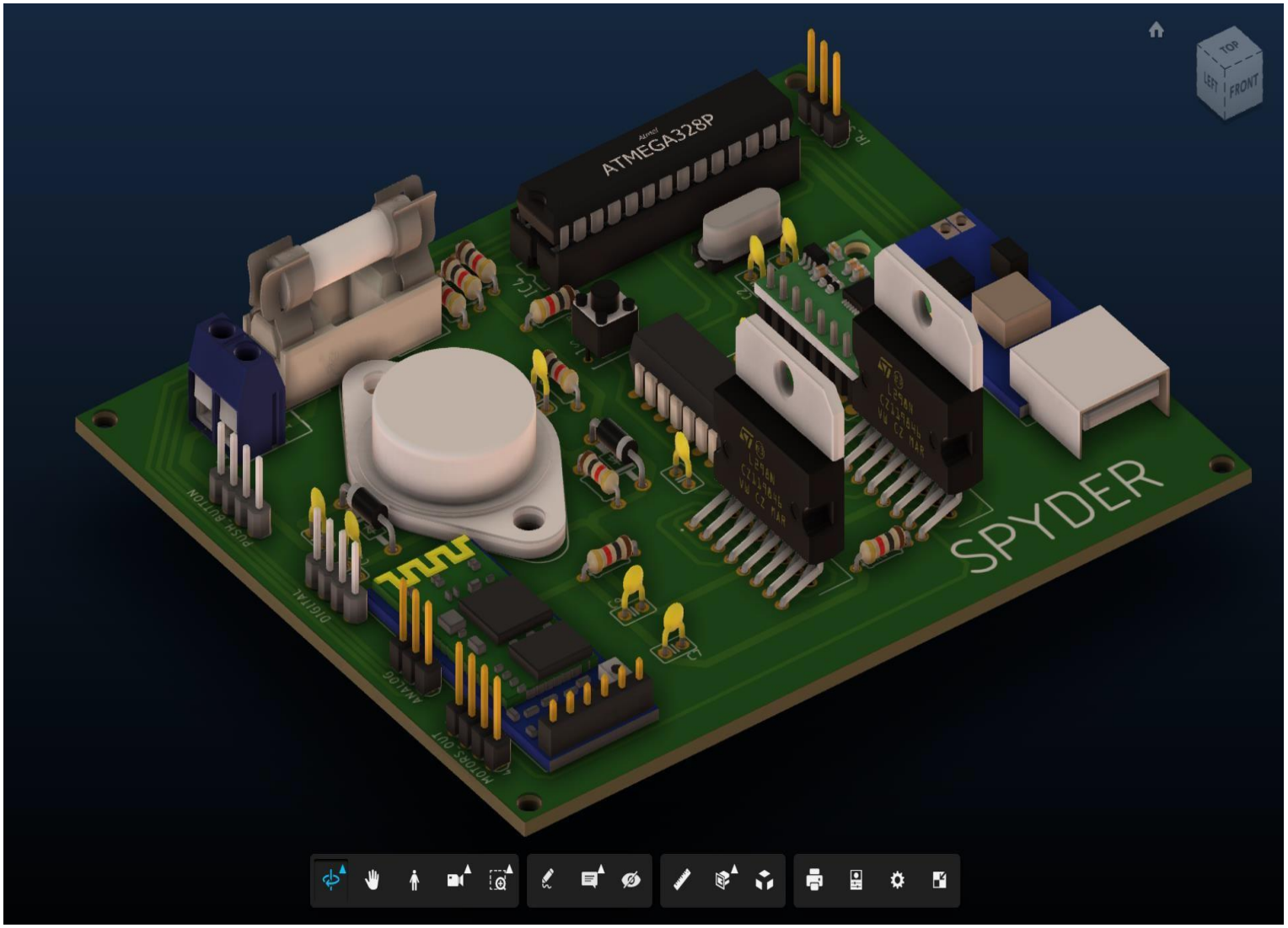
## 4.1.4 PCB layout



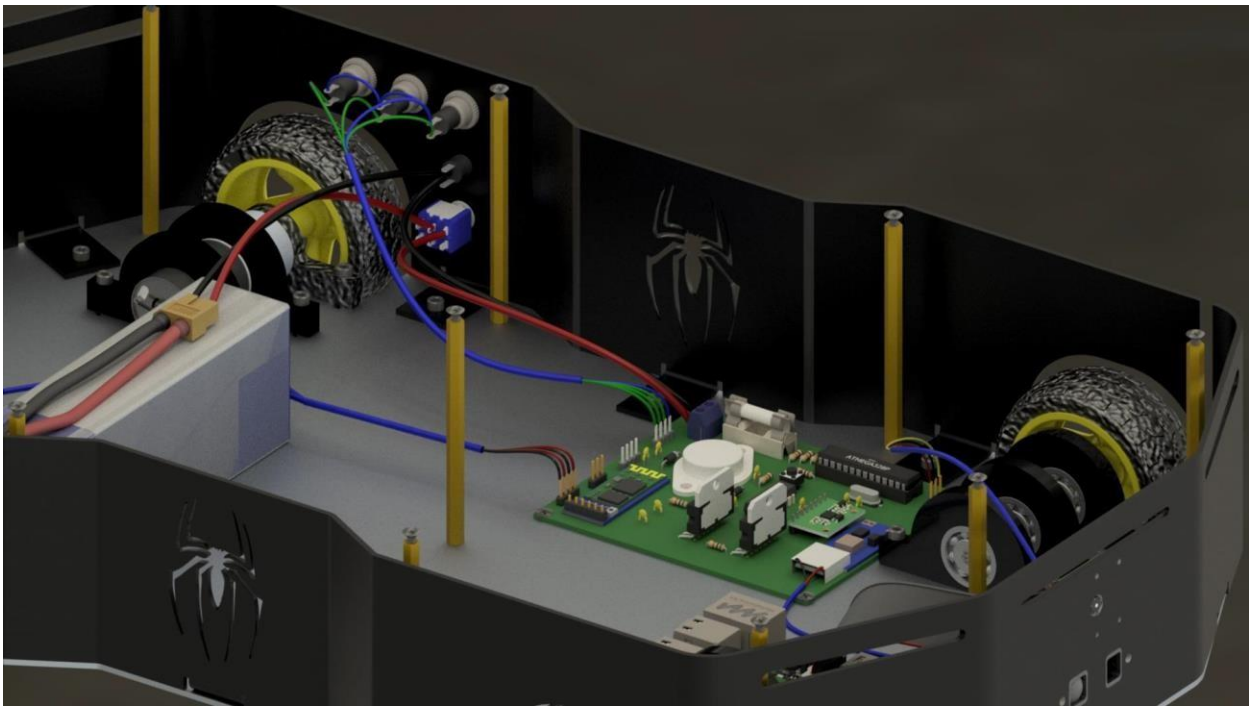

- This is how the board will look