Intelligent Fire Detection and Response System with Dynamic Nozzle Control and Evacuation Planning

Final Presentation &Viva 2024

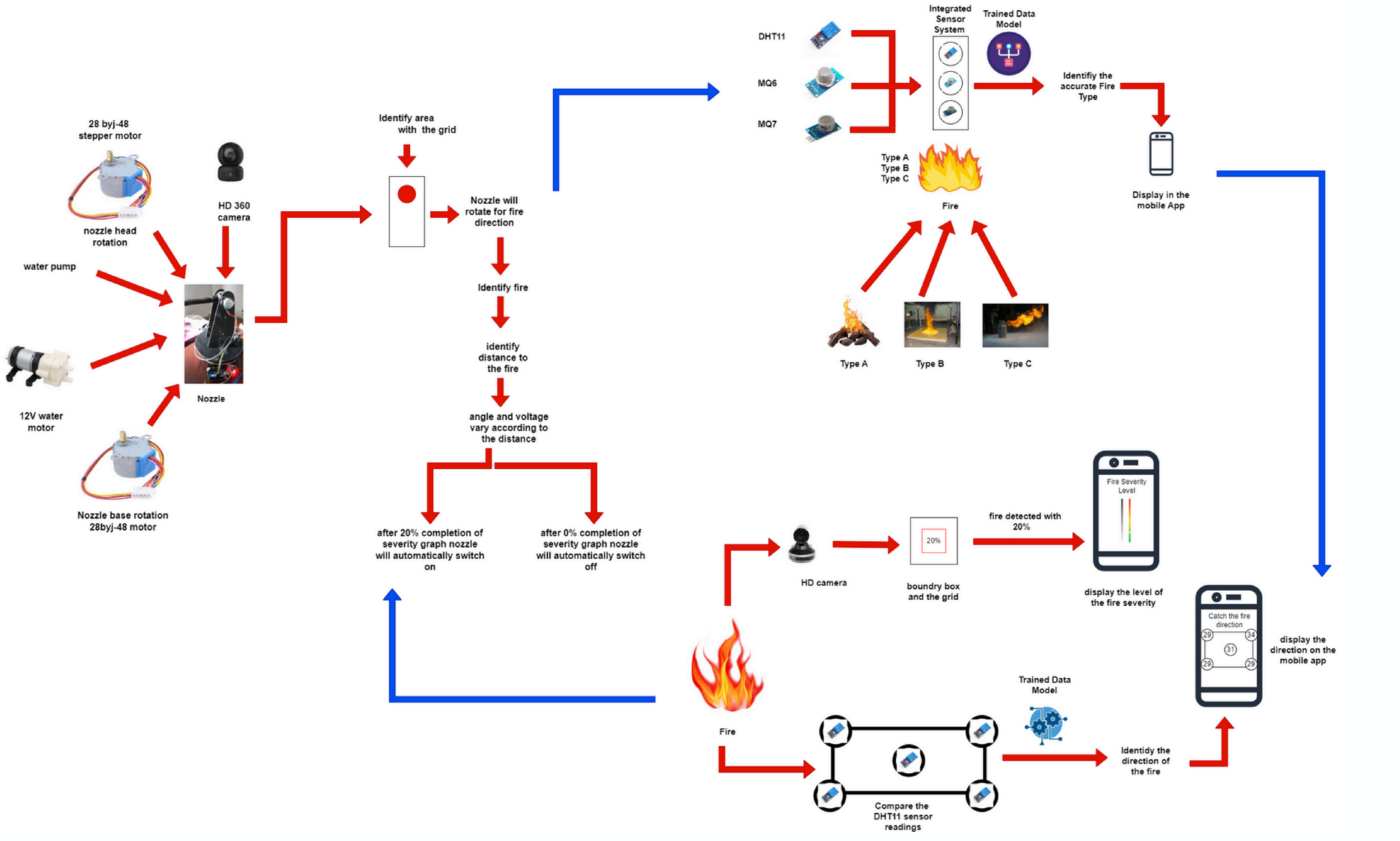
Presented By:

Sachintha Gayashan W.K
Manorathna A.Y.S
Tharushika W.A.V

INTRODUCTION

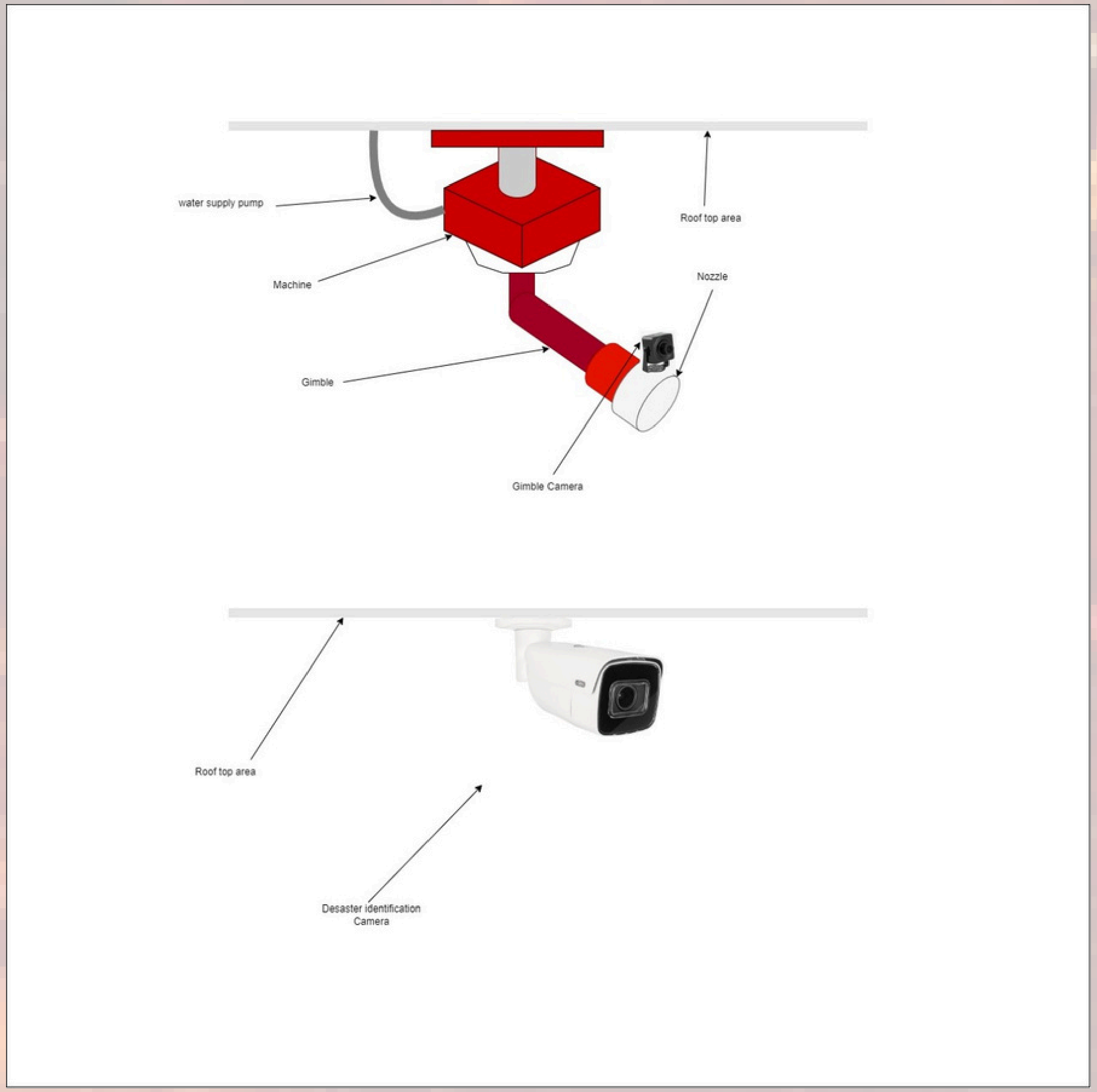
The Intelligent Fire Detection and Response System offers a robust fire emergency solution by combining multi-sensor systems and machine learning to accurately identify fire types and respond in real-time. It enhances safety through precise fire tracking, nozzle control, and integrated evacuation planning. Adaptable and scalable, the system is poised to further improve fire detection and response, minimizing risks and protecting lives and property.

