# Advanced Vehicle Fire Safety and Monitoring with Rapid Emergency Dispatch Solutions

R24-058

SLIIT
FACULTY OF COMPUTING

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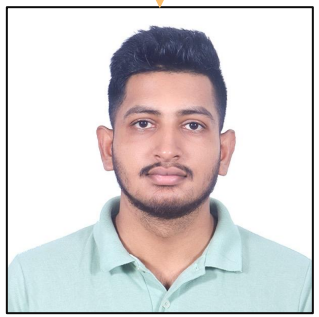

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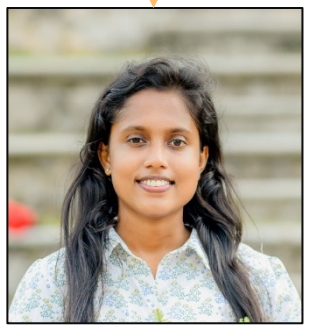

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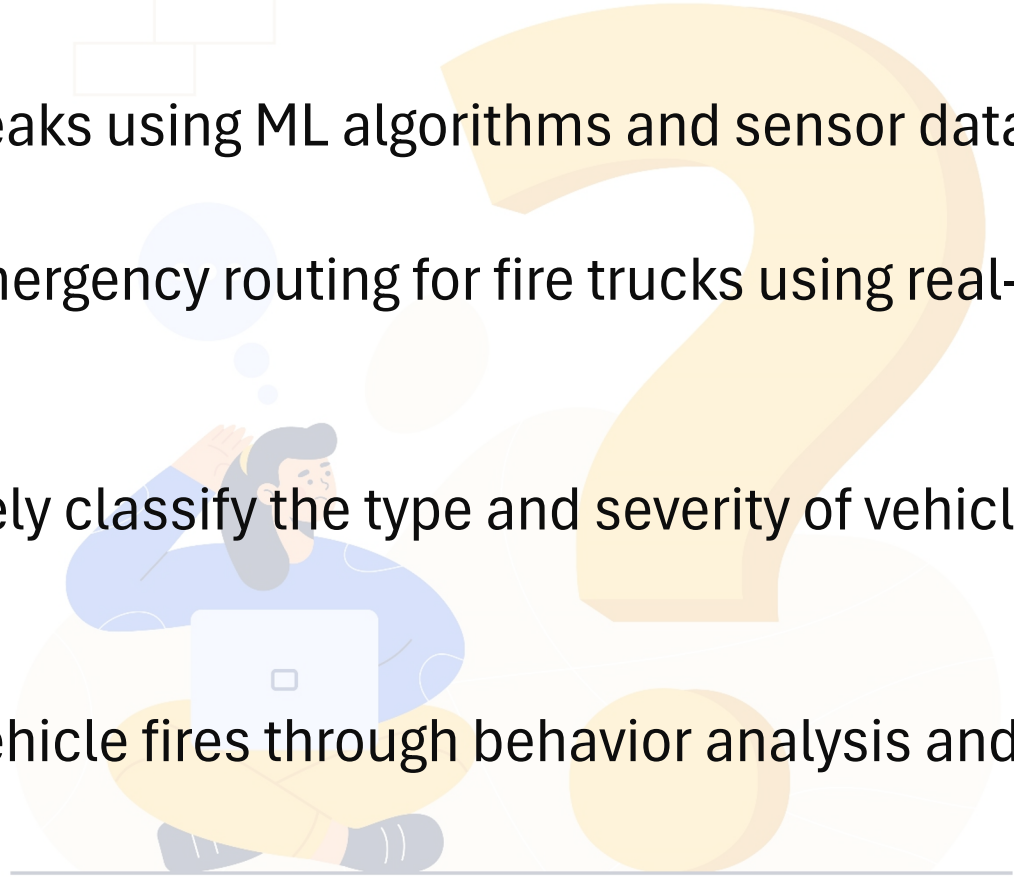
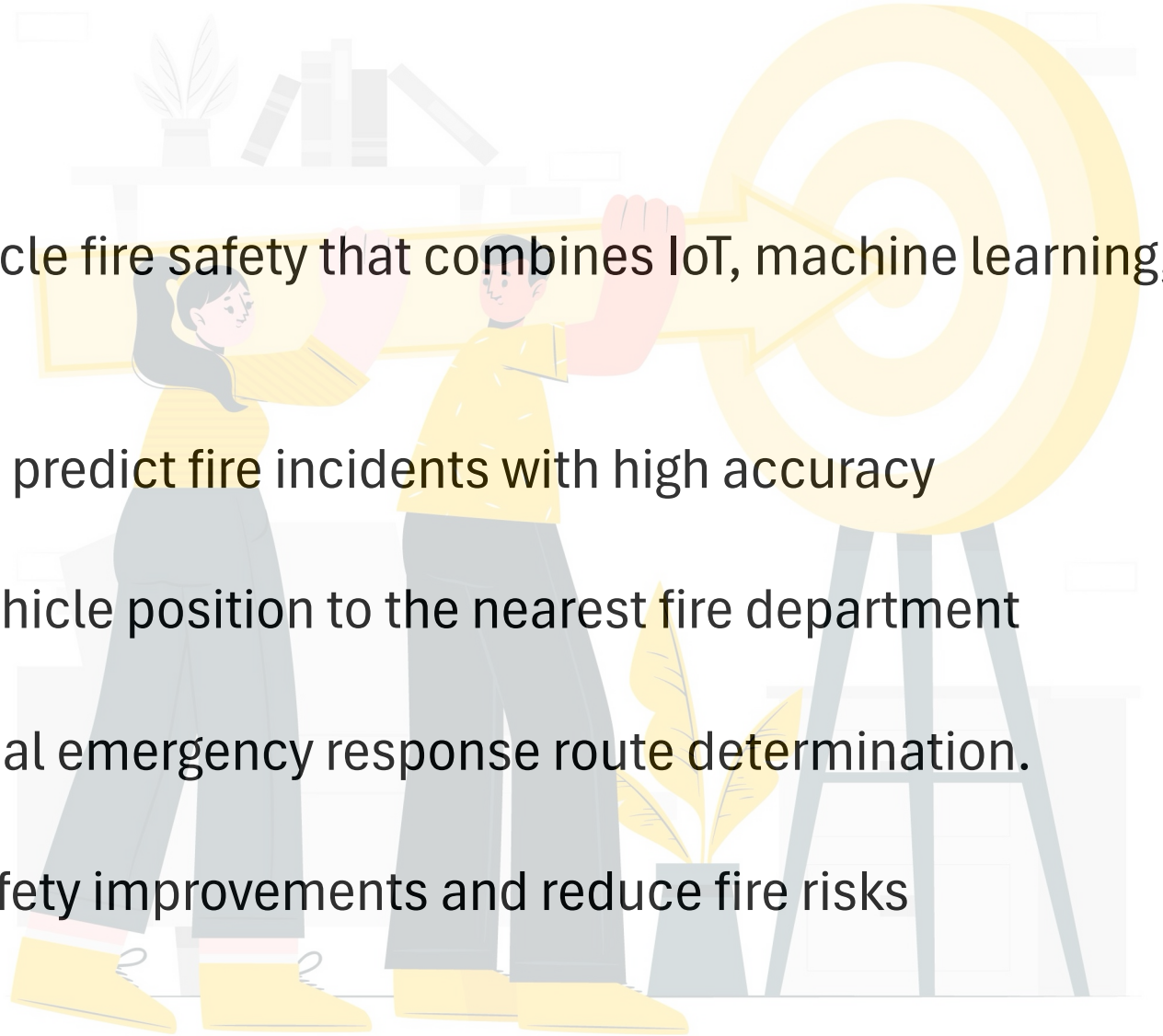
# Research Problem

- How to accurately predict vehicle fire outbreaks using ML algorithms and sensor data?
- How can cloud-based analytics optimize emergency routing for fire trucks using real-time and historical traffic data?
- What methods can be employed to accurately classify the type and severity of vehicle fires using sensor data?
- How to enhance driver safety and prevent vehicle fires through behavior analysis and feedback mechanisms?