like after fabrication.

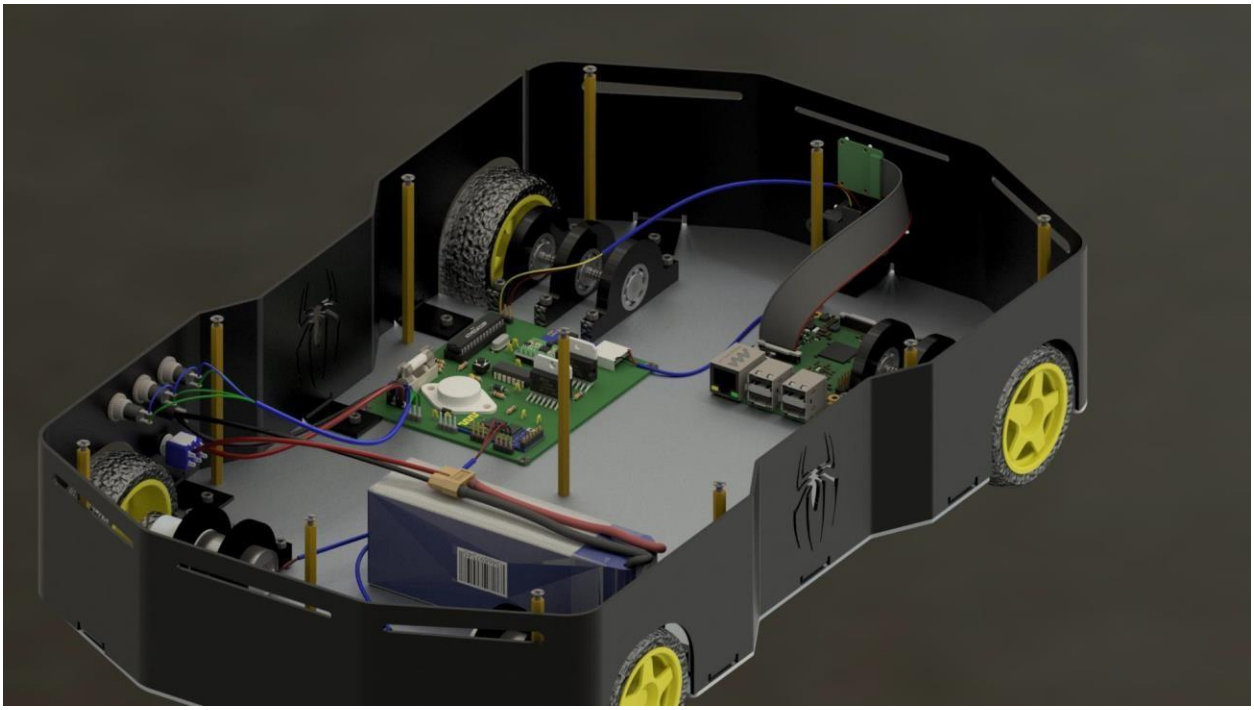



- This is how to PCB will look like after installing the components.