SYSTEM OVERVIEW DIAGRAM

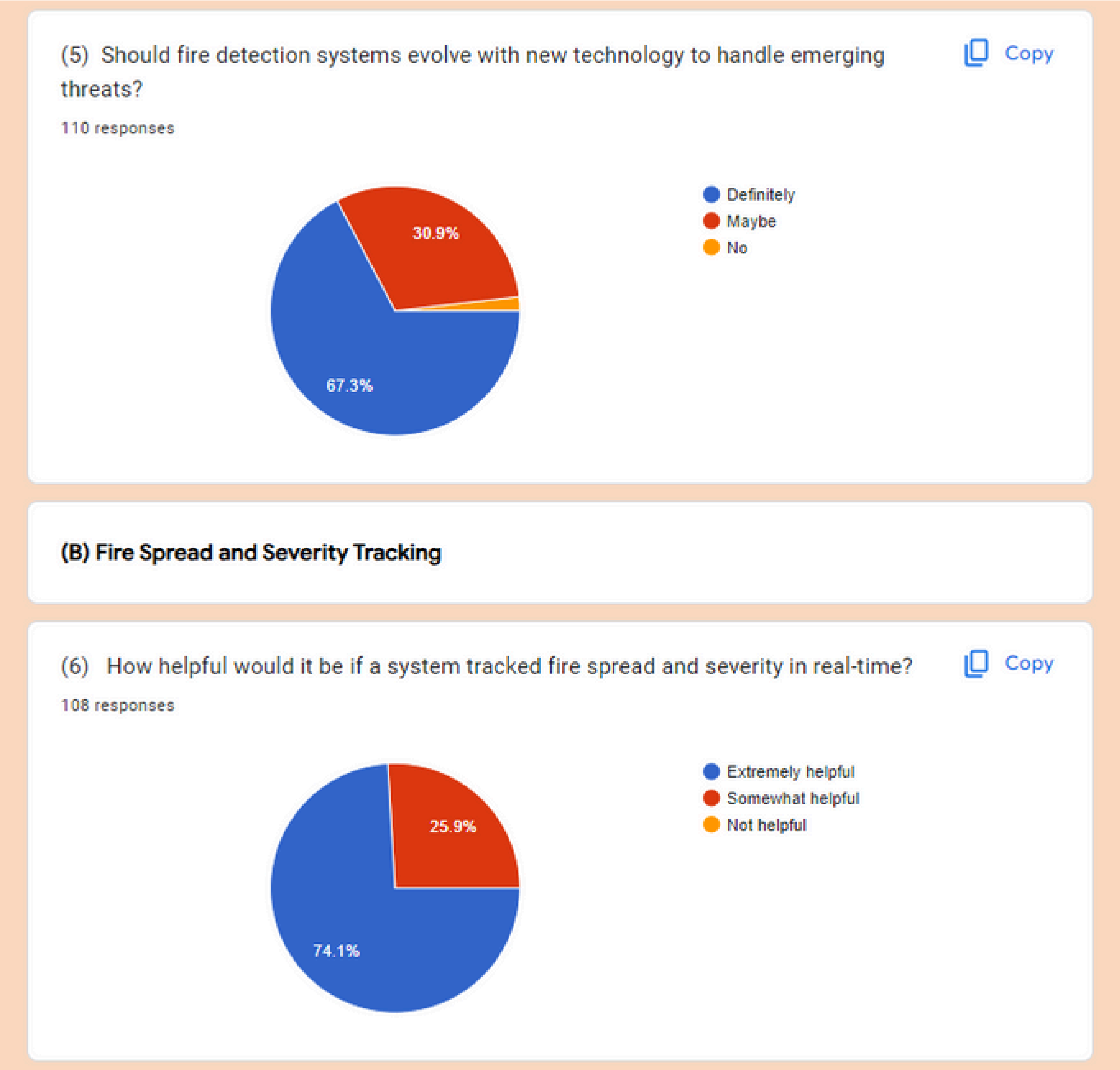


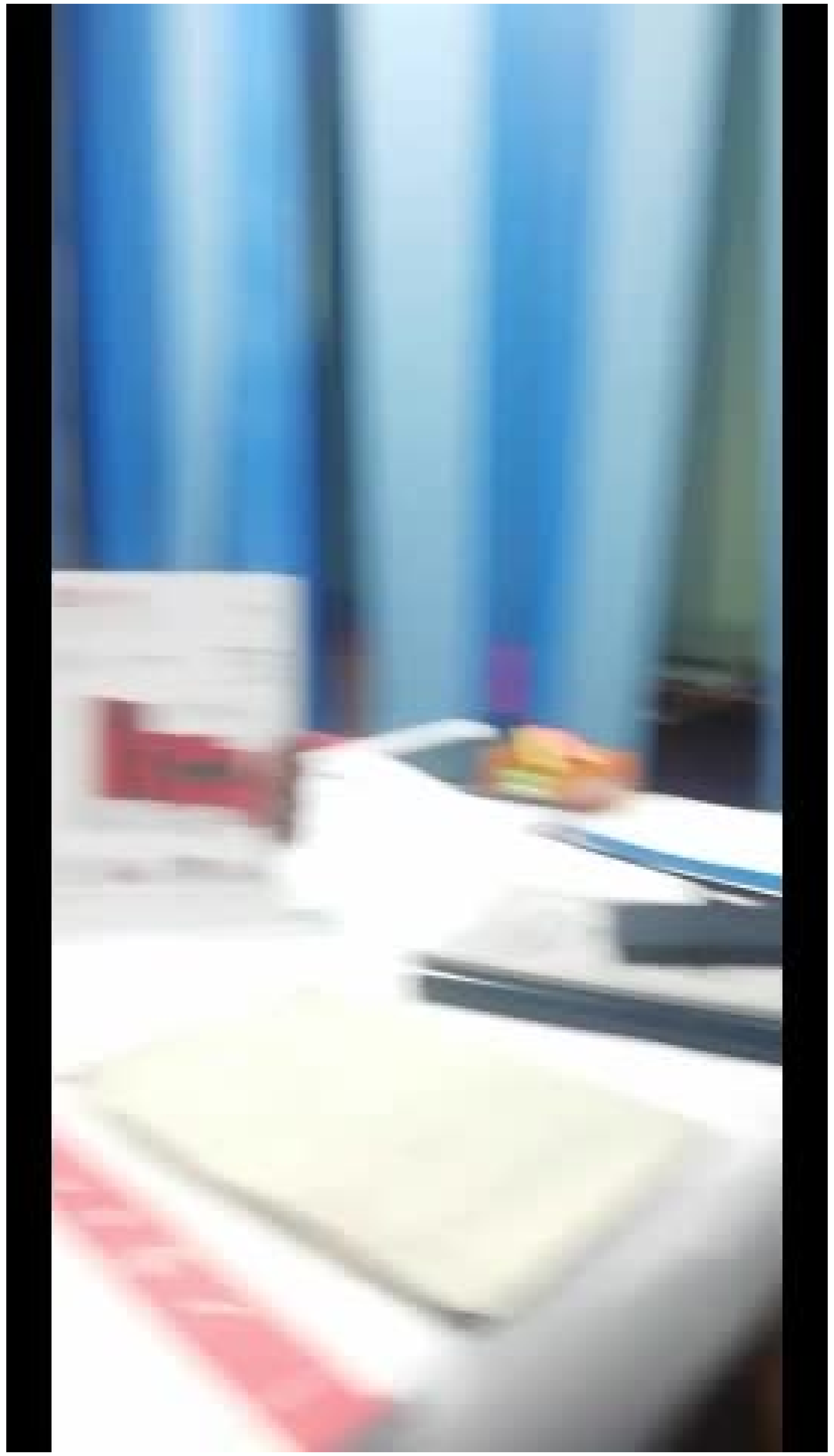
TECHNOLOGIES

- ML
- Python
- Arduino
- FireBase
- IOT



DATA GATHERING TECHNIQUES





RESEARCH QUESTIONS

How can temperature, smoke, and gas sensors be effectively integrated with machine learning to enhance real-time fire type identification?

How can real-time fire data improve evacuation safety and efficiency in complex building layouts?

What methods can improve the accuracy of predicting and tracking fire severity and spread in buildings?

