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AI-POWERED
V2V SAFETY

Presented by
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CONTENT

IDEA AND PROBLEM STATEMENT

Utilize AI in V2V to predict and alert dangerous situations, ensuring safer driving.

IMPLEMENTATION OF THE IDEA

Develop AI models using data from simulated sensors and traffic software.

EXPECTED OUTCOMES

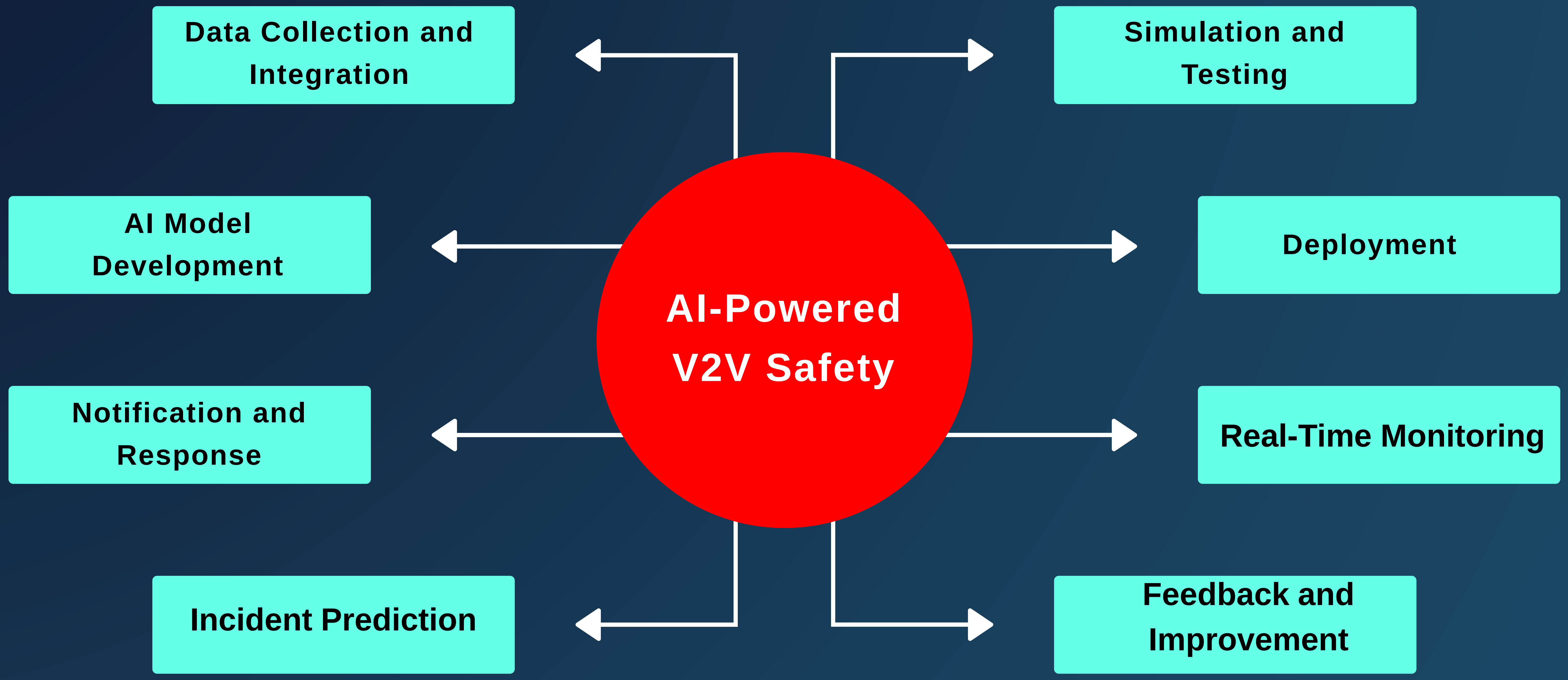
Build a smarter, safer, and more efficient traffic ecosystem.

IDEA AND PROBLEM STATEMENT

- Current traffic systems face major challenges: frequent accidents, congestion, and inefficiencies during emergencies.
- According to the WHO, 1.35 million lives are lost each year to road accidents, with 94% caused by human error.

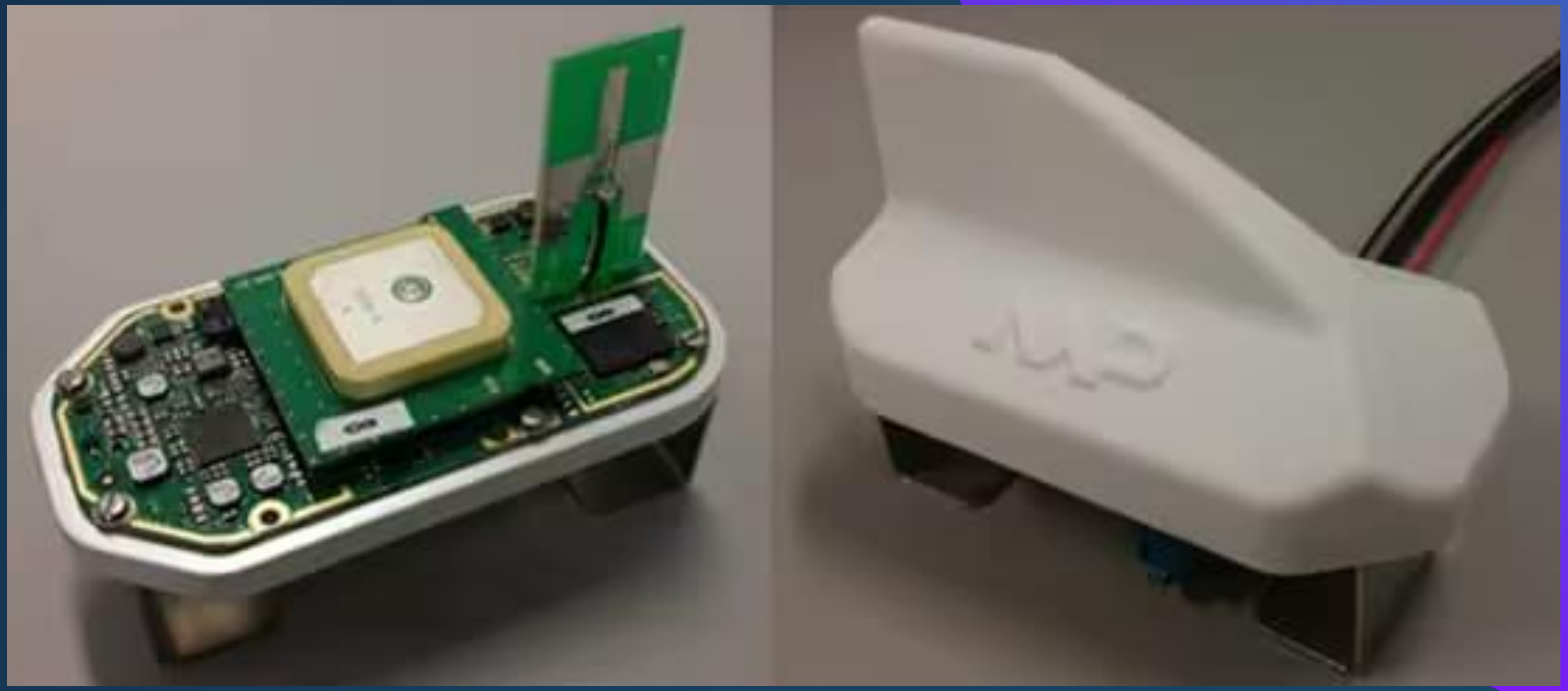
What if technology could predict and prevent such incidents?

