Ain Shams University

Faculty of Engineering

MCT 332 – Design 2
Team 5

Semi-autonomous machine vision robot

Technical Report

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Contents

Table of Figures

1. Introduction

This project aims to design and manufacture a functional machine vision robot that can achieve a targeted task that is helpful in any environment or field of our choice. However, the robot needs a vision, mission, Gantt chart, and a carefully planned timeline to study and achieve a market value for the robot. Furthermore, to ensure the functionality of the robot; Simulation using Vrep and CAD models were done.

Our robot can be divided to:

- Mission and vision
- Project management
- Mechanical Design
- Electrical Design
- Simulation
- PID Control
- Testing and integration
- Machine Vision

2. Mission and vision

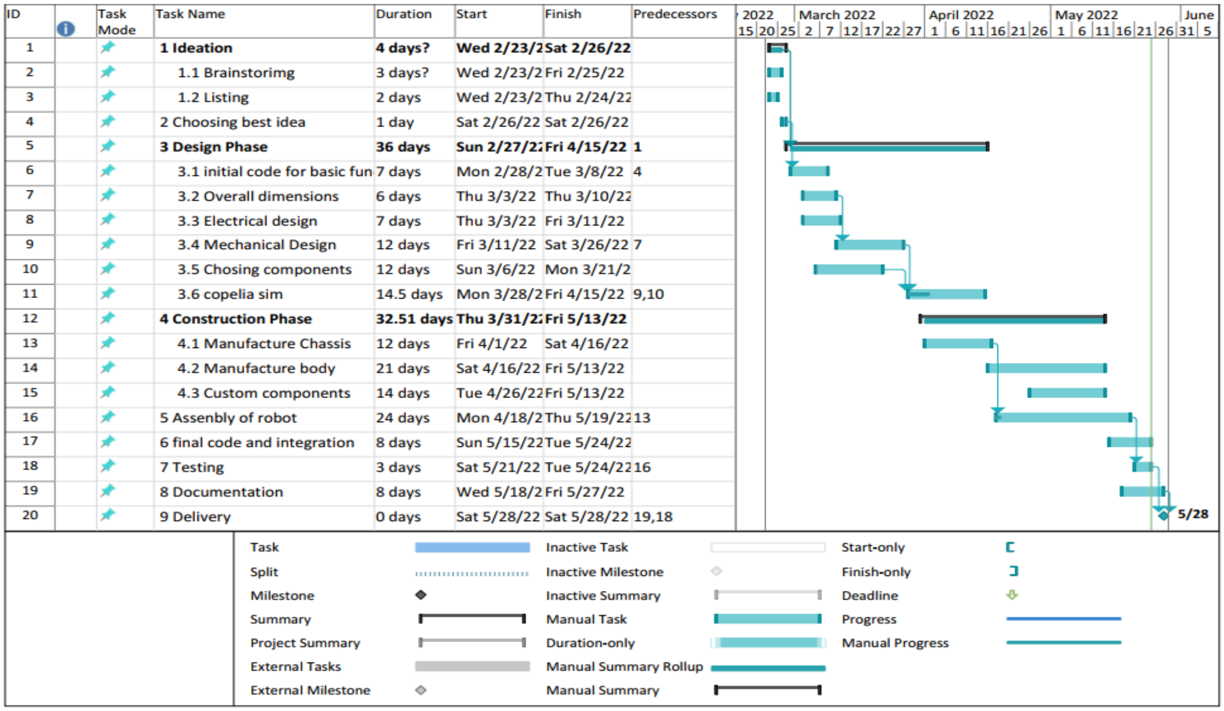
Our robot function is "Train attendant". Responsible for checking High speed rail train tickets for a much more convenient ride with no human error and unnecessary interactions. This can be achieved by designing a small size robot that can detect passengers sitting using machine vision, then politely asking for their tickets using LCD screen. The passenger then is required to present his/her ticket (in the form of a card) that can be scanned by the card reader on the top of the robot. Moreover, the robot is equipped by an ultrasonic sensor to avoid collisions with passengers in the hallway.

The vision of our robot can be described as passengers' convenience and comfort when travelling long distances using railways High-speed trains.

3. Project management

On the non-technical side of our project, we focused on coming up with a well-balanced timeline and project planning to facilitate an easier overall managerial side.

3.1. Gantt chart



ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		1 Ideation	4 days?	Wed 2/23/2	Sat 2/26/22	
2		1.1 Brainstorimg	3 days?	Wed 2/23/2	Fri 2/25/22	
3		1.2 Listing	2 days	Wed 2/23/2	Thu 2/24/22	
4		2 Choosing best idea	1 day	Sat 2/26/22	Sat 2/26/22	
5		3 Design Phase	36 days	Sun 2/27/2	Fri 4/15/22	1
6		3.1 initial code for basic fun	7 days	Mon 2/28/2	Tue 3/8/22	4
7		3.2 Overall dimensions	6 days	Thu 3/3/22	Thu 3/10/22	
8		3.3 Electrical design	7 days	Thu 3/3/22	Fri 3/11/22	
9		3.4 Mechanical Design	12 days	Fri 3/11/22	Sat 3/26/22	7
10		3.5 Chosing components	12 days	Sun 3/6/22	Mon 3/21/2	
11		3.6 copelia sim	14.5 days	Mon 3/28/2	Fri 4/15/22	9,10
12		4 Construction Phase	32.51 days	Thu 3/31/2	Fri 5/13/22	
13		4.1 Manufacture Chassis	12 days	Fri 4/1/22	Sat 4/16/22	
14		4.2 Manufacture body	21 days	Sat 4/16/22	Fri 5/13/22	
15		4.3 Custom components	14 days	Tue 4/26/22	Fri 5/13/22	
16		5 Assenbly of robot	24 days	Mon 4/18/2	Thu 5/19/22	13
17		6 final code and integration	8 days	Sun 5/15/22	Tue 5/24/22	
18		7 Testing	3 days	Sat 5/21/22	Tue 5/24/22	16
19		8 Documentation	8 days	Wed 5/18/2	Fri 5/27/22	
20		9 Delivery	0 days	Sat 5/28/22	Sat 5/28/22	19,18