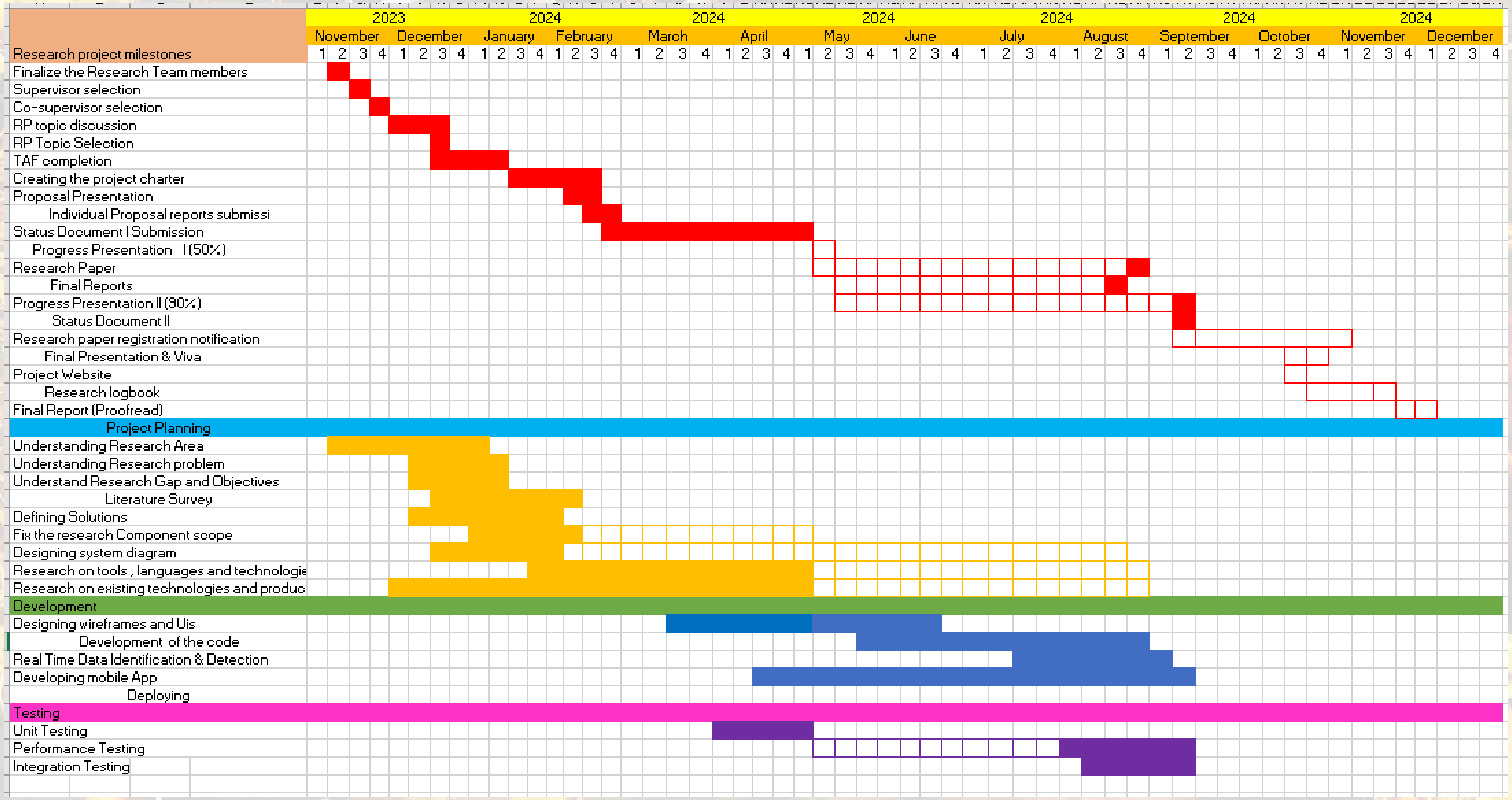
How can dynamic nozzle control systems be optimized for different fire types to ensure effective suppression and efficient water usage?

How can the system's algorithms be refined to reduce false alarms while maintaining high sensitivity to actual fire events?

OBJECTIVES

- Use multi-sensor data and machine learning to accurately detect and classify fire types (A, B, C).
- Develop real-time systems to monitor fire spread and severity, improving response accuracy.
- Design a system to adjust water pressure and flow in real-time for effective fire suppression.
- Create an advanced system that provides real-time safe exit routes based on fire conditions.
- Enhance algorithms to minimize false alarms and increase the system's reliability.

TIMELINE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Integration Testing

Sachintha Gayashan W.K

IT20154462

Specialization : Information Technology

Dynamic Nozzle Control System

Background

- Traditional systems require manual intervention, lacking automation and precision in nozzle control and water pressure release.
- Using 360° cameras and a nozzle mounted with a camera, our system automates nozzle movement and pressure control to target fires effectively.
- The system only activates when the fire severity reaches 20%, preventing unnecessary activation for minor incidents like cigarette or match fires.
- The current system is designed to handle Type A fires (wood, paper, cardboard) using water, with future improvements aimed at other fire types.
- Plans include expanding the system to detect Type B (flammable liquids) and Type C (flammable gases) fires and using appropriate extinguishing agents like foam or powder.

Research Question

How can we automate the nozzle's movement and water release pressure to target fire locations accurately?

Can we implement a system that only activates based on the severity level of the fire (e.g., 20%)?

How can the system calculate the required water pressure and nozzle angle based on distance and fire location?

Can this system be adapted in the future to support fire types beyond Type A, such as Type B and C?

How can we optimize the extinguishing agent (water, foam, powder) based on the fire type?

Research Gap

Traditional systems lack automation in targeting fire locations and adjusting water pressure dynamically.

Current systems are limited in their ability to distinguish between minor and major fires, leading to inefficient resource usage.

Most systems are designed for one type of fire, limiting their effectiveness in diverse fire scenarios.

In many existing systems, water pressure and nozzle angle adjustments are manually controlled, leading to inefficiencies.

There is a gap in systems that can dynamically switch between different extinguishing agents (water, foam, powder) based on fire type.

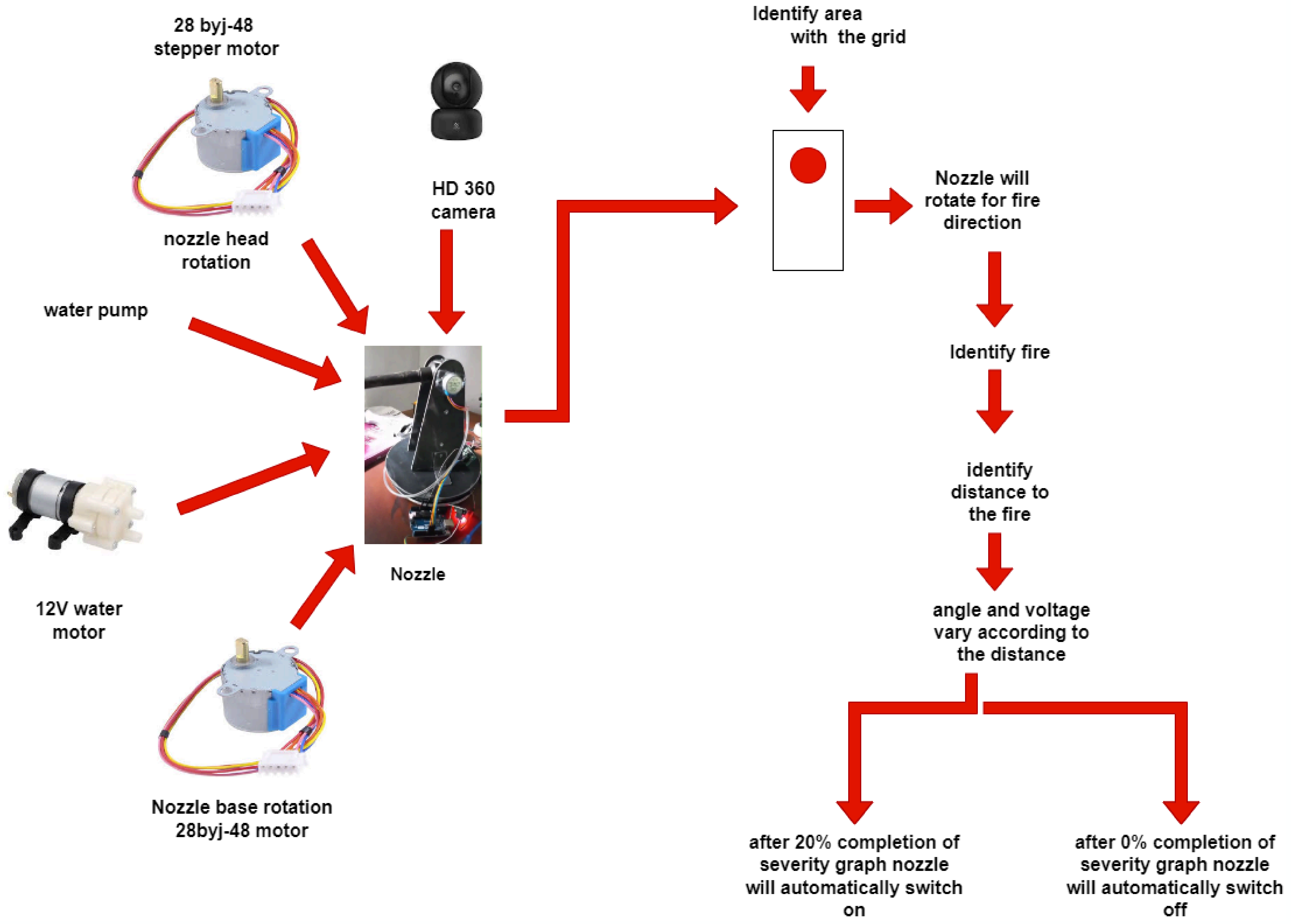
Objectives

- Main Objective: To automate nozzle control and water pressure release based on fire severity and location data from the 360° camera.
- Implement a model that calculates the nozzle angle and required water pressure using distance and fire position data.
- Automatically trigger the nozzle when the fire severity level reaches 20% on the mobile app's graph.
- Stop water release when the fire severity decreases to 0%, ensuring resource conservation.
- Design the system for Type A fires, with plans to expand functionality for Type B and C fires in future upgrades.