IDEA AND PROBLEM STATEMENT



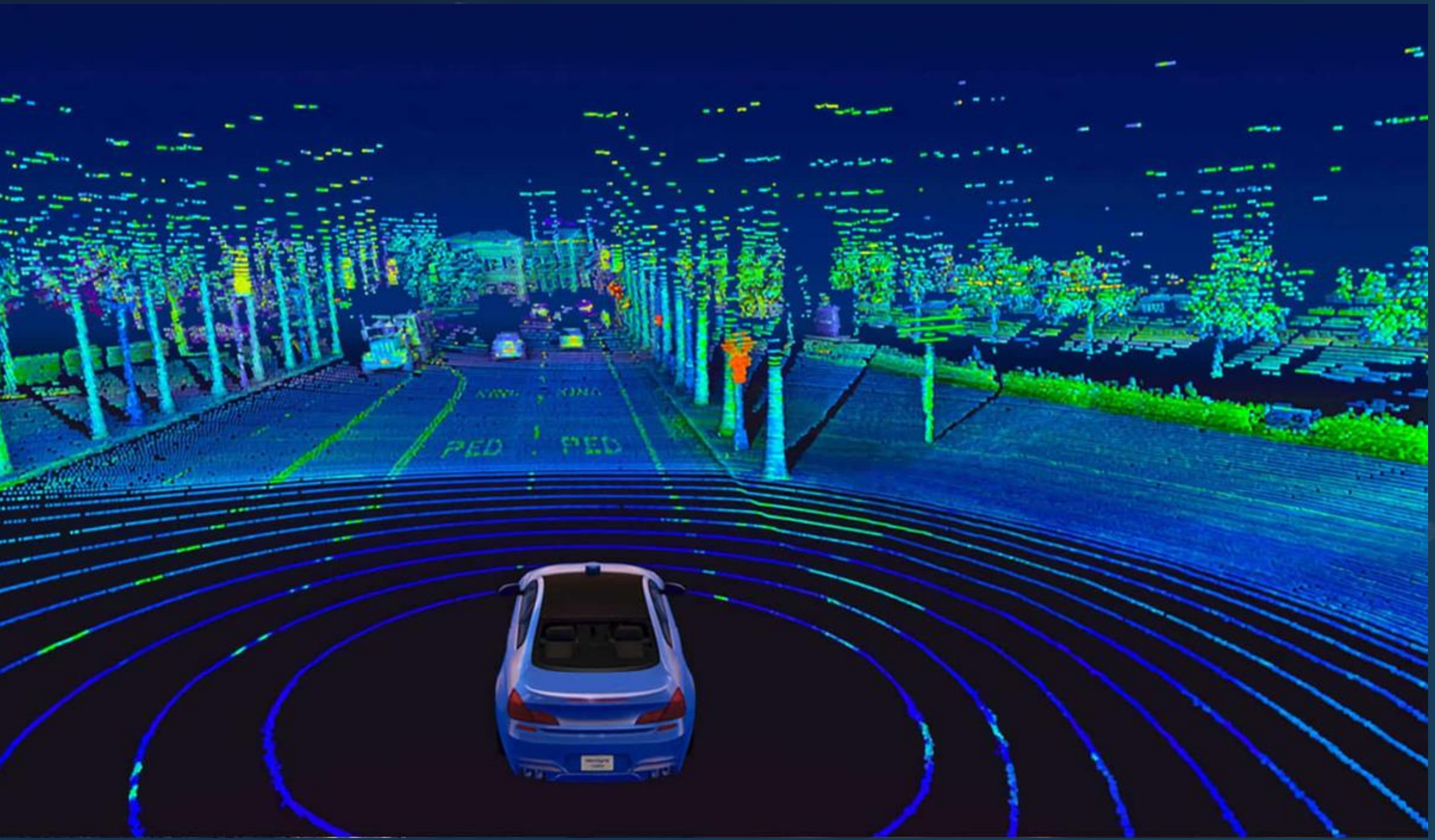
HARDWARE DEVELOPMENT

- Sensor Components:
- V2V Module
- Central Processing Unit
- AI chips
- Wireless Communication
- Integrated Control System



HARDWARE DEVELOPMENT

- Sensors such as LiDAR, radar, and GPS are employed to continuously gather real-time data.
- These devices measure critical parameters like vehicle speed, precise location, and details about the surrounding environment.
- This rich dataset forms the backbone of the system, enabling it to respond dynamically to traffic conditions.



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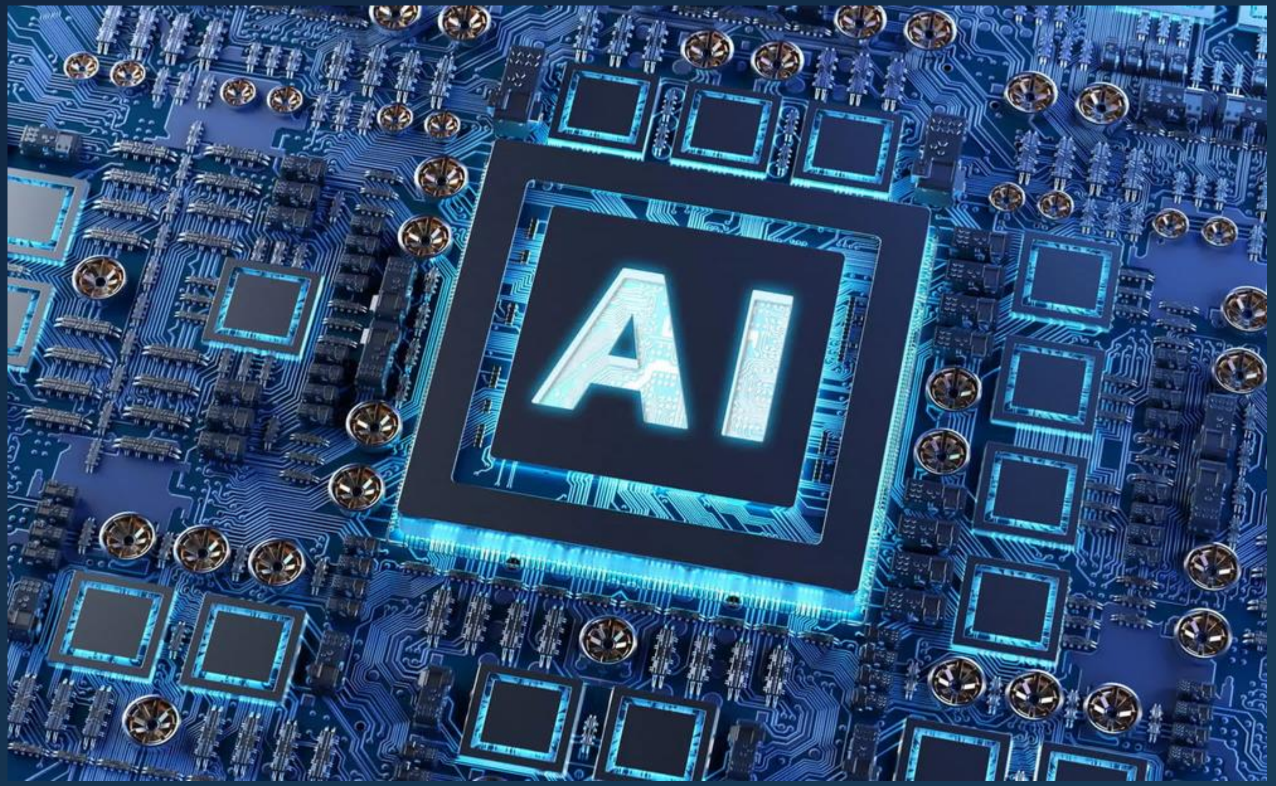
Home About Content Others

HARDWARE DEVELOPMENT

Inside the vehicles, AI chips process this data with remarkable speed.