Figure 1: Gantt chart

3.2. Network chart

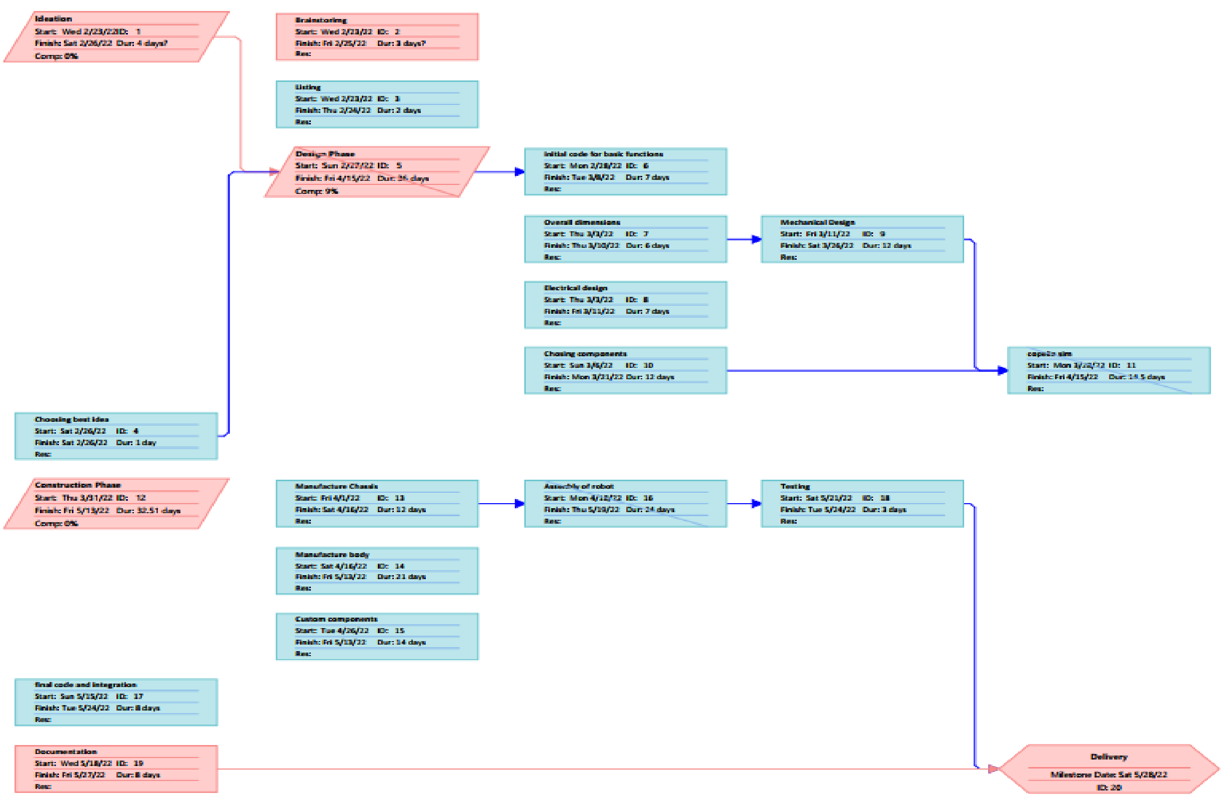


Figure 2: Project network

3.3. Cost and expenses

Figure 3: Costs

parts	amount	price	place
mounting braket motor 25mm	2	70	UGE
Lcd2004 blue backlight	1	100	free electronics
Servo motor metal gear mG90s	1	85	free electronics
caster wheels 30mm	2	60	free electronics
battery(3000mah,12v)	1	250	senior 2
280RPM RC Car Robot 25GA370	2	500	senior 2
65mm wheels +couplers	2	80	senior 2
raspberry pi 3b+ ,camera and cover	1	1200	Joe
LM317 DC Linear Regulator Step Down Module	1	25	free electronics
L298 Motor Driver Module	1	60	free electronics
ultrasonic sensor	1	35	free electronics
Ultrasonic Sensor HC-SR04 Holder 2	1	10	free electronics
arduino uno	1	160	RAM
Raspberry Pi 4B – 4GB – MADE IN UK	1	2500	RAM
camera holder	1	48	RAM
1m aluminum bar 8mm	1	20	sabtya
kf08	4	100	
coupler 4-8mm	2	100	future
RFID 13.56 Mhz (Read - Write) RC522 with 4 Cards	1	100	Senior 2
Emergency push button(22mm)	1	30	free electronics
female charging port	1	5	future
On off button	1	farid	Farid
Raspberry pi camera cable(100cm)	1	60	Alexandria
Line traker	3	90	future
i2c/spi character lcd backpack	1	40	future
spacer 5cm	4	16	
spacer 5cm	8	32	future
logic level conveter	2	50	future
laser metal	1	585	
akleric		100	
body		1000	Kerdasa
benzene		100	
wood		12	
machining		20	
screws		15	
A*		10	
Total		**3637**	