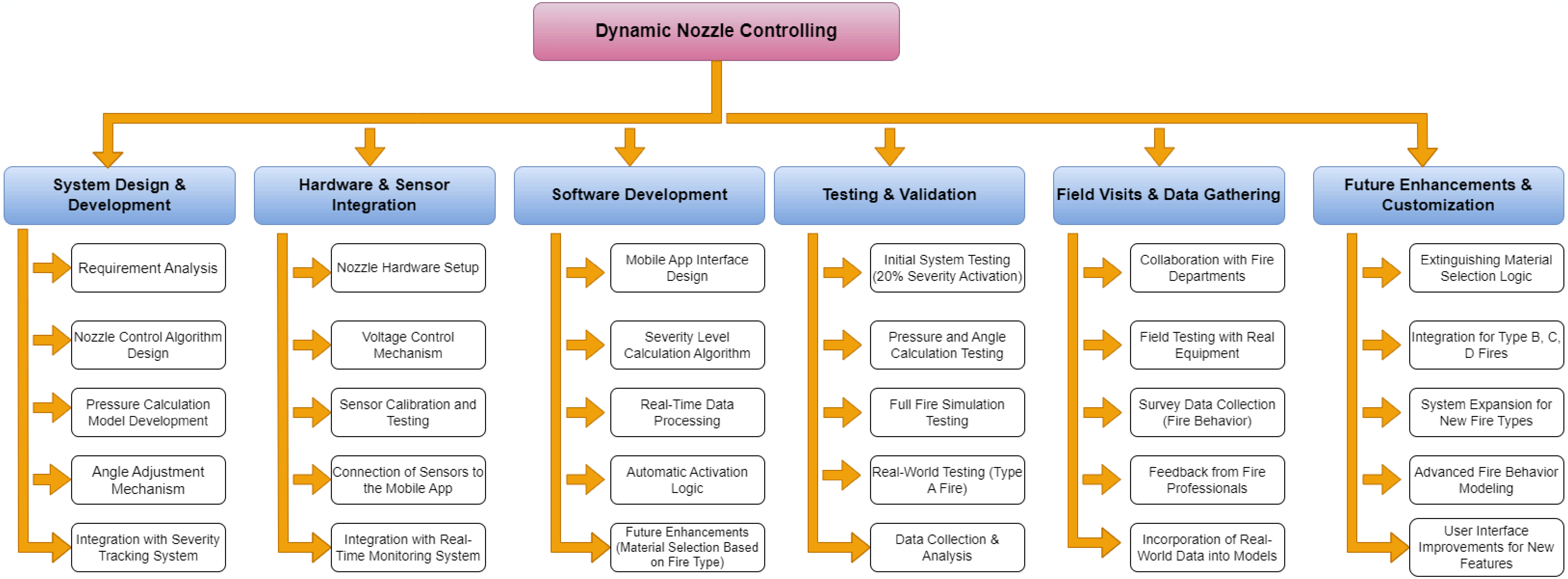
Sub Objectives

- Develop a dataset for nozzle angle and water pressure calculation based on fire distance and severity.
- Implement automatic nozzle activation based on fire severity thresholds (20% and above).
- Fine-tune the system to stop water release immediately once fire severity reaches 0%.
- Enhance the system's ability to handle multiple fire types by incorporating additional extinguishing agents in future upgrades.
- Design future iterations to detect fire types B, C, and D, ensuring appropriate suppression methods for each.

