AI Based Multi Robot Fire Suppression System

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***Abstract*—Imagine a groundbreaking shift in how we tackle fires – we're bringing in a team of really clever robots. These high-tech marvels come with amazing sensors and smart artificial intelligence. They work together seamlessly, using fancy algorithms to quickly spot and stop fires with incredible precision. It's not just about having cool technology; it's a whole new approach to handling emergencies, changing how we ensure safety and efficiency. These futuristic robots aren't just adaptable; they're super smart, responding rapidly to all sorts of fire challenges. Picture a constant, watchful presence of these robotic pals, their collective brilliance and smooth teamwork not just transforming firefighting but also paving the way for exciting progress in a whole new way.**

***Keywords*—Sensors, Slam, Servers**

I. INTRODUCTION

The "AI-Based Multi-Robot Fire Suppression System" project aims to transform firefighting by combining advanced technologies like artificial intelligence (AI) to form a team of highly intelligent robots. To improve their capabilities, these robots are outfitted with advanced artificial intelligence and special sensors. The primary goal is to improve the effectiveness and safety of firefighting operations by allowing these robots to collaborate, respond quickly to fires, and handle dangerous tasks, reducing the need for human firefighters to be in harm's way. The project includes extensive testing to ensure that these smart robots can effectively handle a variety of firefighting challenges. They are equipped with specialized tools and sensors that enable them to understand the dynamics of a fire. Robots are trained to make quick decisions using clever computer programs, allowing them to respond effectively to various firefighting scenarios.

Real-world trials are an important part of the project because they allow the robots to demonstrate their abilities in actual firefighting situations. The hope is that these robots will not only shorten response times during fires, but also cause a paradigm shift in firefighting, making it smarter, more efficient, and safer for everyone involved.

II. LITERATURE SURVEY

[1]introduces an indoor autonomous robot for firefighting and inspection, which uses SLAM and flame image recognition. It describes the hardware design, software architecture, and algorithms used for navigation and fire detection. The robot's effectiveness in real-world scenarios is demonstrated through rigorous experimentation, emphasizing its potential to improve firefighting operations.

[2]introduces a novel IoT and deep learning-inspired framework for monitoring active fire locations in agricultural activities. It proposes a multi- model approach that combines IoT sensors for environmental monitoring with deep learning models for fire detection. The framework's goal is to provide early detection of fire incidents, allowing for quick response and suppression. The proposed framework's architecture, which includes sensor deployment, data preprocessing, deep learning model design, and integration with firefighting systems, is described. The frame- work's effectiveness in detecting fire incidents is demonstrated through experimental evaluation, highlighting its potential to improve firefighting operations in agricultural settings.

[3]presents an advanced firefighting robot with multi-sensor capabilities, wireless control, and a visual system. The robot can quickly detect and combat fires by integrating temperature, smoke, and gas detectors, as well as visual cameras. Its wireless

control system allows for remote operation, which improves firefighters' safety. Furthermore, the visual system aids in precise fire detection and obstacle avoidance. The robot's efficiency and effectiveness highlight its potential to revolutionize fire suppression, as demonstrated by experimental validation.

[4]describes a novel weakly aligned multimodel flame detection method designed for firefighting robots. The proposed approach aims to improve flame detection accuracy and robustness in a variety of environments by integrating multiple sensor modalities and utilizing weak supervision techniques. Implementing this methodology could significantly improve the capabilities of our AI-powered multi-robot fire suppression system, allowing for more efficient firefighting operations.

[5]represents the use of self-organizing drone swarms for firefighting, emphasizing the effectiveness of decentralized multi-robot systems and collective intelligence in addressing fire suppression challenges. It describes the methodology used to design and implement these drone swarms, including hard-ware specifications, software frameworks, and decentralized control algorithms. The study delves into the complexities of task execution and coordination within the drone swarm, revealing mechanisms for effective task assignment, collabo-ration, and information exchange. It also discusses the results of simulation-based evaluations and real-world experiments, which shed light on the system's performance metrics, adapt-ability to dynamic environments, and overall effectiveness in fire suppression. The findings highlight the potential of such systems to transform firefighting operations, with implications for improving efficiency, scalability, and emergency response times.

[6]introduces an important approach for optimizing firefighting operations in complex environments. The study addresses the challenges of navigating dynamic and often hazardous conditions during firefighting scenarios by developing an intelligent path planning mechanism specifically designed for wireless sensor and actor networks. The proposed mechanism aims to improve firefighting efficiency and effectiveness by combining AI-based algorithms with real-time sensor data. Through rigorous experimentation and evaluation, the paper demonstrates the potential of this approach to significantly im- prove response times, coverage areas, and resource utilization in firefighting operations.