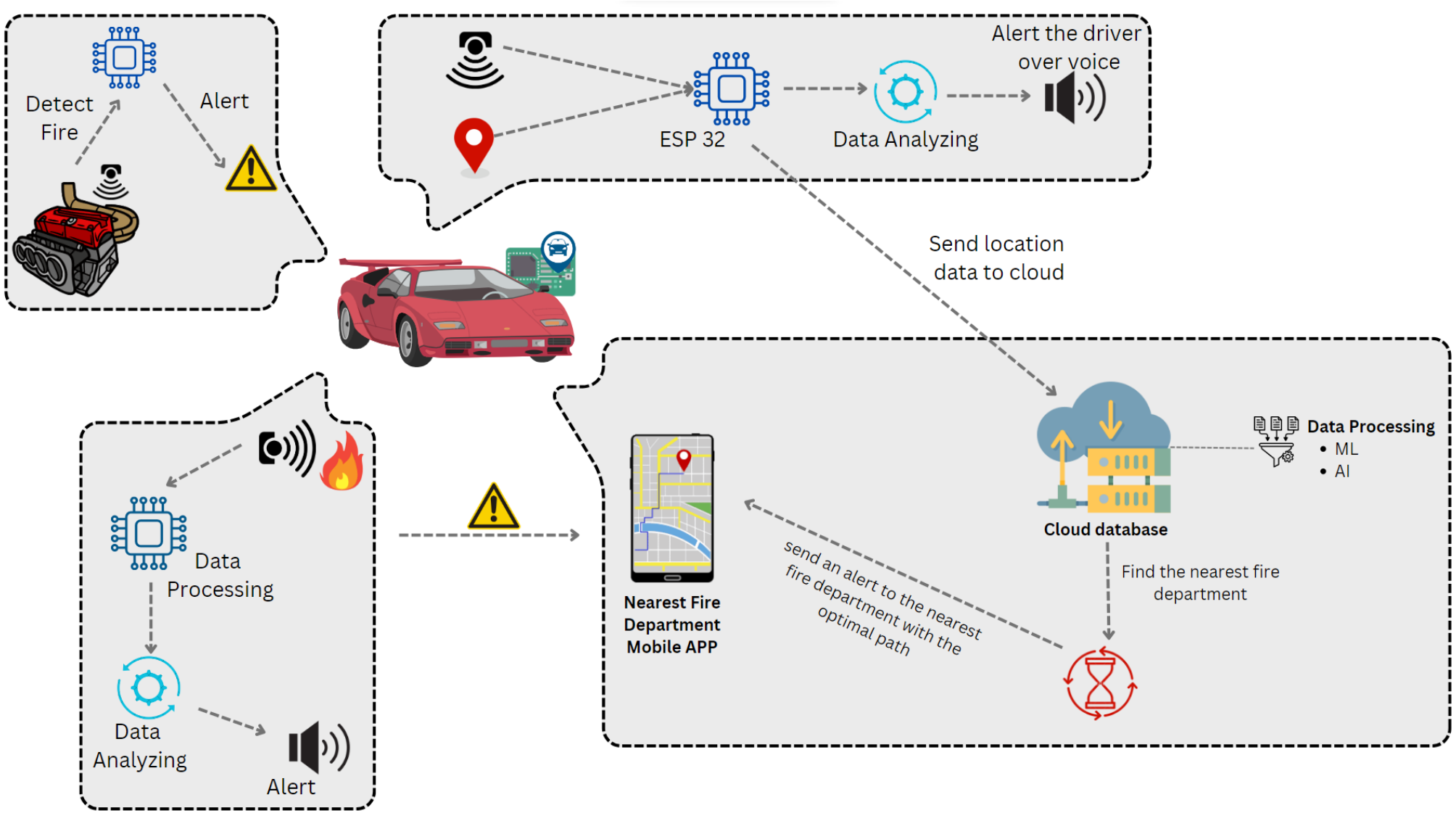


# Objectives

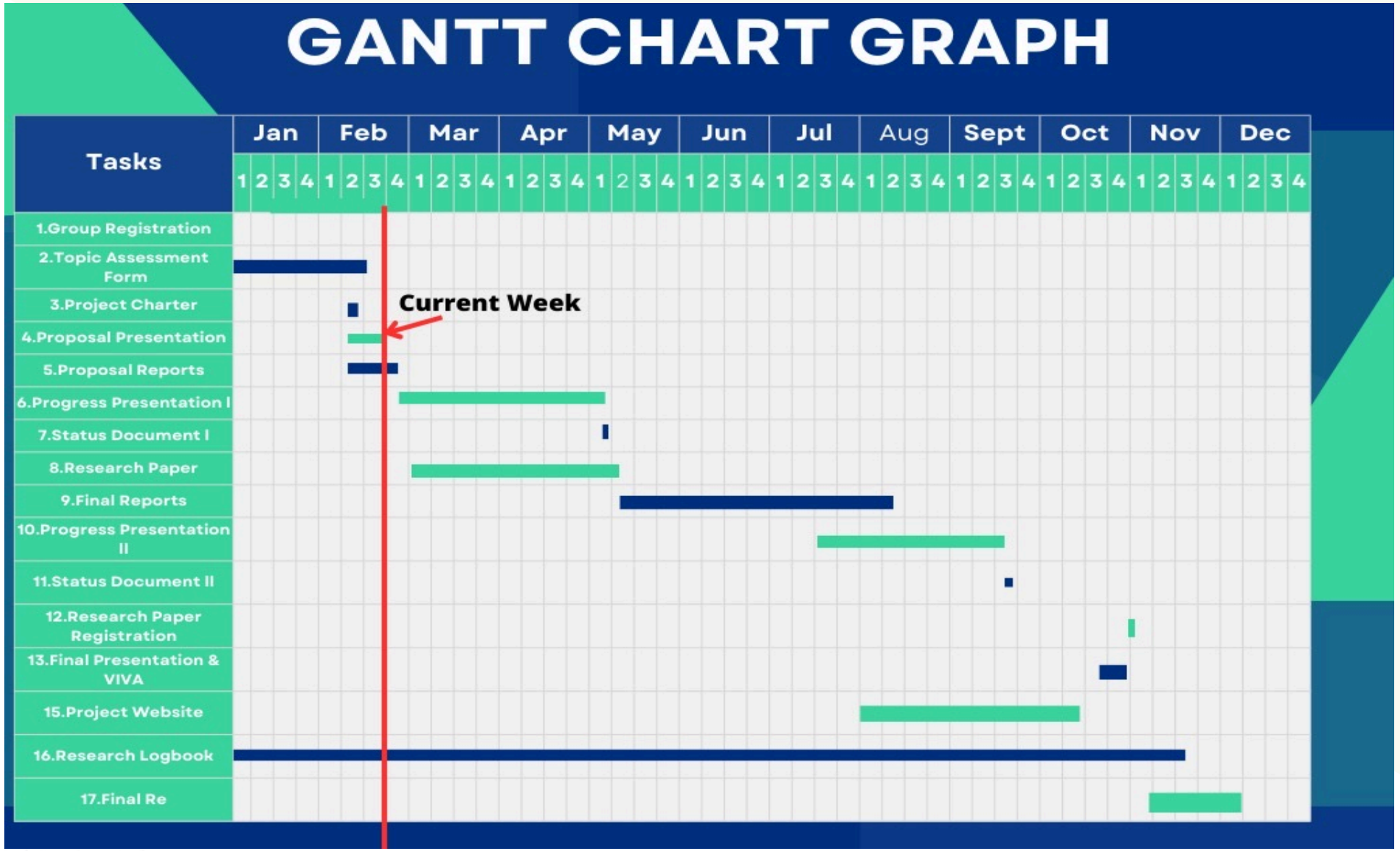


- Create an integrated solution for vehicle fire safety that combines IoT, machine learning, and cloud computing.
- Utilize ML to analyze sensor data and predict fire incidents with high accuracy
- Instantly relay fire information and vehicle position to the nearest fire department
- Monitor vehicle parameters for optimal emergency response route determination.
- Analyze driver behavior to suggest safety improvements and reduce fire risks

# System Diagram



# Gantt Chart


GANTT CHART GRAPH
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1.Group Registration
2.Topic Assessment Form
3.Project Charter
4.Proposal Presentation
5.Proposal Reports
6.Progress Presentation I
7.Status Document I
8.Research Paper
9.Final Reports
10.Progress Presentation II
11.Status Document II
12.Research Paper Registration
13.Final Presentation & VIVA
15.Project Website
16.Research Logbook
17.Final Re
Current Week

# Commercialization

- Collaborate with automobile manufacturers to install the system directly into new vehicles.

