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A Review on Fire Fighting Robot with Communication Technology

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ABSTRACT: In recent times, the frequency of fire accidents has surged, posing significant threats to lives, property, and the environment. Traditional firefighting methods often expose firefighters to high risks, especially in hazardous areas. To address this challenge and prevent the escalation of fires, we are going to analyze the published papers on Fire Fighting Robot and come up with the methodologies which matches to the robot. Our paper provides a comprehensive review of the design and construction of a robot equipped with a communication, fire detection, fire extinguisher modules. This innovative robot system showcases its ability to autonomously identify fire locations and deploy water stored within its container for extinguishment. By intervening in the early stages of fire outbreaks, our paper aims to minimize losses in terms of property, land, human lives, and wildlife, while also contributing to the preservation of environmental balance

KEYWORDS: Microcontroller, Communication module, Sensors, Motor Driver, Water pump, Fire detection, Fire extinguisher, Automatic detection

I. INTRODUCTION

Our paper is focused on firefighting robotic vehicle using Arduino UNO. The landscape of fire fighting robotics has evolved significantly, as evidenced by the comprehensive analysis of twelve seminal papers in this dynamic field. This robots main function is to detect fire and move towards the fire automatically to extinguish it from a safe distance using water sprinkler. This Robot reduces the risk of human lives at the disaster-prone area. The reviewed papers collectively underscore the increasing recognition of the need for innovative solutions to combat fires in complex and dangerous regions. The vehicle consists of a water tank along with a pump that can throw water when needed. This robot is equipped with a three flame sensor used to sense environmental fire and feed the signals to the microcontroller in order to trigger the pump which sprinkles water in order to extinguish the fire. This robot implements the concepts of environmental fire sensing and proportional motor control. The motor driver is used for the bidirectional control of the motors equipped in the robot. Thus, the robot processes information from its various key hardware elements such as the flame sensor. One of the standout features is its built-in communication system. It can send messages and make phone calls to emergency services, other team members, or the incident commander. This helps in real-time coordination and reporting of the situation. By reducing the risk to human firefighters and enhancing their situational awareness, this robot enhances overall safety during firefighting operation.

In recent years, the frequency and intensity of fire incidents have increased, posing a significant threat to human lives and property. Rapid response and effective firefighting measures are critical in minimizing the impact of such disasters. The Fire Fighting Robot is an innovative solution designed to enhance the efficiency of firefighting operations by incorporating robotics and modern communication technologies. The primary objective of this paper is to develop a smart and autonomous robot capable of detecting and extinguishing fires in confined spaces, such as buildings, warehouses, and industrial facilities. As we delve into the synthesis of these twelve papers, we aim to provide a holistic view of the current state of fire fighting robotics, emphasizing both achievements and areas for further exploration. This synthesis serves as a foundation for understanding the collective insights that pave the way for future advancements in the design, deployment, and optimization of fire fighting robots. The purpose of this paper is to design and develop an experimental intelligent fire extinguishing robot designed to run a patrol on a planned trajectory, detect the fire autonomously, locate it and extinguish the flame by water spray.

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II. KEY FEATURES

Fire Detection: The robot is equipped with Fire Detection Module capable of detecting heat and smoke, enabling it to identify the presence of a fire accurately. These module provides a real-time data to the robot's microcontroller, allowing it to swiftly respond to potential fire incidents.

Autonomous Navigation: The robot is designed to navigate autonomously through complex environments, such as indoor spaces with obstacles and varying floor plans. It utilizes obstacle avoidance algorithms and mapping techniques to ensure efficient and safe movement.

Fire Suppression Mechanism: The robot is equipped with a fire extinguisher module, which include water spraying mechanisms or fire-extinguishing agents, to combat and extinguish the fire. The suppression mechanism is activated based on the data received from the fire detection module.

Communication System: An integrated communication module enables the robot to send SMS alerts and make phone calls to pre-programmed emergency contacts regarding the fire detection. The system provides real-time updates on the fire situation, allowing for a swift and coordinated response from firefighting teams.

III. FIRE FIGHTING ROBOT

In general the Fire Detection Module sense the fire and send the information to the Microcontroller which is the brain of this robot as shown in the Fig. 1. The brain(microcontroller) will take the action according to the condition and information getting from the fire detection module. Microcontroller will give the commands to the Fire Extinguisher module to start move in the desired direction of fire. It uses the Communication Module to send message and call. The robot will stop near to the fire and start watering to it till the fire will be under control with help of water pump. The power to the microcontroller is supplied from the Power Source.