ATMEGA328P
SPYDER
TOP
LEFT
FRONT

## 4.2 Wiring





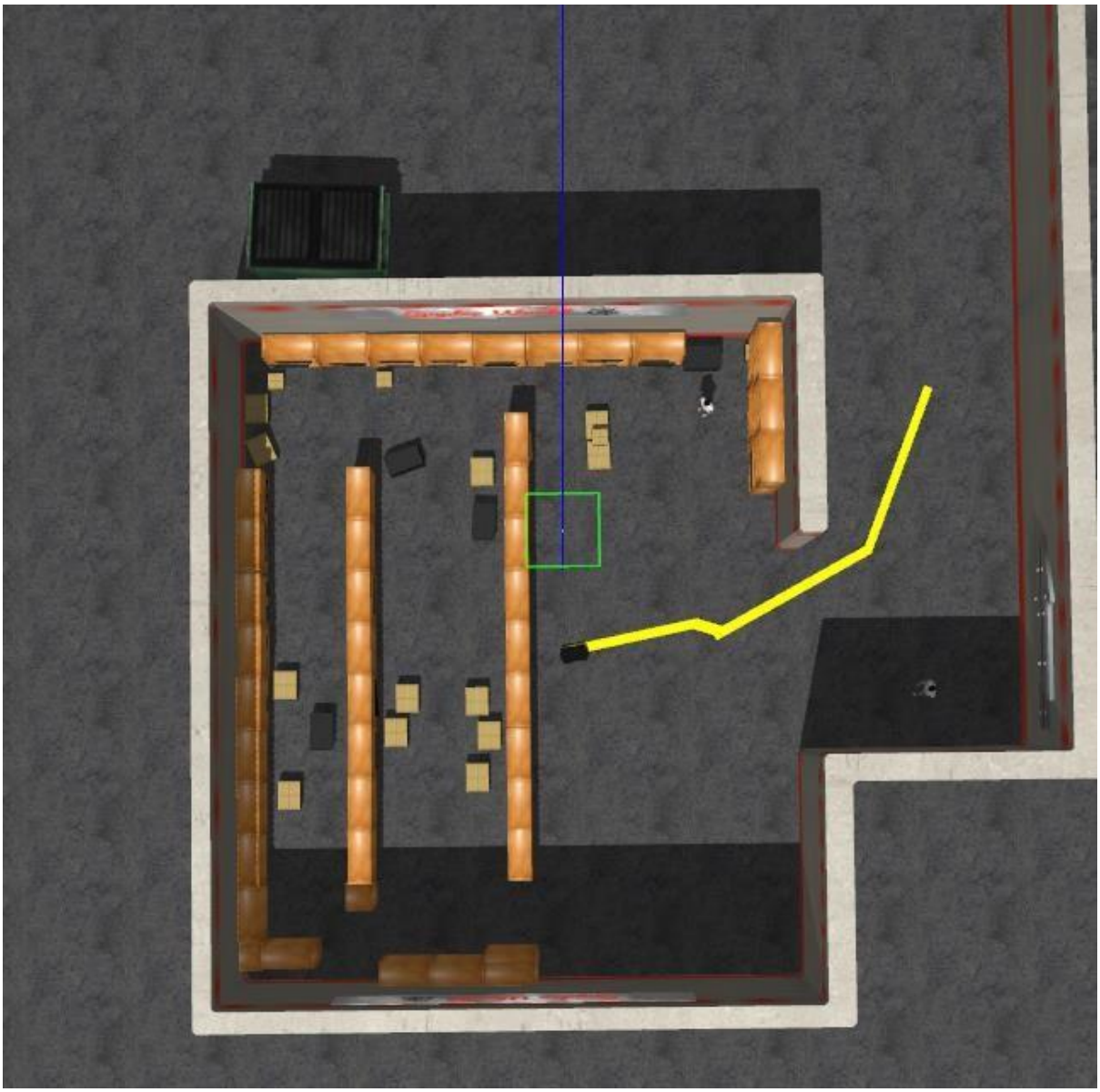
# 5. Gazebo

## 5.1 Robot Environment in gazebo

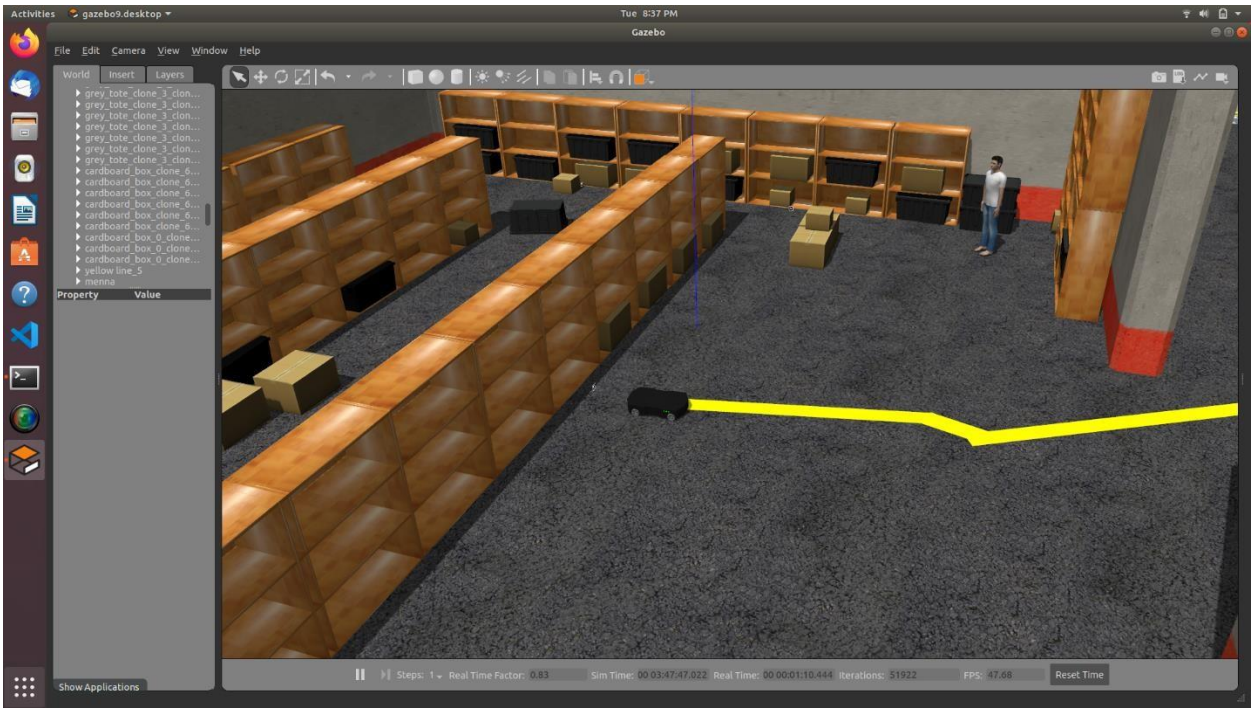
Basically, our robot is operating at Mall or hypermarkets warehouses, which are full of stocks, shelves, and employees everywhere.

Therefore, to simulate our robot in a pretty similar environment we built our own world to match the challenges that will face the robot.

Here is some close up of the environment:



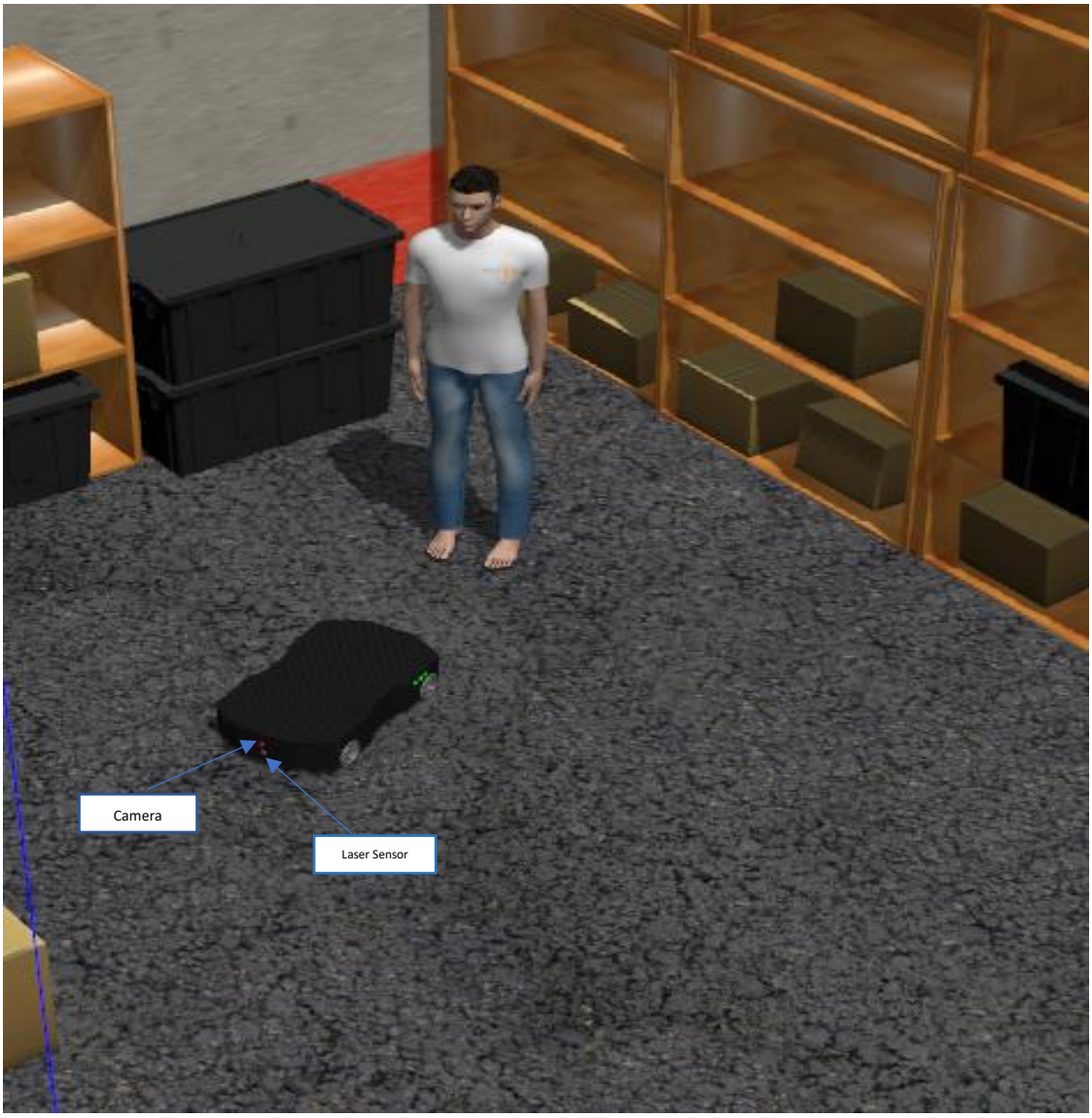

Steps: 1
Real Time Factor: 0.20
Sim Time: 00 03:49:19.113
Real Time: 00 00:04:04.233
Iterations: 144013
FPS: 59.33
Reset Time


Activities
gazebo9.desktop
Tue 8:37 PM
Gazebo
File Edit Camera View Window Help
World Insert Layers
Property Value
Show Applications
Steps: 1
Real Time Factor: 0.83
Sim Time: 00 03:47:47.022
Real Time: 00 00:01:10.444
