



Politechniki
Śląskiej



Politechnika
Śląska



AUTONOMOUS DRIVING USING DEEP LEARNING ARTIFICIAL INTELLIGENCE

Paweł Wawrów, Grzegorz Zając, Paweł Pukocz, Jakub Mazur, Oskar Kowalski,
Kijun Lee, Sanghyun Ahn Youngjin Kim, Wonjae Lee

Opiekunowie projektu

dr hab. inż. Piotr Przyszałka, prof. PŚ, mgr inż. Witold Krafczyk, Prof. Kyungsoon Lee, Prof. Joo-ho Lee

Final Presentation

Autonomous Driving with AI & without AI

Using Image Processing

Date : 29 May, 2025

Team name : SOLLUNA / PBL 10

LEADER : Kijun Lee

MEMBER : Wonjae Lee

MEMBER : Sanghyun Ahn

MEMBER : Youngjin Kim

LEADER : Paweł Wawrów

MEMBER : Grzegorz Zajac

MEMBER : Paweł Pukocz

MEMBER : Oskar Kowalski

MEMBER : Jakub Mazur

Contents

I. Team Members roles

II. Professors

III. Subject Description & Goals

IV. Definition Of The Problem

V. How It Was Solved

VI. Digital Twin & 3D CAD

VII. System Design

VIII. Scenario

IX. Programming & Algorithm

X. Coding

XI. Prototyping Schedule

XII. Prototype Videos

1. Team Members roles

- We are SOLLUNA.



We have First Workshop(26 May 2025).

1. Team Members roles_SMU

LEADER



Kijun Lee

- Development System Setup
- Programming
- System Design
- Scenario Development
- Communication

MEMBER



Sanghyun Ahn

- 3D Design
- Wire Management
- Hardware Assemble

MEMBER



Wonjae Lee

- 3D Assembly
- Hardware Assemble
- Testing

MEMBER



Youngjin Kim

- Circuit Design
- Wire Management
- Consultation



2. Professors



Name : Kyungsoon Lee
University : SunMoon Univ.
E-mail : leecstar@sunmoon.ac.kr
Department : Depart. Of Advanced Automotive Engineering(AAE)

Name : Changseung Kim
University : SunMoon Univ.
E-mail : cskim7378@sunmoon.ac.kr
Department : Depart. Of Advanced Automotive Engineering(AAE)

Name : dr hab. inż. Piotr Przystałka, prof. Pol. Śl.
University : Politechnika Śląska Univ.
E-mail : Piotr.Przystalka@polsl.pl
Department : Mechanical Engineering

Name : mgr inż. Witold Krafczyk.
University : Politechnika Śląska Univ.
E-mail : Witold.Ilewicz@polsl.pl
Department : Mechanical Engineering

3. Subject Description

- Autonomous Driving : A Key Element of the Fourth Industrial Revolution.
- Key functions include.
 - Recognizing lane markings.
 - Detecting stop lines.
 - Interpreting traffic signals.
 - Obstacle Detection.



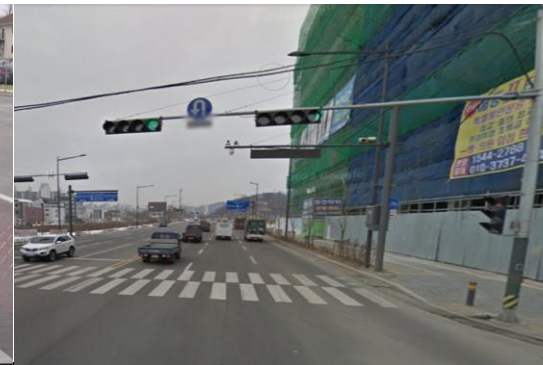
Line Detection

<https://www.youtube.com/watch?v=yvfl4p6Wvyk>



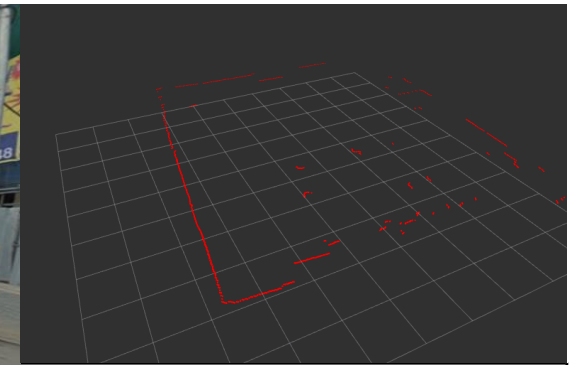
Stop Line Detection

<https://lrl.kr/eiJdG>



Traffic Signal Detection

-



Obstacle Detection

-

3. Goals

Camera

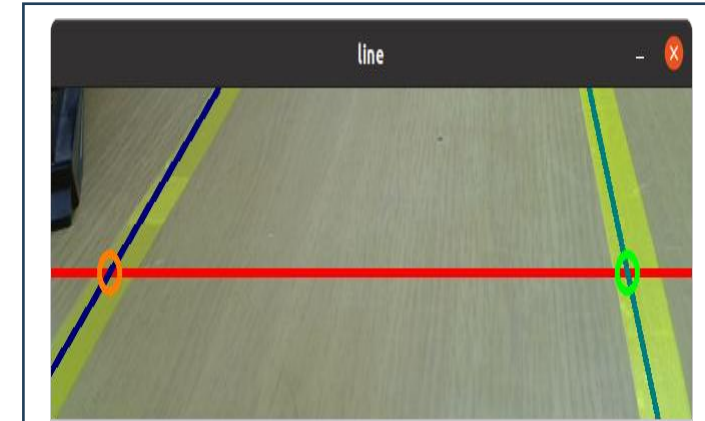
- Steering wheel control for lane keeping.
- Traffic signs recognition.
- Luminance difference detection (Left turn).

LiDAR

- Steering control based on object detection.

PID

- PID-based steering control.
- Comparison Between PID and Non-PID Steering Control.

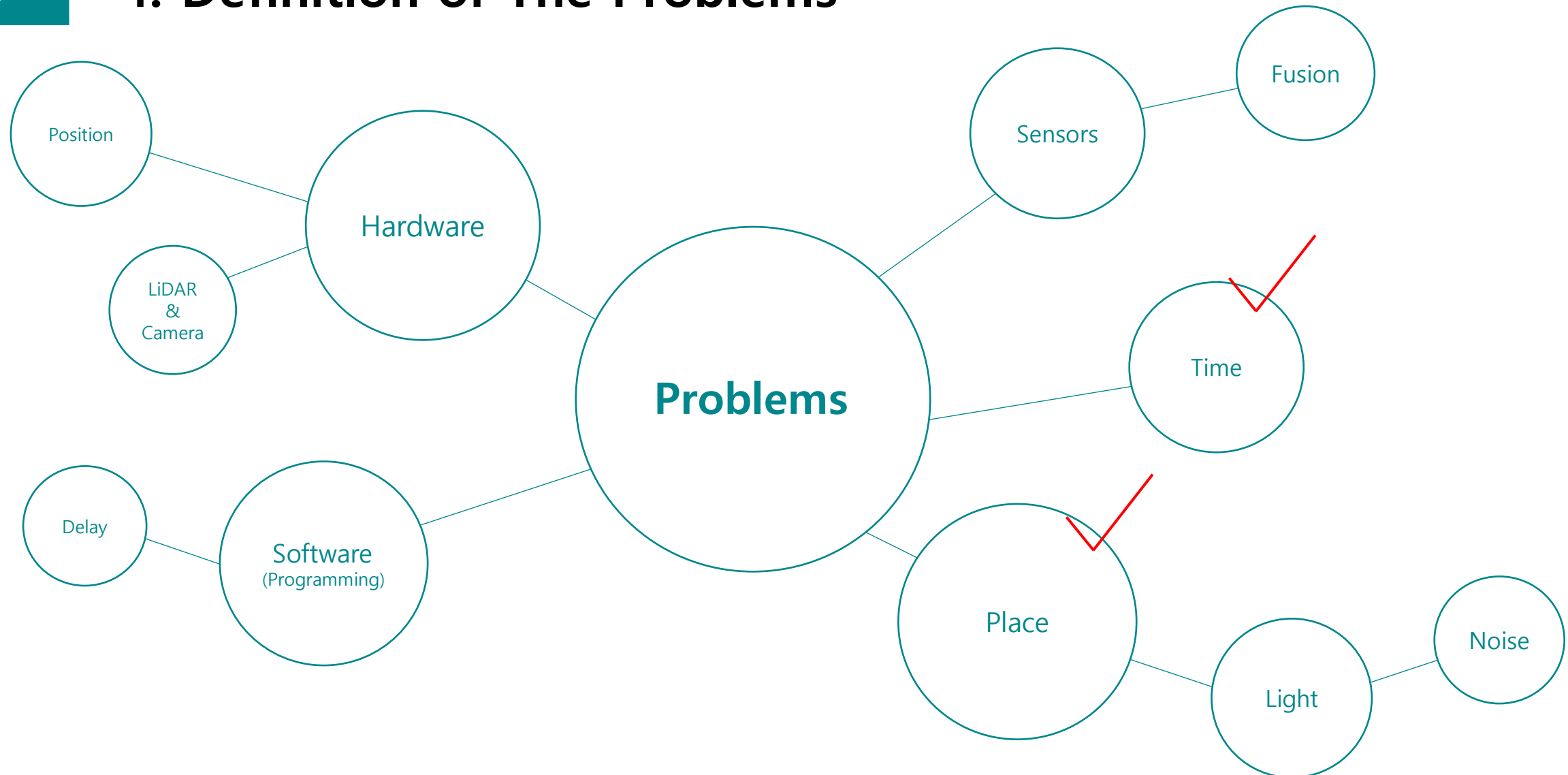


Line Detection

```
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 575, 0.1289999932050705]], [577, 0.1289999932050705, 608, 0.1289999932050705]), 2)
object info = ([[545, 0.13099999725818634, 575, 0.1289999932050705]], [577, 0.1289999932050705, 608, 0.1289999932050705]), 2)
object info = ([[544, 0.13099999725818634, 575, 0.1289999932050705]], [577, 0.1289999932050705, 608, 0.1289999932050705]), 2)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 544, 0.13099999725818634]], [546, 0.13099999725818634, 608, 0.1289999932050705]), 2)
object info = ([[544, 0.13099999725818634, 575, 0.1289999932050705]], [577, 0.1289999932050705, 608, 0.1289999932050705]), 2)
object info = ([[544, 0.13099999725818634, 575, 0.1289999932050705]], [577, 0.1289999932050705, 608, 0.1289999932050705]), 2)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
object info = ([[544, 0.13099999725818634, 575, 0.1289999932050705]], [577, 0.1289999932050705, 608, 0.1289999932050705]), 2)
object info = ([[544, 0.13099999725818634, 608, 0.1289999932050705]], 1)
```

Object Recognition

4. Definition of The Problems



5. How It Was Solved

Hardware - Position

- Camera position adjusted higher.