- Utilize collected data on fire events and responses to provide consultancy services to automobile manufacturers, assisting them in designing safer vehicles.

# Individual Components

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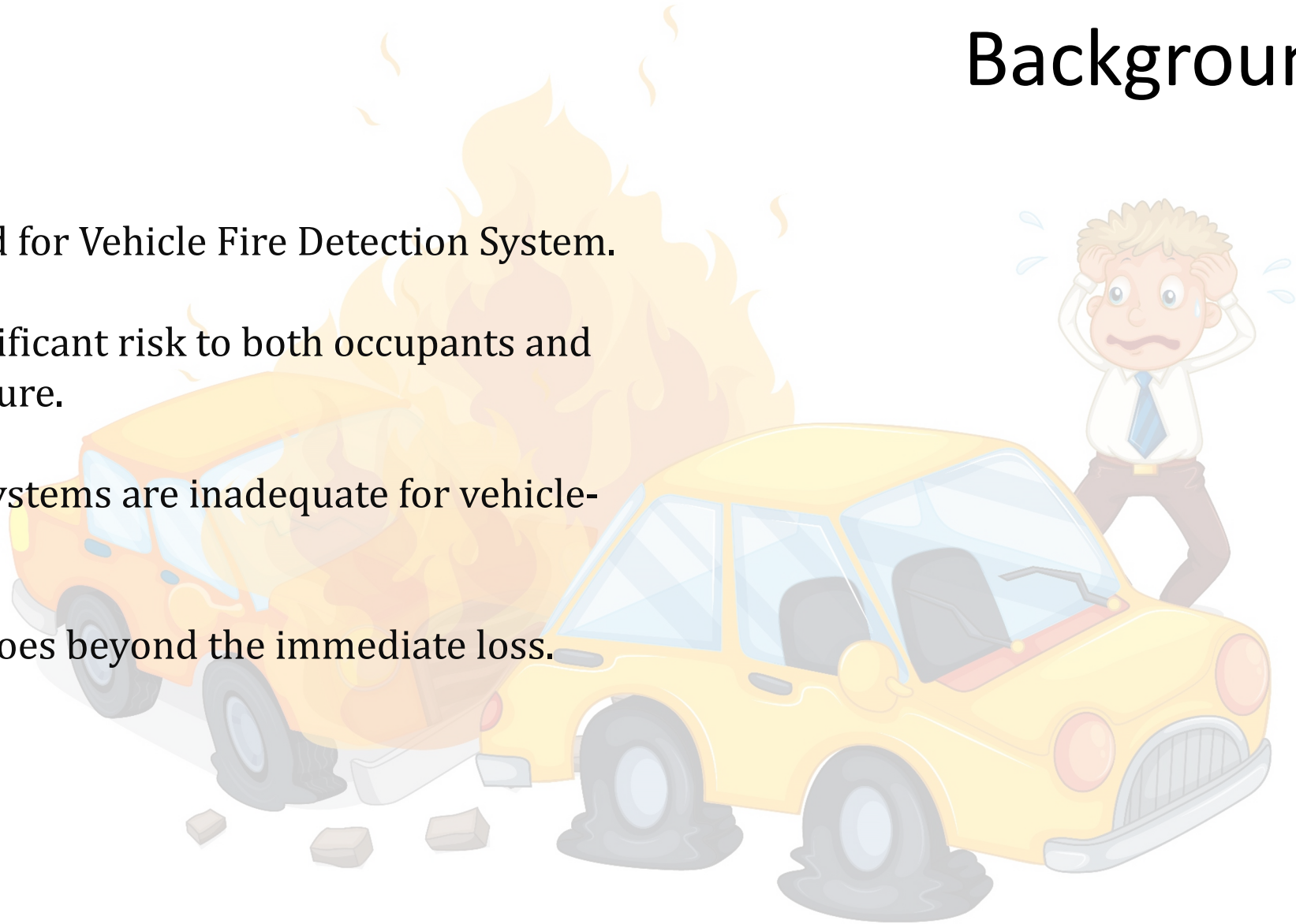
# Vehicle Safety System for Fire Detection and Prevention

# Background

- Understanding the Need for Vehicle Fire Detection System.
- Vehicle fires pose a significant risk to both occupants and surrounding infrastructure.
- Current fire detection systems are inadequate for vehicle-specific scenarios.
- Impact of vehicle fires goes beyond the immediate loss.



# Research Problem

## Limited proactive fire detection

Current vehicle fire detection systems are reactive, lacking the ability to detect potential fire hazards before they escalate.

## Inadequate automotive fire detection technologies

Existing systems are not designed for the automotive environment, leading to suboptimal performance in detecting and preventing vehicle fires.

## Inadequate automotive fire detection technologies

The lack of advanced detection mechanisms in vehicles results in delayed response times, reducing the effectiveness of fire prevention measures.