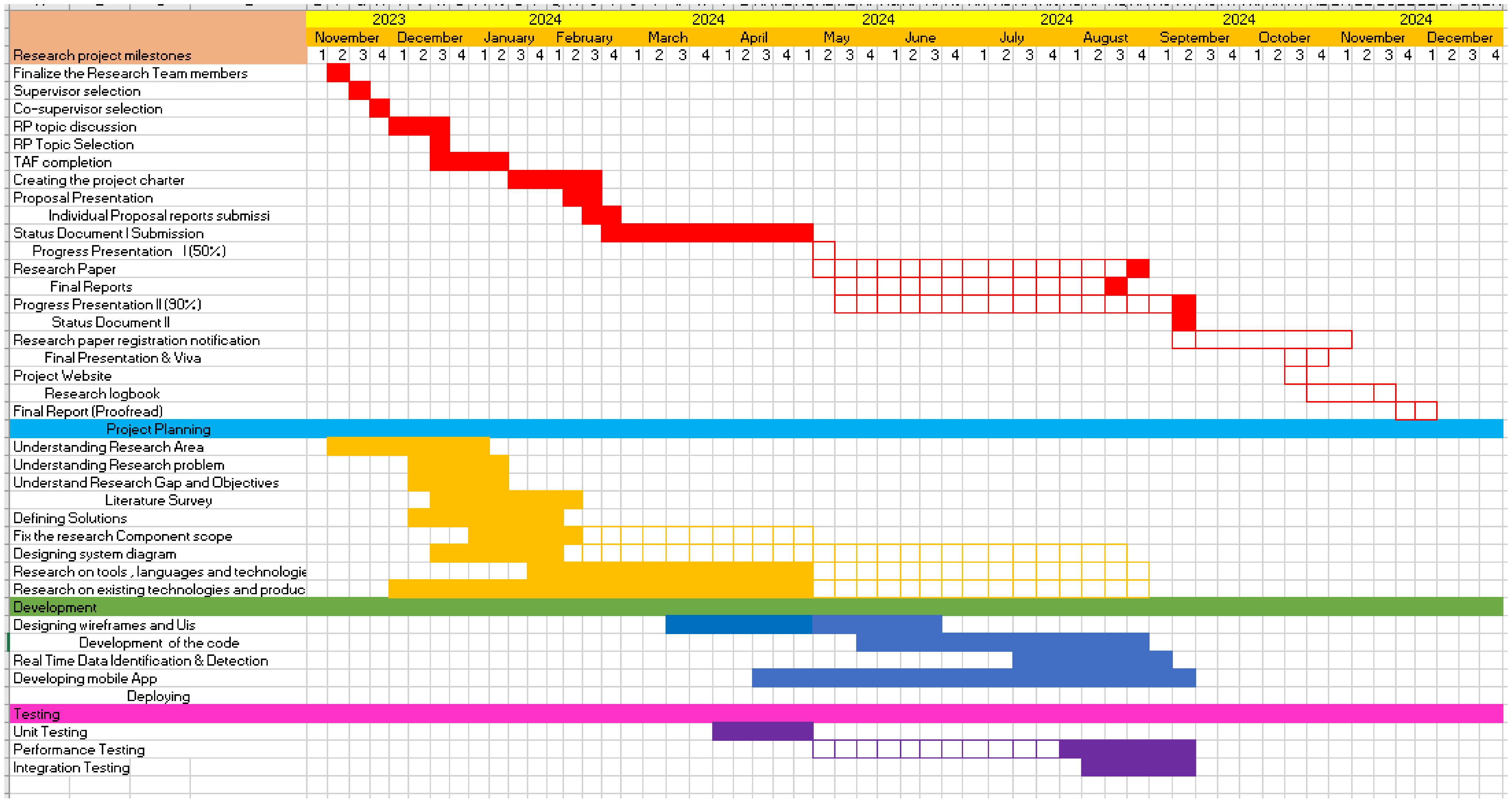
System Diagram



Work Breakdown Structure



Gantt chart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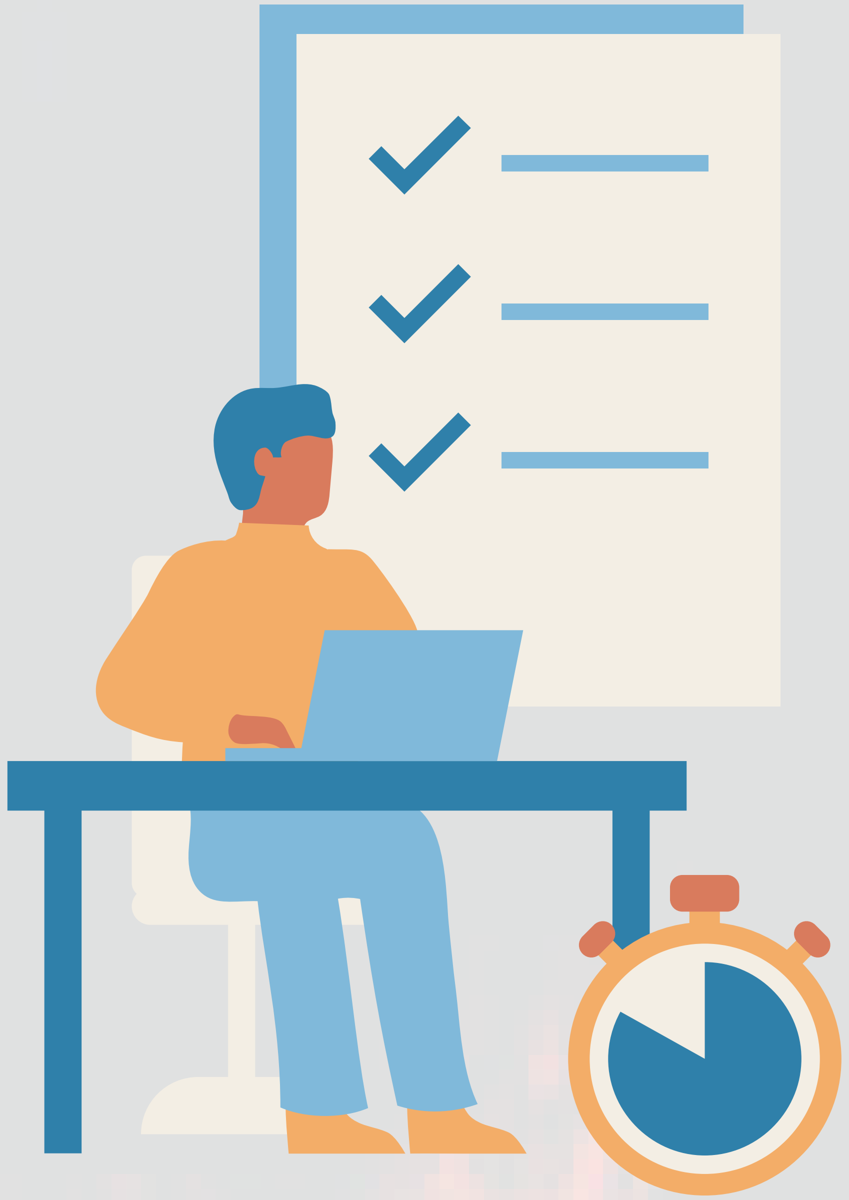
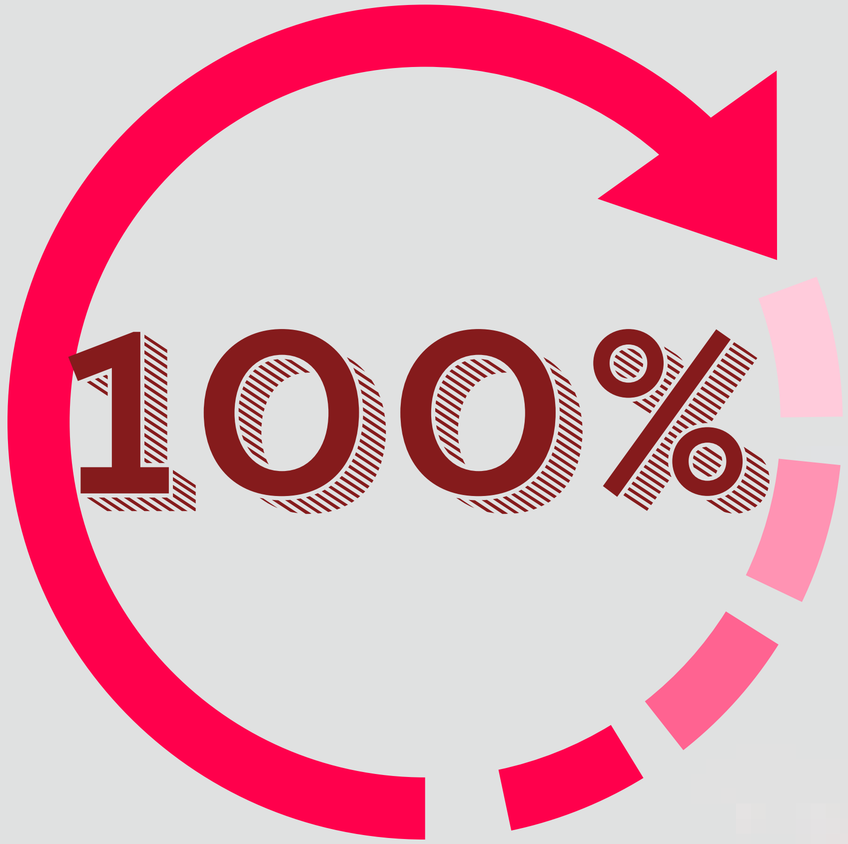
Project Completion





Results

- Successfully developed an automated nozzle control system using 360° camera data to target fires with precision.
- The system calculates the nozzle angle and water pressure needed based on distance and severity of the fire.
- Automatic activation is achieved when fire severity reaches 20%, optimizing water usage for significant fires.
- Water release automatically stops when the fire severity level drops to 0%, conserving resources.
- The current model supports only Type A fires, with future upgrades planned for other fire types and extinguishing agents.

Challenges

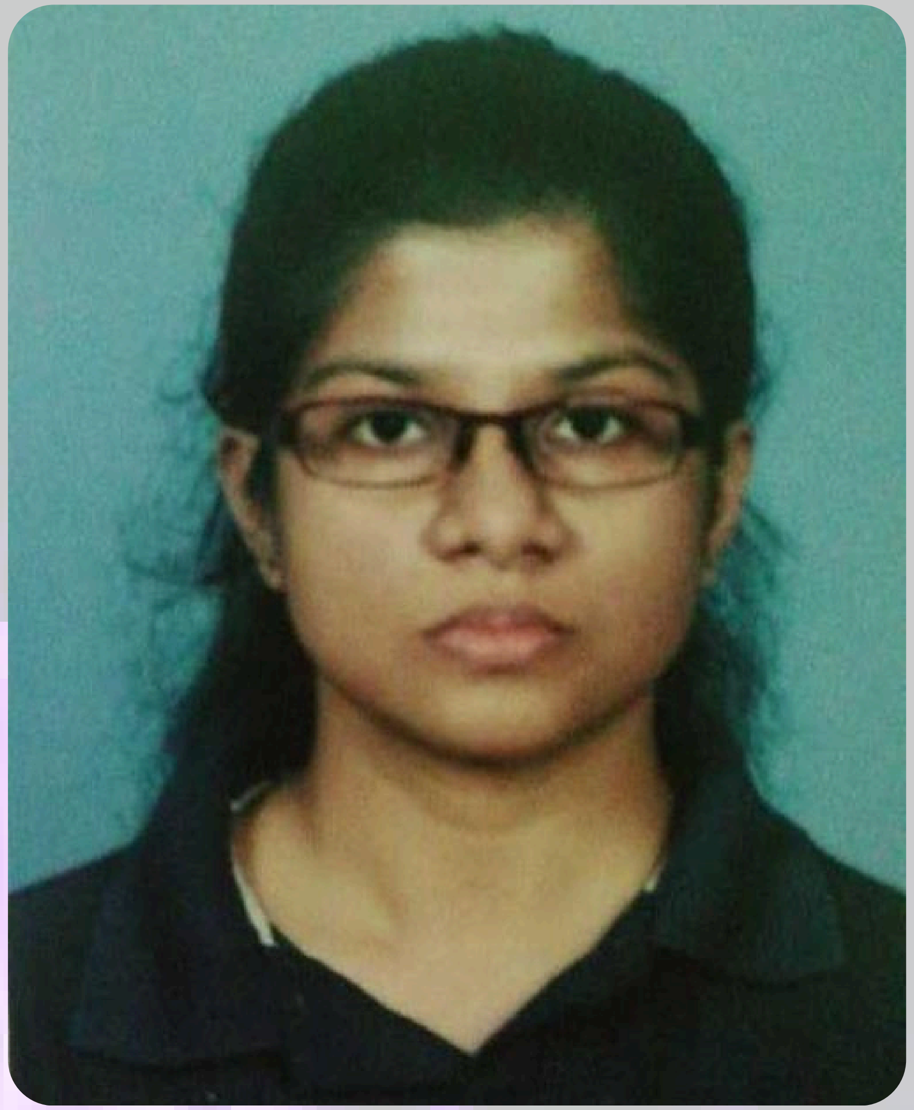
- **Synchronizing Camera and Sensor Data:** Integrating 360° camera data with nozzle control to ensure accurate targeting was complex.
- **Pressure Calculation Accuracy:** Fine-tuning the algorithm to calculate water pressure accurately based on fire distance and severity required multiple iterations.
- **Avoiding False Activation:** Ensuring the nozzle only activates at a 20% fire severity threshold was challenging, particularly for minor fires.
- **Limited to Type A Fires:** The current system is restricted to Type A fires, and future developments will need to account for other fire types.
- **Future Integration of Extinguishing Agents:** Expanding the system to handle foam, powder, and other agents for Type B and C fires requires additional research and testing.