These chips are designed to handle complex calculations in milliseconds, allowing the system to make rapid decisions that ensure the safety of passengers and pedestrians.

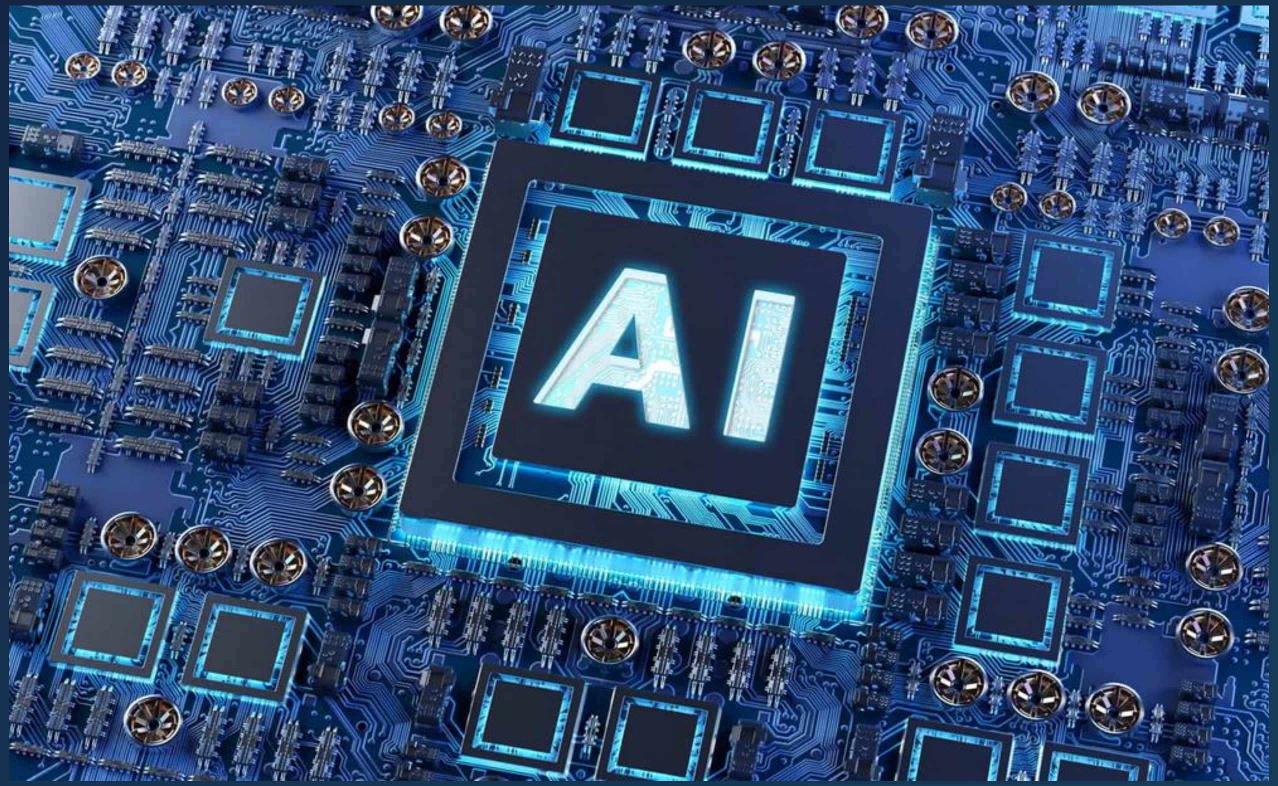
For example, if the sensors detect a potential collision, the AI chip can immediately alert the driver or even activate automated braking systems.



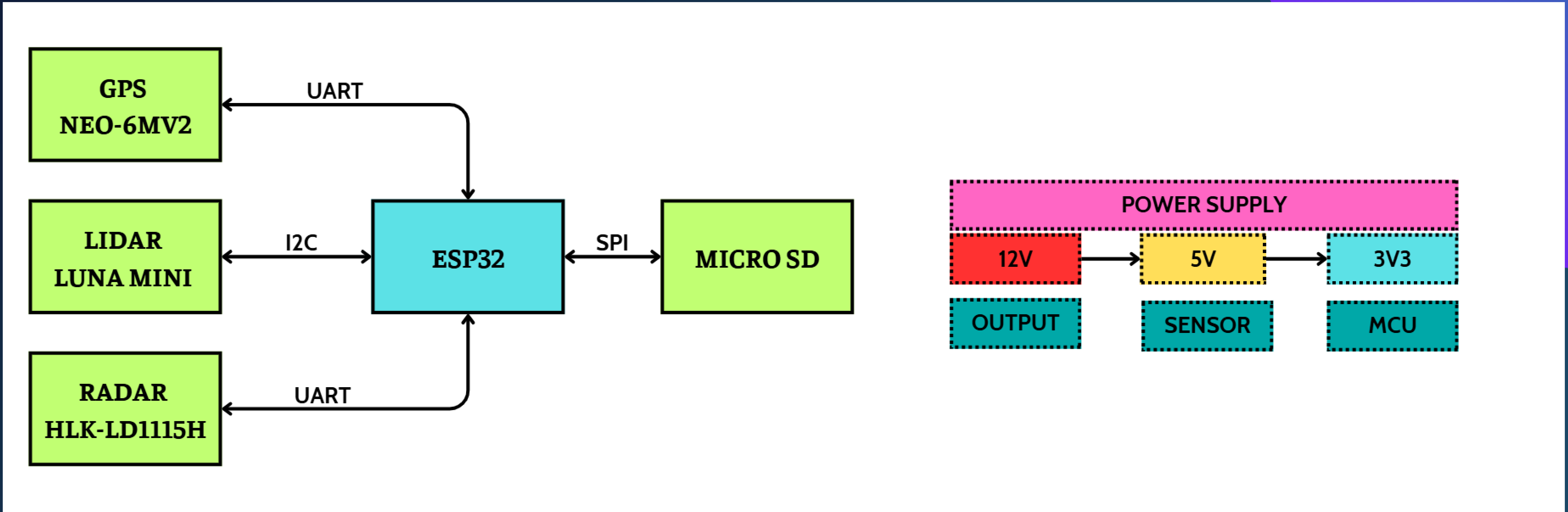
HARDWARE DEVELOPMENT

Wireless communication technology, specifically Cellular Vehicle-to-Everything (C-V2X), ensures the vehicles are interconnected. This allows seamless data exchange not just between vehicles but also with traffic infrastructure, such as stoplights or road signs.

This level of connectivity is critical for creating a synchronized traffic ecosystem where every element communicates to optimize overall efficiency and safety.