# Research Gap

**Research A**

- Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles. [1]

**Research B**

- Research on Multi-stage Early Warning System for Automobile Fire.[2]

**Research C**

- Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles.**[3]**

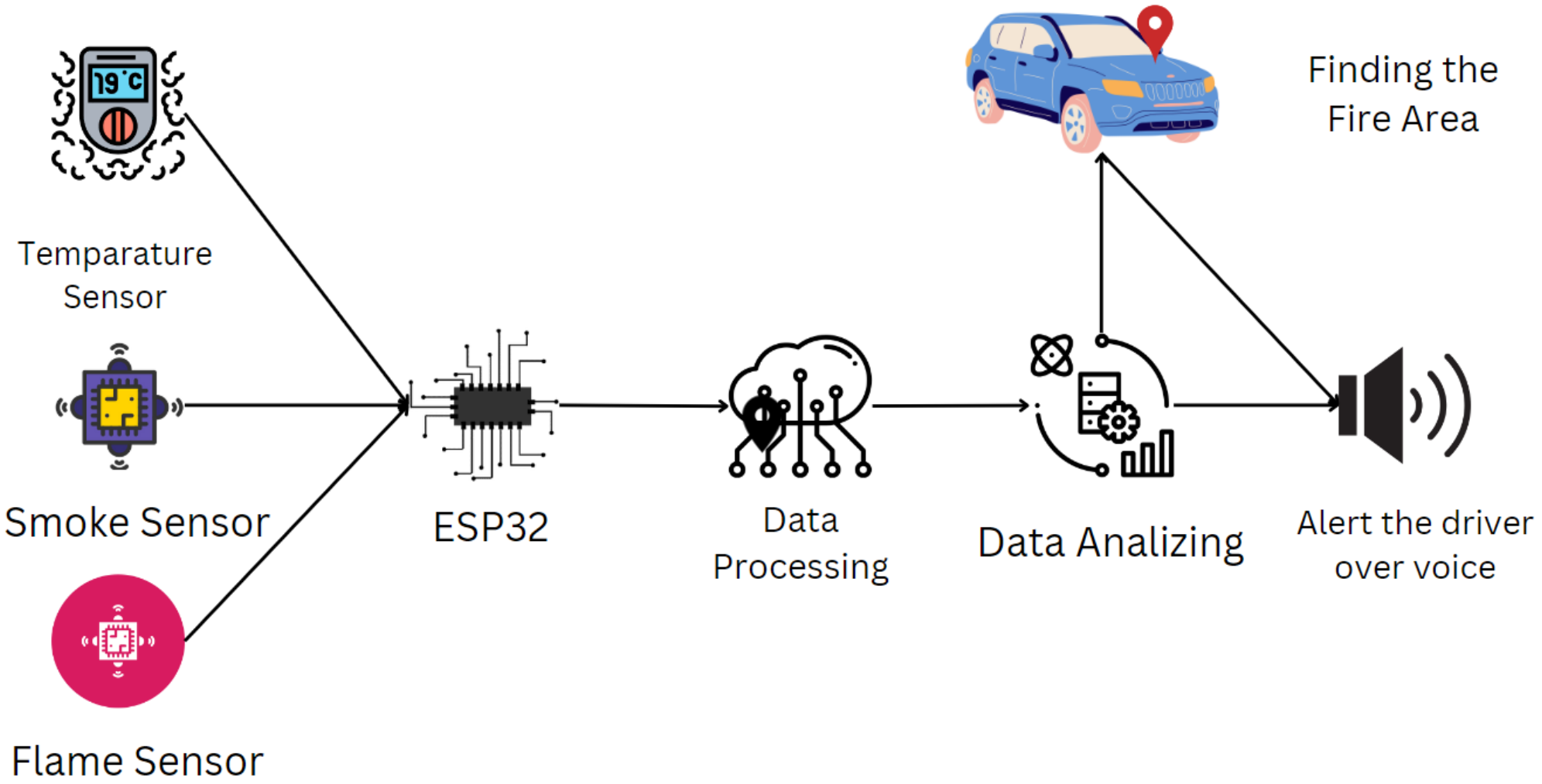
| Features | Research A | Research B | Research C | Proposed System |
|---|---|---|---|---|
| Gathering Data using Sensors | ✓ | ✓ | ✓ | ✓ |
| Setting the IOT devices to several areas | ✗ | ✗ | ✗ | ✓ |
| Indicating the fire area before it happens | ✗ | ✗ | ✗ | ✓ |
| Alerting the Driver using Voice | ✗ | ✗ | ✗ | ✓ |

# Objectives

Design and implement a novel fire detection solution for vehicles by installing sensors to detect smoke, temperature, fire, and vehicle vibrations.

- **Develop ML algorithms for analyzing sensor data and predicting potential fire situations.**
- **Establish a real-time data processing system for immediate response to fire threats.**
- **Create an alert mechanism based on continuous sensor monitoring and integration for accurate detection.**
- **ML for predictive analysis and continuous learning to enhance detection accuracy.**
- **Provide customized alerts to improve driver safety and response time.**

# Component Overview



# Tools and Technologies

## Hardware Tools

- Arduino
- Smoke Detectors
- Flame Sensor
- Temperature sensors
- ESP32


## Software Technologies

- MicroPython
- c/c++
- TensorFlow
- AWS/Azure
- Jupyter Notebook




# Requirement Analysis

## Functional Requirements

- Install sensors for smoke, temperature, fire, and vibration detection.
- Implement algorithms for sensor data analysis and fire prediction.
- Process sensor data in real-time for immediate response.
- Develop a mechanism to alert drivers of potential fire hazards.
- Monitor sensor performance continuously for accurate detection.

## Non-Functional Requirements

- **Ensure quick data processing and alert generation.**
- **Provide accurate detection and alerting under all conditions.**
- **Design the system to accommodate a large number of vehicles and sensors.**
- **Protect sensor data from unauthorized access.**
- **Create a user-friendly interface for easy understanding and response.**
- **Ensure the system is easy to maintain and update.**

# References

[1] Mathavan, J. J., Faslan, A., Basith, N. U. A., & Wanigasinghe, W. (2020, June). Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles. 2020 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184). https://doi.org/10.1109/icoei48184.2020.9142990.

[2] Research on Multi-Stage Early Warning System for Automobile Fire. (n.d.). Research on Multi-Stage Early Warning System for Automobile Fire | IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/9363758.

[3] Sowah, R., Ofoli, A., Koumadi, K., Osae, G., Nortey, G., Bempong, A. M., Agyarkwa, B., & Apeadu, K. O. (2018, August). Design and Implementation of a Fire Detection andControl System with Enhanced Security and Safety for Automobiles Using Neuro-Fuzzy Logic. 2018 IEEE 7th International Conference on Adaptive Science & Technology (ICAST). https://doi.org/10.1109/icastech.2018.8507143.

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# Fire Type Identification and Severity Assessment for Emergency Services

# Background

- **Fire type** refers to the classification of a fire based on its cause, origin, or the materials involved.
- It helps identify where and why the fire started, such as electrical issues, fuel leaks,engine fire or exhaust system fire.
- **Fire severity** in vehicle fires refers to the extent of damage or intensity of the fire.
- It ranges from minor, with little damage, to major, causing extensive harm to the vehicle and potentially endangering lives.
- Recognizing the fire type and the fire severity is essential for safety, firefighting, and assessing the risk to occupants and responders.