- Easier line detection.
- Want to use LiDAR

Sensors - Integration

- Using Linux OS.
- Using ROS.



- Easy programming development.
- Convenient sensor handling.


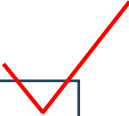
Software - Programming

- Studying Python.
- Learning to programming with sensors.
- Have developed delay issue.



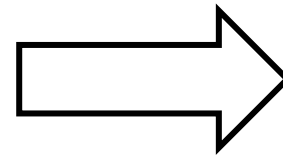
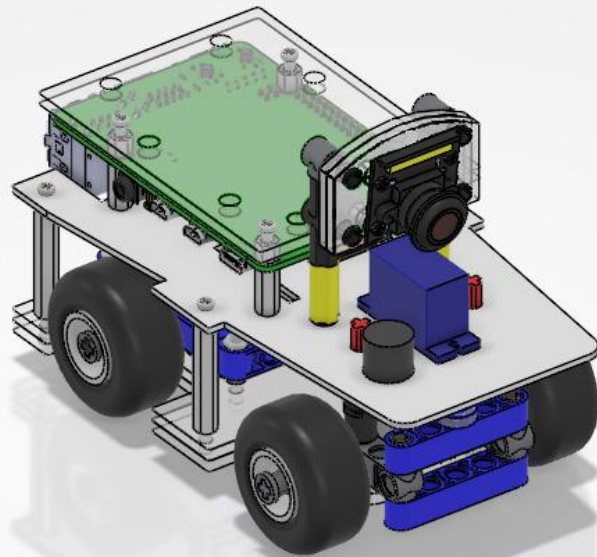
- Helpful for sensor operation.
- Improved motor operation.

Time & Place

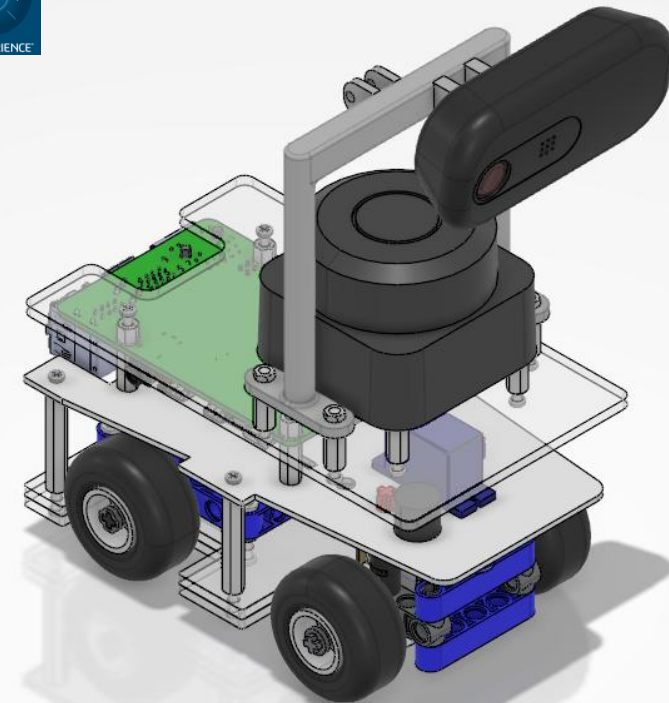
- Difficulty in color recognition due to orange lighting.
 - We can't use the venue.
- 
- A video will be used instead.
- 

6. Digital Twin & 3D CAD

Before

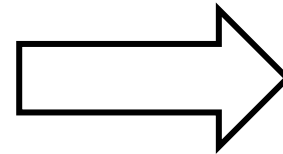
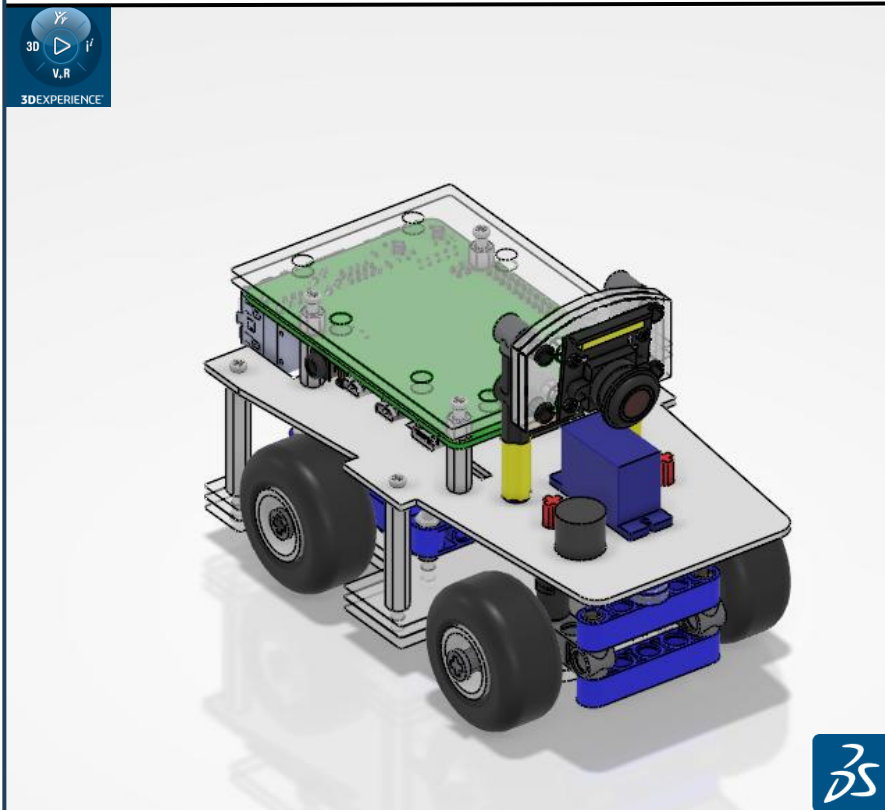


After

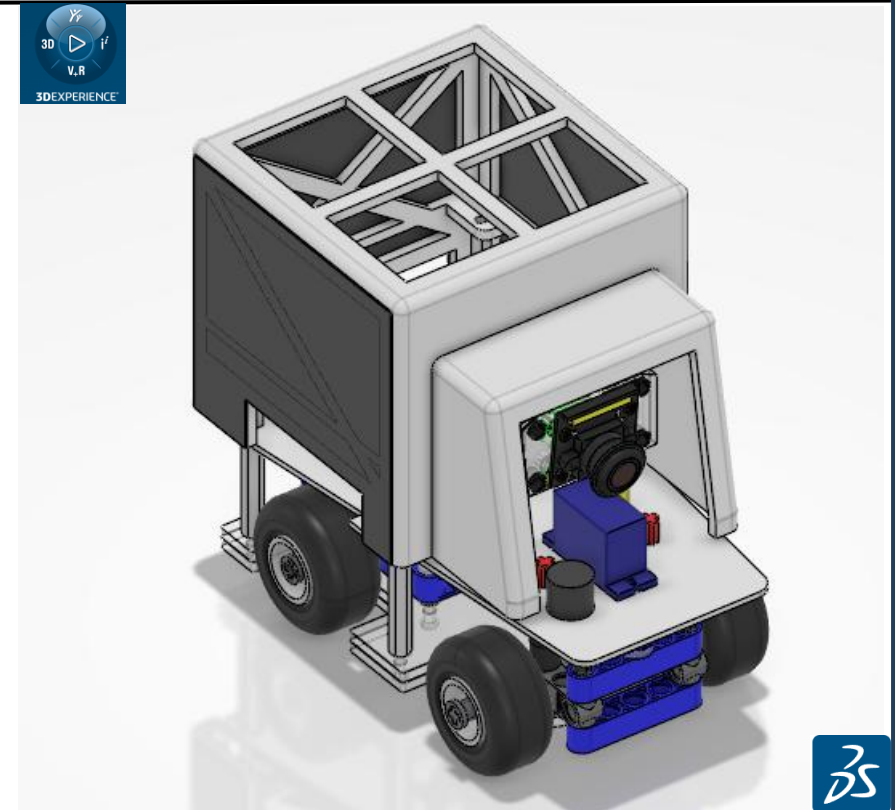


6. Digital Twin & 3D CAD

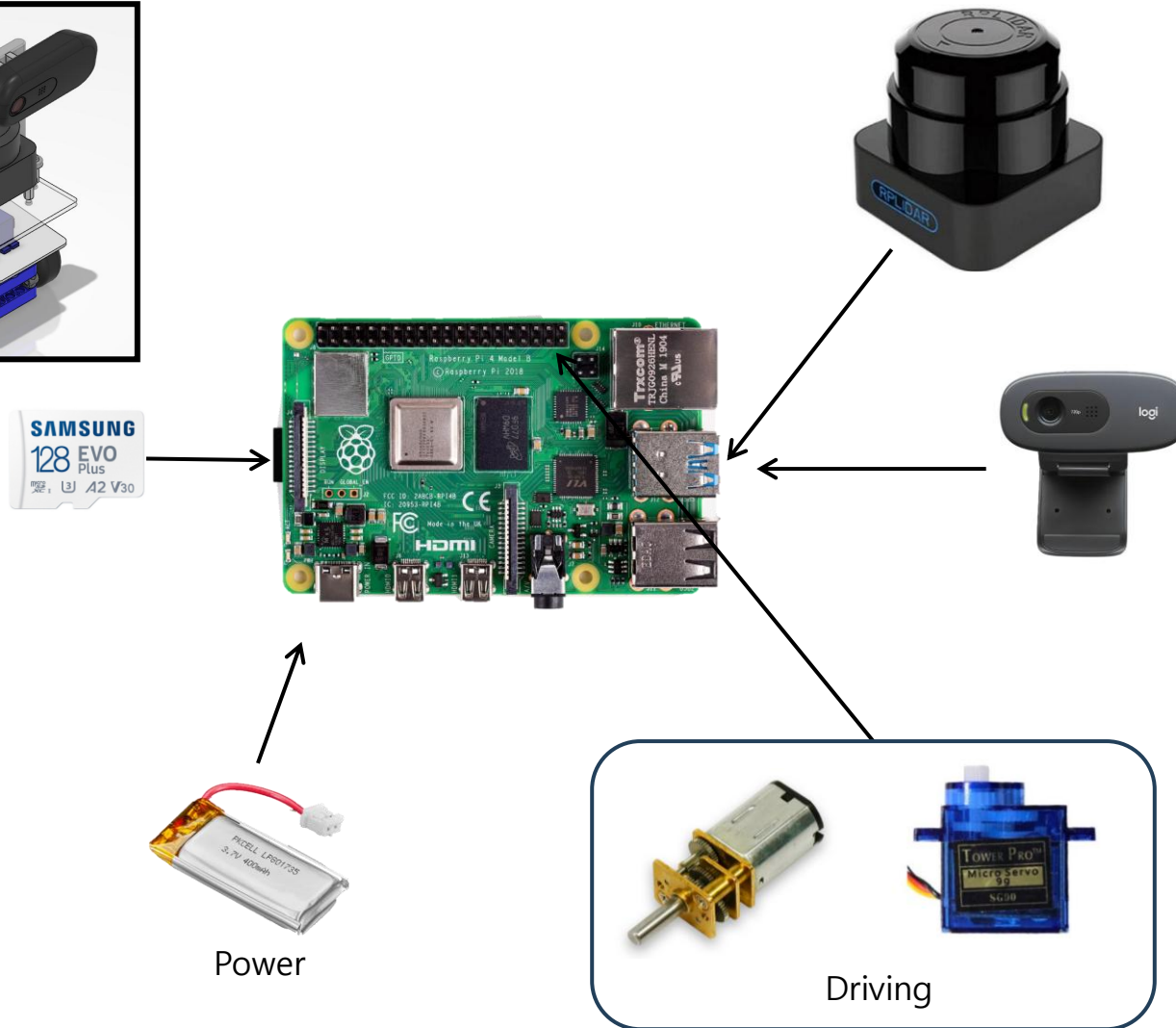
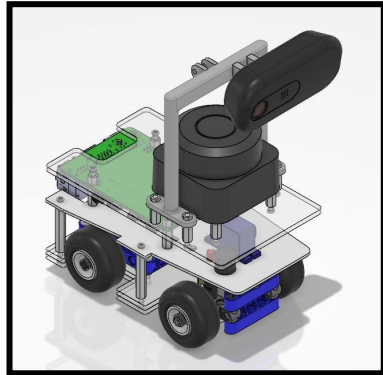
Before