Iterations: 51922
FPS: 47.68
Reset Time

## 5.2 Identifying Movable Joints

Spyder has only **Four** wheels to perform actuation and therefore there are no much of actuating joint except for the aforementioned wheels.

We managed to perform full actuation of the robot.



# 5.3 Sensors

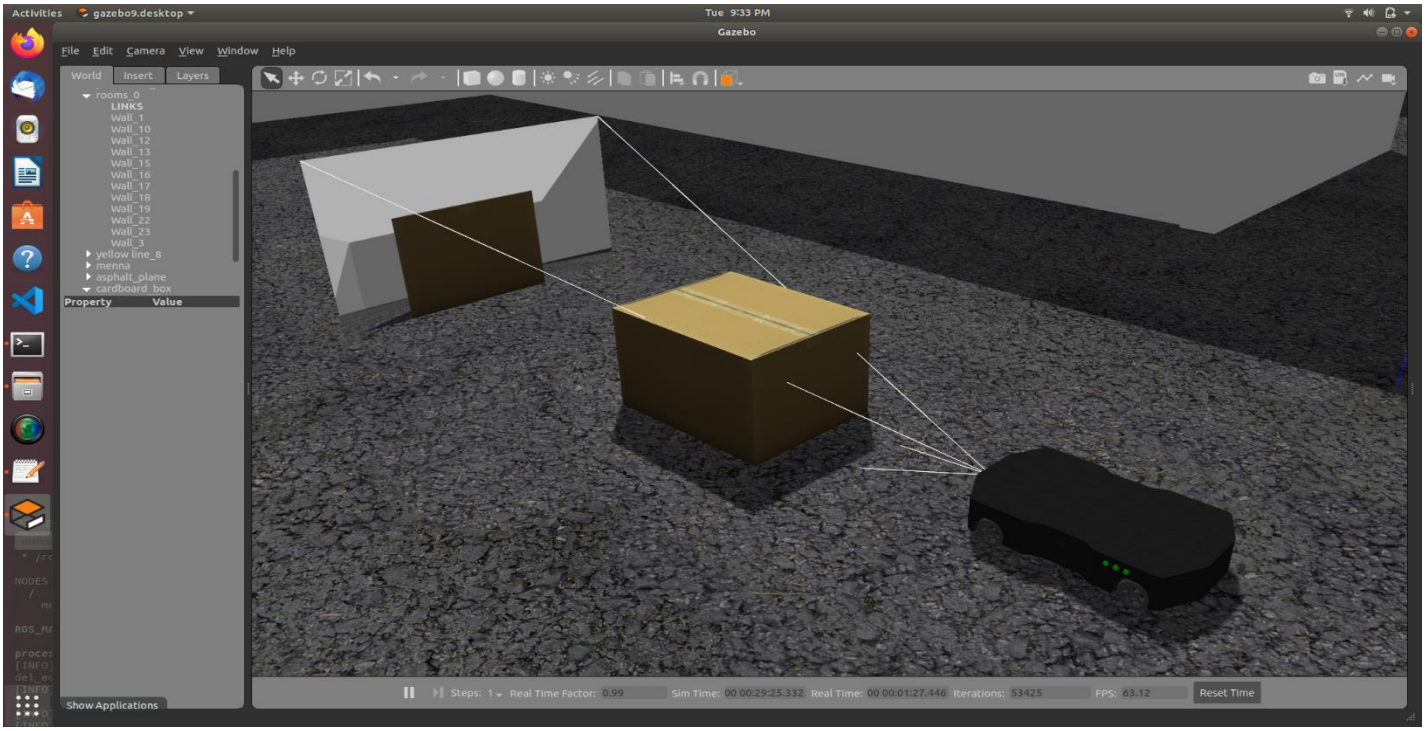
The robot has 2 main sensors to control its movement and actions