4. Mechanical design

4.1. General specification

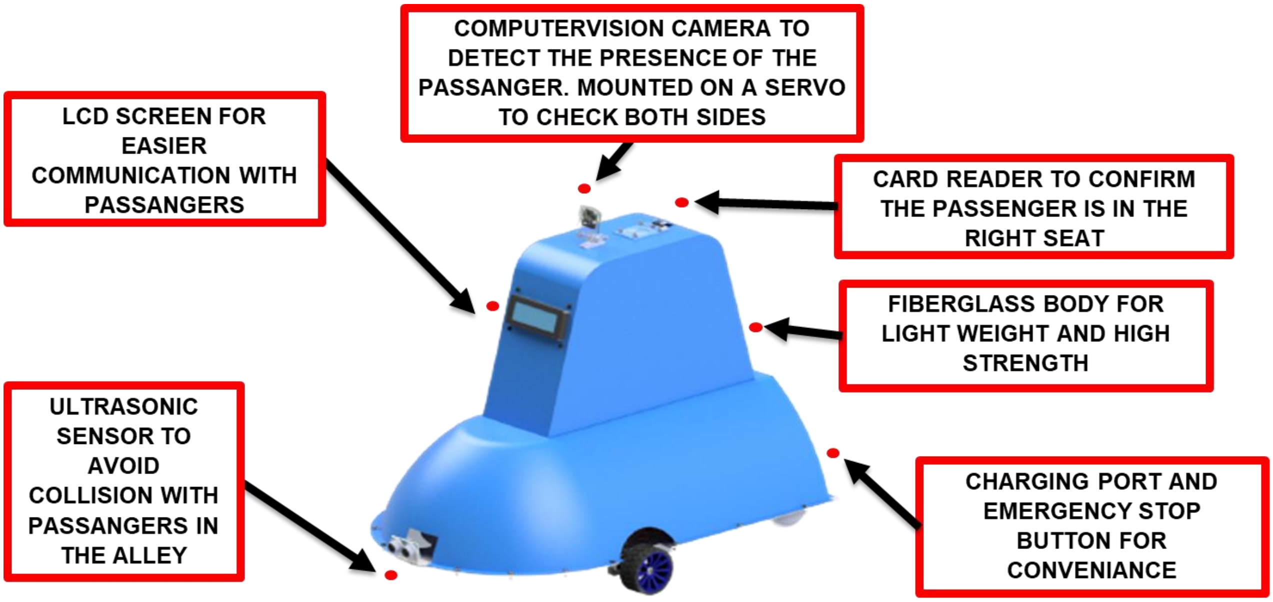


Figure 4: Robot specifications

Our robot had several useful features that aims to ease the accomplishment of the tasks. For instance, an LCD was fitted to communicate easily with the passengers. A small servo motors the rotates the camera is mounted at the top to rotate it 180 degrees to detect passengers on both sides. The card reader is at the top so it can easily be reached. Plenty of other features were added for safety (such as emergency Push button), weight reduction (fiber glass body), and technology (obstacle collision avoidance using ultrasonic sensor).

4.2. Manufacturing Process

- Chassis: Laser cutting aluminum 2mm sheet
- Body: fiber glass using a foam mold

4.3. Wheel assembly

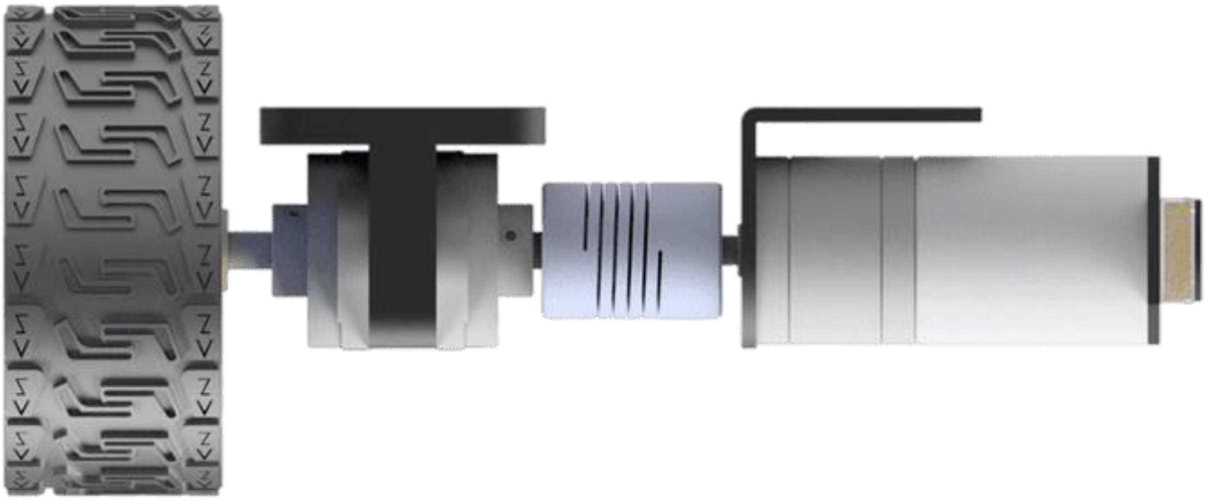


Figure 5: Wheel assembly

The robot locomotion is controlled by 2 DC motors with encoders. Each of these motors are assembled with a flexible coupler, 2 flanged bearings and a couple to connect it to the wheel. Furthermore, no weight is on the motor shaft.