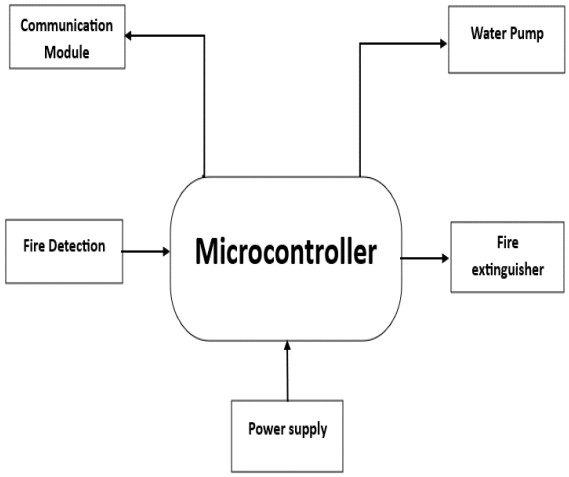

Fig.1. Block Diagram of Fire Fighting Robot

IV. LITERATURE REVIEW

Jijesh J J, Satya Srikant Palle [1] present the Design and Implementation of Automated Fire Fighting and Rescuing Robot. The document discusses the development and implementation of an automated Fire Fighting robot for early action against fire accidents in buildings. The robot is equipped with various sensors like ultrasonic, fire, smoke, and motion sensors, as well as a gripper and IP camera for bi-directional communication. The robot is further improved using BLYNK application linked to the microcontroller ESP32 via Wi-Fi SoC to provide alert messages to the person on duty and residents. The robot is capable of extinguishing fire with water and carbon dioxide sprays, shielding itself from flames, and has live place recording for higher authorities. The research shows the efficiency of the robot in performing in critical conditions and rescuing lives, with a marginal improvement in performance compared to existing systems.

Sreesruthi Ramasubramanian, , A.Sasikala [2] present the Fire Detection using Artificial Intelligence for Fire-Fighting Robots. Fire detection is crucial for saving lives and property. Autonomous fire-fighting robots can detect and extinguish fires. Sensors and IoT are used for detection and communication. Machine learning and deep learning

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algorithms are used for image classification. Haar Cascade Classifier and YOLOv3 are used for fire detection. Transfer learning is used to train models for object detection. Local and global target positions are identified using path-planning algorithms. Results show that deep learning trained model is more accurate than Haar Cascade Classifier. Different types of fires are detected using machine learning and deep learning models. Overall, the document discusses the use of machine learning and deep learning algorithms for fire detection, as well as the comparison of results obtained using different methods.

LIU Qi, wang yig [3] present the Research an key Technologies of intelligent fire fighting robot based on the zigbee network. The document discusses the use of a fire-fighting robot with Zigbee network and wireless sensors. It covers the network topology and control unit of the robot. The document also mentions the central monitoring unit management unit and client snap-in. The focus is on the acquisition unit, control unit, and client snap-in for the fire-fighting robot.

Lin Mingsong, Lin Tugan [4] present the Design and Experiment of Control System of Intelligent Fire Fighting Robot. The document discusses the use of robots in dangerous operations such as fire fighting and disaster relief. The intelligent fire robot rescue system is designed to arrive at the scene of danger or disaster, return real-time video images, put out fires, and search for survivors to minimize loss of life and property. The system includes a control system, trolley travel control circuit, automatic fire source searching circuit, and physical system diagram. Test results and analysis show that the design scheme of the system is feasible and provides a feasible solution for rescue work in the event of a major disaster.

Shang Gao , Zhiyang Zhang [5] present the Vision and Infra-Red Sensor Based Fire Fighting Robot. The fire-fighting robot is designed to spray water from a manipulator to extinguish flames. It uses integrated tracking, obstacle avoidance, flame detection, and motion algorithms. The robot can transfer video to a remote location. The robot has a modular design with a four-axis manipulator for firefighting operations. It uses a MultiFLEX ™ 2-AVR controller with ATmega128 processor and ATmega8 co-processor. Sensors such as far-infrared flame sensor, greyscale sensor, and IR approaching sensor are used for barrier avoidance, flame detection, and extinguishing. The robot has a 640x480 video camera and a spray module for fire extinguishing. The robot is tested in a simulated lab environment and is able to detect and extinguish flames. The average time to extinguish five candles in the simulation is 38.87 seconds.

Tawfiqur Rakib, M. A. Rashid Sarkar [6] present the Design and Fabrication of an Autonomous Fire Fighting Robot with Multisensor Fire Detection Using PID Controller. An Arduino-based algorithm is used for fire detection and distance measurement. A centrifugal pump is used to throw water for extinguishment. Two sensors, LM35 and Arduino Flame Sensors, are used for detection. The robot is made of locally available materials. The water container is made of waterproof white cardboard. The robot is powered by a 12V LiPo battery. The robot's working principle involves rotation and controlled movement. The robot's performance is tested at different daytimes and distances. The flame sensor detects fire effectively at night. The robot's effectiveness is observed in different situations. The robot is designed for fire detection and extinguishing missions.