1- RGB Camera
2- Laser Sensor

## 5.3.1 Camera

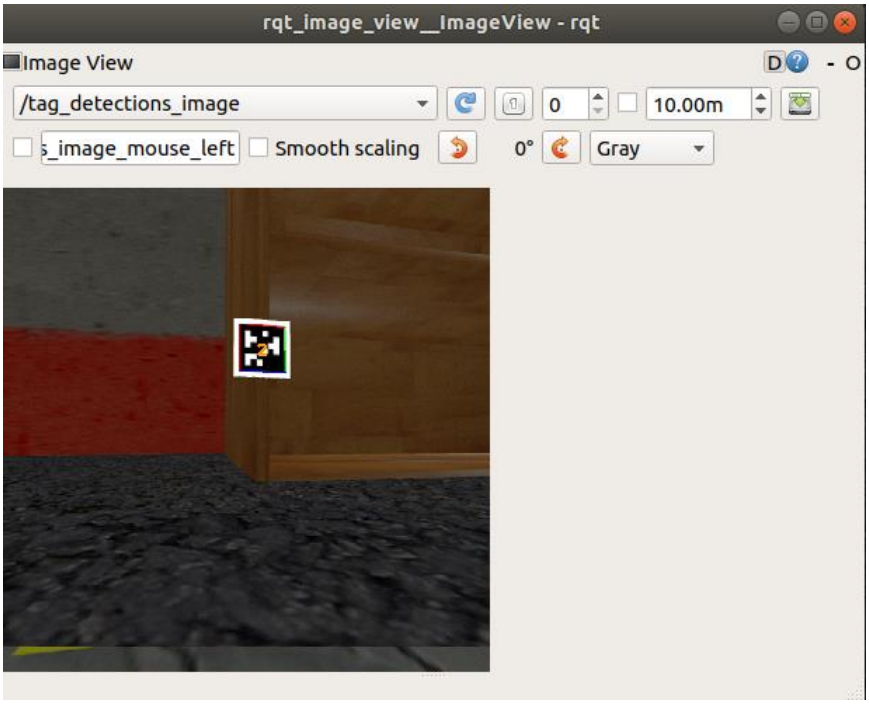
Camera is used to detect different colors, apriltags, obstacles.