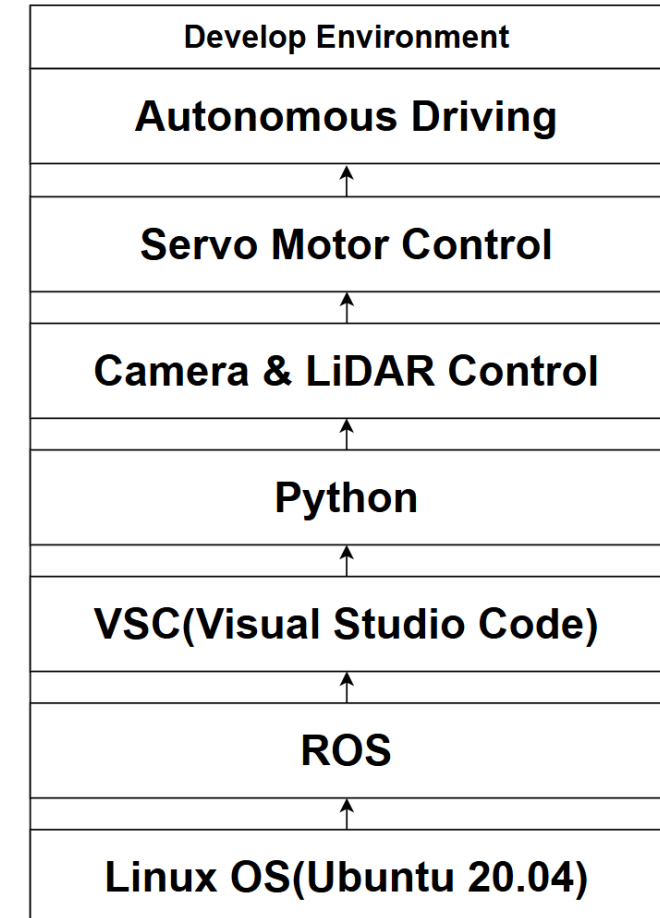
After



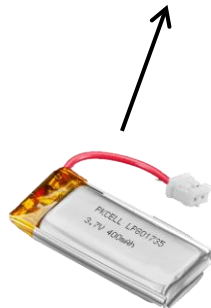
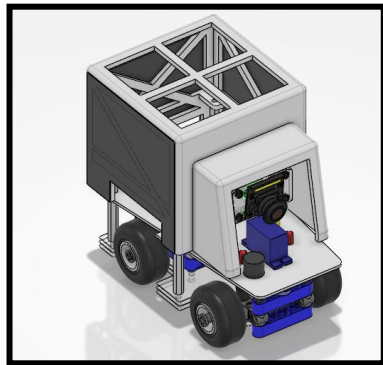
7. System Design



Development System Setup



7. System Design

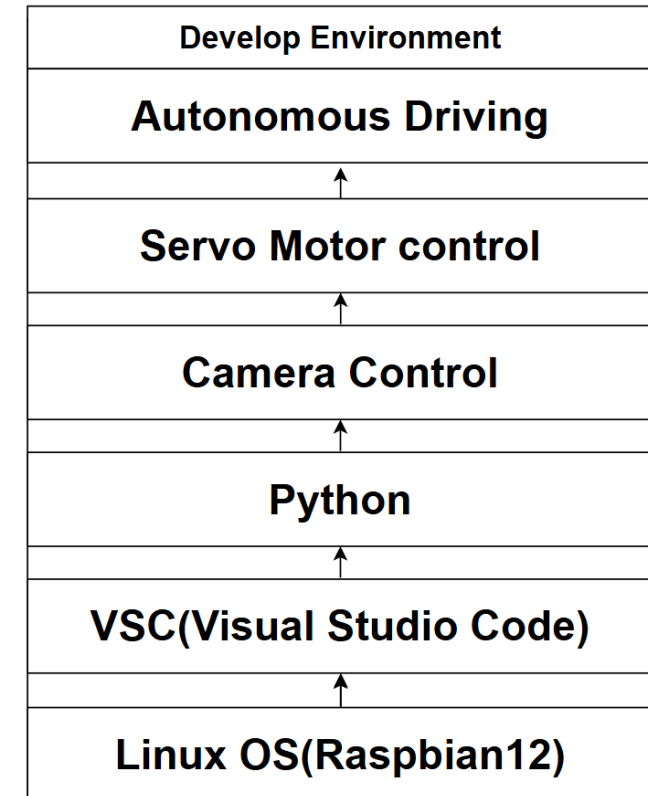


Power



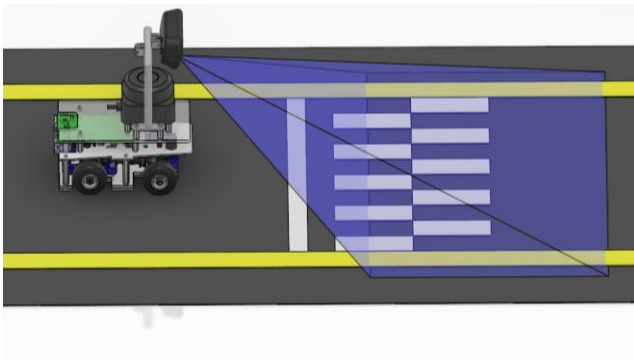
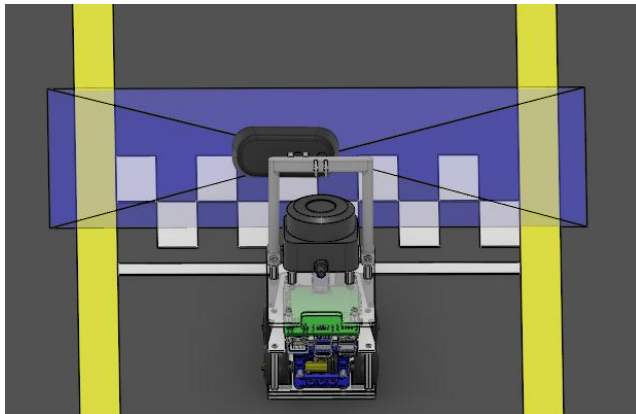
Driving