# Research Problem

**How can fire departments optimize their protocols to enable firefighters to anticipate and mitigate fires more efficiently before upon arrival?**

Fire department emergency systems are not designed with prepare their resources related to real time fire type with more efficiency before reaching the current location.

**How can fire departments prepare their equipment and resources in advance to mitigate potential risks?**

Existing fire Emergency systems are not designed with identify the vehicle fire severity to manage their resources and safety of the responders and the public before arriving.

# Research Gap

**Research A**

- Design and Implementation of A Fire Detection and Control System for Automobiles Using Fuzzy Logic. **[1]**

**Research B**

- Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles. **[2]**

**Research C**

- A Fire-Detection and Control System in Automobiles: Implementing a Design That Uses Fuzzy Logic to Anticipate and Respond. **[3]**

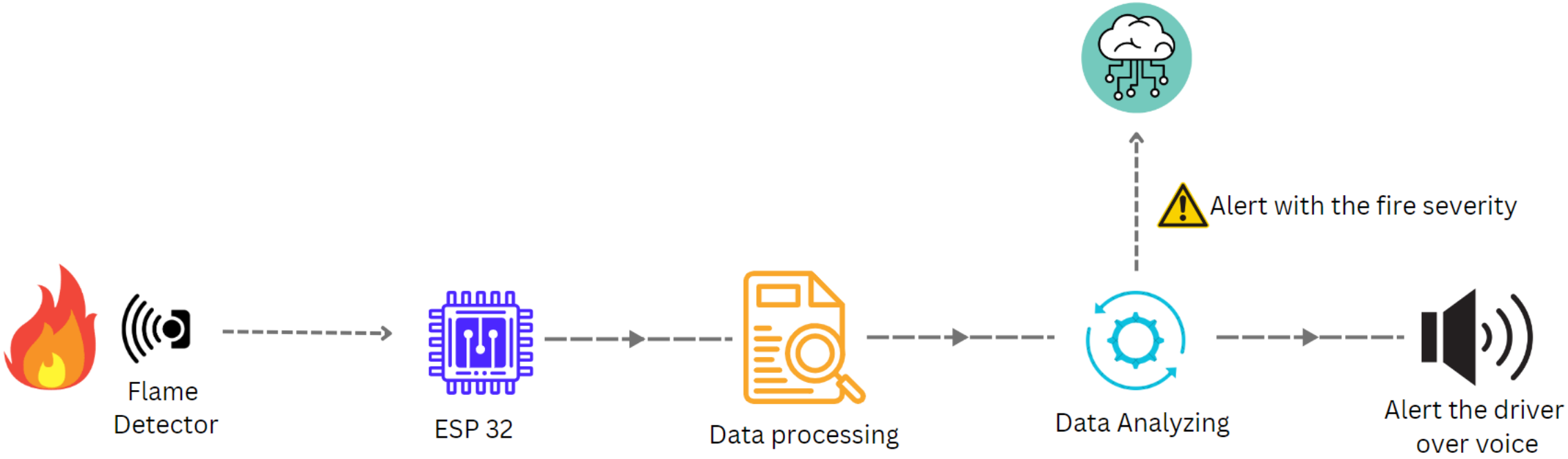
| Features | Research A | Research B | Research C | Proposed System |
|---|---|---|---|---|
| IoT device to detect various fire indicators. | ✓ | ✓ | ✓ | ✓ |
| Predict the fire type | ✗ | ✗ | ✗ | ✓ |
| Predict the fire severity | ✗ | ✗ | ✗ | ✓ |
| Show the real time fire severity levels through mobile app | ✗ | ✗ | ✗ | ✓ |

# Objectives

**Predict the classification of fire type and the severity level of the vehicle fire**

- **Install sensors in vehicles to detect various fire indicators .**
- **Train highly accurate ML models with a collection of real-time data from sensors under various conditions.**
- **After Analyzing data then predict fire type, severity level and send details to the nearest fire department**
- **Display the real time fire severity level in the mobile app**

# Component Overview



# Tools and Technologies

## Hardware Tools

- Arduino UNO
- MQTT Broker
- NodeMCU
- Smoke Detectors
- MQTT Broker
- Temperature sensors'
- Carbon Monoxide Detectors
- Gas Sensors
- Flame sensors




## Software Technologies

- Python
- React Native
- MongoDB
- Node JS
- TensorFlow
- AWS/Azure

# Requirement Analysis

**Functional Requirements**

- System should be able to collect and store real-time data under various conditions from IoT-enabled sensors.
- Fire Type should be appropriately displayed to the mobile app with accessible by the responding firefighters with nearest fire department with high accuracy.
- System should be able to send real time fire severity levels to the mobile app without any delay.

**Non-Functional Requirements**

- Interfaces should be more user-friendly.
- Application should be reliable
- Should respond Realtime.
- Should have high security.

# References

[1] Sowah, R., Ampadu, K. O., Ofoli, A., Koumadi, K., Mills, G. A., & Nortey, J. (2016, October). Design and implementation of a fire detection and control system for automobiles using fuzzy logic. *2016 IEEE Industry Applications Society Annual Meeting*. https://doi.org/10.1109/ias.2016.7731880

[2] Mathavan, J. J., Faslan, A., Basith, N. U. A., & Wanigasinghe, W. (2020, June). Hardware Implementation of Fire Detection, Control and Automatic Door Unlocking System for Automobiles. *2020 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184)*. https://doi.org/10.1109/icoei48184.2020.9142990

[3] Sowah, R., Ampadu, K. O., Ofoli, A. R., Koumadi, K., Mills, G. A., & Nortey, J. (2019, March). A Fire-Detection and Control System in Automobiles: Implementing a Design That Uses Fuzzy Logic to Anticipate and Respond. *IEEE Industry Applications Magazine*, *25*(2), 57–67. https://doi.org/10.1109/mias.2018.2875189

