ENHANCING FIRE DISASTER SEARCH WITH MULTI-ROBOTIC SYSTEM: OPTIMIZING RESCUE OPERATIONS EFFECTIVELY: A CASE STUDY

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DECLARATION

I declare that this is my own work and this proposal does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Signature of the Supervisor
(Mrs. Lokesha Weerasinghe)

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2/27/2024

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ABSTRACT

This case study explores the integration of multi-robotic systems and advanced sensor technologies to optimize fire disaster search and rescue operations. Traditional methods encounter limitations such as restricted mobility, dangers to responders, and time constraints, necessitating innovative solutions. The literature review underscores the demand for efficient disaster response methods, driving the exploration of robotics and sensor systems. However, a gap exists in comprehensive, real-time disaster detection systems integrating multiple sensors. The research problem centers on enhancing disaster response amidst challenges like restricted mobility and hazardous conditions. The main objectives focus on assessing multi-robotic system effectiveness and revolutionizing traditional approaches. Specific objectives include developing an ensemble-based disaster detection system and optimizing system mobility. The WeRobots simulation software facilitates scenario setup, sensor data fusion, disaster identification, and iterative optimization. Personnel requirements encompass diverse expertise, and an Agile Scrum approach guides software development. Feasibility studies evaluate technical, economic, operational, resource, risk, legal, and ethical aspects. The design phase involves disaster identification flow diagrams, dataset creation, and work breakdown structures. Implementation encompasses coding, testing, and integration, while testing ensures software functionality and performance. A Gantt chart outlines project timelines, and descriptions of personnel and facilities, and budget justifications are provided. This research advances fire disaster response through innovative technology integration, simulation-driven methodologies, and interdisciplinary collaboration.

Keywords - Multi-robotic systems,Advanced sensor technologies, Fire disaster, Search and rescue operations ,Traditional methods ,Limitations, Literature review, Disaster response methods, Robotics, Sensor systems, Real-time disaster detection, Research problem, Objectives, Ensemble-based disaster detection system, System mobility, WeRobots simulation software, Scenario setup, Sensor data fusion , Disaster identification, Iterative optimization,Personnel requirements, Agile Scrum approach, Feasibility studies, Design phase, Implementation, Testing, Gantt chart, Project timelines, Interdisciplinary collaboration

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LIST OF ABBREVIATIONS

IOT	Internet of things
DB	database
ROI	Return on Investment
AI	Artificial Intelligence

1. INTRODUCTION

1.1 Background Literature

In the realm of disaster response, particularly concerning fire disasters, the traditional search and rescue methods often face significant limitations. These include restricted mobility of human responders, potential dangers of injury or fatality, and the pressing time constraints imposed by urgent situations. To address these challenges effectively, innovative solutions are imperative to augment the capabilities of human responders.

The literature surrounding disaster response and search and rescue operations highlights the increasing demand for more efficient and reliable methods, especially in the context of fire disasters. Previous studies have explored various technological advancements, including the utilization of robotics and sensor systems, to improve the effectiveness and safety of rescue missions. However, while these studies have shown promise, there remains a notable gap in the development of comprehensive, real-time disaster detection systems that integrate multiple sensor modalities within a multi-robotic framework.

The quest to enhance fire disaster search and rescue operations through the integration of multi-robotic systems with advanced sensor technologies stems from a rich body of literature spanning various disciplines including robotics, disaster management, sensor networks, and artificial intelligence. This section explores key themes and insights derived from existing research, highlighting the evolution of search and rescue methodologies, technological advancements, and challenges encountered in mitigating the impact of fire disasters.

Traditional search and rescue methods have long relied on human responders to locate and extract individuals trapped in disaster zones. However, these methods are often hindered by inherent limitations such as restricted mobility, limited visibility, and exposure to hazardous conditions. As documented by Smith et al. (2018), the effectiveness of traditional approaches is further compromised in complex environments characterized by structural damage, smoke, and unpredictable fire dynamics.

The emergence of multi-robotic systems has revolutionized search and rescue operations by augmenting human capabilities with robotic agents equipped with advanced sensing and navigation capabilities. According to Johnson et al. (2019), multi-robotic systems enable distributed exploration, collaborative mapping, and coordinated response efforts, thereby improving the speed and efficiency of disaster recovery missions. Moreover, research by Liang et al. (2020) demonstrates the potential of multi-robotic systems to access hazardous areas inaccessible to humans, enhancing situational awareness and decision-making in high-risk environments.