- **Camera Visualization:**



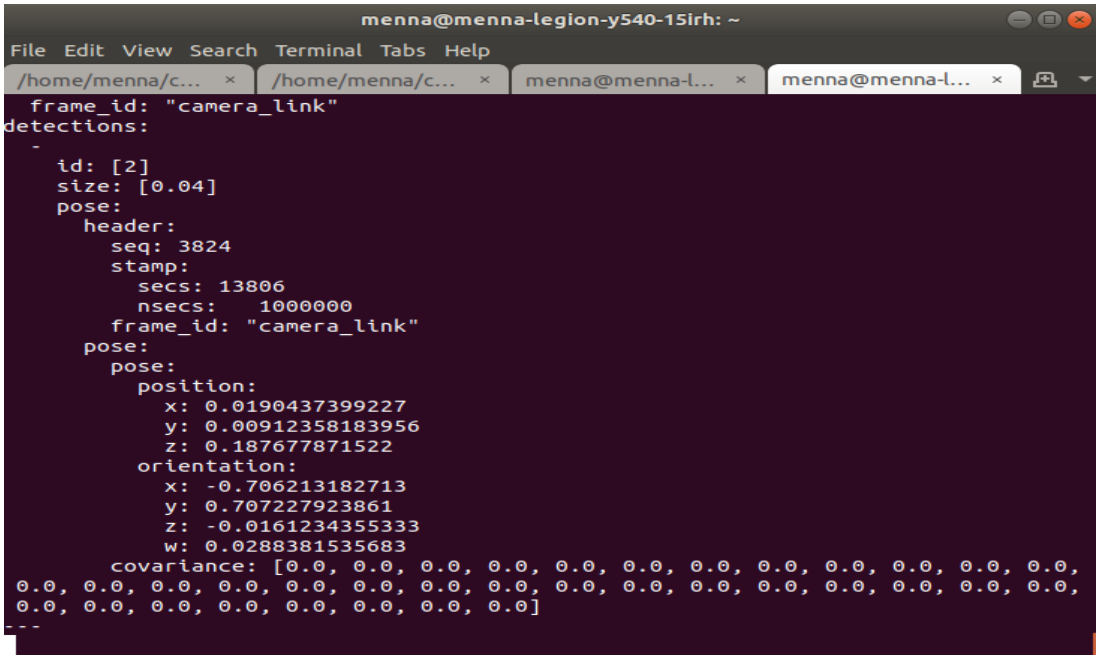
- **Camera detection for Apriltags:**

- **Camera Output**

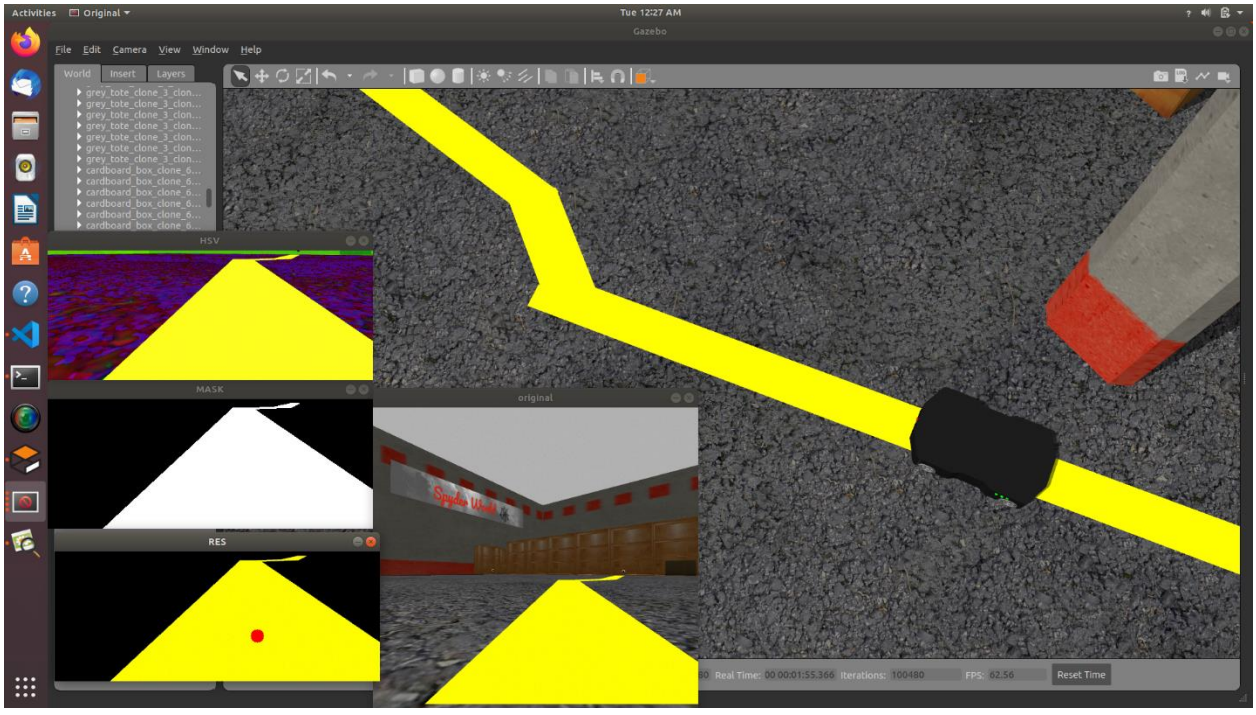


- **Subscribing to Camera topic :**

  Information from Apriltags such as : position, orientation, id, size, and reference frame