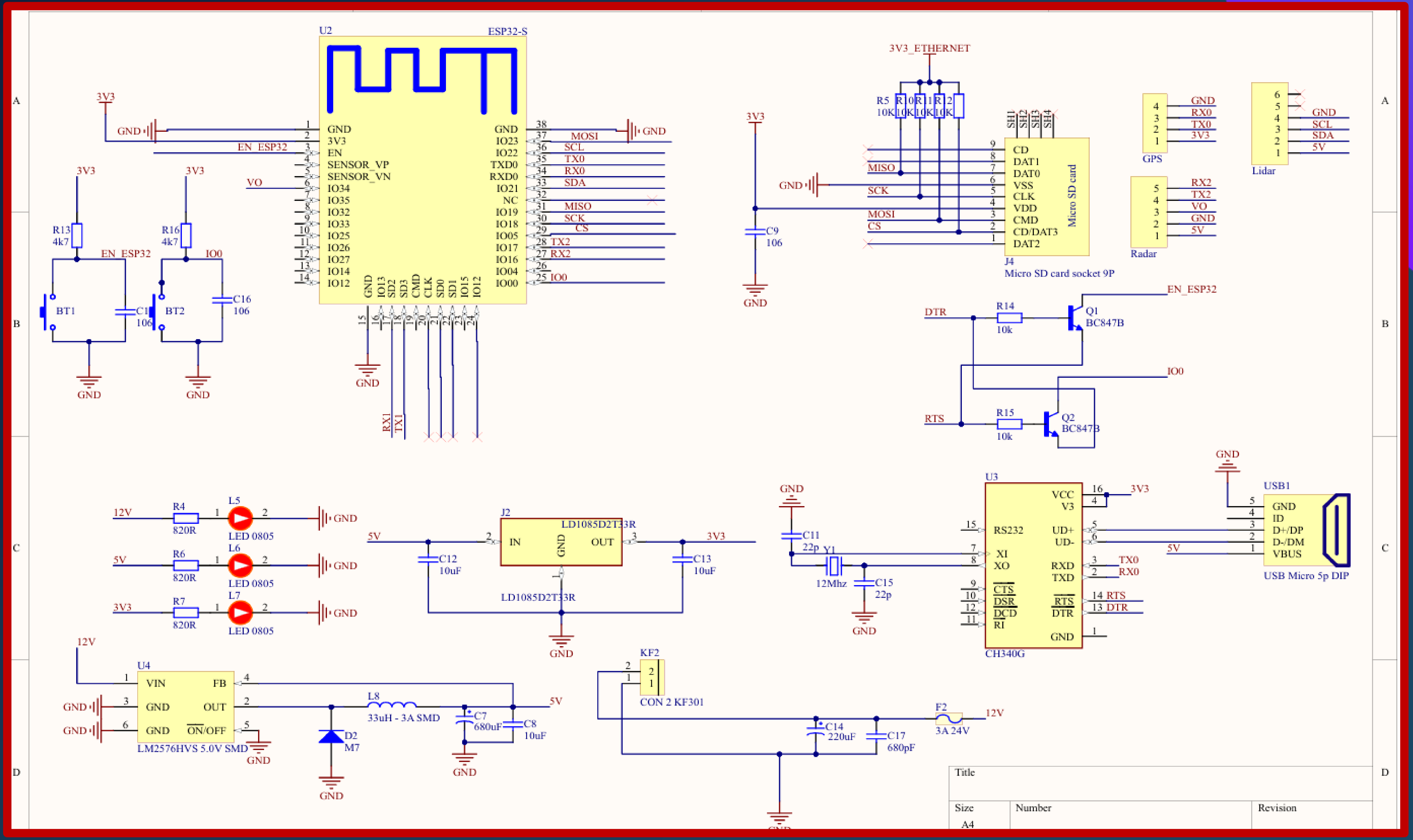


HARDWARE BLOCK DIAGRAM

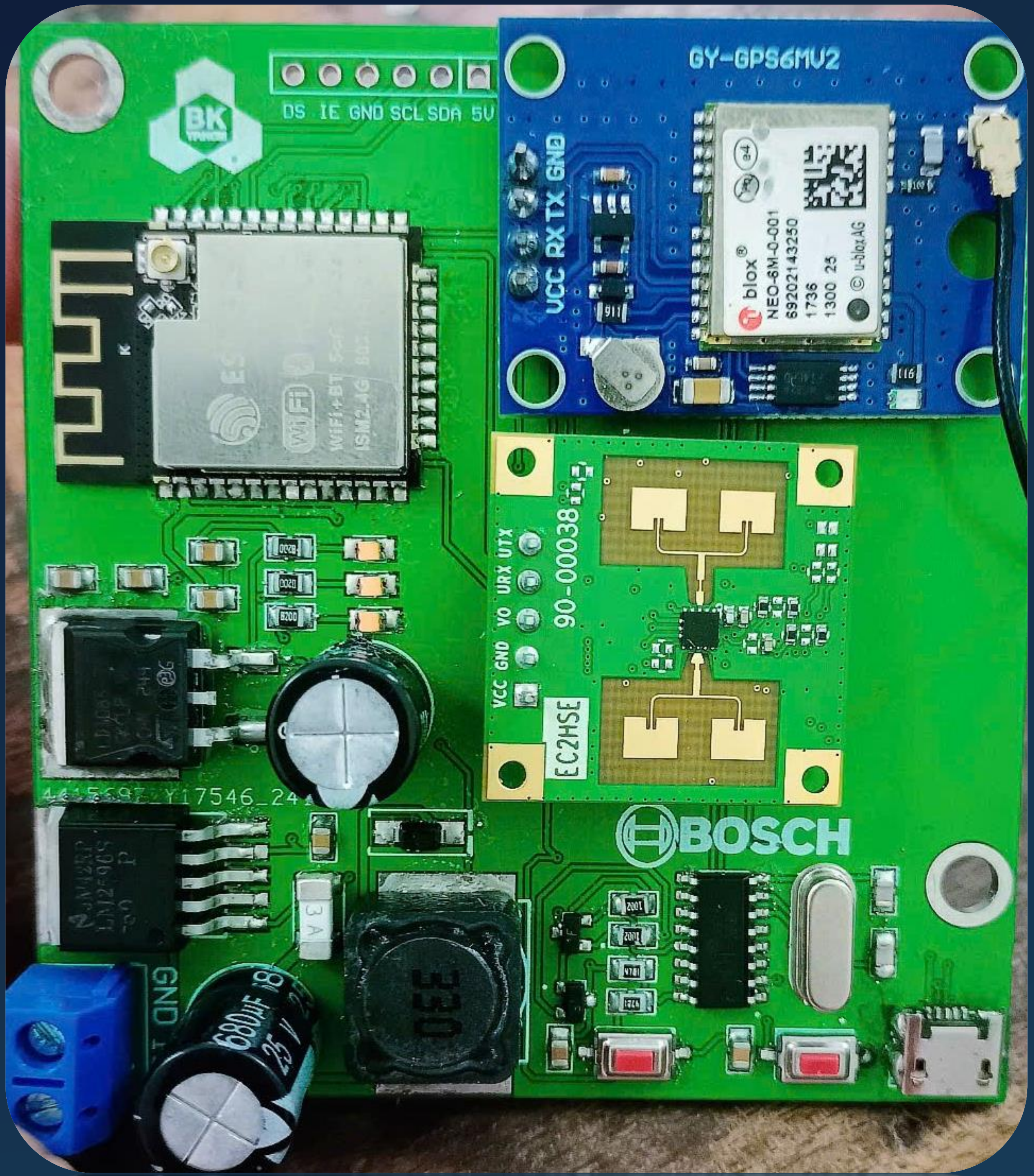


Next, I would like to share about the project I am working on, in which I use the ESP32 microcontroller to collect data from three types of sensors: GPS sensor NEO-6MV2, Lidar sensor TF Luna Mini, and Radar sensor HLK-LD1115H