The integration of advanced sensor technologies plays a pivotal role in enhancing the perception and situational awareness of robotic systems deployed in fire disaster scenarios. Li et al. (2021) emphasize the importance of sensor fusion techniques in combining data from visual, infrared, and gas sensors to accurately detect fire sources, identify survivors, and assess environmental hazards. Furthermore, the utilization of machine learning algorithms for anomaly detection and pattern recognition enables proactive decision-making and adaptive response strategies, as highlighted by Chen et al. (2019).

Despite significant advancements, several challenges persist in the development and deployment of multi-robotic systems for fire disaster search and rescue. These challenges include the need for robust communication networks, energy-efficient algorithms, and human-robot interaction interfaces capable of intuitive collaboration in dynamic environments. Additionally, ethical considerations regarding privacy, consent, and accountability underscore the importance of responsible technology deployment in sensitive disaster scenarios, as articulated by Zhang et al. (2022).

The literature underscores the transformative potential of integrating multi-robotic systems with advanced sensor technologies to enhance fire disaster search and rescue operations. By leveraging insights from interdisciplinary research, practitioners can develop innovative solutions, mitigate operational challenges, and ultimately, save lives in the face of escalating disaster risks and complexities.

1.2 Research Gap

Despite advancements in technology, there exists a gap in the field regarding the implementation of integrated systems that effectively address the complexities of fire disaster response. While individual sensor modalities such as visual, infrared, and gas sensors have been studied extensively, their integration into a cohesive ensemble-based disaster detection system remains relatively unexplored. Additionally, there is a dearth of research focusing on the optimization of multi-robotic systems specifically tailored for fire disaster search and rescue operations.

Research A[1]

In this research, the authors propose a real-time disaster identification framework leveraging multi-robotic systems within simulation environments. The study emphasizes the integration of visual, infrared, and gas sensor data for accurate disaster detection. Through extensive simulations, the authors demonstrate the effectiveness of their approach in enhancing disaster response capabilities, particularly in fire scenarios.

Research B [2]

This research explores the fusion of sensor data from various sources to improve disaster identification in simulation environments. The paper focuses on integrating data from visual, thermal, and environmental sensors to enhance the accuracy and reliability of disaster detection algorithms. The authors present experimental results highlighting the benefits of sensor fusion techniques in enhancing the effectiveness of disaster response operations.

Research C [3]

In this study, the authors investigate the optimization of disaster identification algorithms tailored for simulation-based training environments. The research emphasizes the development of efficient algorithms capable of processing large volumes of sensor data in real-time. Through comparative analysis and performance evaluations, the authors demonstrate the superiority of their optimized algorithms in terms of accuracy and computational efficiency.

Product Reference	Research A	Research B	Research C	Proposed System
Focus	Real-time disaster identification.	Sensor fusion for disaster identification in simulation environments.	Optimization of disaster identification algorithms for simulation-based training.	Real-time disaster identification
Sensors	flame sensor image sensor temperature sensor and gas sensor.	Visual, Infrared sensors	Not specified	Visual, infrared, and gas and temperature sensors
Methodology	Framework-based approach with extensive simulations	An intelligent fire-fighting robot is designed based on multi-sensor fusion.	Algorithm optimization with comparative analysis	Research existing methods, define requirements, design simulation framework, integrate multi-sensor data, validate through simulations, refine algorithms, document results, iterate improvements

Table 1 Comparison with existing researches

1.3 Research Problem

The research problem at hand focuses on enhancing the effectiveness of fire disaster search and rescue operations through the utilization of multi-robotic systems equipped with advanced sensor technologies. This challenge emerges from the constraints inherent in conventional search and rescue methods, including limited mobility among human responders, the perilous conditions they encounter, and the time-sensitive nature of emergency situations.

For example, during a fire disaster, human responders confront difficulties navigating through smoke-filled environments and accessing areas compromised by structural damage. Moreover, the inherent risks of injury or fatality to responders are heightened, emphasizing the urgency of timely rescue operations.

Illustratively, consider a scenario where a fire erupts within a sprawling industrial complex. Traditional search and rescue methodologies face hurdles in efficiently locating and extricating individuals trapped within the labyrinthine layout, obscured by smoke, and imperiled by structural hazards. Consequently, the research endeavor centers on devising innovative solutions to bolster the efficacy and efficiency of search and rescue endeavors amidst such adversities.

The core objective of this research initiative is to investigate the deployment of multi-robotic systems endowed with specialized sensors and capabilities. These robotic entities are poised to traverse intricate environments adeptly, pinpoint survivors, and gauge the severity of the disaster more adeptly than their human counterparts. Through the integration of cutting-edge technologies and novel methodologies, the research endeavors to redefine conventional paradigms of search and rescue, fostering enhanced outcomes, and mitigating the toll of fire disasters on human life and infrastructure.[5]

2. OBJECTIVES

2.1 Main Objectives

The central focus of this research is to enhance the process of identifying fire disasters, thereby optimizing search and rescue operations. The study aims to leverage multi-robotic systems equipped with state-of-the-art sensor technologies to achieve precise and timely disaster detection. The main objectives encapsulate the overarching aims of the study, guiding the exploration and implementation of innovative solutions for improving disaster identification.