Development System Setup



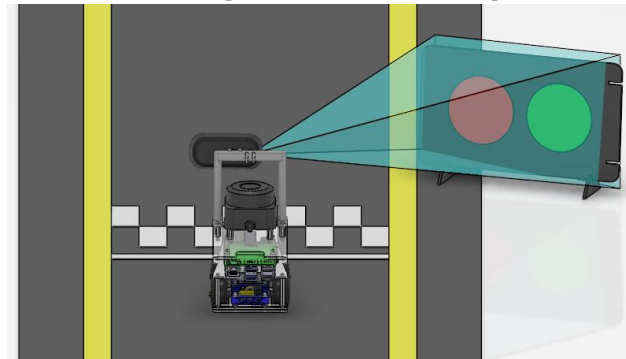
8. Scenario_Mission1

Line Detection

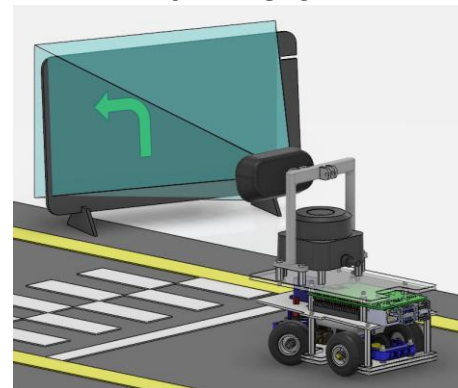


Traffic signs

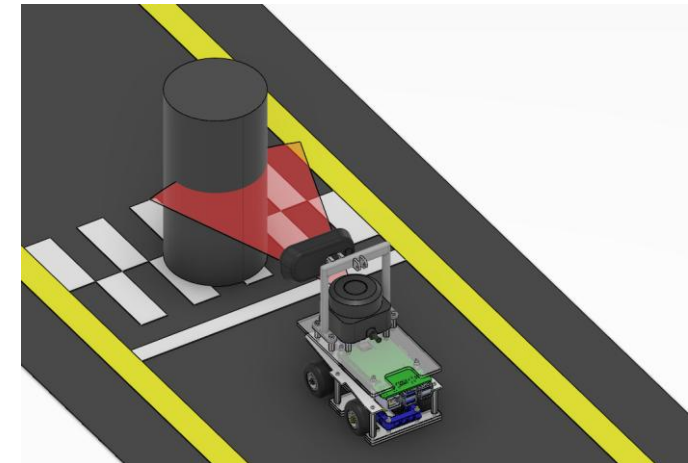
RED Light & Green Light



Turn Left

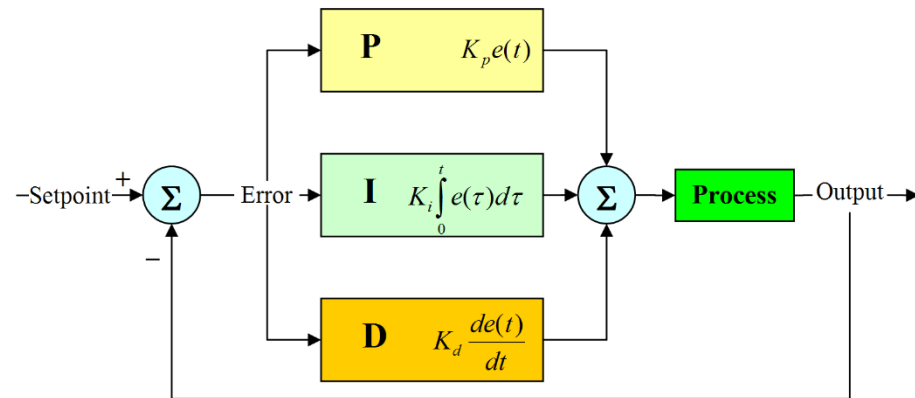


LiDAR Detection



8. Scenario_Mission2

PID Control

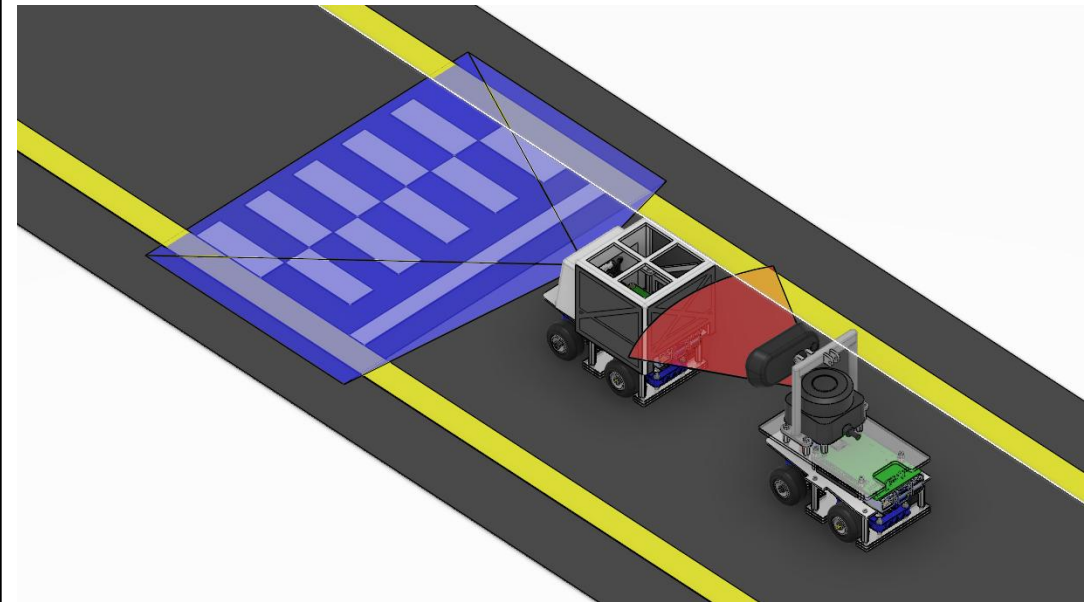


```

PID.py
1 class PID:
2     def __init__(self, Kp, Ki, Kd):
3         self.Kp = Kp
4         self.Ki = Ki
5         self.Kd = Kd
6         self.prev_error = 0
7         self.integral = 0
8
9     def control(self, error):
10        self.integral += error
11        derivative = error - self.prev_error
12        output = (self.Kp*error) + (self.Ki*self.integral) + (self.Kd*derivative)
13        self.prev_error = error
14        return output
15

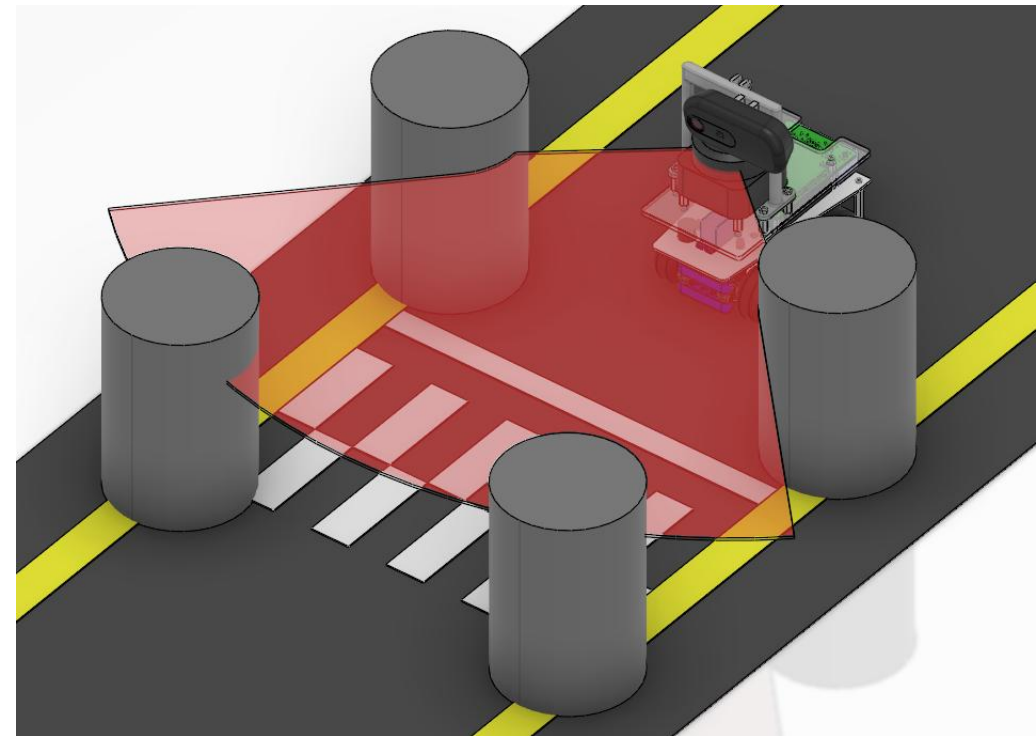
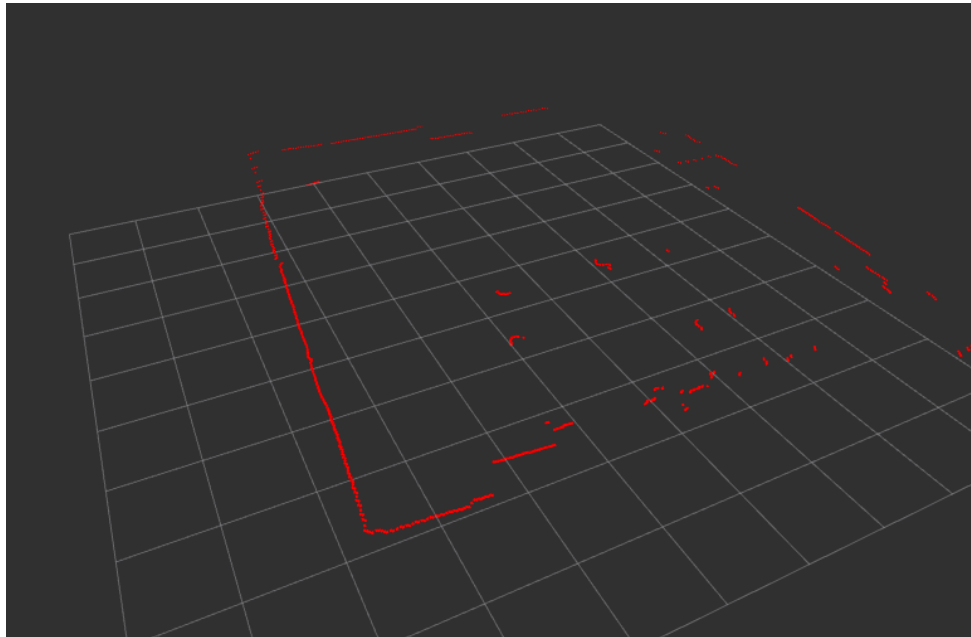
```