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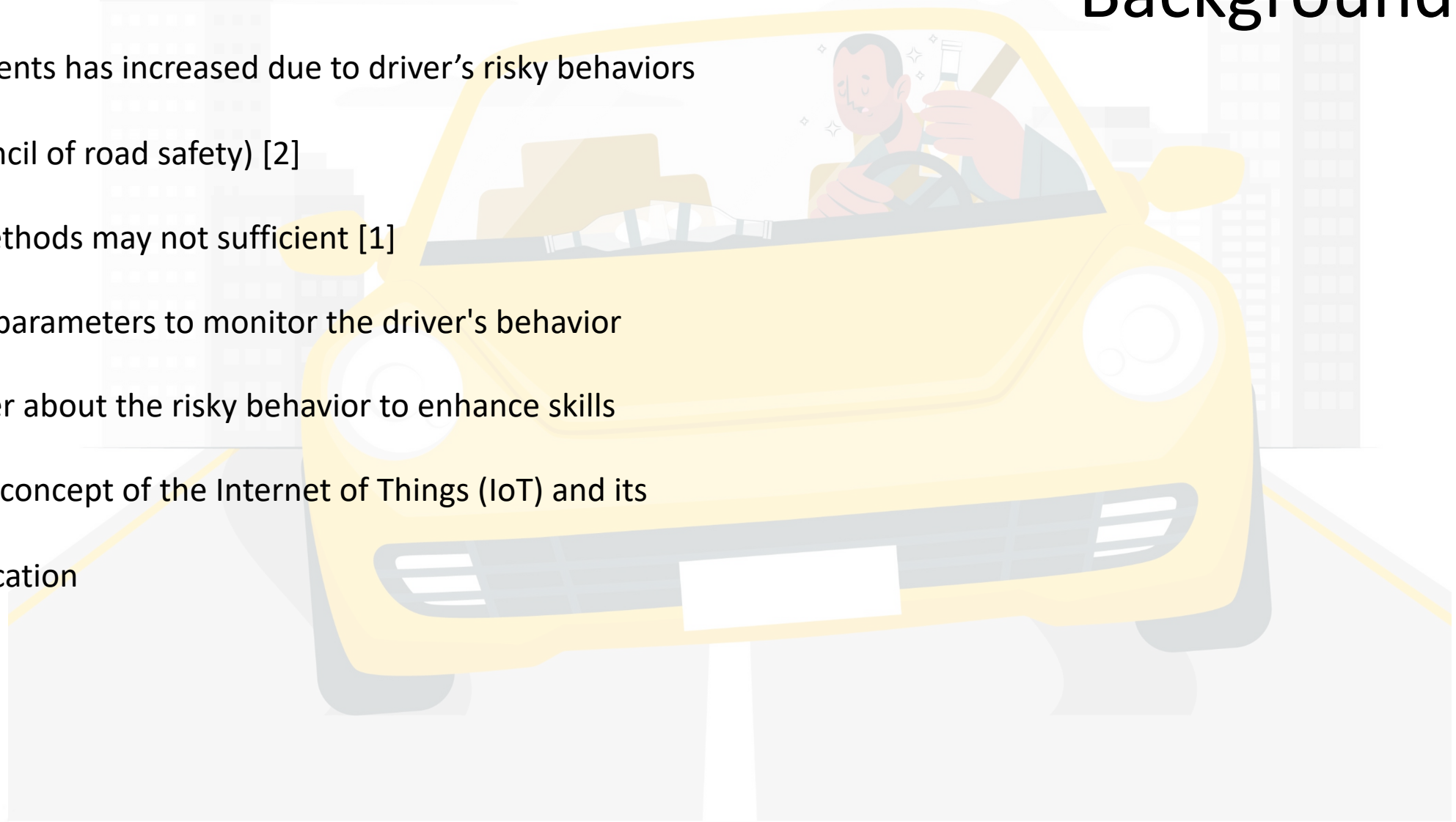
# Enhancing Driver Safety with Real-Time Vehicle Monitoring and Behavior Analysis

# Background

- Vehicles accidents has increased due to driver’s risky behaviors (National council of road safety) [2]
- Traditional methods may not sufficient [1]
- Need various parameters to monitor the driver's behavior
- Alert the driver about the risky behavior to enhance skills
- Introduce the concept of the Internet of Things (IoT) and its growing application



# Research Problem

**How to identify the risky moments of the driver?**

**Ensure passenger safety ?**

**Ensure vehicle safety?**

**What are the social and economic benefits ?**

# Research Gap

**Research A**

- Driver Behavior Analysis for advanced Driver Assistance system[1]

**Research B**

- Driver Behavior Analysis and Warning System for digital cockpit Based on Driving Data.[2]

**Research C**

- Modelling of Driver's Steering Behavior Control in Emergency Collision Avoidance by using Focused Time Delay Neural Network.[3]

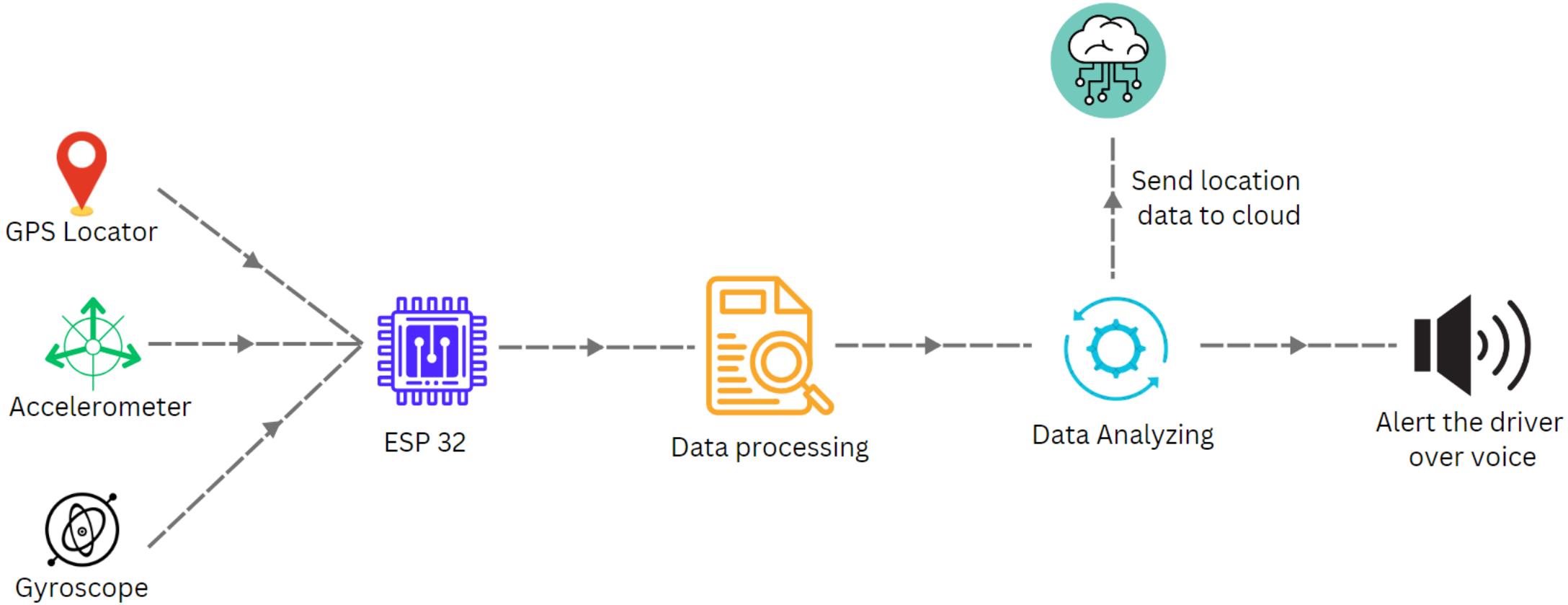
| Features | Research A | Research B | Research C | Proposed System |
|---|---|---|---|---|
| IOT device to track vehicle movement | ✓ | ✗ | ✓ | ✓ |
| Send data to a cloud system | ✗ | ✗ | ✗ | ✓ |
| Centralized device to analyze risky movement | ✗ | ✓ | ✓ | ✓ |
| Alert the driver about the risky movement | ✗ | ✓ | ✗ | ✓ |

# Objectives

**Enhance vehicle safety by analyzing the risky behaviors of driver**

- **Analyze drivers behavior using sensors.**
- **Capture the driver's risky behavior**
- **Alert the driver about his behavior**
- **Improve skills with the given information**

# Component Overview



# Tools and Technologies

**Hardware Tools**

- ESP32
- Accelerometer
- RPM Sensor
- GPS locator
- speaker


**Software Technologies**

- MicroPython
- c/c++
- Jupyter Notebook
- Tensorflow
- AWS/Azure

# Requirement Analysis

## Functional Requirements

- The system must be able to collect real-time data on vehicle movement.
- The system must transmit the collected data securely to a cloud.
- The system must provide real-time feedback to drivers based on the analysis.
- The system must include a user-friendly interface.
- The system must be capable of integrating with existing vehicle systems.