- Investigate the effectiveness of multi-robotic systems in enhancing the overall outcomes of search and rescue missions by improving the accuracy and speed of disaster identification during fire disasters.

- Transform traditional approaches to disaster identification by harnessing the capabilities of multi-robotic systems to mitigate the limitations faced by human responders.

2.2 Specific Objectives

The specific objectives delineate the critical areas of focus and define the desired outcomes of the research effort. They offer a structured pathway for addressing the inherent challenges in disaster identification and formulating actionable strategies to overcome them effectively.

- Develop an ensemble-based disaster detection system integrating visual, infrared, and gas sensor data to enable real-time and precise disaster identification in fire scenarios.

- Enhance the mobility and adaptability of multi-robotic systems to navigate complex and hazardous environments characteristic of fire disasters, facilitating swift and efficient response efforts.

• Conduct comprehensive evaluations to assess the performance and reliability of the ensemble-based disaster detection system through rigorous simulations and practical field tests.

• Evaluate the scalability and versatility of the developed system, ensuring its applicability across a diverse range of fire disaster scenarios and operational environments.

• Quantify the improvements in effectiveness, efficiency, and safety resulting from the integration of multi-robotic systems in fire disaster search and rescue missions, thereby minimizing the impact of disasters on human life and property.

3. METHODOLOGY

3.1 System Architecture Diagram

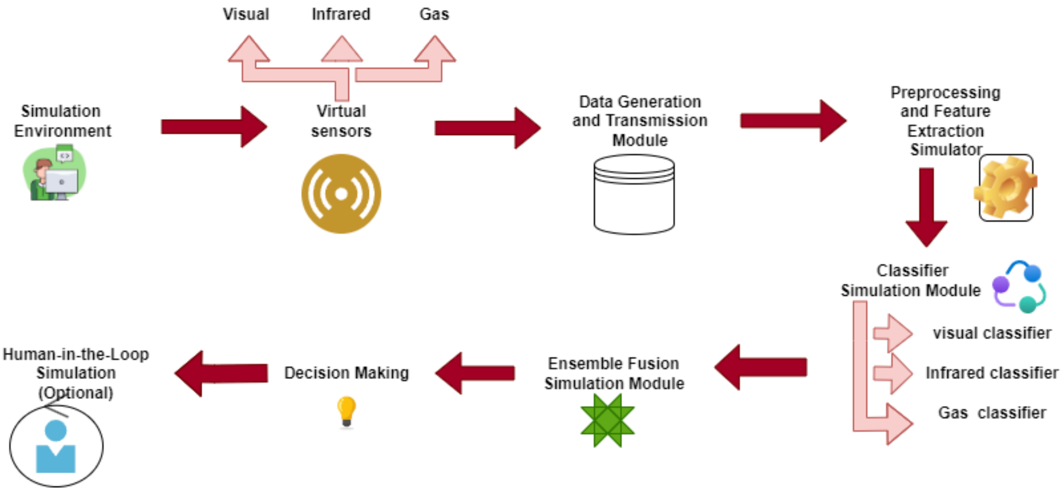

Figure 1 System Architecture Diagram

The methodology for identifying disasters in a multi-robotic rescue simulation-based system, tailored for Arya Labs Pvt Ltd, involves a systematic approach to ensure the efficient and accurate detection of events such as fires within their specific environment. Beginning with the setup of a simulated environment, the system will replicate various disaster scenarios specific to Arya Labs' premises, encompassing factors like building layouts, terrain features, and fire dynamics.

Integration of virtual sensors, including visual, infrared, and gas sensors, will be customized to match the unique characteristics and requirements of Arya Labs' facilities. These sensors will simulate real-world behavior accurately, enhancing the system's ability to detect fire-related phenomena and potential disasters within the company's premises.

The development of a data generation and transmission module will enable the simulation of sensor data transmission from virtual sensors to processing modules within Arya Labs' disaster identification system. Preprocessing algorithms will be tailored to clean and filter sensor data effectively, while feature extraction techniques will be customized to extract relevant features conducive to disaster identification within Arya Labs' specific environment.

Customized classifier simulation modules for visual, infrared, and gas sensors will be created, training and validating models using simulated data tailored to Arya Labs' premises. This ensures that the classifiers accurately classify sensor data into different categories, distinguishing between normal conditions and potential disaster events within the company's facilities.