Following Driving

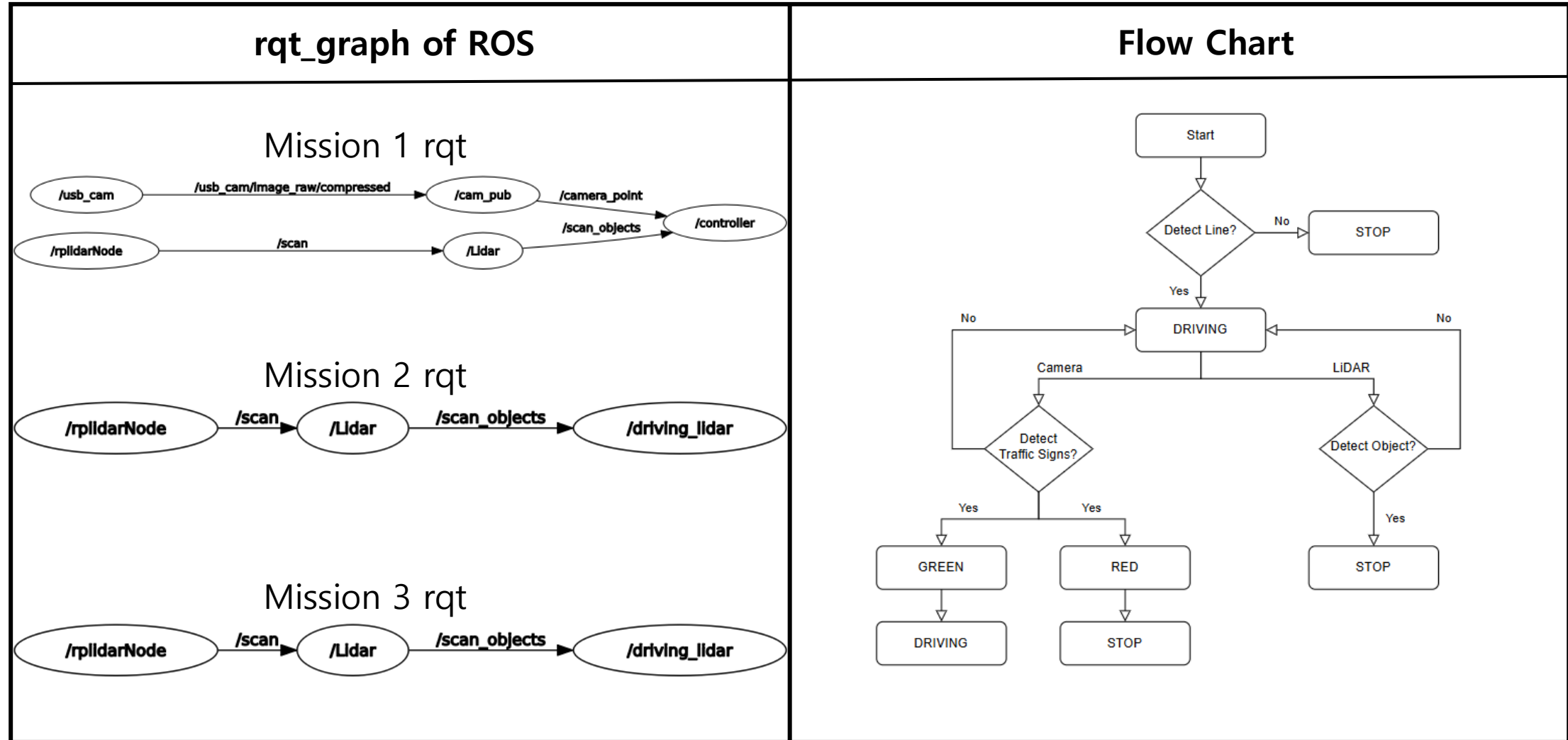


8. Scenario_Mission3

Driving between Traffic cones



9. Programming & Algorithm

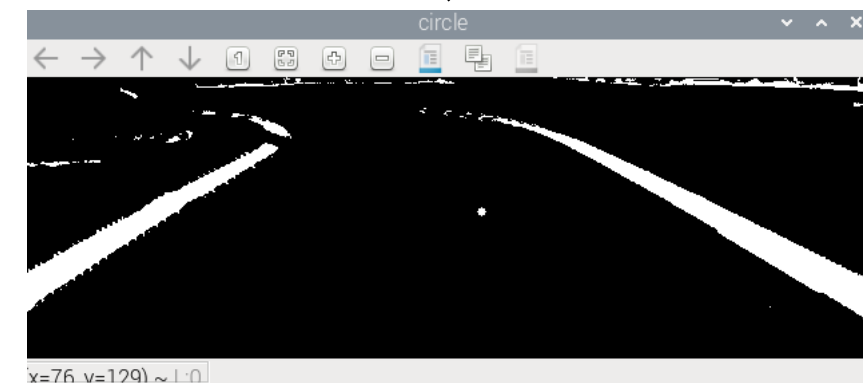
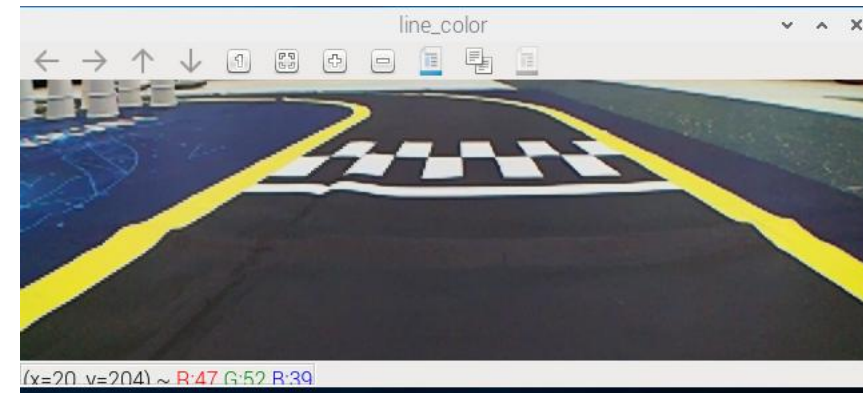


10. Coding

Packages

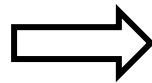
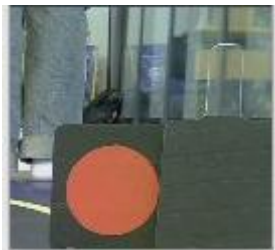
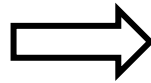
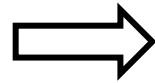
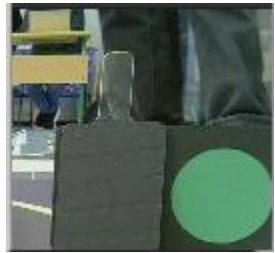
```
1 from picamera2 import Picamera2
2 import cv2
3 from gpiozero.pins.pigpio import PiGPIOFactory
4 from gpiozero import AngularServo, Motor
5 import numpy as np
6 import time
7 from PID import *
8 import matplotlib.pyplot as plt
9 import matplotlib.animation as animation
10 from collections import deque
```

Line Detection



10. Coding

Traffic Signs Recognition



Objects Detection



```
Objects Data = objects_info:  
-  
  start_idx: 357  
  start_dist: 0.1627500057220459  
  end_idx: 501  
  end_dist: 0.16899999976158142  
no: 1
```

10. Coding

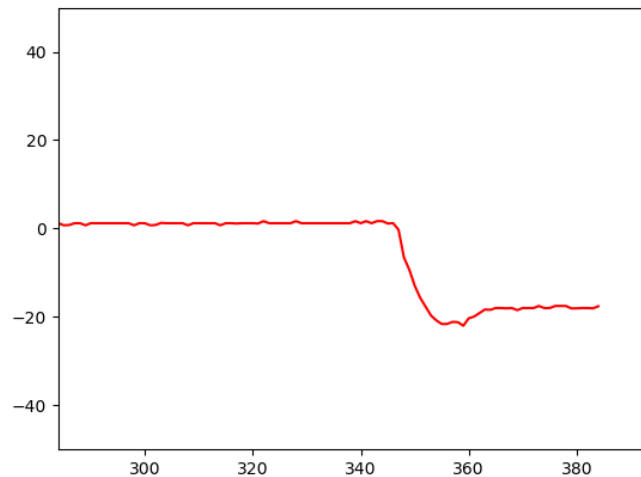
PID Control

$$u(t) = u(t-1) + k_p e(t) + k_i \int_0^t e(\tau) d\tau + k_d \frac{de(t)}{dt}$$

```
self.pid = PID(Kp=0.4, Ki=0.0000001, Kd=0.07)
```

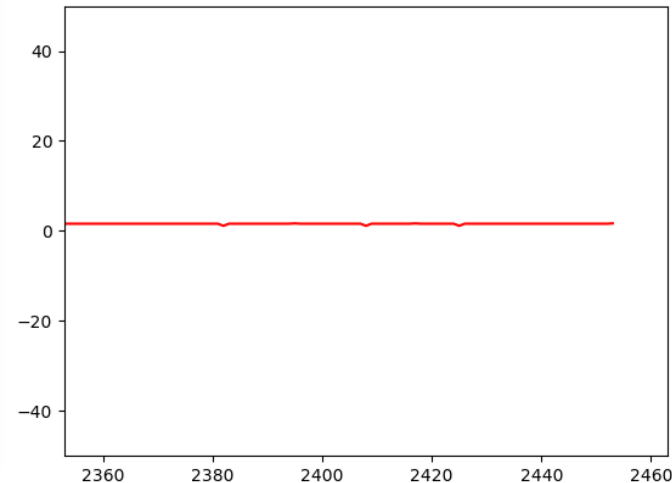
Left

```
error:17.5318808
cx : 136
cx : 136
error:17.6018896
cx : 137
cx : 137
error:18.0018986
cx : 135
```



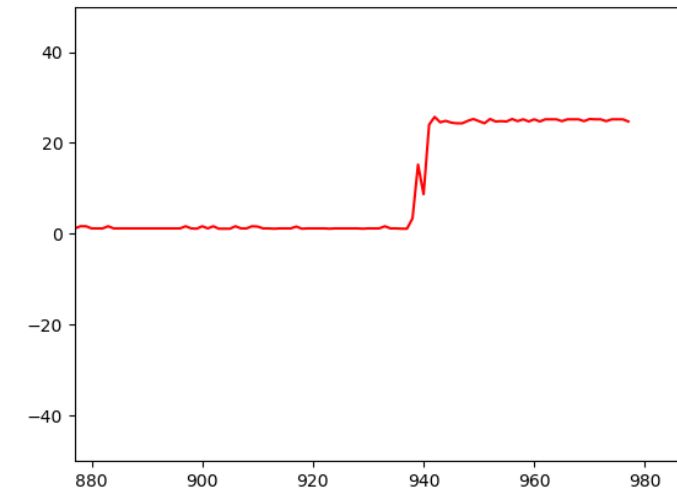
Center

```
error:-1.6004182
cx : 88
cx : 89
error:-1.1304189000000002
cx : 88
cx : 88
error:-1.6004197
cx : 88
```



Right

```
error:-25.197634800000003
cx : 29
cx : 29
error:-25.197647400000005
cx : 30
cx : 29
error:-25.2676599
cx : 30
```



11. Prototyping Schedule

Content	2025															Remarks
	3/2	3/3	3/4	3/5	4/1	4/2	4/3	4/4	5/1	5/2	5/3	5/4	5/5	6/1	6/2	
Capstone Design OT	■															SOLLUNA
Topic Selection		■														SOLLUNA
System Design & Component Selection			■	■	■											Kijun Youngjin
Studying parts(Datasheet) & Programming					■	■										Kijun
3D Design & Modification							■	■	■	■						Wonjae Sanghyun
Configuration & Programming							■	■	■	■	■	■				Kijun
PPT production & Presentation preparation						■	■			■	■					Kijun
Final presentation & Presentation of works											■	■	■			SOLLUNA
Preparing for the competition											■	■	■	■		SOLLUNA
Patents & Report writing														■	■	SOLLUNA