HARDWARE SCHEMATIC



HARDWARE PCB

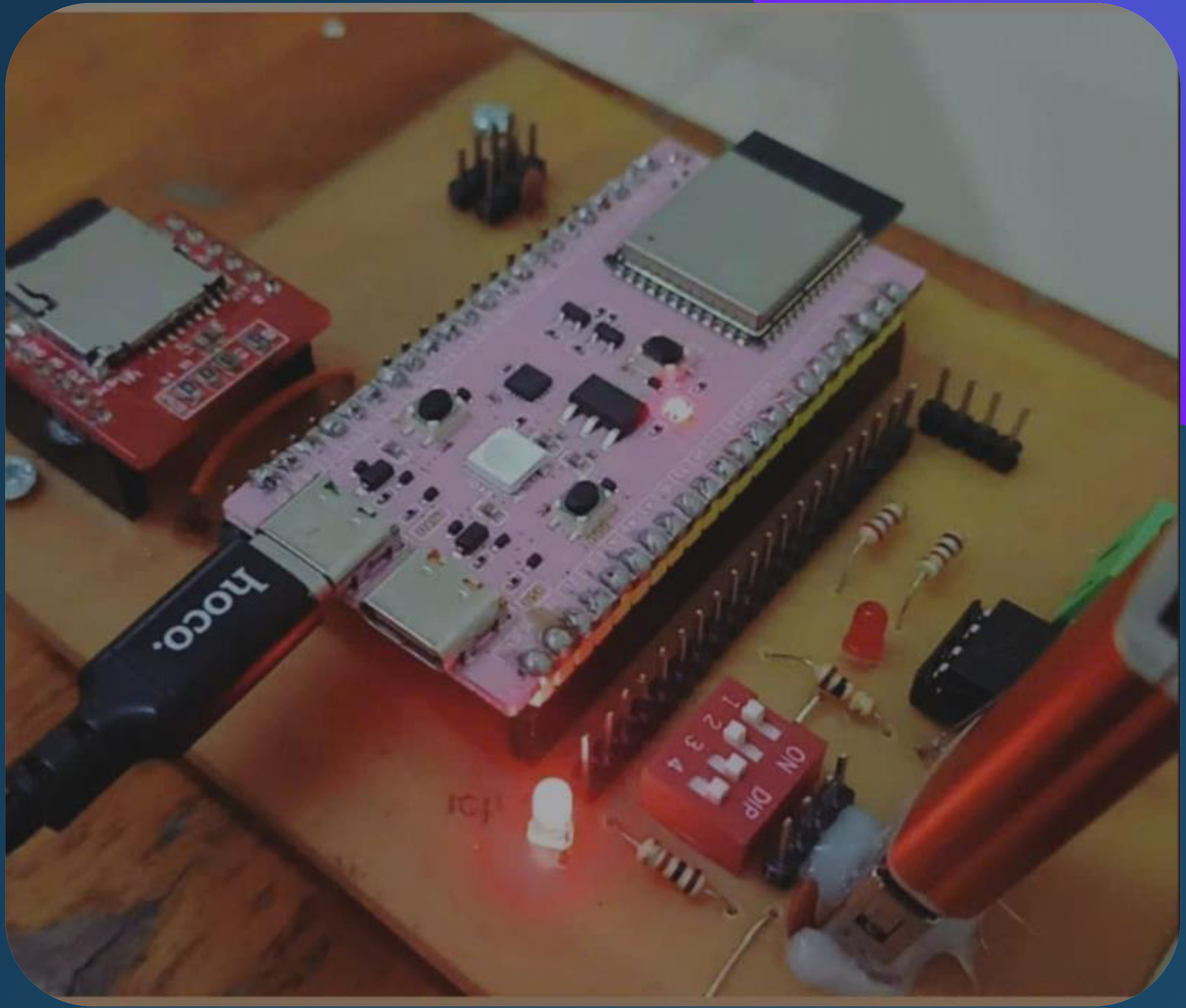


LIDAR MODULE

GPS MODULE

RADAR MODULE

MICRO SD CARD



SOFTWARE DEVELOPMENT

- On the software side, the system leverages advanced machine learning algorithms to interpret the data collected by sensors.
- These algorithms are trained to analyze patterns and identify potential risks in real-time.
- For example, they can predict situations such as sudden braking by a vehicle ahead or changes in traffic flow due to an obstruction.

SOFTWARE DEVELOPMENT

- To ensure the reliability and robustness of the system, traffic simulation tools like SUMO (Simulation of Urban Mobility) are used extensively.
- These tools allow the software to be tested and validated under various real-world conditions.
- Simulations help fine-tune the AI algorithms, ensuring that they can handle diverse scenarios, including urban traffic, highway conditions, and adverse weather.

SOFTWARE DEVELOPMENT

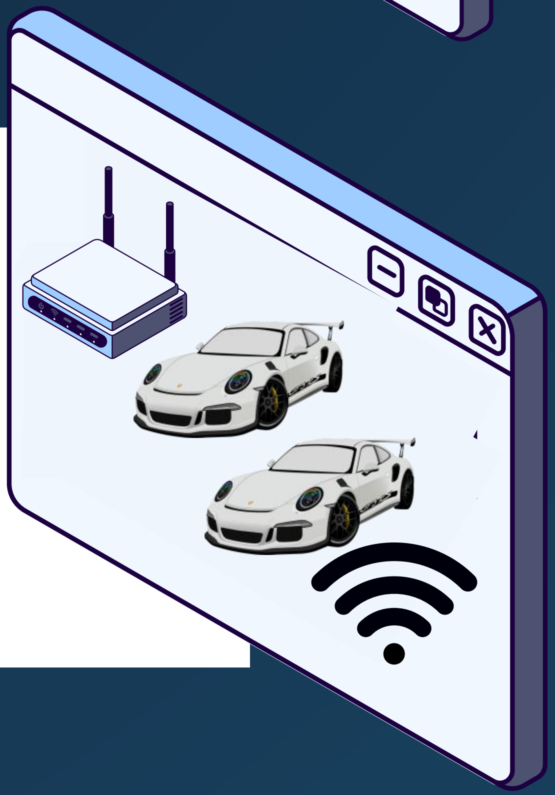
- The software also includes route optimization capabilities. By analyzing current traffic data and predicting potential delays, it suggests the most efficient routes for drivers, minimizing travel time and fuel consumption.

SOFTWARE DEVELOPMENT

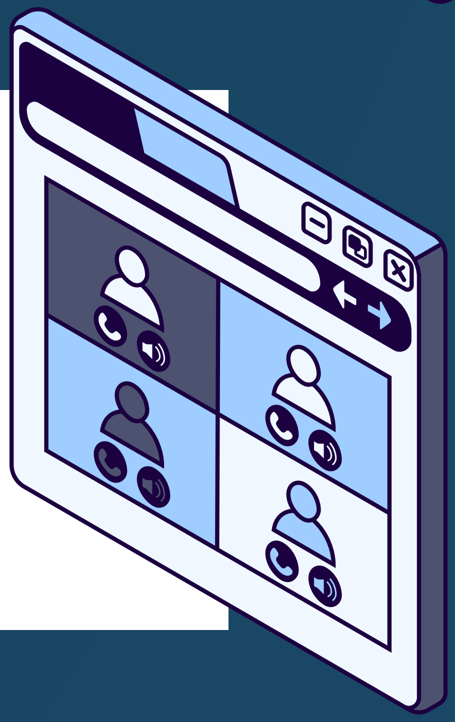
Develop AI algorithms to analyze data from sensors and V2V systems in real-time.

Use machine learning to create models for incident prediction, route optimization, and traffic coordination.