Manorathna A.Y.S

IT21086670

Specialization : Information Technology

Fire Direction and Severity Prediction



Background

- Fire tracking is essential to monitor its spread and intensity in real-time.
- Traditional fire detection systems do not provide detailed information on fire growth or direction.
- Using an HD camera, this system tracks fire spread and size, showing severity levels as a percentage.
- DHT11 temperature sensors help predict the direction of fire spread based on temperature variations.
- Combining visual data and sensor readings improves real-time monitoring and safety measures.

Research Questions

How can we accurately track the spread of fire using HD cameras and temperature sensors?

What methods can be used to predict the fire's direction based on temperature sensor data?

Can the fire severity be effectively measured and displayed in real-time?

How can fire tracking be integrated into a mobile app for user-friendly visualization?

Can this system help reduce the damage by predicting the fire's direction ?

Research Gap

- Existing systems fail to track fire spread and severity dynamically.
- No widespread models currently integrate both camera and sensor data for real-time fire severity and direction prediction.
- Current technologies do not provide actionable data on fire spread direction inside buildings.
- Limited research focuses on integrating multiple data sources (camera and sensors) for precise fire monitoring.
- There is a gap in presenting fire severity and direction in a user-friendly format in mobile apps.

Objectives

- Main Objective: To track the fire’s severity and predict its direction using camera and sensor data.
- Utilize HD camera input to monitor fire spread and provide real-time severity levels.
- Implement a model to display fire severity levels as a percentage on a mobile app.
- Use DHT11 sensors to predict fire spread direction based on temperature readings.
- Display the fire’s direction in a room plan sketch on the mobile app.

Sub Objectives

- Develop an algorithm to detect fire in an HD camera feed and track its growth.
- Implement a progress graph that shows fire severity as a percentage in real-time.
- Predict fire spread direction using DHT11 temperature sensor data.
- Display fire movement on a sketch plan of the room using sensor data in the mobile app.
- Update fire severity and direction every 5 seconds to ensure real-time monitoring.

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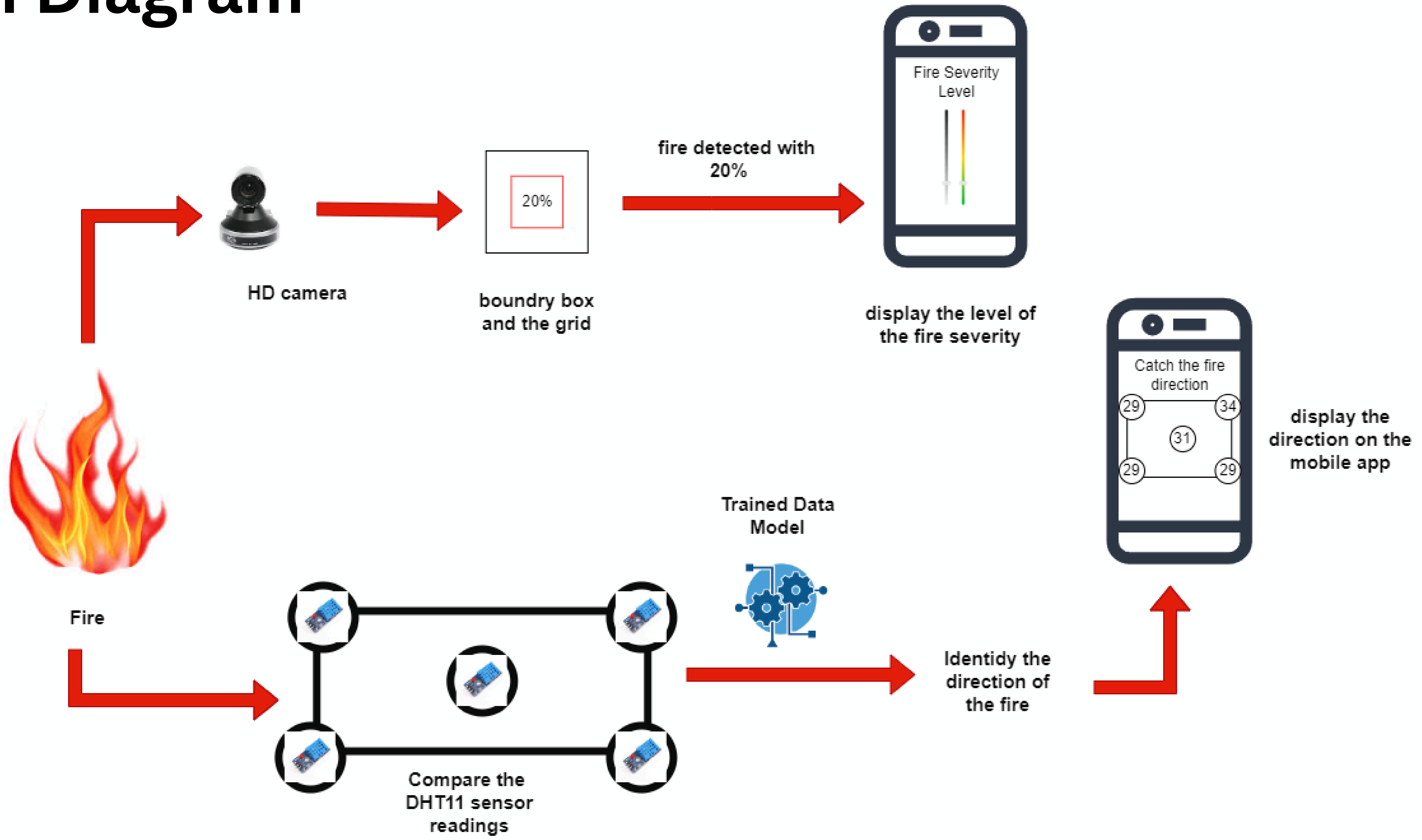