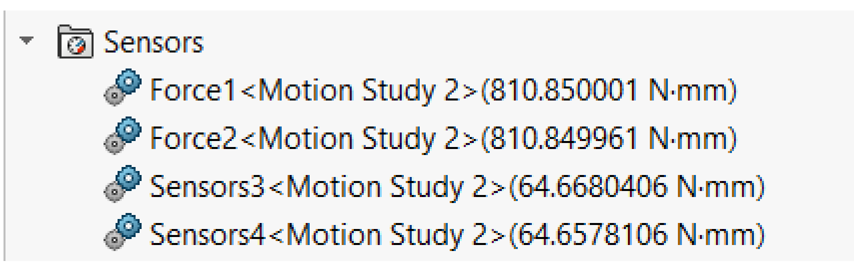
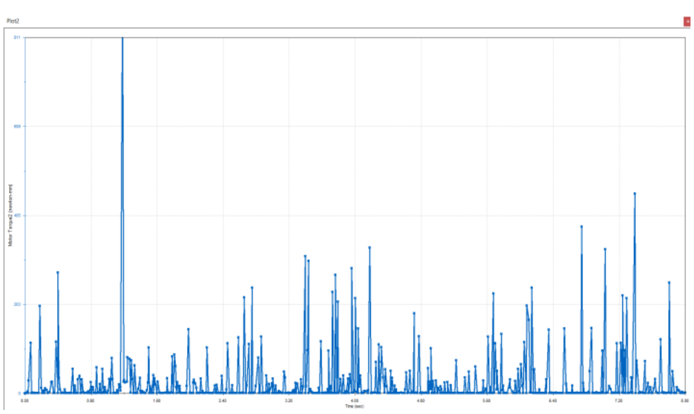
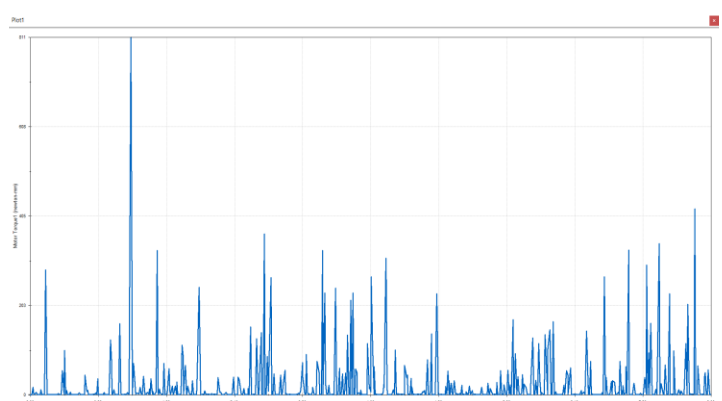


Figure 6: Motor sizing





4.4. Stress analysis

Stress analysis is made on critical parts such as the chassis and the aluminum to output the maximum stresses, Safety factor and maximum displacement.

5.