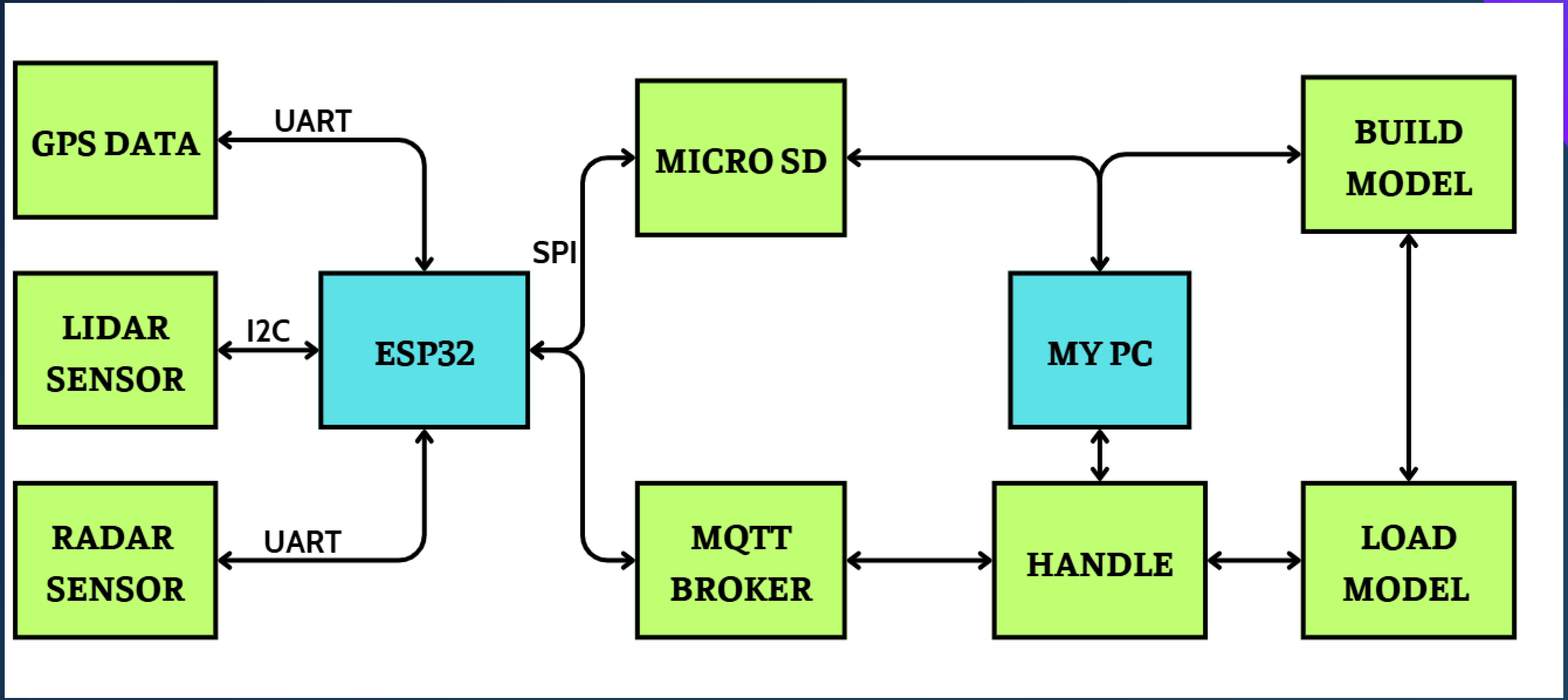
Build protocols to send notifications and warnings from the central system to vehicles.



Utilize tools like SUMO or VISSIM to simulate traffic scenarios and test system performance.

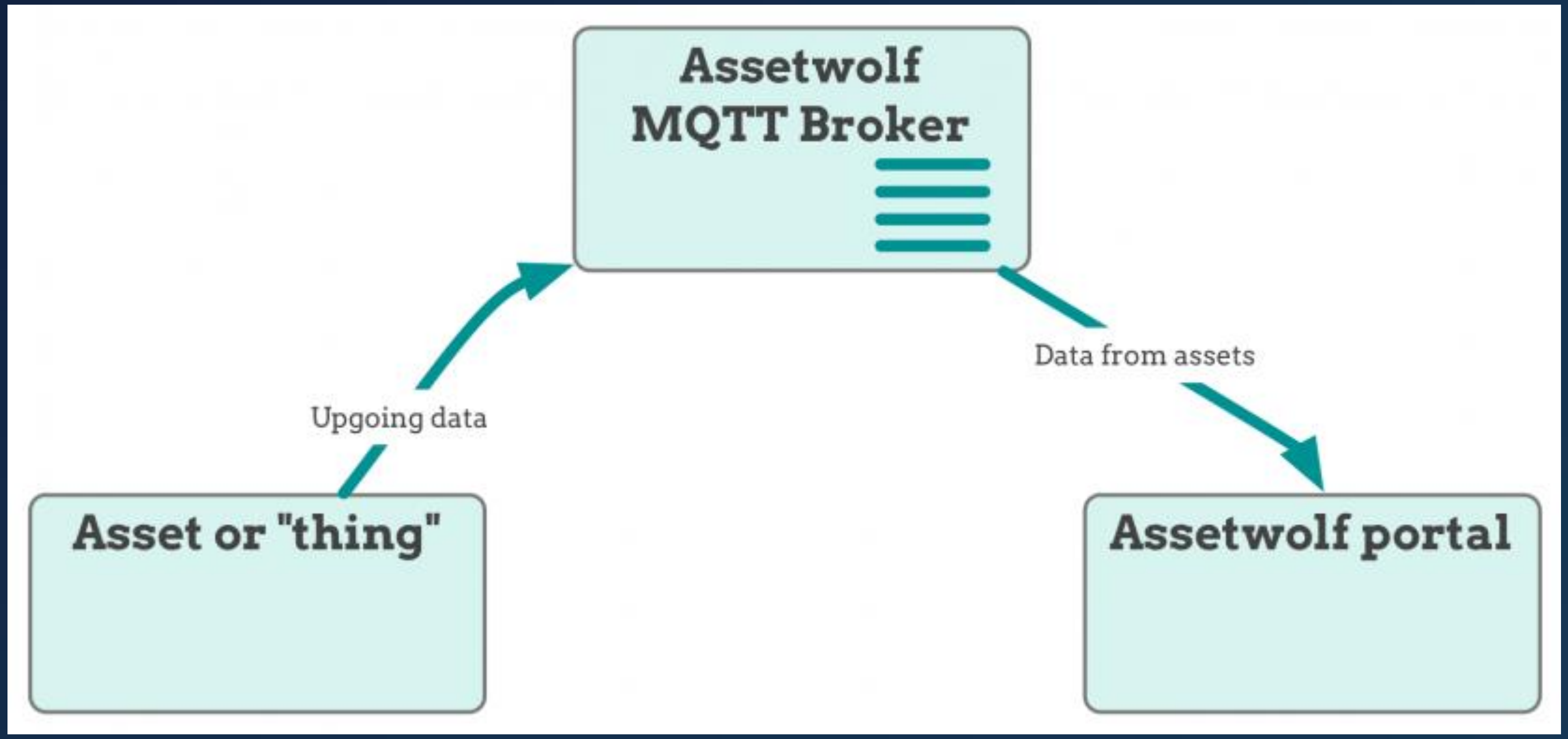


SOFTWARE BLOCK DIAGRAM



The data from these sensors is then saved to a memory card as an Excel file. Since I only own one Lidar sensor but need to simulate five cars, I randomly generated data for the remaining four cars to complete the data for the five V2V_N* topic.

SOFTWARE BLOCK DIAGRAM



IP: 3.25.112.140
PUBLIC SERVER
PORT 1883

With the constant movement of vehicles, it is necessary to use a public MQTT broker. I have set up and tested this broker at IP address 3.25.112.140 and port 1883, and everything works fine. This model has been successfully simulated and enables V2V communication, an important step forward in ensuring intelligent traffic safety.