[7]contains useful information for our project on an AI-powered multi-robot fire suppression sys- tem. It provide useful information about the motion dynamics of firefighting robots, as well as trajectory correction strategies to improve their effectiveness in navigating and extinguishing fires. Motion pattern analysis, obstacle avoidance techniques, and trajectory planning and correction algorithms are examples of potentially useful content. Furthermore, the paper cover real-time monitoring of robot movements and feedback mech- anisms to ensure accurate and efficient firefighting operations. By incorporating the findings of this paper, our project can improve the navigation and maneuverability capabilities of firefighting robots, resulting in more effective fire suppression in a variety of environments.

III. Hardware Requirements

The Hardware Requirement for the AI based multi robot fire suppression system typically includes:

- **Raspberry pi 3B+**
  Is a Quad-core, 1GB RAM, Wi-Fi, Bluetooth, Ethernet, HDMI, GPIO pins. Raspberry Pi 3B+ serves as the central controller in an AI-based multi-robot fire suppression system. It manages robot coordination, processes sensor data for fire detection, and facilitates real-time communication between robots. The system utilizes its GPIO pins for robot control and implements distributed computing for efficient AI processing.

- **L298N Driver Module**

  Is a Dual H-bridge motor driver for DC or stepper motors. Wide input voltage (7V to 35V), max current 2A per channel. Enables bidirectional motor control. L298N is used in the fire suppression system to control robot movements. It enables bidirectional motor control, facilitating precise navigation and coordination between AI-driven robots for efficient fire response.

- **Camera Module**
  Camera modules are compact devices with image sensors for capturing images or video. Integrated with micro controllers or single-board computers, like the Raspberry Pi, they are used in various applications, including photography and robotics. It capture's visual data for object detection, navigation, and collaborative decision- making. Enhance situational awareness, aid emergency response and remote monitoring. Recorded data refines AI algorithms for improved system performance.

- **Ultrasonic Sensor**
  They emits and receives sound waves to measure distance, widely used for obstacle detection in robotics and automation projects. Ultrasonic sensors in AI fire suppression: Navigate robots, maintain safe distances, enhance mapping, and dynamically adjust paths for safety in dynamic fire scenarios.

- **Servo Motor**
  Is a rotary actuator that precisely controls angular position, velocity, and acceleration. Commonly used in robotics and automation for precise motion control. Ensure precise robotic control and targeted nozzle adjustments for accurate flame suppression. Automation of sweeping patterns enhances efficiency, and synchronized movements optimize collaborative firefighting efforts.

- **Mini DC Submersible Pump**
  Is compact, DC-powered water pump for submerged use, ideal for applications like aquariums and water fountains. Mini DC submersible pumps supply water for targeted flame suppression, cool robotic components, and enhance sensor

functionality. Their compact design ensures system mobility in navigating diverse firefighting scenarios.

- **Robot Chassis with Motors and Wheels**
  A platform for building robots, equipped with integrated motors and wheels for mobility. Ideal for hobbyist and educational robotics projects. Robot chassis with motors and wheels are the mobility backbone in AI-based multi-robot fire suppression. Their customizable design integrates AI components and sensors, facilitating synchronized movements for effective responses to dynamic firefighting scenarios.
- **Rechargeable Batteries**
  Energy storage devices designed to be charged and used multiple times, providing a sustainable power source for various electronic devices and applications. Rechargeable batteries provide sustainable power, ensuring continuous operation during firefighting tasks and contributing to system longevity.

IV. Software Requirements

The Software Requirement for the Ai based multi robot fire suppression system typically includes:

- AI Algorithms: Fire detection using machine learning.
- Robot Control:Real-time coordination for multiple robots.
- Sensor Integration:Cameras, ultrasonic sensors, and temperature sensors.
- Communication Protocols:Seamless data exchange for collaboration.
- Navigation Algorithms:Obstacle avoidance and efficient mapping.
- Power Management:Optimize energy consumption.
- User Interface:User-friendly monitoring interfaces.
- Data Logging:Mechanisms for logging and analysis.

V. Proposed Methodology

Integrating an AI-based multi-robot fire suppression system with cloud technology involves a coordinated blend of hardware and software elements. Initially, a cloud infrastructure is established using platforms like AWS, Azure, or Google Cloud to host and manage computational resources for AI processing and data storage. Concurrently, physical robotic components, including chassis, motors, sensors, and pumps, are intricately assembled to create operational units. Real-time sensor data is then transmitted to the cloud, where AI algorithms analyze it for fire detection and decision-making. The cloud serves as a central decision hub, fostering real- time coordination among robots through secure communication protocols. Operators access real-time insights via a cloud-based interface, facilitating prompt intervention when needed.