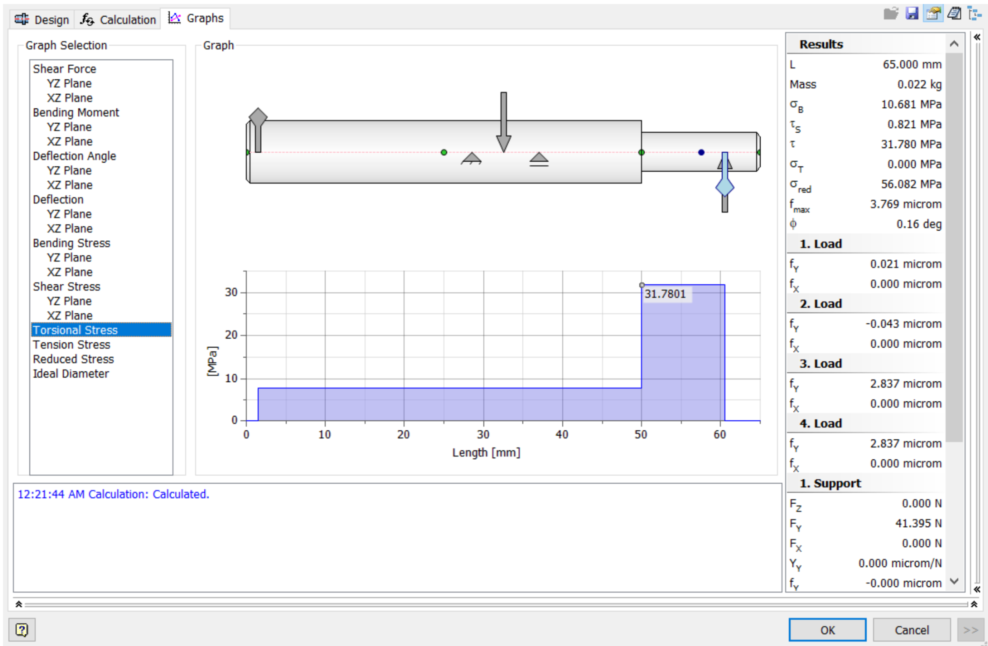


Figure 8: Motor shaft Torsional stress

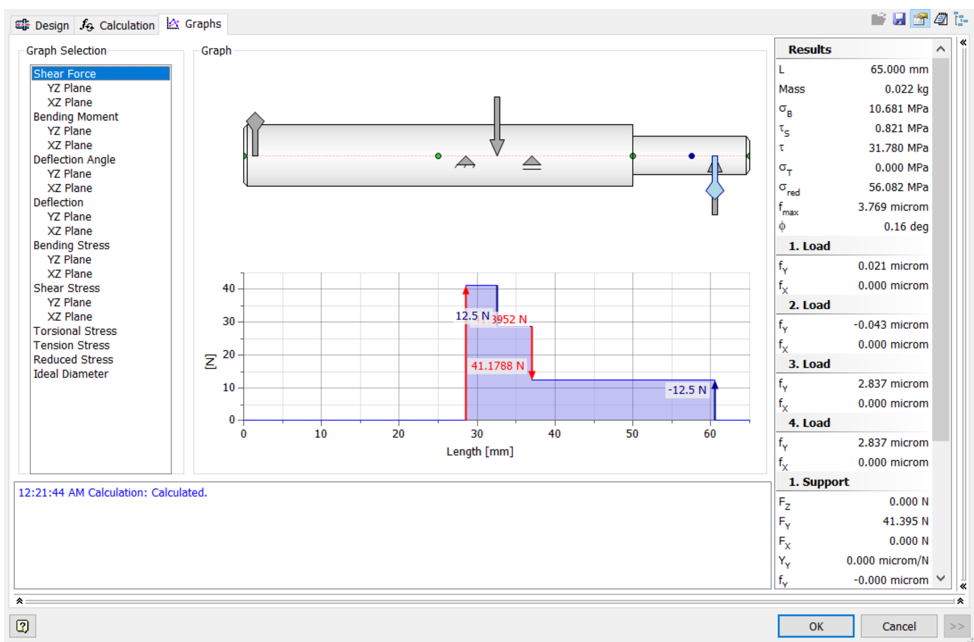


Figure 7: Motor shaft shear force

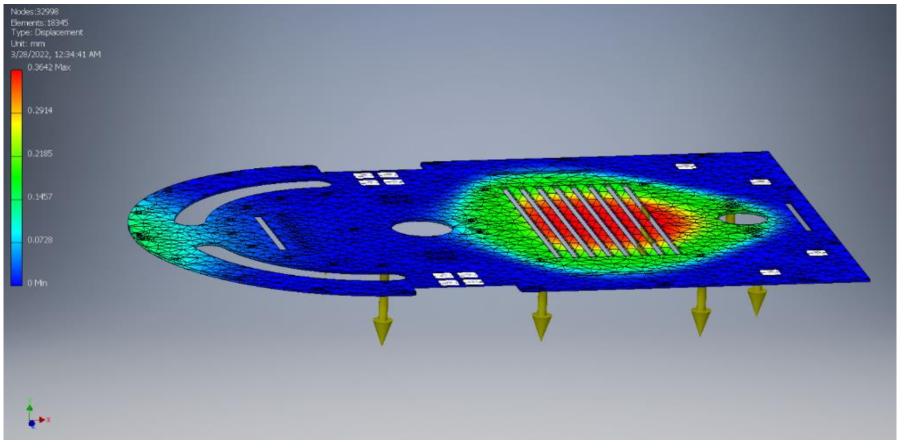


Figure 9: Chassis maximum displacement

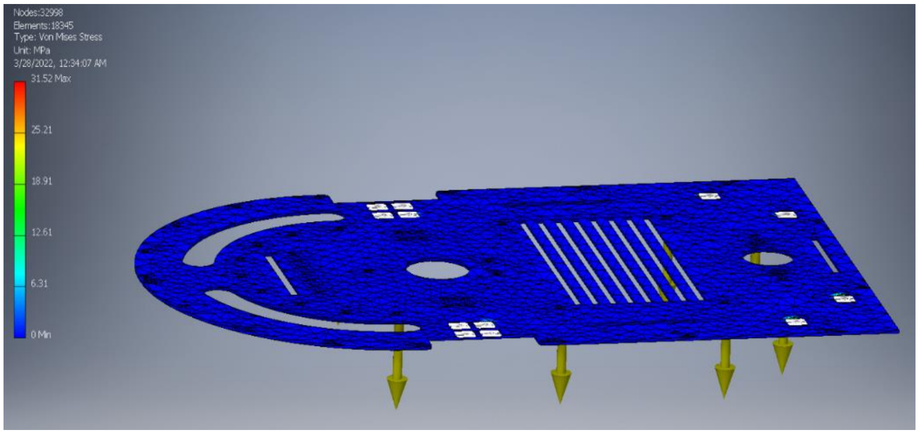


Figure 10: Chassis maximum stress

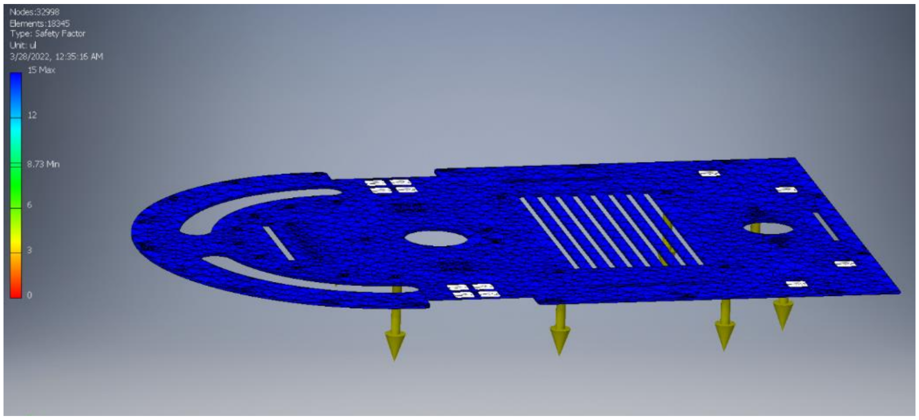


Figure 11: Chassis safety factor

5. Electrical Design

5.1. Components

Electronics are separated for power electronics to avoid noise and the battery is installed in a low position for a better CG (which is around 70mm from ground).

