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ADVANCED FIRE FIGHTING ROBOT USING ESP32 MICROCONTROLLER

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ABSTRACT
Fire fighting robot primarily focuses on the development of an advanced, semi-automatic and an efficient fire Fighting system. This autonomous robot is integrated Firefighting robot primarily focuses on the development of an advanced, semi-automatic and an efficient fire Fighting system. This autonomous robot is integrated the the cutting-edge sensor technology to not only detect fires but also analyze their intensity. The design of this robot incorporates intelligent control of moves in defined directions depending on the speed and the fire intensity of the movements. A built-in water pump is used for efficient and targeted extinguishing of fires. In addition to its main fire-fighting functions, the robot has a GSM alert system that sends real time notification to predetermined personnel or the registered mobile number (including the fire station). In addition to this, an integrated buzzer alarm sounds when fire is detected in order to immediately alert those who are near the surrounding areas of danger. This combination of notification and local alarm makes the robot's functionality much improved and contributes significantly to the rapid response and control of fire related damage and fire. This can also be operated manually using Bluetooth through mobile, which can be controlled and sprays water in the direction which fire was spread.
KEYWORDS: ESP32 Microcontroller, Flame sensors, Fire detection, GSM Alert system, Rechargeable batteries HC 05 module and flame suppression.

INTRODUCTION:
Fire accidents are a serious threat to our lives, our belongings and the environment, often leading to devastating consequences. Traditional fire Fighting. Conventional fire Fighting techniques expose human fire Fighters to the dangers of heat, harmful smoke, and hazards. This is the rationale for intelligent, autonomous fire extinguishing systems. These systems must be capable of Fighting fires in real time and as an early warning system. To tackle this problem, we created an autonomous robot powered by ESP32 technology that can quickly detect and put out fires before they have a chance to spread. This robot features an intelligent control system that makes real-time decisions, adjusting its actions as the fire evolves. Project study offers an advanced Fire-fighting robot that uses ESP32 technology to improve control and communication capabilities. The ESP32 microcontroller manages sensor inputs, acts as an actuator controller, and enables wireless communication. The modified water pump system enables precise and efficient flame extinguishing. Because of its clever design, the robot can measure the intensity of fire while moving and adjust its speed to control its movements in that direction. It possesses flame detectors, motorized wheels, and a servo-driven water nozzle, supported by a water pump for efficient fire extinguishing. A GSM module provides real-time SMS notification to specific numbers, and a high-intensity alarm notifies people to evacuate the area. The robot comes

with a buzzer, a water pump system for flame suppression, a GSM alert mechanism for remote notifications, an alarm for locally visible warnings, and manual operation with HC-05 Bluetooth connectivity. Solar panels monitor the battery status to ensure it functions at all times, and there is manual control in the event of a malfunction, making it a secure solution for various locations.

OBJECTIVES:

The key objectives of this project are:

- Fire Detection and Localization
- Autonomous Navigation
- Fire Suppression
- Energy Efficiency
- Safety Protocols
- Data Logging and Analysis
- Quick Setup and Flexibility

LITERATURE REVIEW:

The ESP32 Micro-controller-based fire Fighting robot works on the automatic fire detection and fire suppression by water spraying mechanisms. In addition to these, the system also gives an SMS alert to the registered personnel along with the buzzer alert to the surrounding areas. This system also features solar charging of the batteries used.

"Internet of Robotic things based autonomous fire Fighting robot" by Anantha Raj,P.,& Srivani,M., illustrated the basic concepts of the project which included the design of an autonomous mobile robot along with the fire Fighting technique using Io Rt technique [1].

Title: "Fire Fighting Robot "by Rutuja Parshetti, Miss. Shruti Burbure, Miss. Shrutika Chavan, Miss. Vijayalaxmi Tamshetti, and Miss. Pradnya deals with the recent advancements and technologies in Robotics, AI and sensor technologies which enables the robot to navigate easily through the fire accidents, buildings prone to accidents and others. This also discusses with the advantages and the robotic potential to handle fire, suppress it and save the damage of various equipment.

This gave the economic and environmental impact. This paper shows that the continuous working capability of a fire Fighting robot increases its efficiency [2].

Headed as "An autonomous Fire-fighting robot" by A. Hassanein, M. Elhawary, N. Jaber and M. El-Abd the system of vehicle mobility is discussed and the basic methodology of the construction, flame detection and the fire suppression techniques with various classes of fire are detailed [3].

This paper titled "An automated fire Fighting robot" by Asif Liyakat Shaikh, Sushil Jotiram Shinde, Sarika Gaikwad tells the compactness of the robot to able to get into smaller areas to prevent the fire from being spread into a larger area. This tells about the ability to be operated remotely for distances beyond certain limits and can autonomously detect fire for the distances within the range of sensors [4].