11. Prototyping Schedule

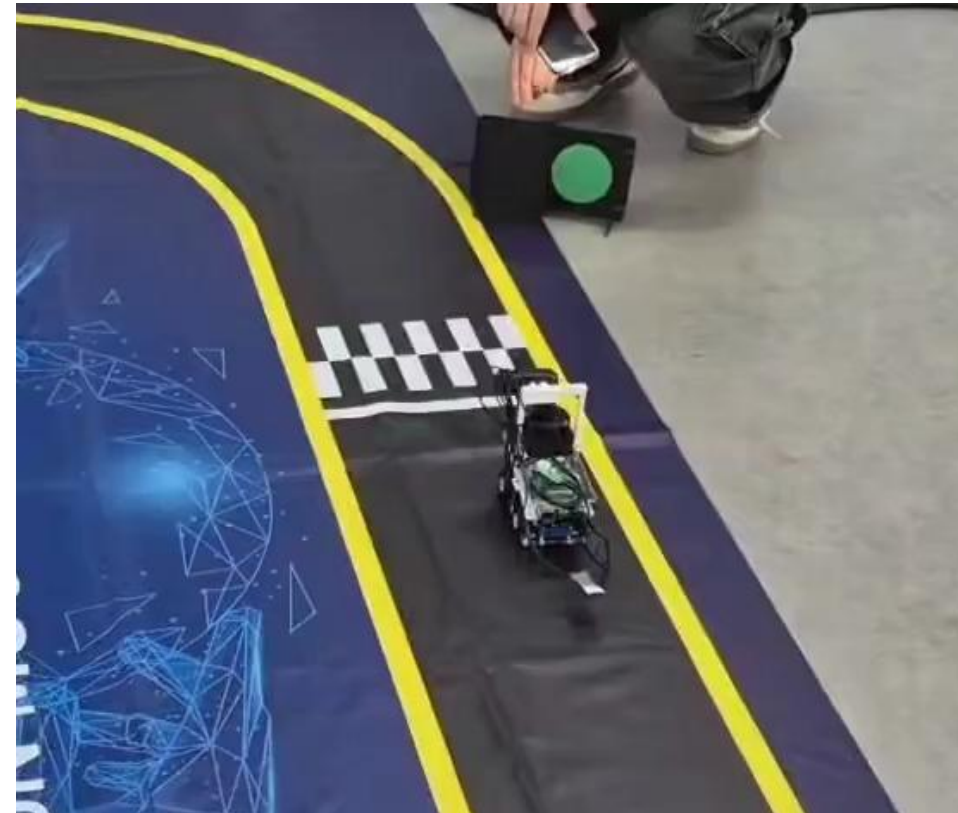
Works \ Weeks	2025				
	4/5	5/1	5/2	5/3	5/4
3D Modification		█		█	
Line Detection	█	█			
Steering Upgrade		█	█		
LiDAR Detection		█			
Traffic Signs			█	█	
Turn Left				█	
PID Control		█		█	
Following Driving				█	█
Traffic Cones			█	█	█
Preparing PPT					█