On the back of the robot there is an On/Off switch, emergency Push button and the charging port

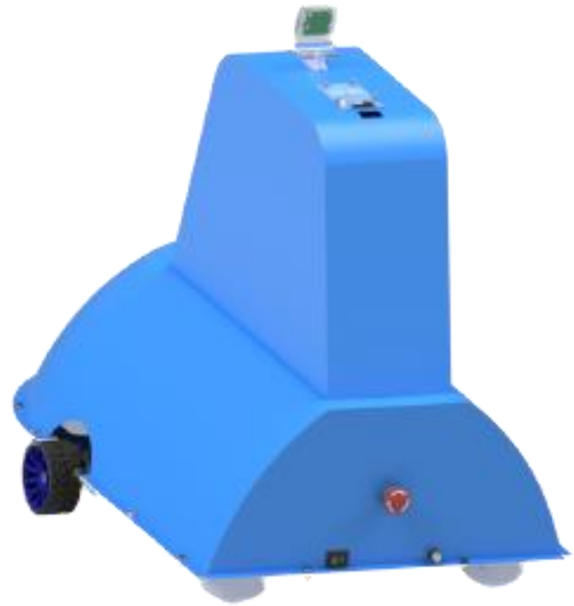


Figure 12: CAD rear view

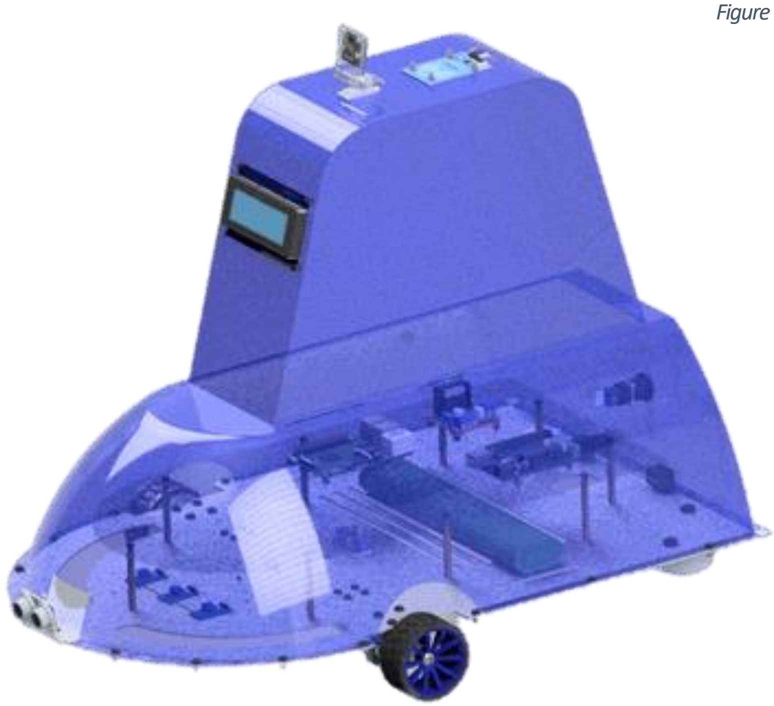


Figure 13: CAD transparent view

5.2. Low voltage circuit

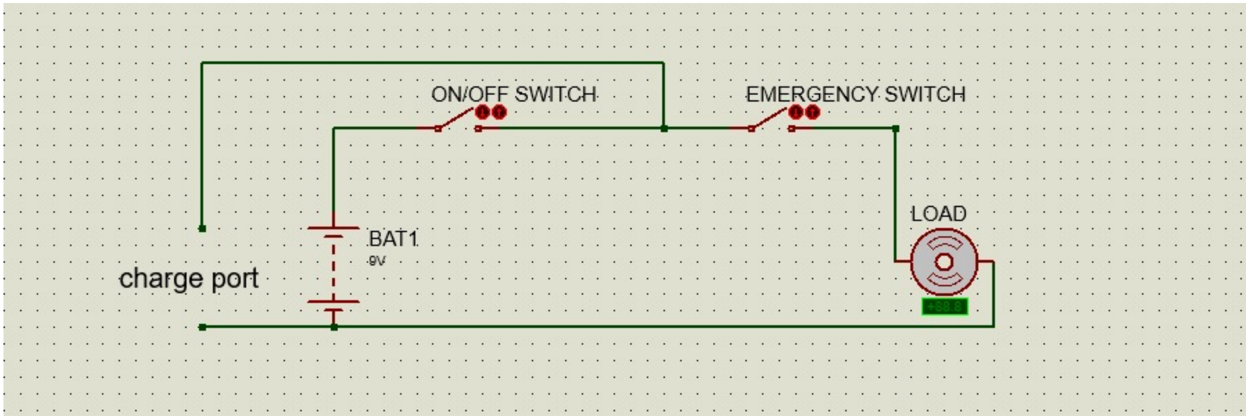


Figure 14: Low voltage

6. Simulation

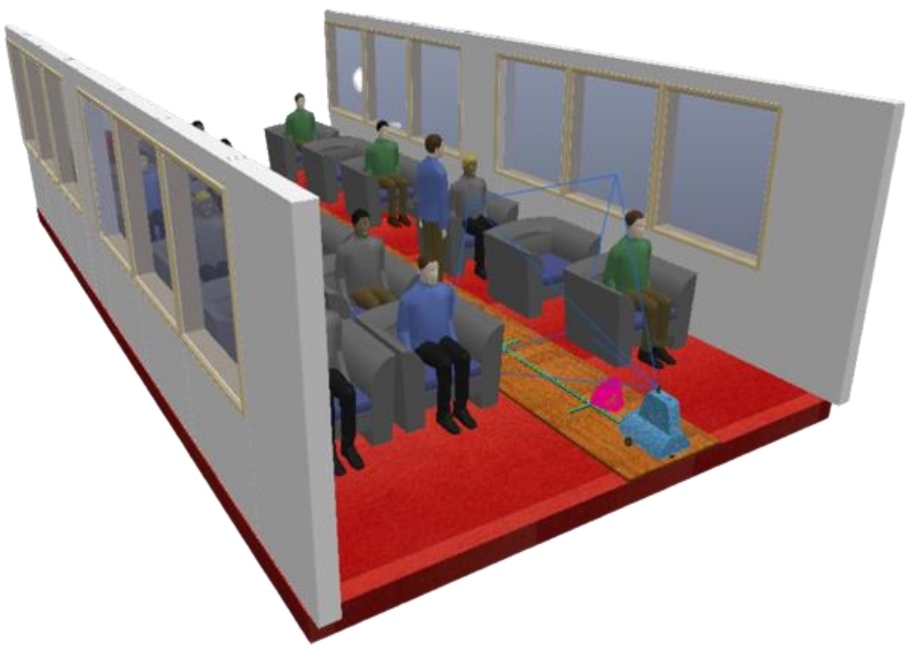


Figure 15: CoppeilaSim environment

The working environment was simulated in CoppeilaSim. After research on the seat's setup in our targeted trains it is commonly a 2-1 per row seats and that's what we presented in the environment above.

7. PID Control

Our robot is a line follower, where it is the most efficient way to ensure the robot is always moving where it is intended to go. For our Line-following we used 3 IR sensors and a PID control code to output a smooth response from our DC motors. The motors has an integrated magnetic encoders as the feedback sensors for the encoder.

8. Machine vision

The robot detects the presence of passengers using machine vision OpenCV library by face detection. Once the face is detected the LCD sends a message to inform the passenger to scan his ticket on the card reader.