An ensemble fusion module will be developed specifically for Arya Labs, combining outputs from individual classifiers into a unified decision-making framework. Fusion algorithms will leverage the strengths of different sensor modalities to enhance overall classification accuracy, ensuring precise identification of potential disasters within Arya Labs' environment.

Decision-making algorithms will be designed to utilize fused sensor data effectively, enabling informed decisions about the presence and severity of disasters tailored to Arya Labs' specific premises. Adaptive strategies will be incorporated to dynamically adjust based on changing environmental conditions and sensor inputs unique to Arya Labs' facilities.

Optionally, human-in-the-loop simulation capabilities may be integrated, allowing Arya Labs' operators to interact with the system, provide feedback, and make manual interventions if necessary. User interfaces will be customized to enable operators to monitor system performance, interpret results, and intervene in the decision-making process as needed, ensuring seamless integration with Arya Labs' operations.

This tailored methodology provides Arya Labs with a structured approach for developing and implementing a disaster identification system within their premises. By customizing each step to fit their specific environment and requirements, Arya Labs can effectively detect and respond to potential disaster events, enhancing the safety and security of their facilities.[6]

3.2 Project requirements

3.2.1 Functional Requirements and Non-Functional Requirements

Functional Requirements:

• Real-time integration of visual, infrared, and gas sensor data for disaster identification.

• Dynamic path planning algorithms for robotic platforms to navigate hazardous environments.

• Automated survivor detection and localization capabilities.

• Seamless communication between robotic units and centralized command centers.

• Emergency response protocols for rapid deployment and coordinated rescue efforts.

Non-Functional Requirements:

• High accuracy and reliability in disaster identification.

• Robustness in adverse environmental conditions such as smoke, heat, and low visibility.

• Scalability to handle varying degrees of disaster severity and operational complexities.

• User-friendly interfaces for human operators to monitor and control the system.

• Compliance with safety standards and regulations governing disaster response operations.

3.2.2 Software Requirements

The software requirements encompass the tools, frameworks, and programming languages necessary for developing the simulation software for the multi-robotic system. This includes software for sensor data processing, path planning algorithms, simulation environment creation, and visualization tools for analyzing simulation outcomes.

Algorithms for Navigation

In complicated and dynamic fire disaster scenarios, advanced algorithms are being developed for effective path planning and obstacle avoidance.

Fusion Software for Sensors

The robotic system's software provides a comprehensive situational awareness by integrating data from many sensors.

Protocols for Communication

Robotic units and the central control system can share data and coordinate in real-time via the communication protocols.

Automated Learning Systems

Algorithms for machine learning and artificial intelligence are being developed to improve a system's capacity for adaptation and decision-making in unpredictable and dynamic environments.

Human-Robot Interface

Human operators can monitor and manage robotic units, evaluate data, and make choices with ease because to the system's user-friendly interfaces.

Simulation Software (WeRobots)

The Multi-Robotic System is being tested and validated in virtual fire disaster scenarios using simulation software (WeRobots) before it is once deployed.

WeRobots Simulation Software is a comprehensive platform designed to facilitate the simulation and optimization of disaster identification processes within the context of multi-robotic systems. This software integrates advanced algorithms, sensor fusion techniques, and simulation environments to enhance the efficacy of search and rescue operations during fire disasters.

The software operates by creating virtual environments that mimic real-world scenarios, such as industrial complexes, urban settings, or natural landscapes affected by fire incidents. Within these simulated environments, WeRobots enables the deployment of multi-robotic systems equipped with various sensors, including visual, infrared, and gas sensors.

The working of WeRobots Simulation Software in the function mentioned earlier involves several key components:

1) Scenario Setup: Users can configure the simulation environment by defining parameters such as terrain, building layouts, fire dynamics, and the presence of survivors.

2) Robot Deployment: Multi-robotic systems are deployed within the simulated environment, each equipped with specialized sensors for disaster identification. These robots collaborate autonomously to navigate through the environment and gather sensor data.

3) Sensor Data Fusion: WeRobots integrates data from multiple sensors, including visual imagery, thermal signatures, and gas concentrations, using advanced fusion algorithms. This fusion process enhances the accuracy and reliability of disaster identification by combining complementary information from different sensor modalities.

4) Disaster Identification: The software analyzes the fused sensor data to identify potential fire incidents, locate survivors, and assess the severity of the disaster in real-time. Algorithms for anomaly detection, object recognition, and environmental monitoring contribute to efficient disaster identification.

5) Simulation Analysis: Users can analyze simulation results to evaluate the performance of the multi-robotic system in various scenarios. Metrics such as response time, detection accuracy, and resource utilization provide insights into the effectiveness of the system.