12. Prototype Videos

LiDAR Detection

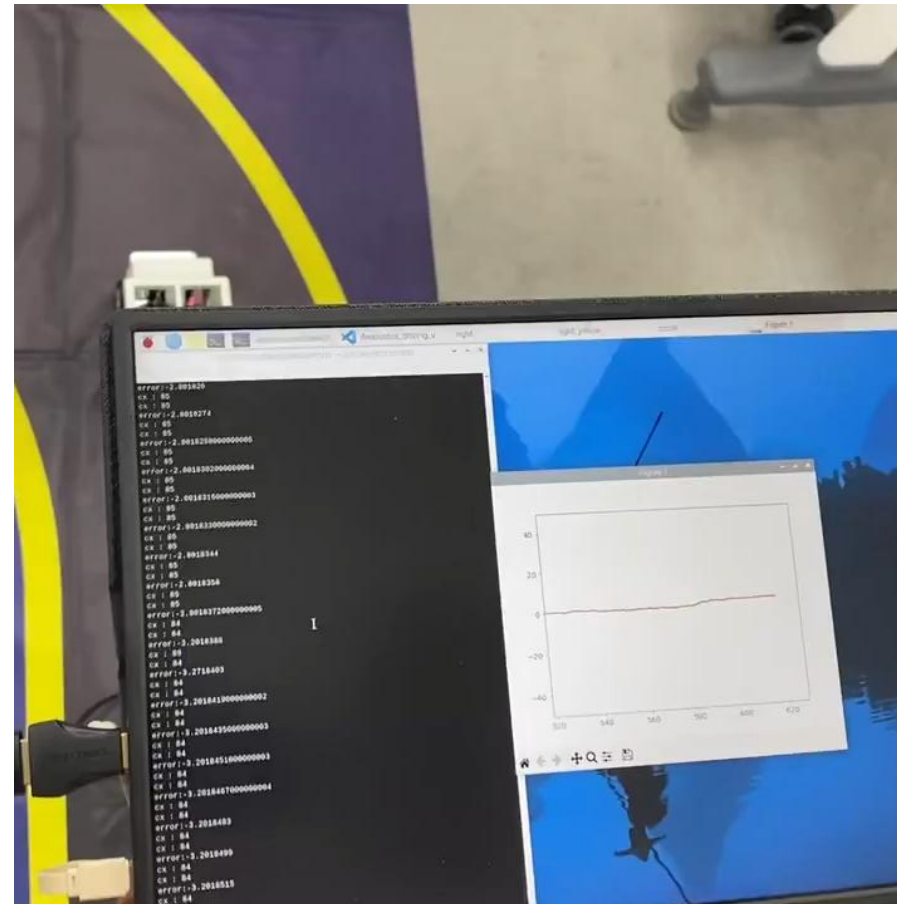


Traffic Signs Recognition



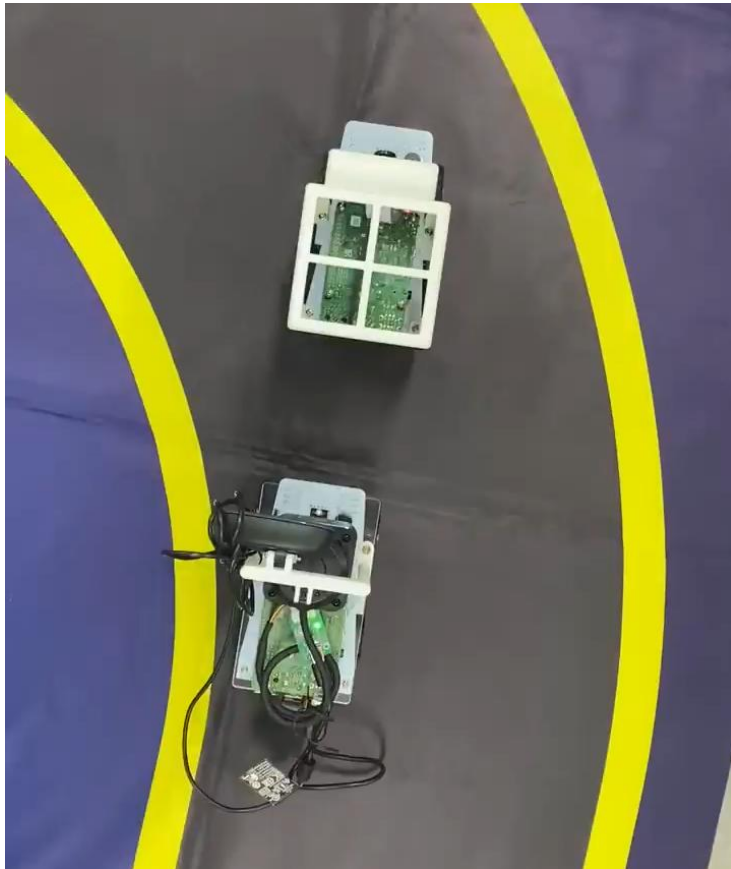
12. Prototype Videos

PID Control

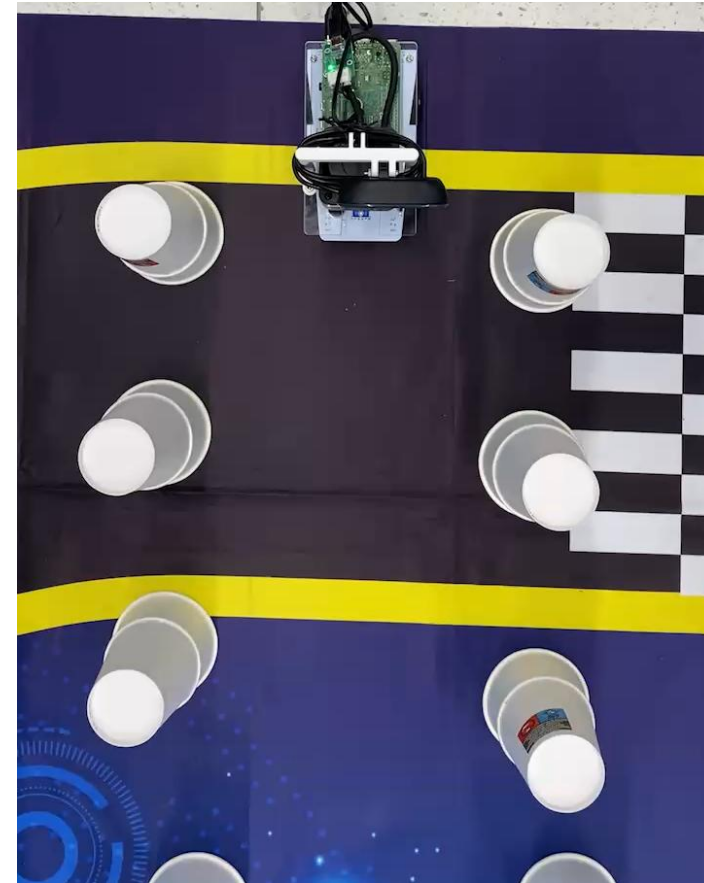


12. Prototype Videos

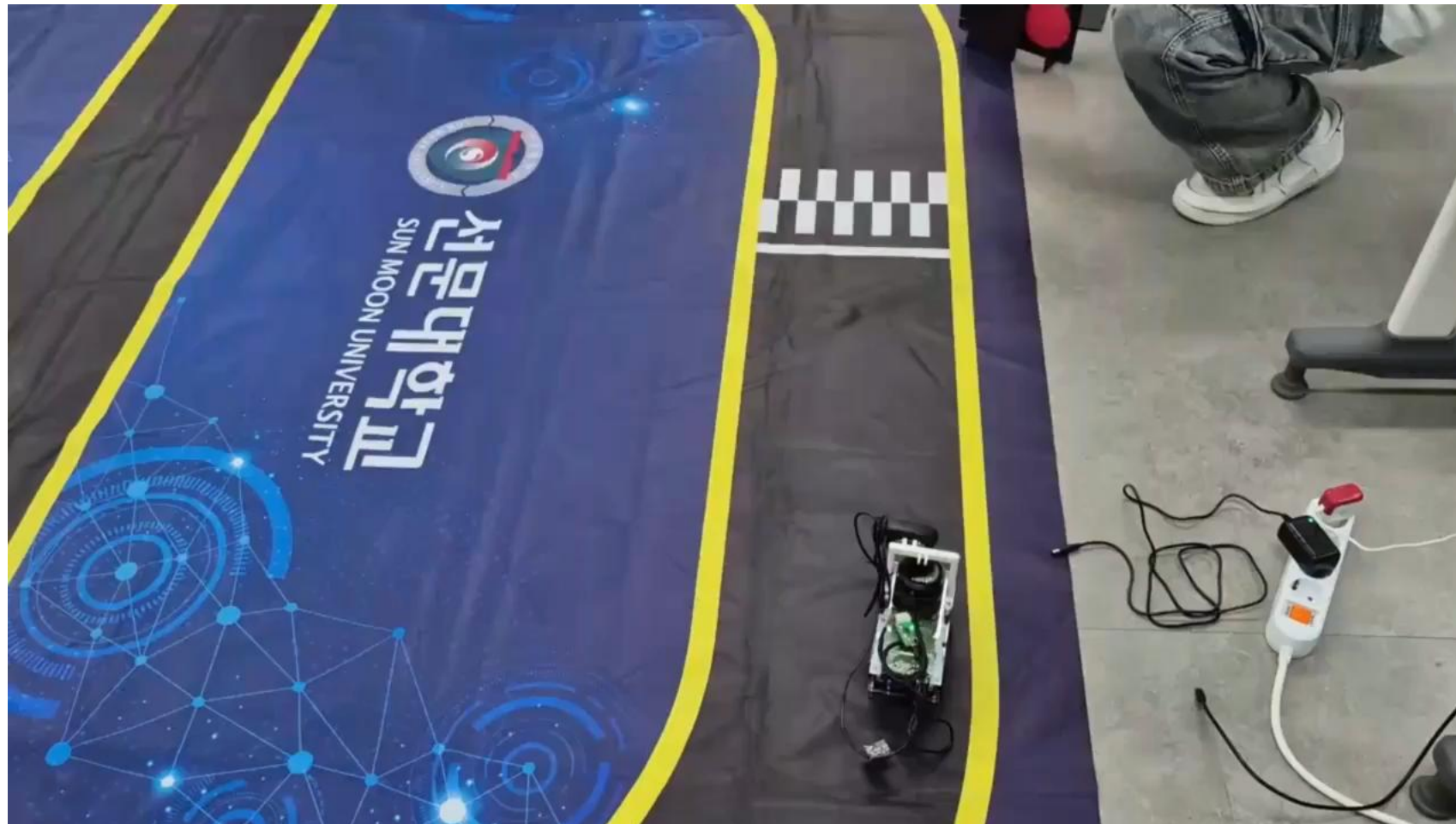
Follow Driving



Driving between Traffic cones



12. Prototype Videos_Mission1





POLAND PRESENTATION

Contents

I. Team Members

II. Professors

III. Project goals

IV. Encountered problems

V. Our solutions

VI. System Design






VII. Model of the City

VIII. Models & Algorithm

IX. Running Program

X. Prototype Video

1. Team Members and roles POLAND

LEADER	MEMBER	MEMBER	MEMBER	MEMBER
 <p>Paweł Wawrów</p>	 <p>Grzegorz Zając</p>	 <p>Paweł Pukocz</p>	 <p>Oskar Kowalski</p>	 <p>Jakub Mazur</p>
<ul style="list-style-type: none"> • Programming • Soldering • Communications with Korean's 	<ul style="list-style-type: none"> • Track design • Decoration design • Data Collection 	<ul style="list-style-type: none"> • Presentations • Data Collection • Decoration design 	<ul style="list-style-type: none"> • Programming • Data Collection • Presentation 	<ul style="list-style-type: none"> • Track design • Decoration design • Presentation



2. Professors



Name : Kyungsoon Lee
University : SunMoon Univ.
E-mail : leecstar@sunmoon.ac.kr
Department : Depart. Of Advanced Automotive Engineering(AAE)

Name : Changseung Kim
University : SunMoon Univ.
E-mail : cskim7378@sunmoon.ac.kr
Department : Depart. Of Advanced Automotive Engineering(AAE)

Name : dr hab. inż. Piotr Przystałka, prof. Pol. Śl.
University : Politechnika Śląska Univ.
E-mail : Piotr.Przystalka@polsl.pl
Department : Mechanical Engineering

Name : mgr inż. Witold Krafczyk.
University : Politechnika Śląska Univ.
E-mail : Witold.llewicz@polsl.pl
Department : Mechanical Engineering

3. Project Goals

- Construction of a miniature vehicle simulating an autonomous car.
- Development of a miniature test track for vehicle control validation.
- Implementation of Python scripts for training neural networks for control and object detection.
- Collection of a training dataset.
- Successful training of a DNN for vehicle control and traffic sign recognition. Execution of verification tests and evaluation of results.