## Non-Functional Requirements

- The system must be reliable with minimal downtime.
- The solution should be cost-effective.
- The system must process and analyze data in real-time.
- The system should be easy to maintain.

# References

[1] *Sri Lanka's Journey to Road Safety*. (n.d.). World Bank.

https://www.worldbank.org/en/news/feature/2021/11/04/sri-lanka-s-journey-to-road-safety

[2] R. (n.d.). National Council for Road Safety. National Council for Road Safety. https://www.transport.gov.lk/web/index.php?option=com_content&view=article&id=29&Itemid=149&lang=en#number-of-persons-killed-in-road-accidents.

[3] Chen, H., Zhao, F., Huang, K., & Tian, Y. (2018, May). Driver Behavior Analysis for Advanced Driver Assistance System. 2018 IEEE 7th Data Driven Control and Learning Systems Conference (DDCLS). https://doi.org/10.1109/ddcls.2018.8516059

[4] Choi, J. K., Kwon, Y. J., Kim, K., Jeon, J., & Jang, B. (2019, October). Driver Behavior Analysis and Warning System for Digital Cockpit Based on Driving Data. 2019 International Conference on Information and Communication Technology Convergence (ICTC). https://doi.org/10.1109/ictc46691.2019.8939875

[5] Hassan, N., Zamzuri, H., & Ariff, M. H. M. (2018, March). Modelling of driver's steering behaviour control in emergency collision avoidance by using focused time delay neural network. 2018 International Conference on Information and Communications Technology (ICOIACT). https://doi.org/10.1109/icoiact.2018.8350750

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# Optimizing Emergency Response Paths with Advanced Traffic and Location Analytics

# Background

- The rapid expansion of urban areas has resulted in increased traffic congestion, complicating emergency response routes.
- In emergencies, particularly vehicle fires, firetrucks' ability to travel rapidly is critical to saving lives.
- Fluctuating urban traffic circumstances make it difficult for firefighters to get at incident sites on time.
- A quick reaction to vehicle fires is not only important for public safety, but also for limiting property damage.
- There is a pressing need for better routing algorithms to efficiently navigate firetrucks in busy metropolitan environments.

# Research Problem

Modern routing systems are not designed with the urgent requirements of firetrucks in mind, often leading to delays in critical situations

There's a lack of routing solutions that can adapt to both the predictable and unpredictable changes in road and traffic conditions in real-time

Existing navigational aids struggle to balance the need for speed in emergency responses with the safety of the responders and the public

# Research Gap

**Research A**

- The OCW-Dijkstra algorithm enhances urban vehicle routing by incorporating oil consumption weights, reducing fuel usage and improving efficiency in path planning for optimal routes. [1]

**Research B**

- Dijkstra's and A-Star algorithms for finding the shortest path between gas stations, comparing their efficiency and performance in route selection. [2]

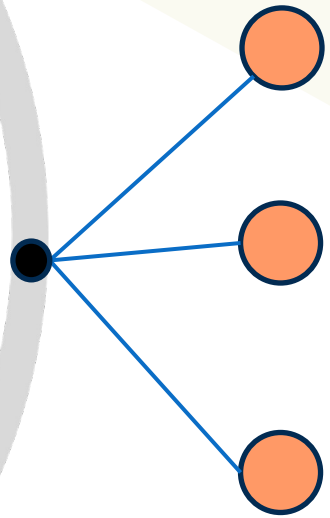
**Research C**

- Enhancements to Dijkstra's algorithm for road network route planning. By optimizing data storage and restricting search areas, improved algorithm efficiency and reduced computational requirements, demonstrating its effectiveness through experimental results. [3]

| Features | Research A | Research B | Research C | Proposed System |
|---|---|---|---|---|
| Dynamic Re-Routing | ✗ | ✗ | ✗ | ✓ |
| Algorithm Employed (Dijkstra) | ✓ | ✓ | ✓ | ✓ |
| Algorithm Employed (A*) | ✗ | ✓ | ✗ | ✓ |
| AI Technology Used (GNN) | ✗ | ✗ | ✗ | ✓ |
| Customization for Emergency Vehicles | ✗ | ✗ | ✗ | ✓ |