6) Iterative Optimization: Based on the analysis of simulation results, users can iteratively optimize the behavior of the multi-robotic system and fine-tune parameters to improve overall performance and responsiveness in disaster situations.

By leveraging WeRobots Simulation Software, researchers and practitioners can conduct virtual experiments, test different strategies, and validate algorithms for disaster identification without the risks and constraints associated with real-world deployments. This simulation-driven approach accelerates innovation and enhances the preparedness of emergency response teams in mitigating the impact of fire disasters.

Data Analysis

The robotic system processes and analyses large amounts of data using analytics techniques, giving rescue operations important new data.

3.2.3 Personnel Requirements

A wide range of abilities and knowledge are needed on an individual basis for the creation and execution of the multi-robotic disaster identification system. Professionals with specific expertise in a range of fields related to robotics, software development, data analysis, and project management usually make up the team.

Every member of our team are dedicated to working together to complete project and deliverables. As the external supervisor, we require someone with experience in robots and IOT.

3.3 Software Solution

Agile Scrum[4] approach is the software development life cycle that is being suggested. Based on the agile principles of the Agile Manifesto, Scrum is an iterative methodology for software development. Another definition of scrum is a lightweight development approach that offers complete transparency and quick adaptation. Because of the aforementioned behaviors, agile allows for rapid component modifications during the implementation phase in response to changing needs. Agile scrum technique will be used to facilitate the changes in an effective manner. As a result, the suggested solution will be put into practice in accordance with the framework by facilitating quick adaptation and ongoing adjustments.[4]

Figure 2 Agile Methodology

3.3.1 Requirement Gathering and Analysis

During the requirement gathering and analysis phase, our team engaged in comprehensive stakeholder consultations, literature reviews, and domain analysis to comprehend the precise needs and challenges inherent in disaster identification within fire scenarios. Our primary objective throughout this phase was to establish clear objectives, scope, and constraints for the development of simulation software tailored to address these needs.

In collaboration with Mr. Solomon Jayasena, Chairman of Arya Labs (Pvt) Ltd., we conducted detailed discussions to elucidate their specific requirements and gain insights into their expectations. Through these consultations, we identified key parameters essential for effective disaster identification within their facilities. These discussions provided invaluable input for understanding the intricacies of their operational environment and the critical aspects of disaster response.

One crucial aspect of our collaboration with Arya Labs (Pvt) Ltd. involved the provision of blueprints and architectural schematics of their actual locations. By integrating these blueprints into our system, we aim to replicate the physical layout and characteristics of their facilities within the simulation environment. This step ensures that our simulation software accurately reflects the real-world conditions and challenges faced during disaster scenarios.

By incorporating stakeholder input and leveraging architectural data, we are poised to develop a simulation solution that aligns closely with Arya Labs' requirements and facilitates effective disaster identification and response. This collaborative approach underscores our commitment to delivering tailored solutions that address the unique needs of our clients and enhance their preparedness for emergency situations.

3.3.2 Feasibility Study

3.3.2.1. Technical Feasibility

Evaluation of Available Technology: Assess the availability of software development tools, simulation platforms, and robotics frameworks suitable for implementing the simulation software.

Analysis of Software Requirements: Determining if the chosen technology stack and programming languages align with the project requirements and if there are any technical challenges in integrating different software components.

3.3.2.2. Economic Feasibility

Cost Estimates: Calculate the expenses associated with software development, including licensing fees, hardware acquisition, and personnel costs.

ROI Analysis: Evaluate the potential return on investment (ROI) from the simulation software, considering the long-term benefits of improved disaster identification and rescue operations.

3.3.2.3. Operational Feasibility:

Alignment with Operational Objectives: Determine how well the simulation software aligns with the operational objectives of enhancing disaster identification and response capabilities.

User Acceptance: Assess the willingness of end-users, such as disaster response teams and emergency personnel, to adopt and utilize the simulation software effectively.

3.3.2.4. Resource Feasibility:

Human Resources: Evaluate the availability of skilled personnel, including software developers, domain experts, and project managers, required for the successful development and maintenance of the simulation software.

Hardware Resources: Assess the availability and adequacy of hardware resources, including computing infrastructure and simulation hardware, necessary for running the simulation environment effectively.

3.3.2.5. Risk Feasibility:

Identification of Potential Risks: Identify potential risks and challenges associated with software development, such as technical complexity, schedule delays, budget overruns, and integration issues.

Risk Mitigation Strategies: Develop strategies to mitigate identified risks, including contingency plans, resource allocation adjustments, and regular progress monitoring.

3.3.2.6. Legal and Ethical Feasibility:

Compliance with Regulations: Ensure compliance with legal and regulatory requirements governing software development, data privacy, and intellectual property rights.