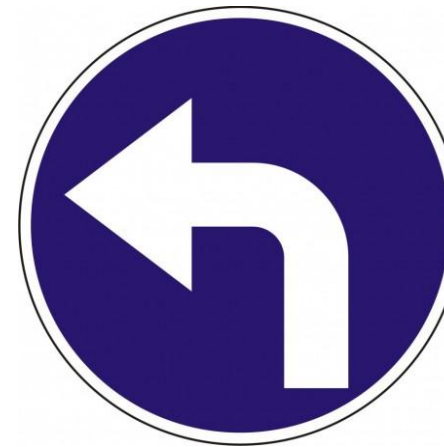
3. Project Goals



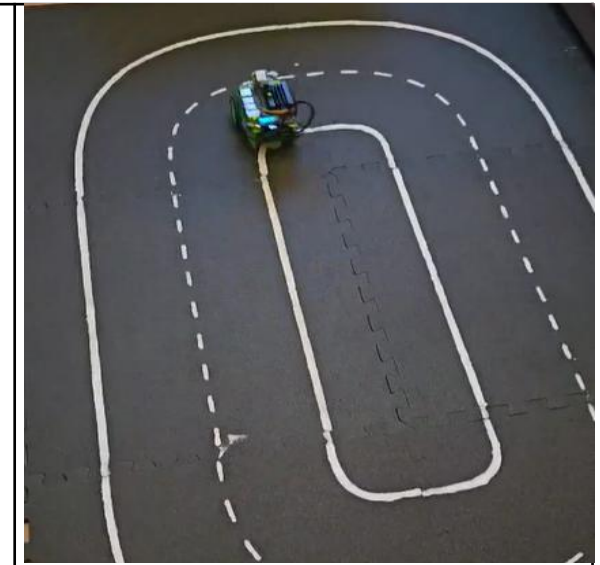
Road Following



STOP
sign detection

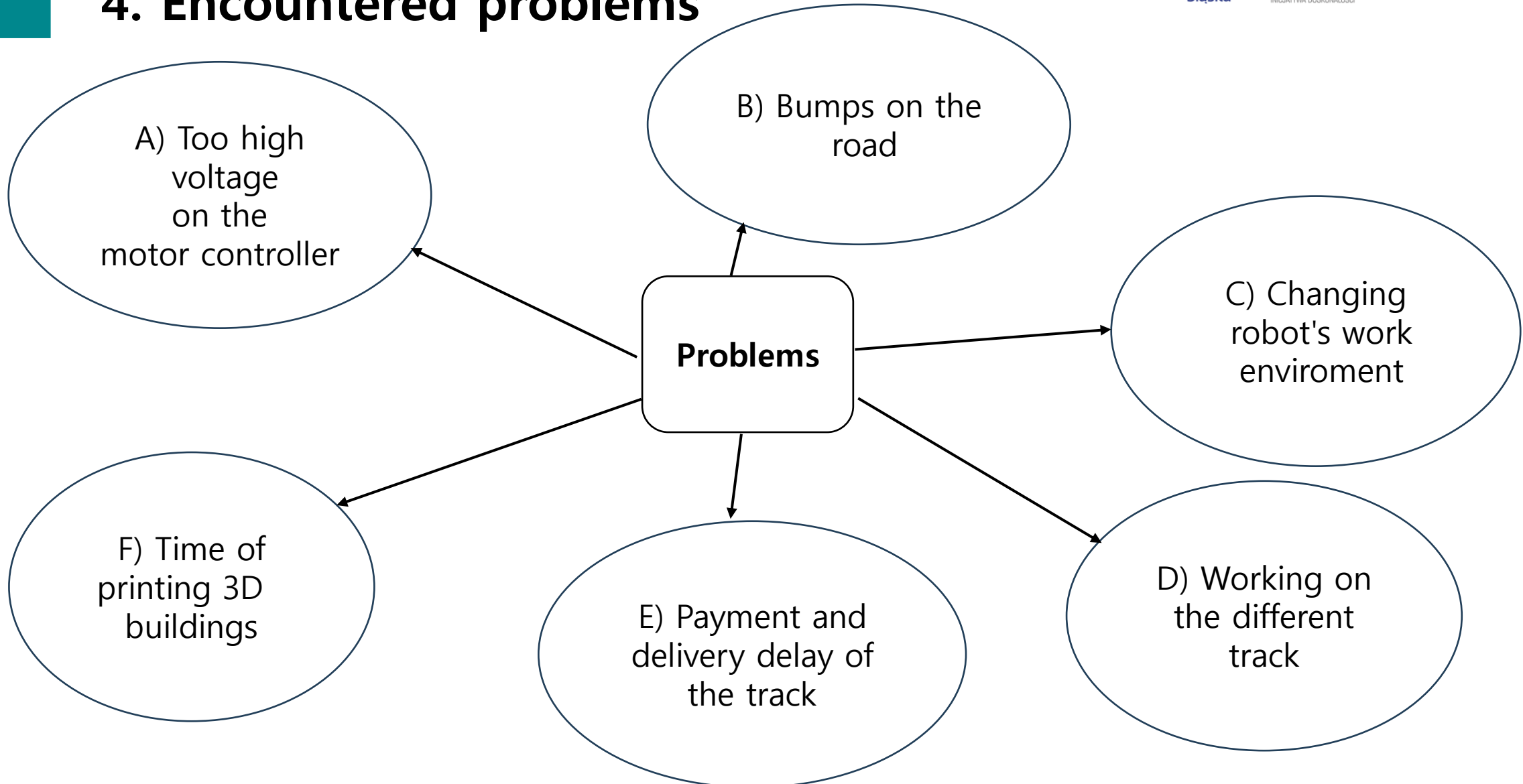


TURN LEFT
sign detection

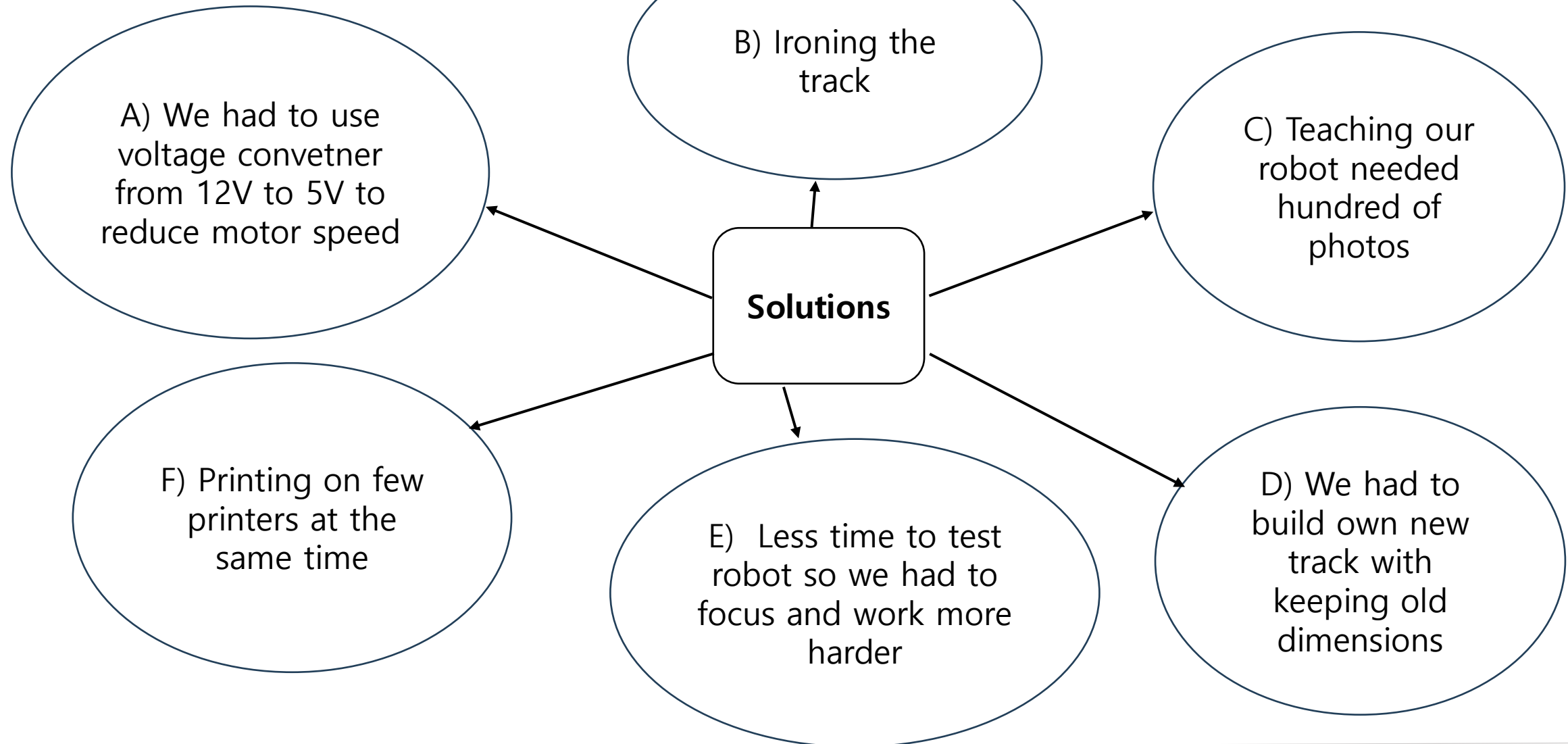


Test Track

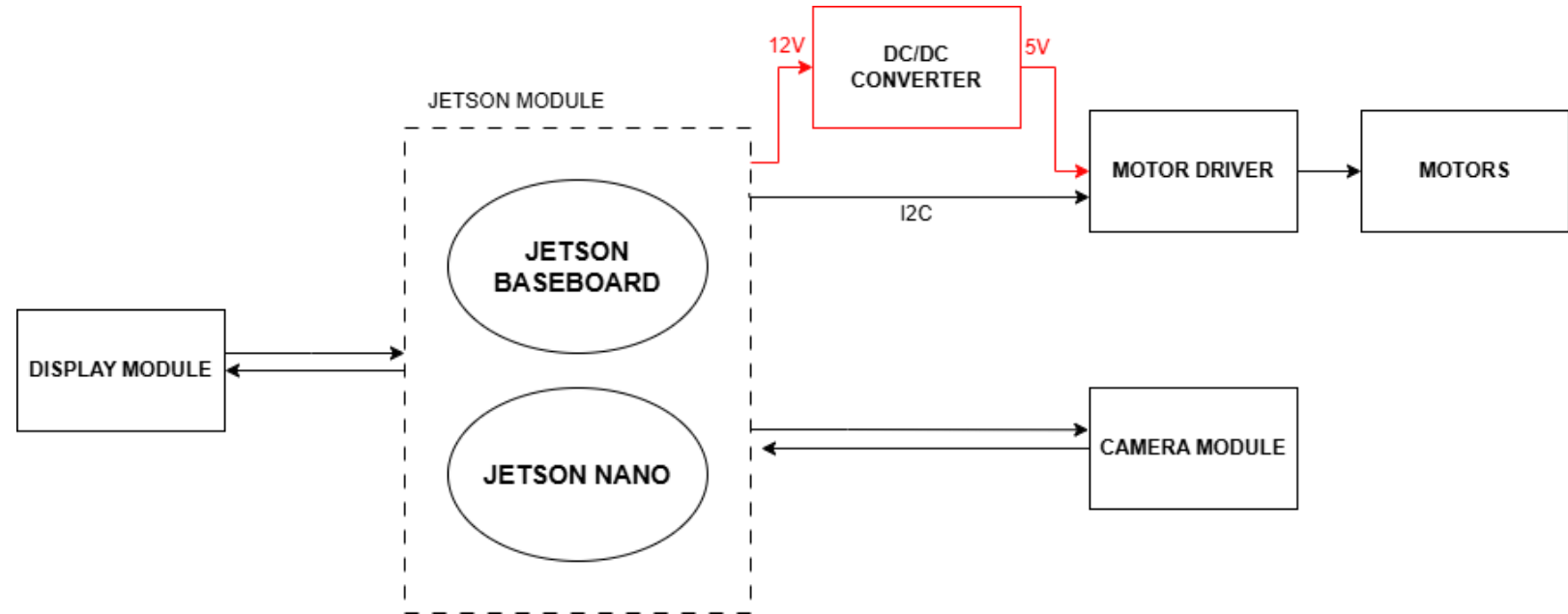
4. Encountered problems



5. Our solutions



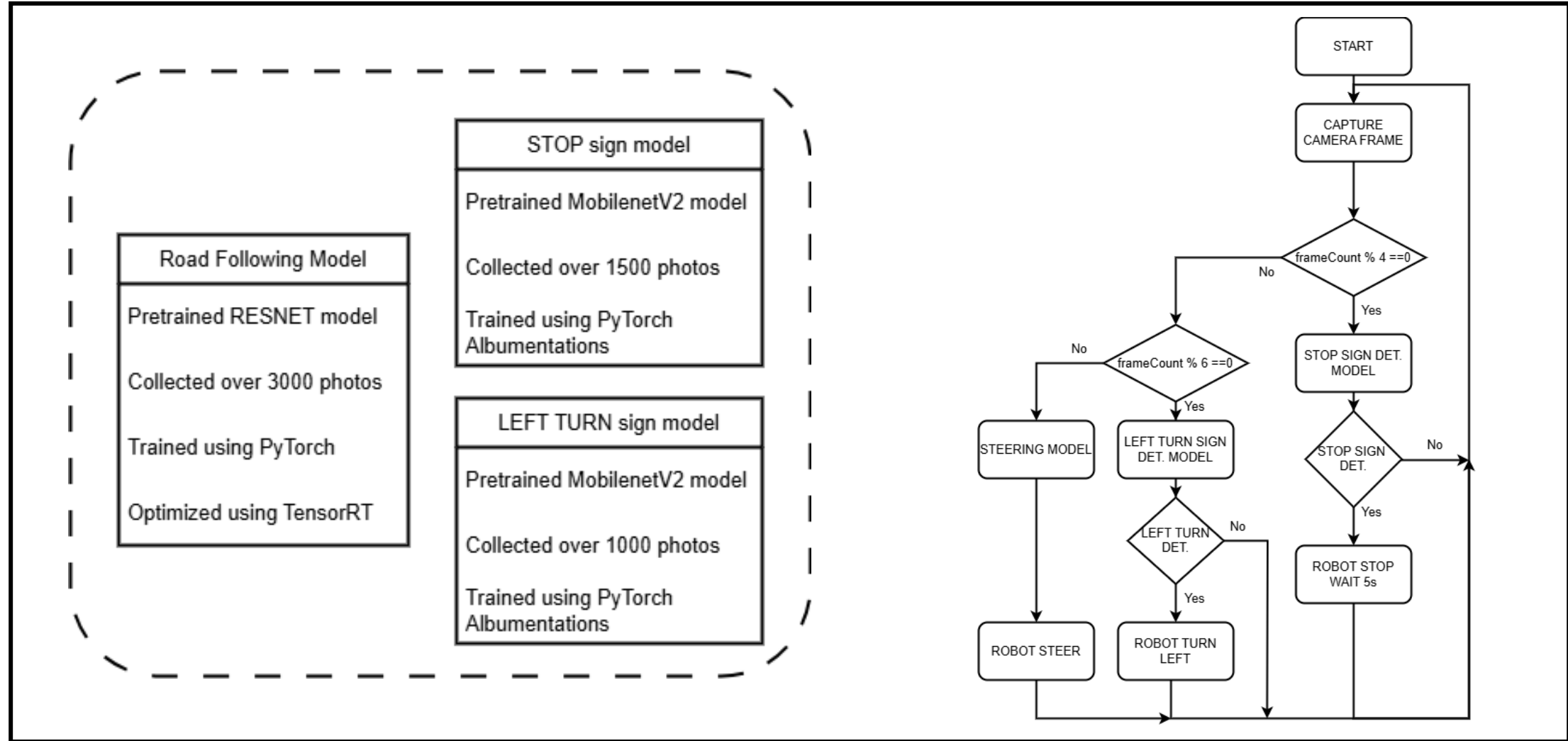
6. System Design



7. Model of the Track

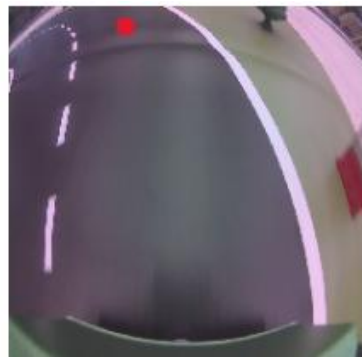


8. Models & Algorithm



9. Running Program

Road line detection



y
0.72

speed
0.28

x	<input type="range"/>	-0.39
steering	<input type="range"/>	-0.06
speed gain	<input type="range"/>	0.28
steering gain	<input type="range"/>	0.18
steering kd	<input type="range"/>	0.50
steering bias	<input type="range"/>	0.03
X:	<input type="range"/>	120
X:	<input type="range"/>	100
stop th	<input type="range"/>	0.01

264692

Signs detection



y
0.72

speed
0.28

x	<input type="range"/>	-0.18
steering	<input type="range"/>	-0.02
speed gain	<input type="range"/>	0.28
steering gain	<input type="range"/>	0.18
steering kd	<input type="range"/>	0.50
steering bias	<input type="range"/>	0.03
X:	<input type="range"/>	120
X:	<input type="range"/>	100
stop th	<input type="range"/>	0.01

264692

10. Prototype Video



10. Prototype Video



Activity Photos_Day1



Activity Photos_Day2



Activity Photos_Day3





**THANK YOU
FOR YOUR ATTENTION**