9. Block diagrams

9.1. Hardware architecture

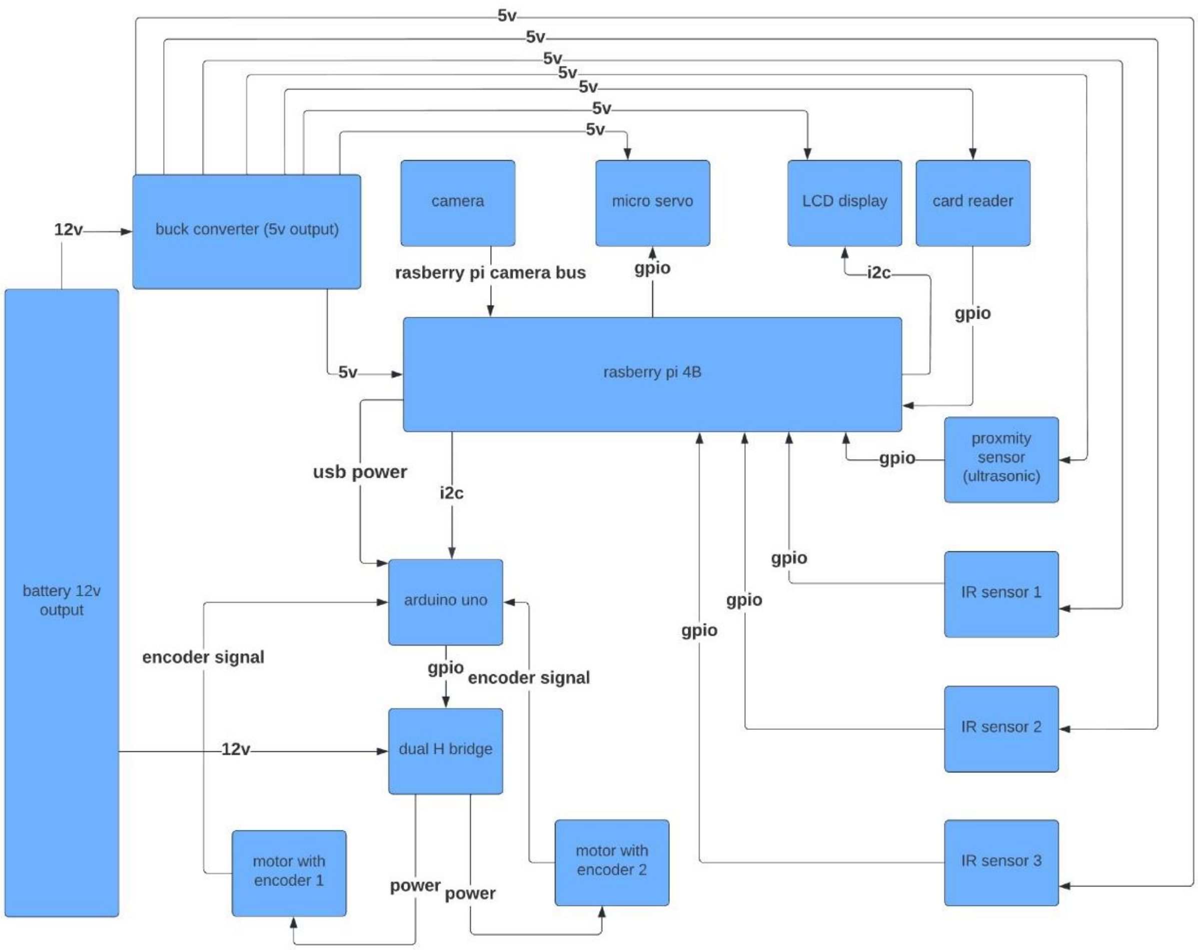


Figure 16: Hardware Block diagram

9.2. Software architecture

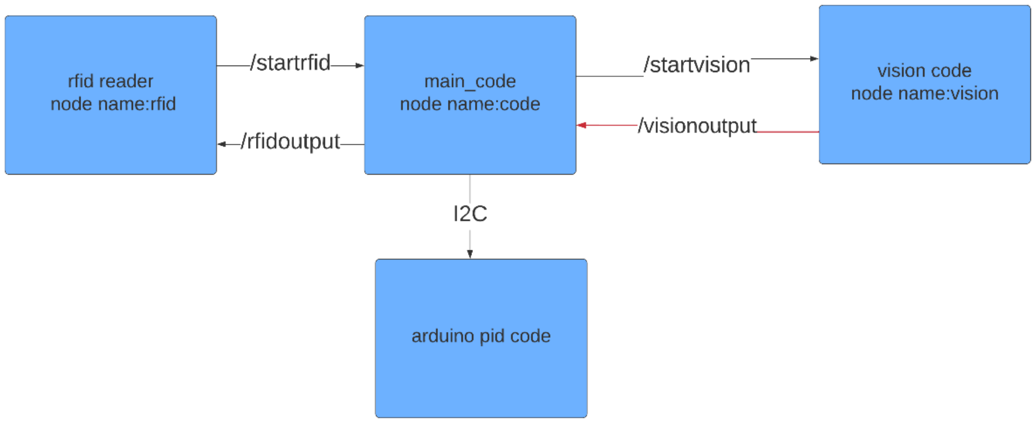


Figure 17: Software block diagram

10. Testing and integration

The project was sequentially tested and integrated with checkpoints and phases . The following diagram can represent the process.

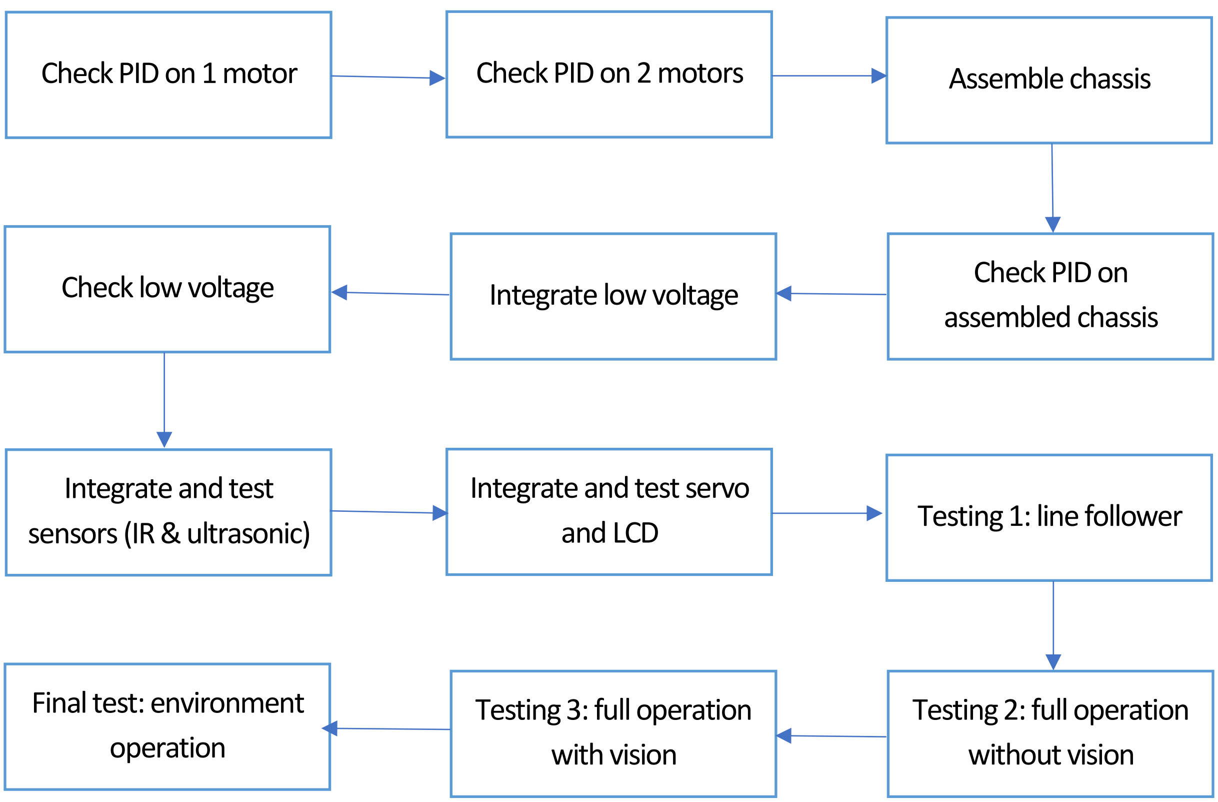


Figure 18: Testing and integration diagram

11. Real Model

Figure 20: Real model top view

Figure 19: Real model isometric

12. Conclusion

Constructing this project has given us a plethora of experience in machine vision, testing, debugging, ROS, and environment simulations. And the final product performance is close to the expected output of the simulations and models, suggesting that we have preciously followed the project instructions. Finally, can safely push our limits when it come to a similar but advanced project.

13. Appendix

Drive link that includes videos, code, CAD, and other documents:

https://drive.google.com/drive/folders/1Xaf27Kr5p3cleWZGlrXlbDX_gMHLt7CV?usp=sharing