SOFTWARE DEVELOPMENT

MQTT Explorer

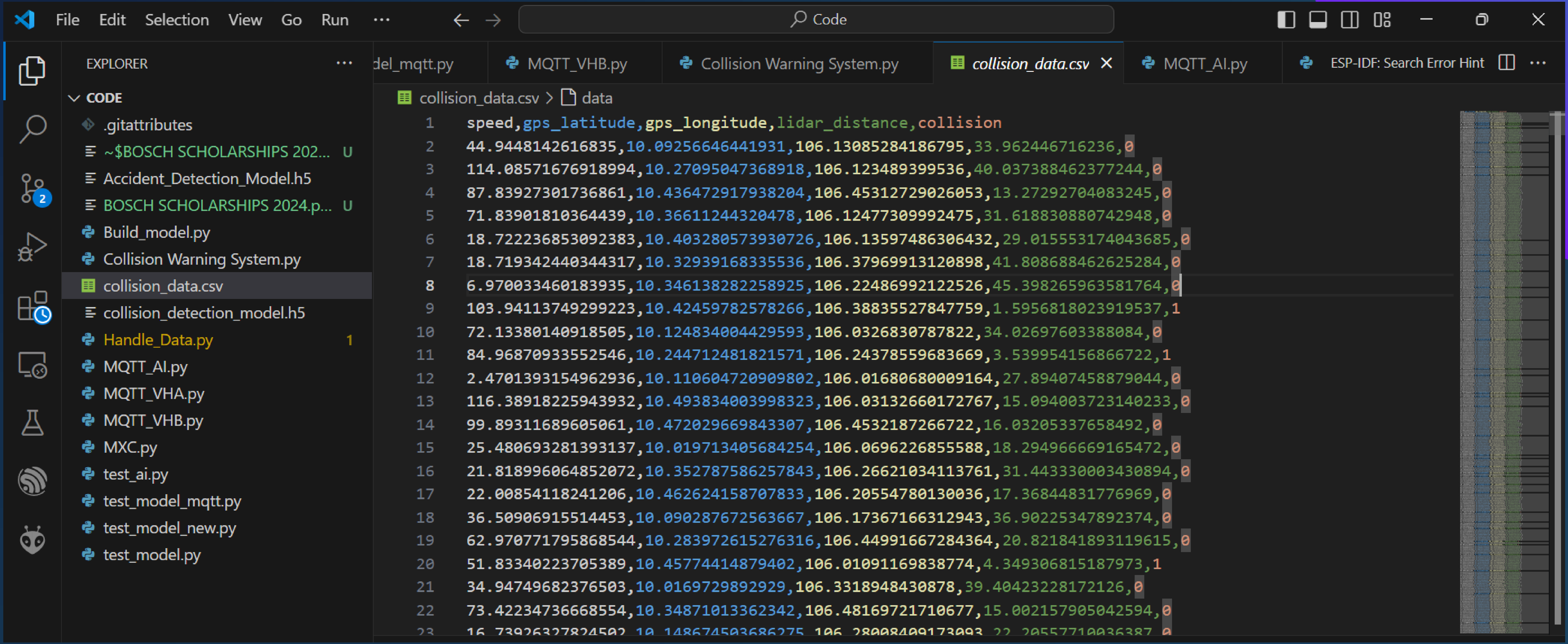
Search...

▼ 3.25.112.140
- ▶ **Sensor** (14 topics, 14 messages)
- ▶ **v2v** (1 topic, 1 message)
- ▼ **V2V_N1**
  - ▶ **Sensors** (9 topics, 9 messages)
  - ▶ **Camera** (2 topics, 2 messages)

speed = {"data":89.89836,"name":"Vehicle Speed Sensor","unit":"km/h","timestamp":"2024-12-03 22:31:53"}
gps = {"latitude":10.61995,"longitude":106.3209,"name":"GPS Position Sensor","unit":"degrees","timestamp":"2024-12-03 22:31:47"}
lidar = {"distance":32.19519,"name":"Lidar Distance Sensor","unit":"meters","timestamp":"2024-12-03 22:31:47"}
accelerometer = {"x_axis":-4.380544,"y_axis":-5.173062,"z_axis":-4.079111,"name":"Accelerometer","unit":"m/s²","timestamp":"2024-12-03 22:31:47"}
steering_angle = {"data":1.588867,"name":"Steering Angle Sensor","unit":"degrees","timestamp":"2024-12-03 22:31:47"}
temperature = {"data":25.52414,"name":"Ambient Temperature Sensor","unit":"°C","timestamp":"2024-12-03 22:31:47"}
humidity = {"data":64.62172,"name":"Humidity Sensor","unit":"%","timestamp":"2024-12-03 22:31:47"}
tire_pressure = {"data":28.19536,"name":"Tire Pressure Sensor","unit":"psi","timestamp":"2024-12-03 22:31:47"}
tilt = {"data":0.698776,"name":"Tilt Sensor","unit":"degrees","timestamp":"2024-12-03 22:31:47"}

People can connect to the provided IP address to follow and better understand how the V2V simulation system I built works.

SOFTWARE DEVELOPMENT



CREATE MODEL COLLISION_DETECTION

Build_model.py M | test_model.py | test_model_mqtt.py | MQTT_VHB.py | Collision W | ESP-IDF: Search Error Hint