"The intelligent fire Fighting tank robot" by Kristi Kosasih, E. Merry Sartika, M. Jimmy Hasugian and Dan Muliady dealt with the general building and development of an autonomous fire Fighting robot. It has an integrated feature of carrying a tank of water suppressing agents such as water, C02 gas etc. This tells the importance of the system to be able to navigate through the places along with the tank [5].

"Design and Fabrication of an Autonomous Fire Fighting Robot with Multi sensor Fire Detection Using PID Controller" by Tawfiqur Raki and M.A. Rashid sarkar gives a clear view of the multi sensor integration to the system in order to improve the response time of the vehicle and it also useful in detecting the harm of fire and the intensity of fire. This helps the robot to choose the direction to be navigated to [6].

"General Application Research on GSM Module" by Ma Yuchun, Huang Yinghong and Zhang Kun, Li Zhuang depicts that GSM is the most worldwide communication network now a days. This is used to send and read SMS, send SMS to a group of users all at one go. This allows the system to alert the corresponding owner of the site or the equipment to take further actions after being alerted with the SMS notification [7].

"Communication Security in GSM Networks," by "P. Bouška and M. Drahanský, stated the theme of securing GSM connections with a number of features that included Subscriber Identity Confidentiality, authentication, Encryption and other privacy considerations [8].

"Solar powered battery charging system with maximum power point tracking" by V. vanitha and N. Ramesh shows the environmentally friendly solar based charging system for batteries and battery propelling systems such as Electric vehicles, trains and trams etc..,[9].

"Fire Fighting robot" by Ms Devi. P, Kumaravel. H, Nakul. R, Kavin Kumar TR gives the idea of operating the robot with a blue tooth module using a mobile application to control the vehicle [10].

METHODOLGY:

Several parts are combined in the Fire-fighting robot project to produce an autonomous system that can identify fires, find their origin, and put out the flames. For certain correct operation, the hardware configuration—which consists of flame sensors, motors, a water pump, and a GSM module—is meticulously designed with exact pin assignments for Bluetooth. In order to improve fire safety and response, this Fire-fighting robot paper introduces a sophisticated, self-governing Fire-fighting robot. It makes use of sensors, algorithms, and ESP32 technology to detect and put out fires quickly. The robot uses a water pump for effective extinguishing, evaluates the intensity of the fire, and navigates with intelligence. Fast notification is ensured by two alerts (a buzzer and GSM). Manual operation is possible with a remote Bluetooth control. By managing fires more quickly and effectively, the system wants to reduce damage and save lives. Upcoming improvements

As per the detailed in Fire-fighting robot project gives outlines an autonomous Fire-fighting robot built around an ESP32 microcontroller, which serves as the central processing unit. The robot utilizes flame sensors to detect fire intensity and direction within the 760nm-1100nm wavelength range. An L289N dual H-bridge motor driver facilitates navigation, while an SG90 servo motor allows for precise targeting of the fire with a suppressing agent. A 5V four-channel relay module acts as an electrical switch for controlling various components, including a water pump and the robot's motors. Power is provided by a series of 18650 batteries, rechargeable via a solar panel. DC motors enable movement and other functions. A GSM800L module enables remote communication through SMS alerts, and an HC-05 Bluetooth module, integrated using an Arduino UNO, allows for remote control and navigation, expanding the robot's operational range.

The Fire-fighting robot's code is divided into multiple important sections, each of which is in charge of a distinct function, such as sending SMS notifications, reading sensor values, controlling motors, and spraying water. Robots used for Fighting fires and robotics in general are programmed in C++. Because C++ is a compiled language, it usually performs more quickly than interpreted languages like Python.

The microcontroller processes analog signals from the sensors to determine fire severity and intensity, enabling navigation and suppression actions. Designed for rapid response, the robot aims to minimize fire spread, and it incorporates a buzzer to alert surrounding areas upon fire detection. The robot incorporates a GSM800L module to enable real-time communication, sending SMS alerts to designated personnel upon fire detection. This module, requiring an external antenna for reliable communication, is connected to the microcontroller, triggering alerts when fire is sensed. Additionally, the robot utilizes a dual one bidirectional bridge to facilitate precise wheel movement, allowing for forward, backward, left, and right motion.

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This motor control system enables the robot to navigate effectively, particularly in confined spaces, enhancing its overall performance and safety. For efficient suppression of fire, the robot uses a servo motor to precisely aim water spray nozzles. The 180-degree fire detection provided by three flame sensors allows the robot to Figure out the fire's intensity and adjust the nozzle accordingly. The robot's batteries are also recharged by two 5V solar panels that are connected in series to produce 10V. An Arduino UNO is used to integrate an HC-05 Bluetooth module to increase its operational range, especially in regions that are inaccessible to the flame sensor. Remote navigation is made possible by this configuration, which improves the robot's performance and adaptability in difficult situations.