Ziliu Ye, Fuwen Su , Qingyong Zhang,Lili Wan [7] present the Intelligent Fire-fighting robot based on STM32 The paper discusses the design of an intelligent fire-fighting robot based on STM32, including control, motor drive, and power circuits. The robot uses sensors such as JY-901 attitude sensor, photoelectric sensor, flame sensor, and ultrasonic sensor to track and avoid obstacles and find fire sources independently. The JY-901 attitude sensor uses a hexadecimal mode to send data and can output high-precision acceleration, angle, and angular velocity data. The robot is powered by two 18650 lithium batteries and uses a booster circuit to supply power to the motor and single-chip microcomputer. The robot's control algorithm includes a balance control algorithm and a steering algorithm, which uses differential steering and sensor data to determine the direction of steering. The paper emphasizes the significance of fire-fighting robots in protecting people's lives and property in complex environments.

Ma Zhenming, Li Deliang [8] present the Suspension System Design of All-terrain Firefighting Robot The paper proposes a single longitudinal arm suspension structure for a fire-fighting robot, which has good adaptability to the ground. The suspension structure consists of a shock absorber, ball cage coupling, and cradle, which allows the robot to absorb impact energy and climb obstacles. The research group has carried out a lot of simulation and analysis on the cradle of the most important component of the single longitudinal arm suspension pendulum type mechanism. The work is supported by the national key research and development project during the 13th Five-Year. The paper includes references to related research on suspension systems for all-terrain vehicles and robots.

Ya-zhou Jia, Ji-shun Li, [9] present the Design and Research of Small Crawler Fire Fighting Robot. The document discusses the development and research of a small crawler fire-fighting robot. The importance of fire-fighting robots in harsh environments is highlighted. The hardware composition and total plan design of the fire-fighting robot are detailed. The advantages of the crawler type walking mechanism are explained. The design of the fire-fighting robot carrying

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system, including the fire water cannon and visual monitoring system, is described. The conclusion emphasizes the high reliability and significance of the fire-fighting robot in disaster scenes.

Anantha Raj P , Srivani M [10] present the Internet of Robotic Things Based Autonomous Fire Fighting Mobile Robot. The document discusses the development of intelligent systems and robots for fire detection and extinguishing. It covers the use of mobile robots for dynamic environment handling, path planning, and obstacle detection. The system architecture involves nodes with microcontrollers and sensors to detect fire, and a coordinator unit to connect all nodes and the mobile robot. The hardware requirements for the robot design include a mobile robot chassis, Raspberry Pi, DC motors, and various sensors. The discussion emphasizes the importance of safety and security, and the potential integration of machine learning and computer vision frameworks for increased performance accuracy.

Elizabeth Baum, Mario Harper [11] present the Sound Identification for Fire-Fighting Mobile Robots. A structure engulfed in flames poses a danger for fire-fighting personnel and trapped individuals. Robots need to operate in low visibility conditions and comply with domain-specific issues. An audio classification algorithm was developed to identify sounds relevant to fire-fighting. The algorithm uses Mel-spectrogram, Mel-Frequency Cepstral Coefficients (MFCC), chroma-stft, octave-based spectral contrasts, and tonal centroids. The dataset for the algorithm was constructed from various sources including the UrbanSound8K dataset, Freesound.org, and FreeSoundEffects.org. The outputs of the classifier are used as alerts for the fire-fighter or to modify the configuration of the robot's behavior. The robot performs specific behaviors upon detecting sounds of interest, such as searching for distressed humans or reducing speed in areas with multiple relaxed humans. The robot increases its speed of motion and takes other actions upon detecting the sound of a nearby fire.

Mukul Diwanji, Saurabh Hisvankar [12] present the Autonomous Fire Detecting and Extinguishing Robot. This paper examines the potential of automation in firefighting. The Fire Fighting Robot is designed to find the location of fire and reduce the risk of injury to victims. The development of the robot is divided into three elements: hardware, electronic, and programming. The robot uses various sensors and Arduino Uno board for programming. The methodology includes mechanical structure, hardware, and programming. The robot is powered by Arduino Uno board and uses flame sensors for fire detection. The working concept involves detecting fire and extinguishing it using water spray. The robot has limitations in terms of distance and terrain. Further improvements can be made by adding ultrasonic sensor, gas sensor, and smoke sensor.

V. CONCLUSION

The Fire Fighting Robot Paper represents a significant advancement in the realm of automated emergency response systems. By integrating the fire detection, fire extinguisher, communication modules the paper aims to enhance the efficiency and effectiveness of firefighting operations. The implementation of a robotic platform equipped with fire detection module and the ability to navigate through challenging environments allows for rapid and precise identification of fire incidents. The incorporation of SMS and call alert of communication module features adds an extra layer of real-time communication, enabling quick response and coordination among emergency personnel. This innovative solution addresses the limitations of traditional firefighting methods, particularly in scenarios where human intervention may be delayed or restricted. The autonomous nature of the robot reduces the risk to human lives and provides a swift response to mitigate potential damages caused by fires. In essence, the Fire Fighting Robot with SMS & Call Alert paper stands as a testament to the transformative power of technology in enhancing the capabilities of emergency services, ultimately contributing to the safety and well-being of communities.

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