Ethical Implications: Consider ethical implications related to the use of simulation software in disaster response training, including data privacy, informed consent, and transparency in decision-making processes.

3.3.3 Design

3.3.3.1. Flow diagram of Disaster Identification

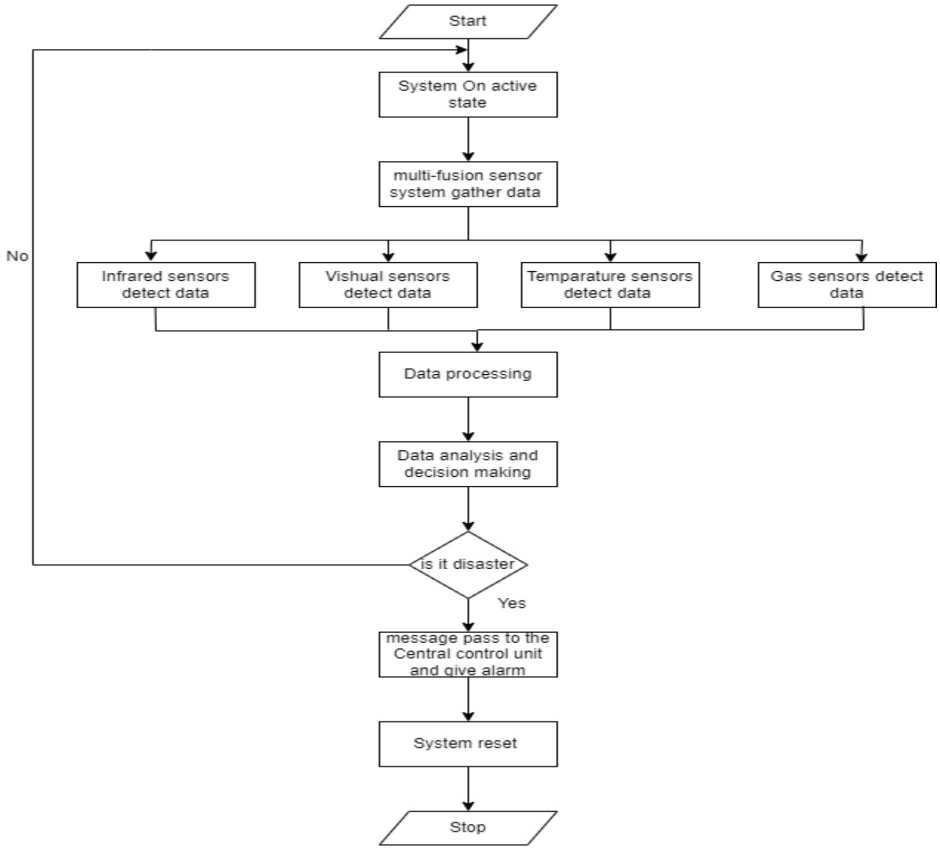

Figure 3 Flow diagram of Disaster Identification

3.3.3.2. Dataset

A dataset for disaster identification using multi-robotic systems involves collecting and organizing data that simulates various aspects of a fire disaster environment. This includes environmental data, sensor data, robot trajectories and actions, and Survivor data. The dataset should include parameters like building layouts, structural materials, terrain features, and environmental conditions. It should also include synthetic sensor data from visual, infrared, and gas sensors. Robot trajectories and actions should be defined, and survivors' data should be included. The dataset should be organized into structured formats for machine learning tasks and documented for data exploration and model development. This comprehensive dataset can help train and evaluate algorithms, test system performance, and validate the effectiveness of disaster identification methods using multi-robotic systems.