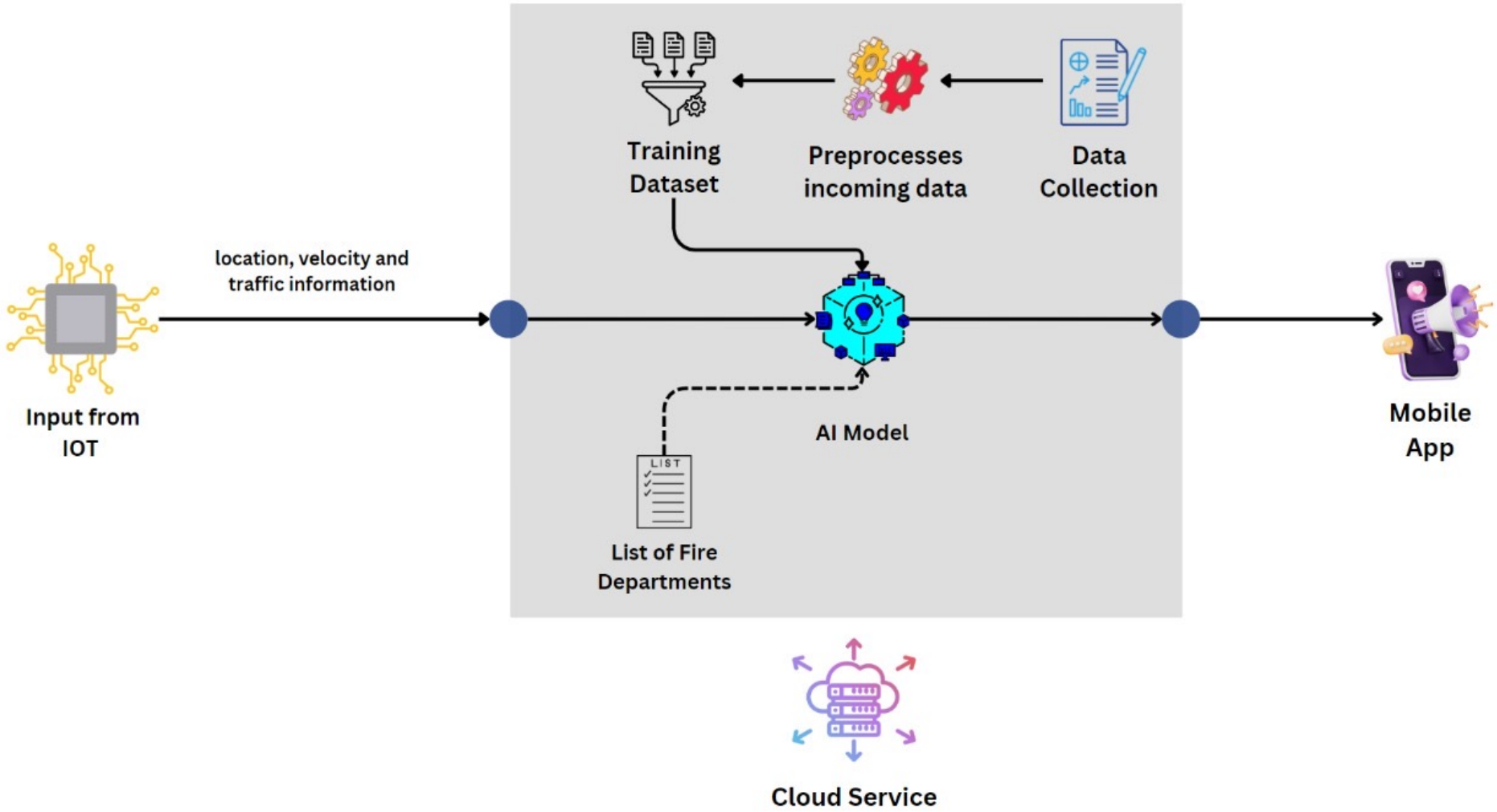
# Objectives

Modern routing systems are not built to meet the urgent needs of fire vehicles, resulting in delays in crucial situations.



- **Collect and preprocess traffic data and vehicle telemetry.**
- **Integrate A*, Dijkstra algorithms, and GNNs for dynamic routing.**
- **Simulate and validate the system under various traffic conditions.**

# Component Overview



# Tools and Technologies

## Software Technologies

- Python
- TensorFlow
- AWS / Azure
- Jupyter Lab
- SUMO



# Requirement Analysis

## Functional Requirements

- Collect real-time traffic and telemetry data from IoT-enabled vehicles.
- Combine data from various sources for comprehensive analysis
- Train GNN models using historical traffic data for route optimization
- Analyze current traffic data to provide optimal routing predictions.
- Ensure system compatibility with emergency dispatch protocols.

### Non-Functional Requirements

- **Achieve low-latency processing for real-time routing decisions.**
- **System must handle increasing data volumes and user requests.**
- **Provide an intuitive interface for emergency services personnel.**

# References

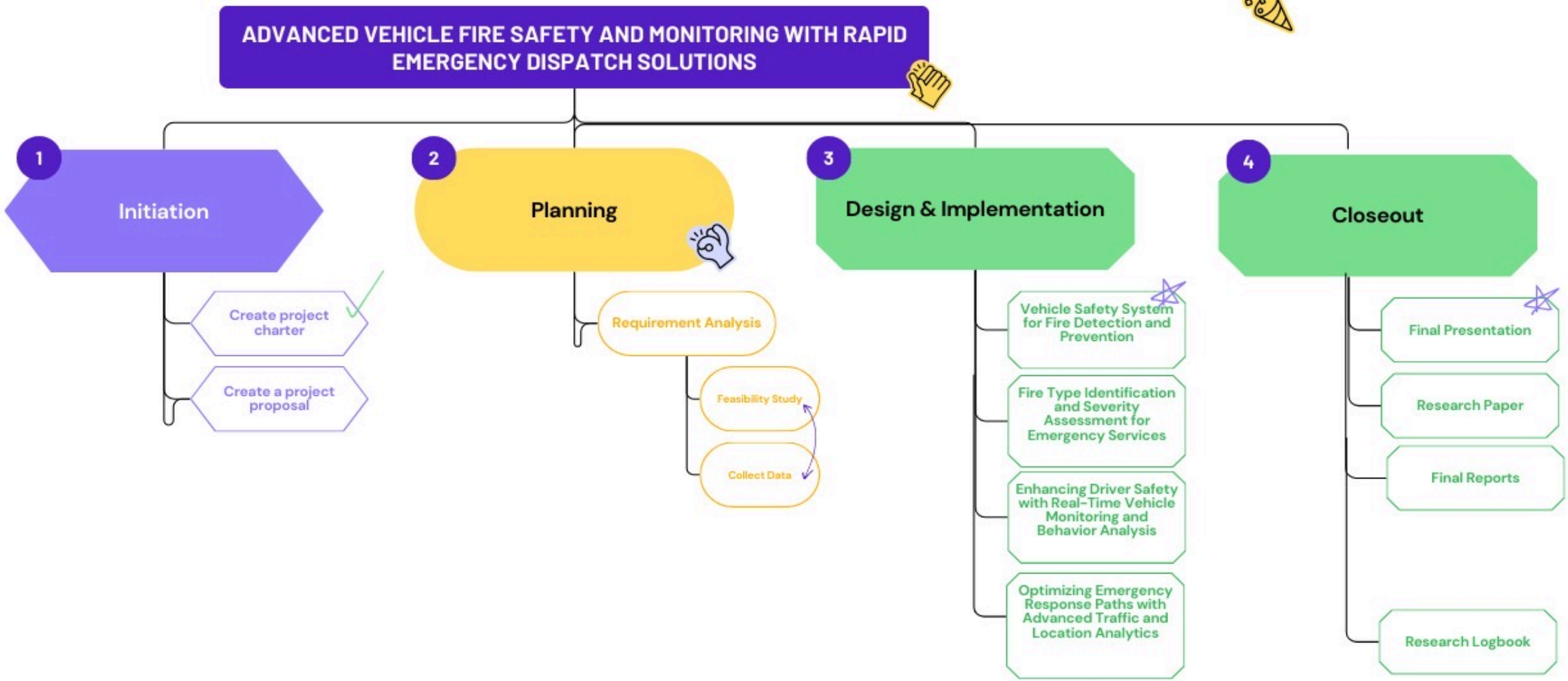
[1] J. Zhang *et al.*, “Vehicle routing in urban areas based on the Oil Consumption Weight -Dijkstra algorithm,” *IET Intelligent Transport Systems*, vol. 10, no. 7, pp. 495–502, Sep. 2016, doi: 10.1049/iet-its.2015.0168.

[2] A. Candra, M. A. Budiman, and K. Hartanto, “Dijkstra’s and A-Star in Finding the Shortest Path: a Tutorial,” *2020 International Conference on Data Science, Artificial Intelligence, and Business Analytics (DATABIA)*, Jul. 2020, **Published**, doi: 10.1109/databia50434.2020.9190342.

[3] D. Fan and P. Shi, “Improvement of Dijkstra’s algorithm and its application in route planning,” *2010 Seventh International Conference on Fuzzy Systems and Knowledge Discovery*, Aug. 2010, **Published**, doi: 10.1109/fskd.2010.5569452.

# Work Breakdown Structure

Organize tasks according to project phases so the team can accomplish goals



# Thank You !