- **Detection of colors & lines:**

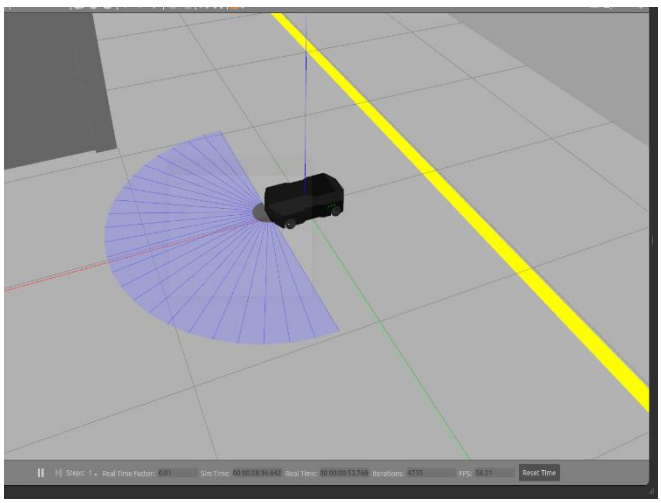


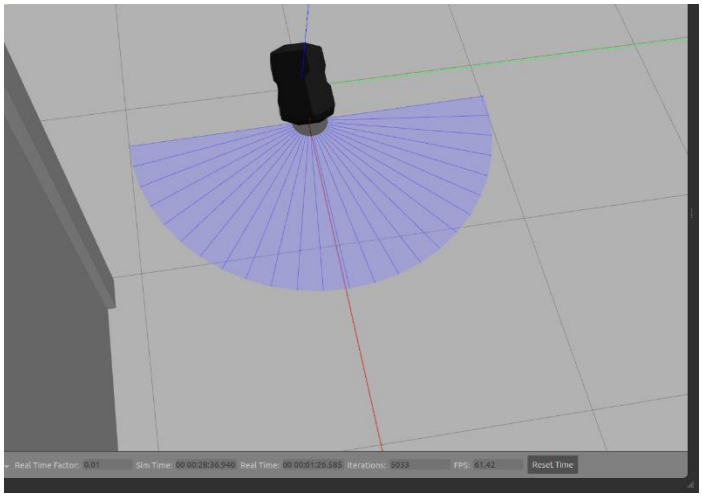
### 5.3.2 Laser Sensor

- **Laser Visualization**

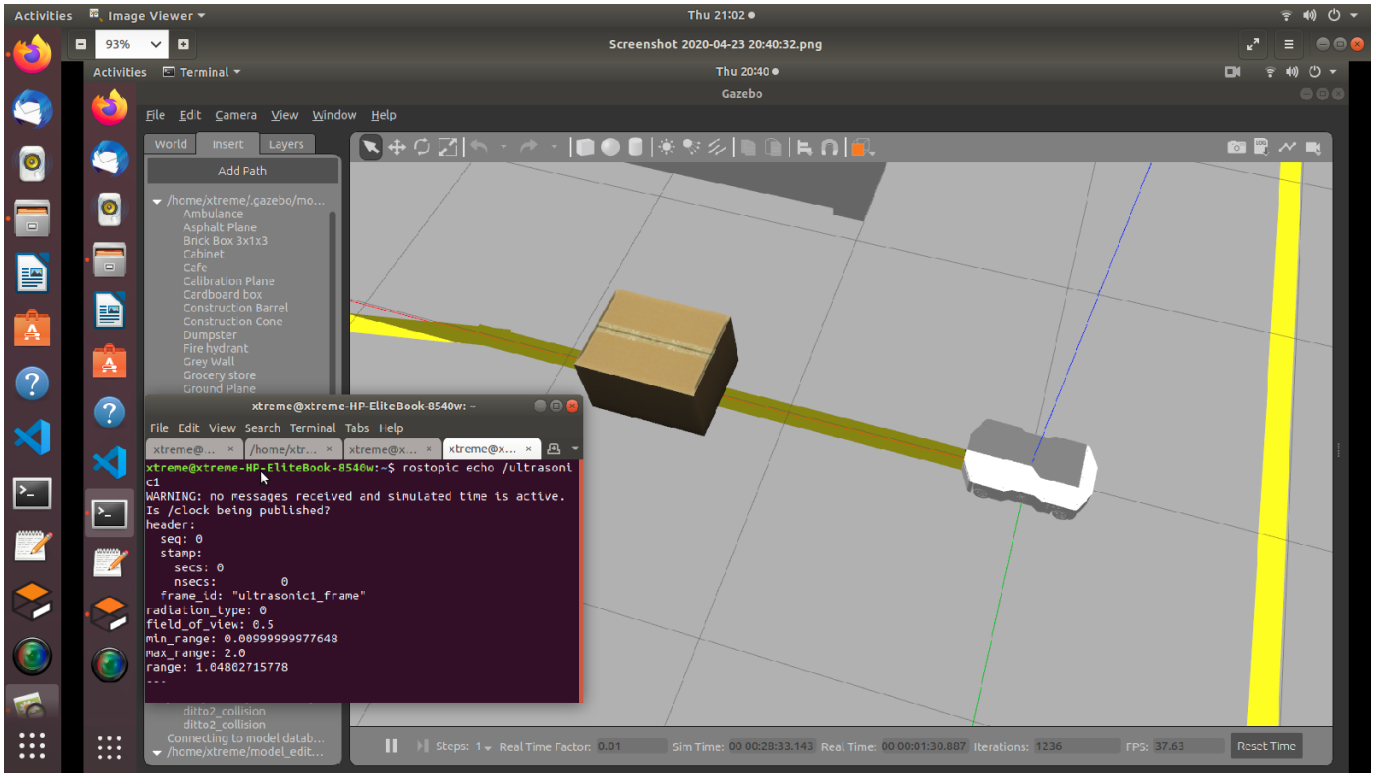
  Laser scan has an angle range of -180 ° to 180 ° and distance range is 1 meter, it has exactly 25 laser rays

  Here is a visualization of laser rays:





- **Laser Sensor Output**



# USEFUL LINKS

1 – Videos for different test cases:

Spawning Robot: https://youtu.be/fINsGkA0FTc

Obstacle Avoidance using Laser Sensor: https://youtu.be/XNDTKQNkk3w

2 – Diver folder containing all project files:
https://engasuedumy.sharepoint.com/:f:/g/personal/16p5015_eng_asu_edu_eg/EpKUlwiN
KzlJtSJSiF9c2_YB5hJjnlGGEyeHkWzZ_XwhbQ?e=mg7hH5