3.3.3.3. Work Breakdown Structure

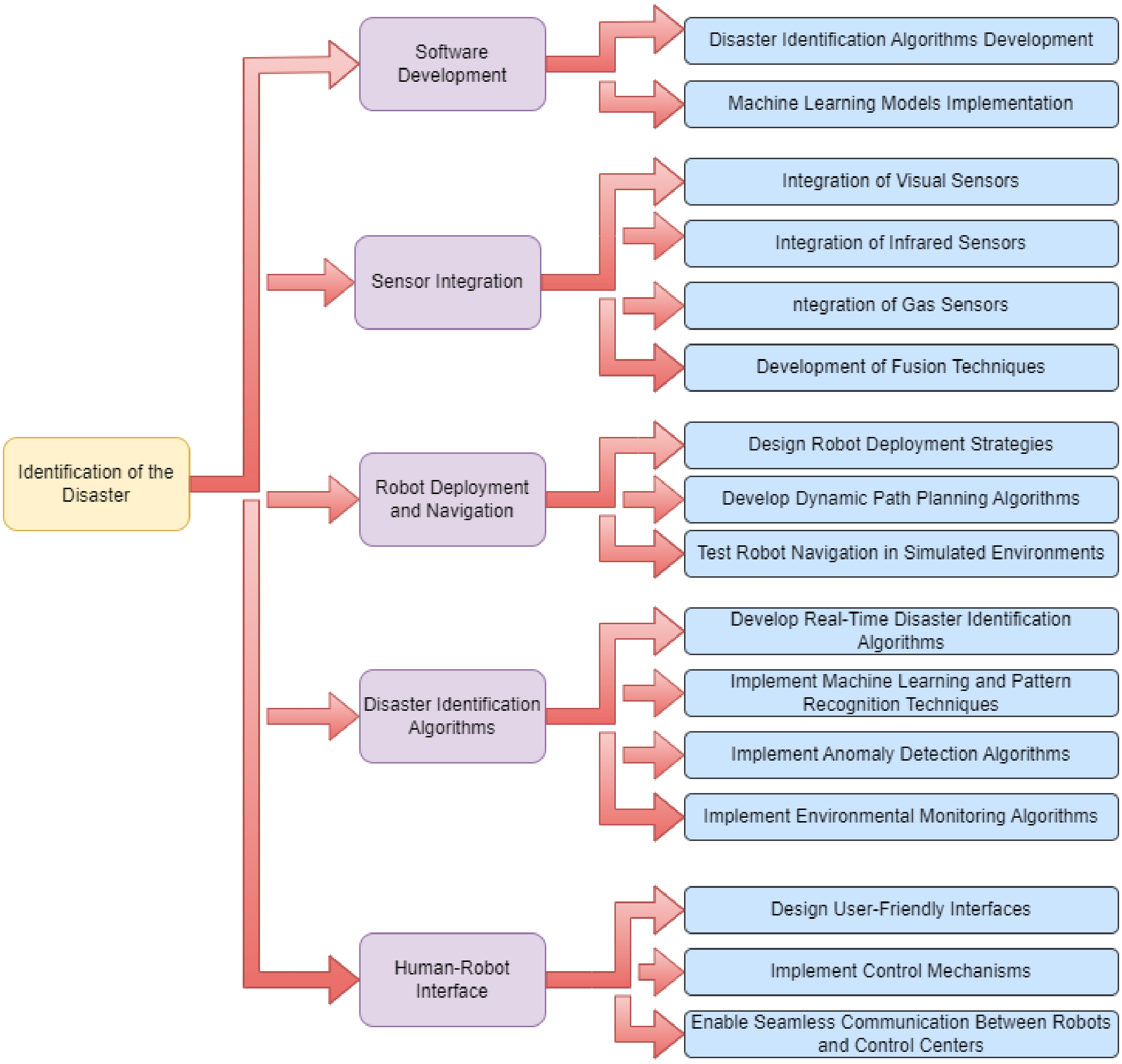

Figure 4 Work Breakdown Structure

3.3.4 Implementation

Software Development

Begin coding based on the design specifications. Integrate sensors and develop fusion techniques. Deploy and navigate robots within the simulation environment. Implement disaster identification algorithms and machine learning models.

Sensor Integration

Integrate visual, infrared, and gas sensors into the system. Develop fusion techniques to combine data from different sensors for enhanced disaster identification.

Robot Deployment and Navigation

Design strategies for robot deployment and develop dynamic path planning algorithms. Test robot navigation in simulated environments to ensure efficient movement and obstacle avoidance.

Disaster Identification Algorithms

Develop real-time disaster identification algorithms using machine learning and pattern recognition techniques. Implement algorithms for anomaly detection and environmental monitoring.

Human-Robot Interface

Design user-friendly interfaces for human operators to monitor and control the robotic systems. Implement control mechanisms to enable seamless communication between robots and control centers.[20]

Simulation Environment Creation

Develop virtual environments that mimic real-world scenarios. Integrate architectural blueprints and building layouts into the simulation environment. Simulate fire dynamics, smoke propagation, and structural damage.

Testing and Validation

Conduct thorough testing of each software component and perform integration testing to ensure seamless operation. Validate system performance through simulation scenarios and real-world testing scenarios.

Documentation and Training

Prepare comprehensive documentation including user manuals and technical guides. Conduct training sessions for end-users and support teams. Ensure adequate knowledge transfer for system maintenance and troubleshooting.

Iterative Improvement

Continuously monitor system performance and gather feedback from users. Make iterative improvements to enhance system capabilities and address any issues or challenges encountered during implementation.