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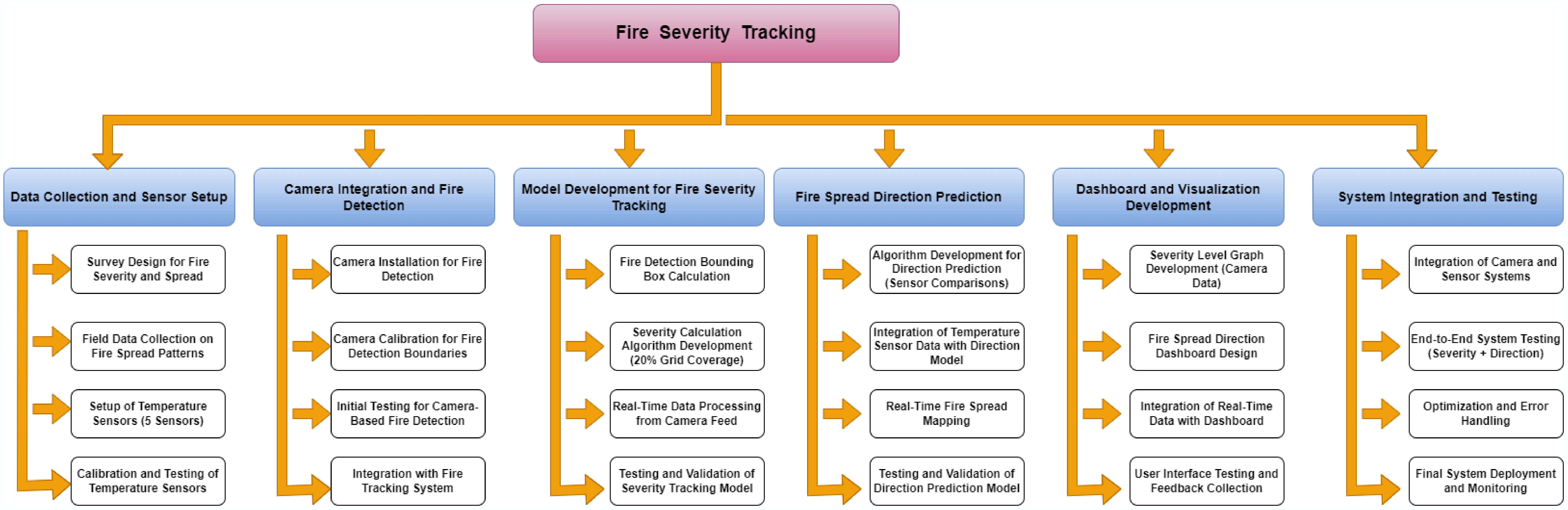
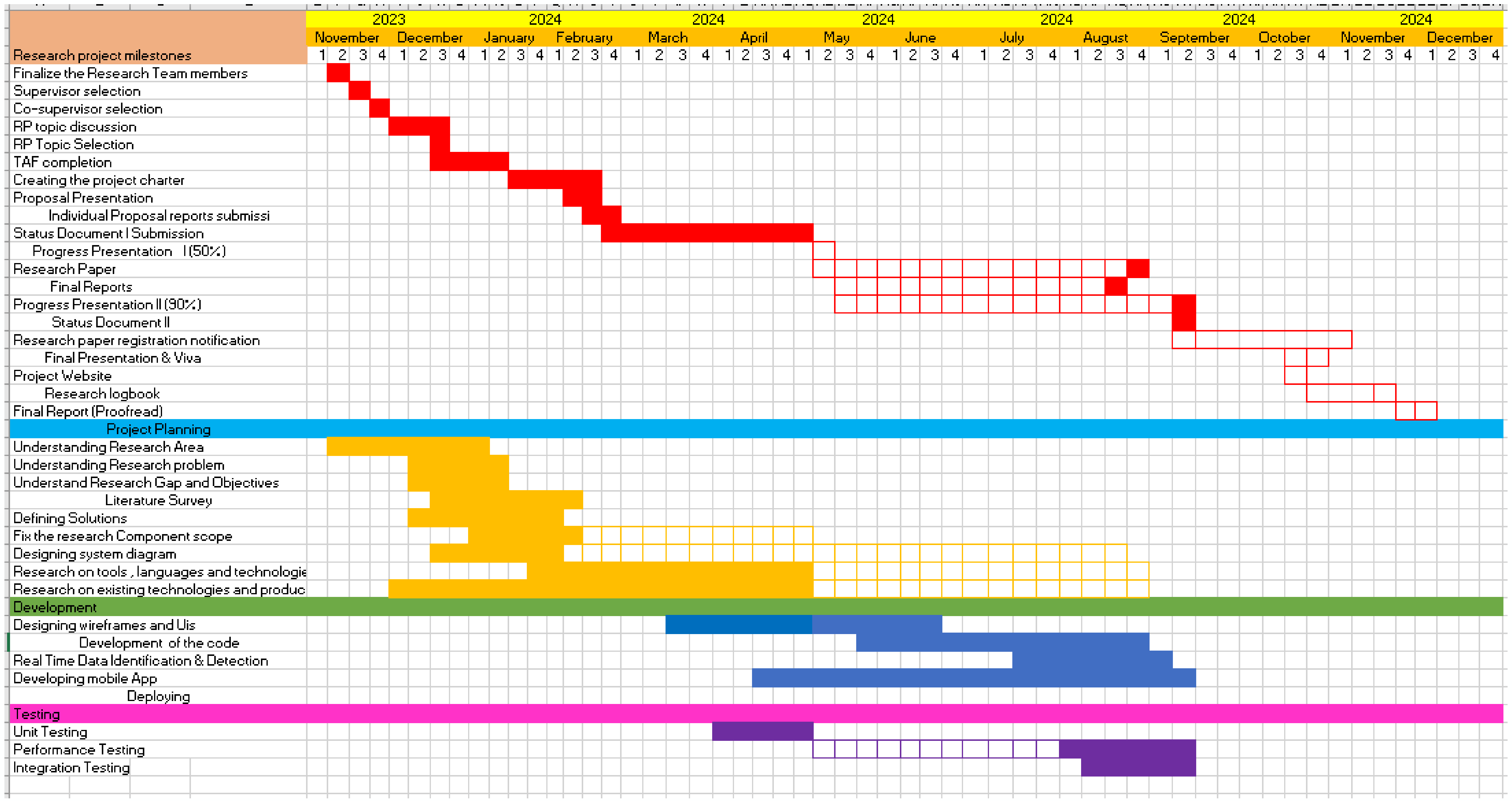


Gantt Chart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Project Completion

Result

- Successfully developed a model to track fire severity using camera feed and sensor data. Achieved real-time fire tracking with severity displayed as a percentage.
- Predicted fire spread direction based on DHT11 sensor data, displaying accurate direction in the app.
- Integrated both severity and direction visualization into a mobile app with room sketch plans.
- Fire severity and direction are updated every 5 seconds, providing continuous monitoring.

Challenges

- Synchronizing data between the camera feed and DHT11 sensors for real-time updates.
- Ensuring accuracy in fire severity percentage calculation and prediction.
- Handling variable temperature readings from DHT11 sensors in different room conditions.
- Ensuring the mobile app can handle real-time fire severity and direction updates without delays.
- Dealing with sensor malfunction or interference, which may affect fire direction predictions.

THARUSHIKA W.A.V

IT21100116

Specialization : Information Technology

Fire Types Identification

Background

- Fires can be categorized into Types A, B, and C based on the material involved.
- Identifying the fire type is crucial to applying the correct suppression technique.
- Traditional fire detection systems lack the capability to differentiate between fire types.
- Sensors like DHT11, MQ7, and MQ6 can provide real-time data on temperature, smoke, and gas levels.
- Accurate fire type identification enables timely and appropriate responses, minimizing damage.
- Machine learning models can leverage sensor data to classify fire types effectively.

Research Question

1

How can we accurately identify fire types (A, B, C) using DHT11, MQ7, and MQ6 sensors?

2

Can multi-sensor data improve the accuracy of fire detection systems?

3

What machine learning techniques are most suitable for classifying fire types based on sensor data?

4

Can sensor-based fire detection systems operate in real-time to provide instant identification?

5

How can identified fire types trigger the appropriate fire suppression mechanisms?

Research Gap

Existing systems use single sensors, limiting fire type identification accuracy.

Few systems integrate temperature, smoke, and gas sensor data to distinguish fire types.

Current models focus on detection but lack advanced classification for real-time application.

Limited research exists on using DHT11, MQ7, and MQ6 together for comprehensive fire type identification.

No widely adopted system offers high-accuracy, sensor-based fire classification and response.

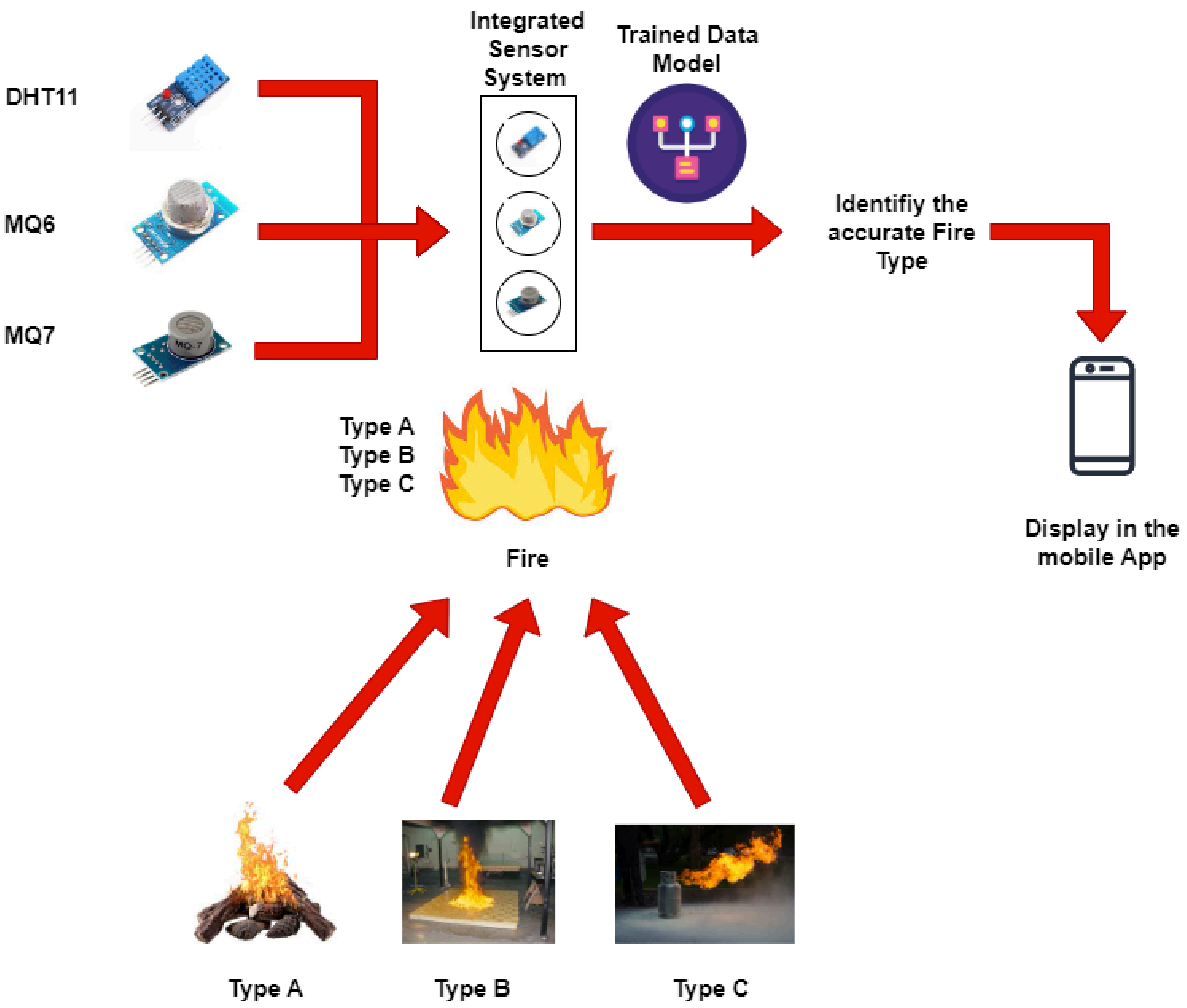
Objectives

- Main Objective: To accurately identify fire types (A, B, C) using DHT11, MQ7, and MQ6 sensors.
- Collect and preprocess sensor data (temperature, smoke, and gas) for model training.
- Develop a machine learning model to classify fire types based on sensor inputs.
- Validate the model’s accuracy using real-time data from sensors.
- Enable real-time fire type identification to optimize fire suppression methods.