Build_model.py > ...

```python
import pandas as pd
from sklearn.model_selection import train_test_split
from tensorflow.keras.models import Sequential  # type: ignore
from tensorflow.keras.layers import Dense  # type: ignore

# Read data
data = pd.read_csv("collision_data.csv")
X = data[["speed", "gps_latitude", "gps_longitude", "lidar_distance"]]
y = data["collision"]

# Split data into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Build the model
model = Sequential([
    Dense(64, input_dim=4, activation='relu'),  # 4 input features
    Dense(32, activation='relu'),
    Dense(1, activation='sigmoid')  # Predict collision probability
])

# Compile the model
model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

All this data is sent as JSON to my personal computer, which acts as a server for collection and processing. I built an AI model called collision_detection_model.h5 using the tensorflow.keras.models library to process this data.

RESULTS

▼ V2V_STATUS
▼ status
▼ V2V_N1
= {"status": "Safe", "probability": 2.4003415921569626e-10, "sensor_data": {"speed": 94.28429, "gps_latitude": 10.61995, "gps_longitude": 106.3209, "lidar_distance": 32.19519}}
▼ V2V_N2
= {"status": "Safe", "probability": 0.4051865339279175, "sensor_data": {"speed": 86.73718, "gps_latitude": 10.50876, "gps_longitude": 106.5506, "lidar_distance": 10.31252}}
▼ V2V_N3
= {"status": "Safe", "probability": 2.3101529222913086e-07, "sensor_data": {"speed": 33.04372, "gps_latitude": 10.67467, "gps_longitude": 106.0262, "lidar_distance": 25.32774}}
▼ V2V_N4
= {"status": "Safe", "probability": 1.4074484104759956e-14, "sensor_data": {"speed": 48.29198, "gps_latitude": 10.54437, "gps_longitude": 106.7408, "lidar_distance": 48.27663}}
▼ V2V_N5
= {"status": "Collision Warning", "probability": 0.9960370659828186, "sensor_data": {"speed": 91.77197, "gps_latitude": 10.07754, "gps_longitude": 106.3679, "lidar_distance": 5.225141}}

- The model is designed to determine whether the condition is safe or dangerous based on the data from three sensors and then send the processing results back to the MQTT broker with the topic V2V_STATUS.
- In the future we use 4g/5g with high speed wireless communication and support integrated gps through modules such as QUECTEL EC25 and SIM7600G-H to be more practical instead of wifi.

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INNOVATIONS

What sets this project apart is its innovative integration of AI into the V2V system. Traditional V2V systems typically rely on pre-defined protocols for data sharing and decision-making. However, by embedding AI, this system gains the ability to predict incidents proactively, automate critical decisions, and continuously learn from new data.

INNOVATIONS

For example, as more vehicles equipped with this system enter the network, the AI becomes more intelligent through shared experiences, improving its accuracy and adaptability over time. This self-learning capability ensures that the system remains effective as traffic conditions evolve, providing long-term value and scalability.

INNOVATIONS

By combining cutting-edge hardware, intelligent software, and innovative approaches, this project not only addresses existing traffic issues but also lays the foundation for a future where transportation is safer, more efficient, and deeply interconnected.

DEVELOPMENT PATH
FROM V2V TO V2X

1

Vehicle-to-Infrastructure

Communication with traffic lights, road sensors, and digital signage

2

Vehicle-to-Pedestrian

Connecting with pedestrians' mobile devices to enhance safety in urban areas

3

Vehicle-to-Network

Accessing real-time data such as weather, traffic conditions, and infotainment services

4

Vehicle-to-Grid

Interaction with the power grid to optimize energy usage and support electric vehicles

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EXPECTED OUTCOMES

The expected outcomes of the *AI-Powered V2V Safety* project are both impactful and transformative, addressing some of the most pressing issues in traffic systems today.

First and foremost, the system aims to improve safety on the roads. By utilizing AI to predict potential accidents and sending early warnings to drivers, the project has the potential to reduce road accidents by up to 30%. This translates to fewer injuries, fewer fatalities, and a safer environment for all road users.

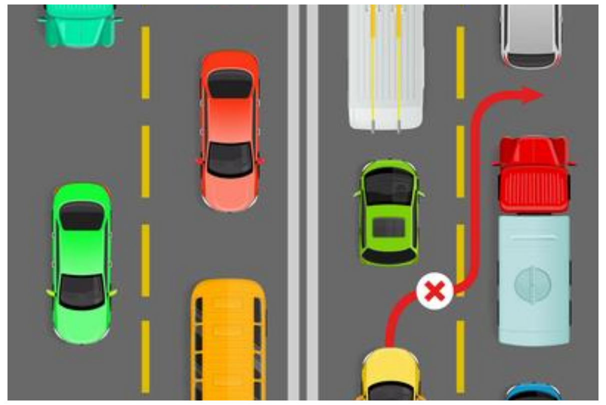
AI-POWERED V2V Safety

EXPECTED OUTCOMES

Availability

Reduced Traffic Accidents

Performance

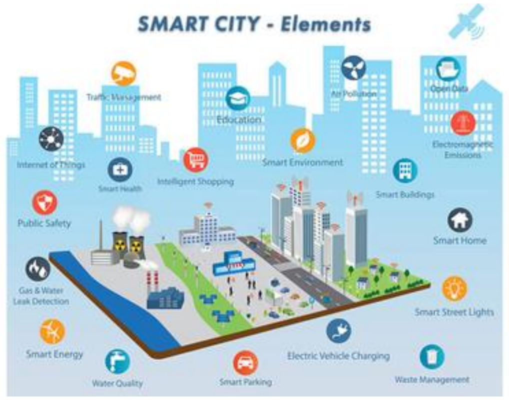


Optimized Traffic Flow

Management

Energy Savings

Future



Smart City Integration

[SHORT TERM] **[LONG TERM]**

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SECURITY AND SAFETY

Data Security: Encrypt data to prevent unauthorized access and cyberattacks.

Threat Detection: Use AI to identify and neutralize abnormal behaviors

System Safety: Ensure stable and reliable operations under emergency conditions

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Home About Content Others

FINANCIAL ASPECTS

IMPLEMENTING AI V2V

- High setup costs for V2V hardware and AI integration
- Reduced accident-related expenses and property damage
- Economic Efficiency, Improved traffic flow reduces delays and energy waste

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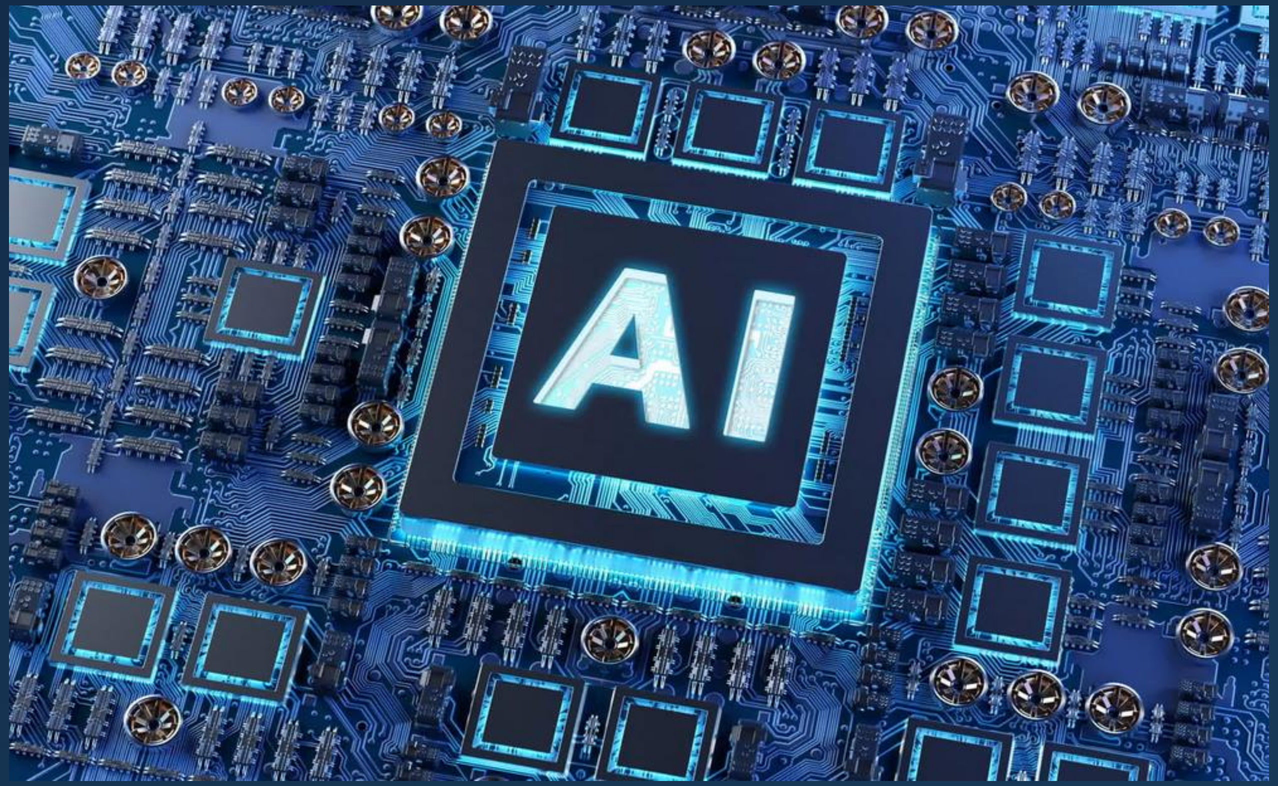
APPLICATION AT BOSCH

- The innovations from this project align perfectly with Bosch's expertise and long-term goals, making it highly applicable to various Bosch initiatives.
- One of the primary applications is the integration into Advanced Driver Assistance Systems (ADAS). By enhancing ADAS with AI-driven V2V communication, Bosch can improve intelligent vehicle management, enabling vehicles to respond to their environment more effectively.



APPLICATION AT BOSCH




The system also supports the development of autonomous vehicles, a key area of focus for Bosch. With its advanced capabilities in obstacle detection and route optimization, the project provides critical tools for ensuring the reliability and safety of autonomous vehicles in complex traffic scenarios.

Furthermore, the project contributes to energy-efficient solutions, helping Bosch achieve its sustainability objectives. By reducing fuel consumption and emissions, the system aligns with Bosch's commitment to environmental responsibility.

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THANK YOU!

Thank you for the wonderful opportunity that the Activator Scholarship 2024 at Bosch offers.

I am extremely grateful for your support and belief in my potential to contribute to innovation and challenge.