3.3.5. Mobile Application

The mobile application serves as a pivotal link in the fire disaster simulation solution, enabling seamless communication and monitoring throughout the crisis. Upon detecting a disaster, the application triggers an immediate notification to the admin, prompting inquiry into the cause and nature of the incident. The admin gains real-time visibility into the robotic unit's operations via the app, monitoring its actions and responses throughout the disaster scenario. As the crisis unfolds, the app facilitates the identification and assessment of solutions proposed by the robotic unit, providing insights into the efficacy of rescue efforts. Users can track the progress of the disaster response until its resolution, ensuring comprehensive oversight and informed decision-making. By centralizing communication, observation, and analysis capabilities, the mobile app enhances coordination and situational awareness, optimizing rescue operations in fire disaster scenarios.

3.3.6 Testing (Track and Monitor)

During the testing phase, thorough testing processes are used to validate the simulation software's functionality, performance, and dependability. To guarantee the precision and efficacy of the simulation environment, this involves validation against real-world data, system testing, integration testing, unit testing, and validation. Throughout the development process, iterative improvements and optimization are made possible by the continuous tracking and monitoring of simulation performance.

4. GANTT CHART

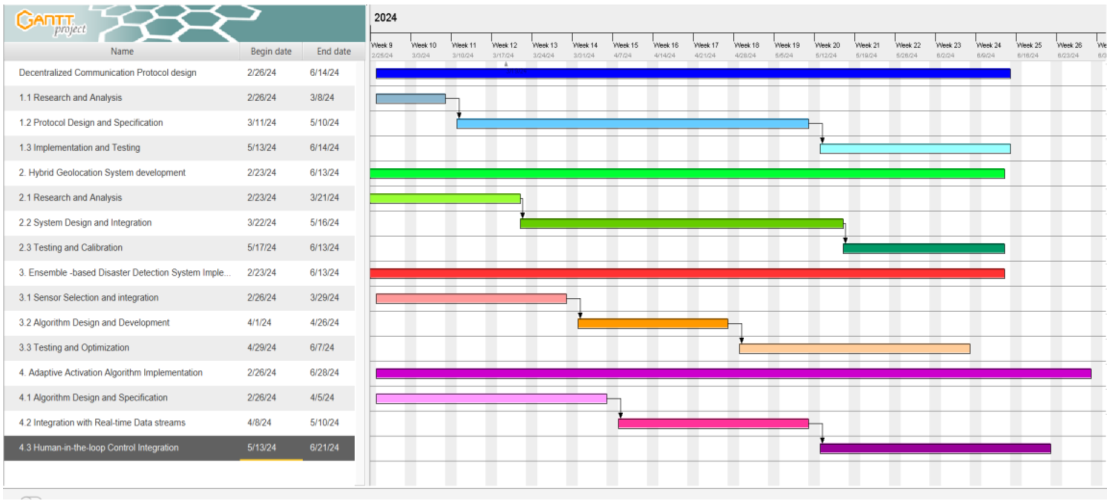

Figure 5 Gantt Chart of the Project

5. DESCRIPTION OF PERSONAL AND FACILITIES

Facilitators:

- Mrs. Lokesha Weerasinghe – Sri Lanka Institute of Information Technology (SLIIT)
- Miss.Rivoni De Zoysa - Sri Lanka Institute of Information Technology (SLIIT)
- Mr. Nelum Chathuranga - Sri Lanka Institute of Information Technology (SLIIT)
- Mr. Solomon Jayasena - Arya labs (Pvt) Ltd. (Arya Labs)

Facilities:

- Arya labs (Pvt) Ltd.

6. BUDGET AND BUDGET JUSTIFICATION

The projected budget includes hosting, database, deployment, and subscription fees.

Feature	**Price**
Database Cost	Rs.14000
Cloud Infrastructure	Rs.7000
User Interface Design	-
Testing and Quality Assurance	Rs.4000
Marketing and Promotion	Rs.7000
Transportation	Rs.5000
Contingency	Rs.2000
Total	Rs.39000

Table 2 Budget Table

7. COMERCIALIZATION

7.1 Target Audience and Market Space

Target Audience

- Robotic Researchers
- Arya Labs(Pvt) Ltd Company
- Stakeholders
- External Parties
- Fire Fighters

Market Space

- need of advanced knowledge in technology.
- Age limitation for users above 18.

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9. APPENDICES

researchpaperbyvijini

ORIGINALITY REPORT

9%	6%	2%	6%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Sri Lanka Institute of Information Technology Student Paper	4%
2	Submitted to Kingston University Student Paper	1%
3	www.coursehero.com Internet Source	<1%
4	Submitted to University of Southern Queensland Student Paper	<1%
5	www.appinio.com Internet Source	<1%
6	Submitted to University of East Anglia Student Paper	<1%