Sub objectives

- Gather and clean data from DHT11 (temperature), MQ7 (smoke), and MQ6 (gas) sensors.
- Apply machine learning techniques (e.g., decision trees, support vector machines) for fire classification.
- Train the model using labeled datasets for Type A, B, and C fires.
- Test the model's accuracy in identifying fire types across various conditions.
- Integrate the fire type identification function into a real-time monitoring system.

System Diagram



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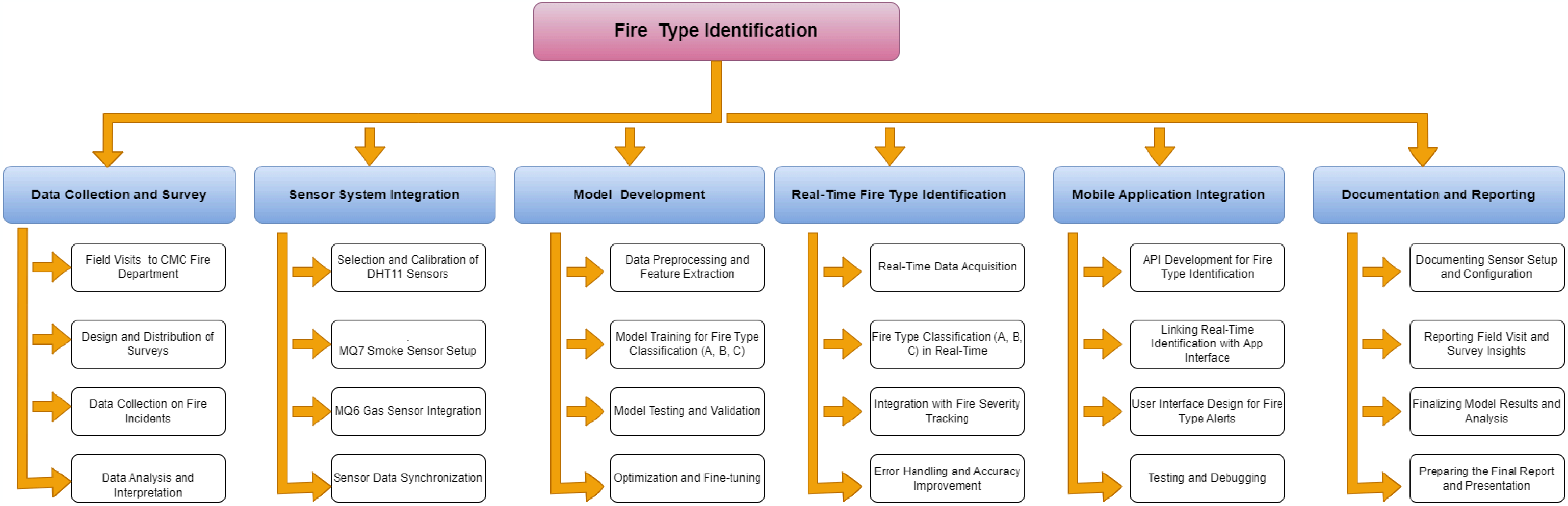

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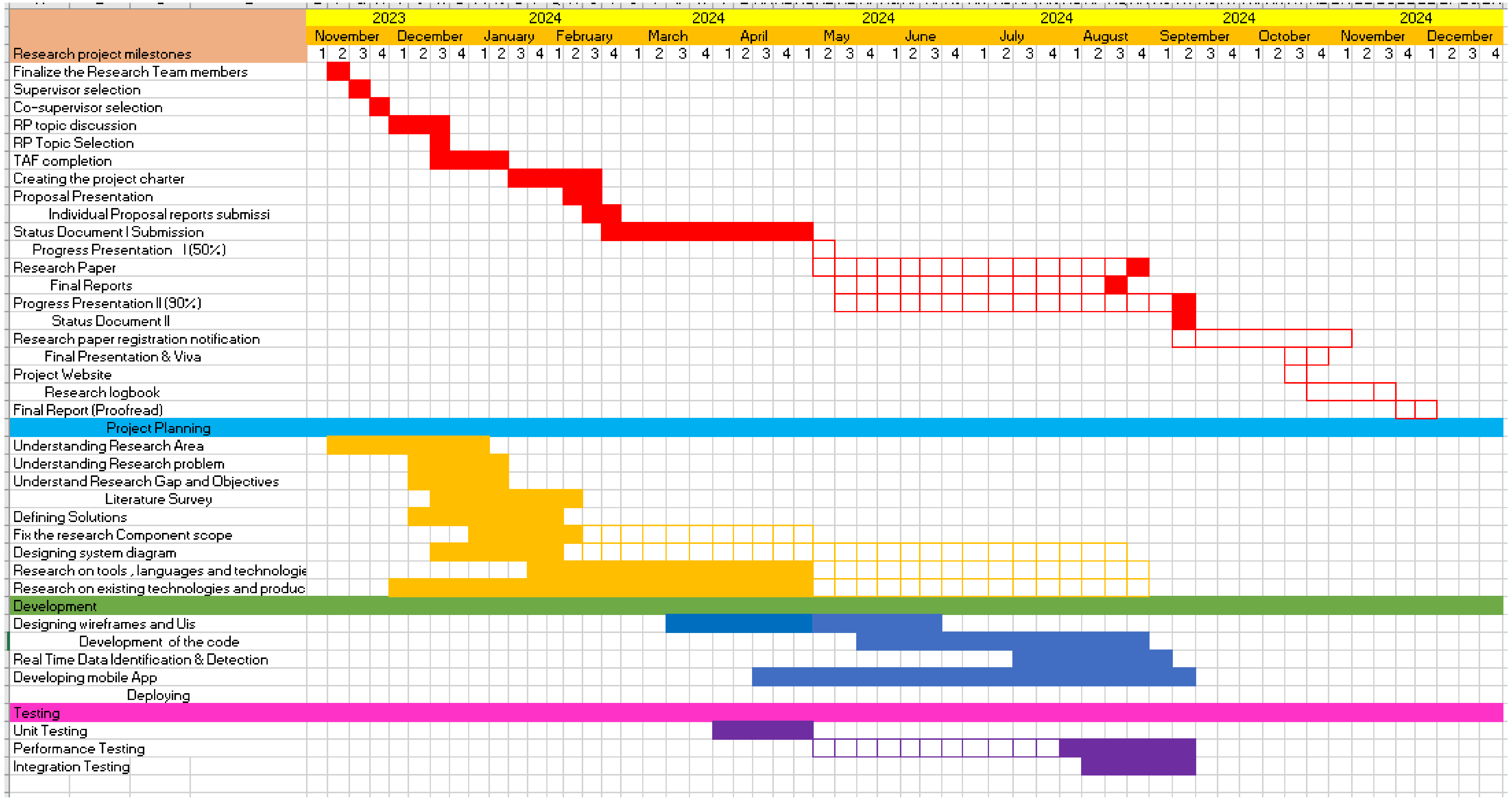

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Project Completion

Results

- Successfully developed a model to classify fire types (A, B, C) with high accuracy.
- Achieved >90% accuracy in distinguishing between different fire types.
- Real-time identification of fire types using data from DHT11, MQ7, and MQ6 sensors.
- Validated model performance under various fire conditions with minimal false positives.
- Fire type identification integrated into the system for optimized fire response.

Challenges

- Difficulty in accurately distinguishing between Type B (liquids) and Type C (gases).
- Ensuring sensor accuracy and data reliability in real-time fire scenarios.
- Managing data preprocessing and feature extraction from multiple sensor inputs.
- Reducing latency in fire type identification to ensure timely suppression.
- Training the model to handle edge cases and unexpected fire conditions.

Conclusion

The Intelligent Fire Response System offers a comprehensive solution by integrating multi-sensor detection, real-time tracking, and dynamic nozzle control. It accurately identifies fire types and provides tailored responses, enhancing safety. With future scalability, it promises to address complex fire scenarios, minimizing damage and protecting lives effectively.

Thank you !!!