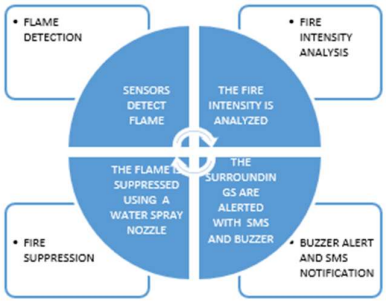
Considering all the aspects from the references and the methodologies so involved, this project is an integration of the ESP32 micro controller technology to control the robot and this serves as the main part of the robot. In addition to the ESP32 technology, the robot is equipped with flame sensors to detect and sense the flame. This sensor detects the intensity of the flame and allows for the robotic navigation. The water is sprayed in the navigated direction.

The robot is also connected to solar panels which are connected in series and contribute for the recharging of batteries whenever needed. It sends an SMS alert to the registered personnel after the fire detection. This not only sends the SMS but also alerts the surroundings with a buzzer.

In addition to this, the robot has an additional feature of remote controlling with a blue tooth module. The overview of this project shows an effective, economic and efficient fire Fighting robot that is very essential in the sudden disasters such as fire accidents and forest fires.

Fig 1 diagram of the fire Fighting robot actions

The above Figure i.e Fig 1, shows the cyclic diagram of the robotic actions. These actions include flame detection, the analysis of the fire intensity, sending alert SMS and the buzzer signals and flame suppression using water sprayer.



TESTING AND EVALUATION:

Flame detection**:** The detection of flame by using high quality sensors and the output is an analog signal.

Flame suppression: The detected flame is suppressed with a high-power water sprayer that acts upon the action of relay. Every action of the system is carried out by the heart of the robot, which is the ESP32 microcontroller. It analyses the fire intensity, helps in the navigating direction of the robot and helps for an efficient operation of the robot. The construction of the robot is as shown in Fig 2.

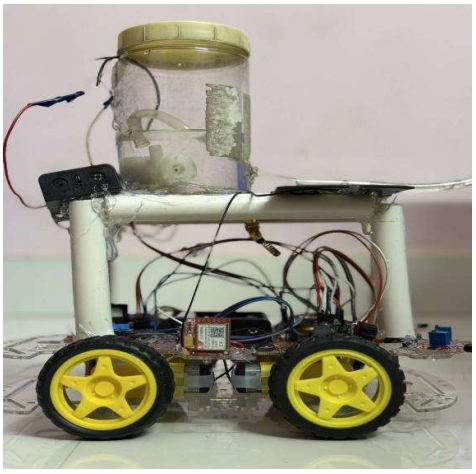


Fig 2 fire Fighting robot

SMS alert: An alert message is sent to the registered mobile number as soon as the flame is detected by the flame sensor. This is sent via a GSM module that transmits signals and sends an SMS.
Buzzer: An integrated buzzer gives alerting sound which is useful in warning the surroundings and people out of sight in case of smoky areas.
Solar charging: The robot is enabled with 2 solar panels connected in series. This helps for the recharge of batteries in case of complete discharge.
Bluetooth control: The robot is designed in such a way that it is able to control the robot navigation using Bluetooth module. This feature helps for easy and effective performance of the robot.

CONCLUSION :

The Fire-fighting robot project combines many components to make an autonomous system that can detect fires, navigate to the source and extinguish the flames. Through the utilize of ESP32-powered extinguishing mechanisms, smart control algorithms, and modern sensor systems, this robotic solution offers an active, intelligent, and effective fire management system that reduces fire damage efficiently and rapidly. The Fire-fighting Robot Project fully shows our design and deployment of an advanced, autonomous Fire-fighting robot that claims to advance quick-response technology and fire safety.
The hardware setup which includes flame sensors, motors, water pump and GSM module, Bluetooth is well structured with specific pin assignments to work properly. This paper presents an advanced autonomous Fire-fighting robot to enhance fire safety and response. It uses ESP32, sensors and algorithms for fast fire detection and suppression. The robot analyses fire intensity, navigates smartly and uses water pump for efficient extinguishing. Dual alerts (GSM and buzzer) for quick notification. Remote Bluetooth control for manual operation. The system aims to minimize damage and save lives through faster and efficient fire management. Future updates will include remote power monitoring and smart solar charging. Overall, the system integrates sensors, actuators and communication components to make a responsive autonomous Fire-fighting robot to provide safety and assistance in fire emergencies.

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