The cloud's computational resources are optimized for mapping, navigation algorithms, and data logging, enhancing post-event analysis efficiency. Additionally, rigorous security measures are implemented on the cloud to safeguard sensitive data, and scalability considerations ensure seamless integration of more robots or additional cloud resources. Operator training and comprehensive documentation form the final pillars of the framework, ensuring the successful deployment and maintenance of the AI-based multi-robot fire suppression system with cloud integration.

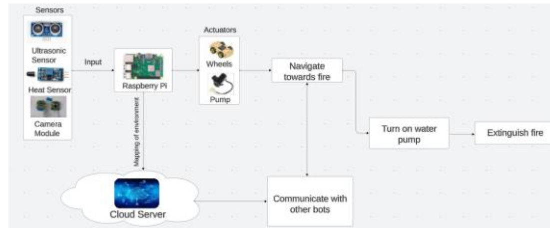

Fig. 1. Architecture

Performance Graph

The ultrasonic sensor accuracy graph depicts the sensors' performance in accurately detecting distances across various scenarios. It compares measured distances to actual distances to determine the precision and reliability of the ultrasonic sensors. By analyzing this graph, we can determine the consistency of sensor readings and identify any differences between measured and true distances. Such insights are critical for optimizing the placement and calibration of ultrasonic sensors in the AI-based multi-robot fire suppression system, which ensures accurate detection of obstacles, fire sources, and other critical elements in the operational environment. Furthermore, trends in the graph can guide refinement efforts to improve the overall accuracy and effectiveness of the sensor subsystem within the project.

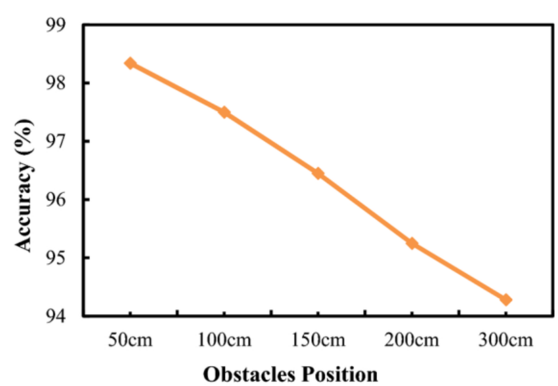

Fig. 2. The Ultrasonic sensor accuracy graph

The x-axis is labeled "Obstacles Position" and measured in centimeters. The y-axis is labeled "Accuracy" and expressed as a percentage. The graph shows that the ultrasonic sensor's accuracy decreases as the obstacle position increases. Ultrasonic sensors provide a reliable method of measuring distance, but their accuracy is not perfect.

High-end models can achieve impressive accuracy within 0.1-0.2 percentage of their range, whereas the majority of good sensors fall between 1-3 percentage. However, there are several factors that can affect this accuracy. Readings become less precise as distance increases. Temperature variations, as well as the shape and material of the target object, can all have an impact on the sensor's ability to interpret sound waves. Airflow can also degrade the signal. To address these concerns, some sensors allow for calibration for specific environments. While ultrasonic sensors can be a useful measurement tool, understanding their limitations is critical for interpreting readings and achieving the desired level of accuracy in the project.

RESULT

The combination of AI-based multi-robot fire suppression systems and cloud computing represents a significant advance in firefighting technology. This fusion combines physical robotics with the cloud's immense computational power and connectivity, ushering in an era of unprecedented effectiveness and adaptability in emergency response. The cloud infrastructure serves as the backbone, housing sophisticated AI algorithms that process real-time data feeds from sensors, environmental conditions, and previous fire incidents. This data analysis enables the system to make more informed decisions, such as precisely optimizing navigation routes and suppression strategies.

Furthermore, the centralized nature of the cloud ensures that strong data security measures are in place to protect sensitive information. AI-equipped robots are at the forefront of this innovation, serving as first responders in fire emergencies. These self-sufficient agents are outfitted with advanced sensors that can detect even the smallest signs of heat or smoke. Their ability to assess fire severity and execute suppression measures autonomously reduces risks to human responders while also improving overall firefighting efficiency. Furthermore, the scalability of both the robotic fleet and the cloud infrastructure allows the system to seamlessly adapt to fires of varying sizes and complexity. This integration marks a significant advancement in firefighting capabilities, demonstrating the transformative power of technology in protecting lives and property from the ravages of fire.

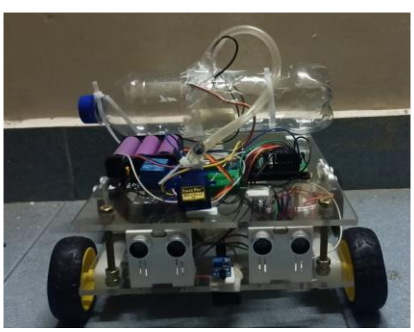

Fig. 3. Predicted Output

Fig. 4. Predicted Output

The above represents the control of a self-driving car or robot. The code uses functions for basic movements such as

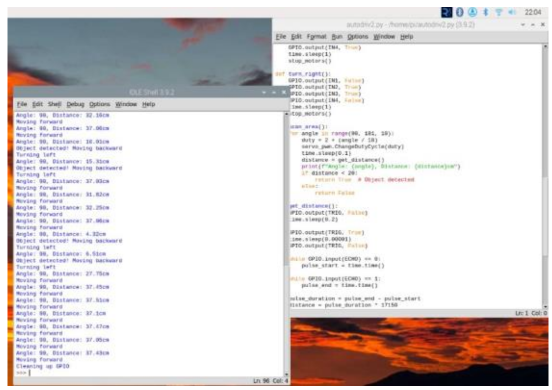

Fig. 5. object detection

stopping, turning left/right, and moving forward. Sensor integration is demonstrated by functions that presumably retrieve distance readings and scan surrounding areas, most likely using ultrasonic sensors. Notably, the 'get-distance()' function determines the distance to an object in front of the vehicle. This snippet could be combined with other code to form a comprehensive program for autonomous navigation.

CONCLUSION

Our AI-powered multi-robot fire suppression system ushers in a new era of firefighting technology, combining artificial intelligence, robotics, and sensor networks to provide unprecedented efficiency and efficacy in fire mitigation. At its core, the system uses AI algorithms to detect, localize, and extinguish fires in real time. Our robots speed up firefighting operations by analyzing environmental cues and coordinating responses, while reducing risk to human responders via remote monitoring and control.

The system's ability to collaborate with multiple robots is critical to its effectiveness. A fleet of specialized robots, each with unique capabilities such as flame detection and water deployment, collaborate to maximize firefighting efforts. These robots' seamless communication and coordination allow them to adapt to changing fire conditions and allocate resources dynamically.

Furthermore, our system prioritizes safety and reliability with robust sensor suites and fail-safe mechanisms. Thermal imaging cameras, gas detectors, and LiDAR sensors provide real-time situational awareness, allowing robots to navigate complex environments and make informed decisions, ensuring continuous operation even in challenging conditions.

Looking ahead, our project lays the groundwork for future advancements in autonomous firefighting technologies. Further advancements in AI algorithms, sensor technologies, and robotic platforms will expand our system’s capabilities and usefulness. Collaboration with stakeholders, including firefighters and policymakers, will be critical in validating and refining our system for real-world deployment.

Finally, our AI-powered multi-robot fire suppression system represents a game-changing advancement in firefighting technology, promising to protect communities with unprecedented efficiency and effectiveness in fire response and disaster management.

REFERENCES

[1] An Indoor Autonomous Inspection and Firefighting Robot Based on SLAM and Flame Image Recognition by Sen Li 1,Junying Yun 1,Chun- yong Feng 2,Yijin Gao 1,Jialuo Yang 1,Guangchao Sun 1 andDan Zhang 1,*
[2] IoT and deep learning-inspired multi-model framework for monitoring Active Fire Locations in Agricultural Activities Akashdeep Sharma 1,*, Harish Kumar 2, Kapish Mittal 3, Sakshi Kauhsal 4, Manisha Kaushal 5, Divyam Gupta 6, Abheer7 Narula
[3] A multi-sensor based fire fighting robot with wireless control and visual system Md. Mahmudul Hasan, Nayeem Al-Tamzid Bhuiyan
[4] Weakly Aligned Multimodal Flame Detection for Fire-Fighting Robots Chenyu Chaoxia , Weiwei Shang , Senior Member, IEEE, Fei Zhang , and Shuang Cong , Senior Member, IEEE
[5] Self-organising swarms of firefighting drones: Harnessing the power of collective intelligence in decentralised multi-robot systems Mauro S. Innocente, Paolo Grasso
[6] An Intelligent Path Planning Mechanism for Firefighting in Wireless Sensor and Actor Networks Farzad H. Panahi , Fereidoun H. Panahi , and Tomoaki Ohtsuki , Senior Member, IEEE
[7] Motion analysis of the fire-fighting robot and trajectory correction strategy Shuo Zhang a,c, Ruochao Wang a,d, Yu Tian a,c, Jiantao Yao a,b,c,*, Yongsheng Zhao a,b,c