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Autonomous Vehicle for Fire Detecting and Extinguishing

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autonomous rover system. Leveraging fire sensors integrated with a node MCU, the system swiftly identifies fire outbreaks and transmits alerts to the rover via the ThingSpeak cloud platform. Upon receipt of the alert, the rover activates a buzzer for immediate local notification and dispatches alerts through a dedicated mobile application, ensuring rapid response from relevant personnel. Employing a line follower mechanism, the rover autonomously navigates towards the fire-affected area. Equipped with a water spraying system, the rover efficiently extinguishes flames, minimizing water wastage and enhancing firefighting effectiveness. This approach significantly reduces response time, enhancing safety across diverse environments. The system's ability to optimize resource utilization and automate firefighting procedures makes it adaptable to various settings, including industrial facilities, urban areas, and remote locations. Overall, our autonomous rover system represents a substantial advancement in firefighting technology, offering swift and efficient fire detection and extinguishing capabilities to mitigate fire hazards effectively.

***Keywords*— NodeMCU, Rover, Flame Sensors, Servomotor, L293d motor drivers, Li-ion batteries**

I.INTRODUCTION

Fire outbreaks pose significant threats to lives, properties, and the environment, necessitating the development of advanced fire detection and extinguishing systems[3]. Traditional firefighting methods often rely on manual intervention, leading to delayed response times and increased risks. In recent years, technological advancements have paved the way for the integration of autonomous systems in firefighting operations, offering enhanced efficiency and effectiveness in combating fires.Our project addresses this critical need by proposing an autonomous rover system designed for fire detection and extinguishing. With the increasing prevalence of Internet of Things (IoT) technology and cloud computing, there's a growing interest in leveraging these advancements to develop intelligent firefighting solutions. The integration of sensors, cloud platforms, and autonomous vehicles presents a promising approach to improving fire safety measures.

The core of our proposed system lies in the utilization of a node MCU equipped with specialized fire sensors. These detection of a fire, the node MCU promptly transmits an alert signal to an autonomous rover stationed within the vicinity. This communication is facilitated through the ThingSpeak cloud platform, ensuring real-time data exchange and seamless integration between the sensors and the rover.

In addition to alerting the rover, the system also incorporates local notification mechanisms to raise awareness among nearby individuals[4]. A buzzer activation accompanies the alert signal, providing an audible warning to alert personnel in the vicinity of the fire. Furthermore, notifications are dispatched through a dedicated mobile application, enabling remote stakeholders to be informed of the situation and initiate appropriate responses.

II. METHODOLOGY

The methodology can be divided into three parts namely mechanical structure, hardware and programming [7].

A. Mechanical Structure :

The mechanical structure of the autonomousvehiclefor fire detection and extinguishing consists of a sturdy chassis made from lightweight yet durable materials such as aluminum or carbon fiber. This chassis supports two large rear wheels for propulsion and a front castor wheel for stability and maneuverability. Fire sensors are mounted on the front section of the vehicle to detect fire outbreaks, while a water spraying mechanism, connected to a centrally positioned water tank, is integrated to extinguish fires upon detection. A line follower system guides the vehicle autonomously towards the fire area, and a buzzer provides audible alerts upon fire detection. Communication components enable data transmission to a cloud platform and mobile app. Additionally, protective enclosures shield sensitive electronic components, while overall ergonomics and aesthetics prioritize user-friendliness and visual appeal[7].

B. Hardware:

The hardware used is ESP8266(NodeMCU), L293D Motor Driver Module, DC geared motors, 12V DC pump, Servo Motor SG90, IR based Flame Sensors, 3.7V Li-ion

batteries, water pump, water spraying container

C. Programming:

For programming the control of the robot for mobility and fire detection and extinguishing, Arduino IDE is used. The Algorithm for the source code is given below

III.BLOCK DIAGRAM AND COMPONENTS EXPLANATION

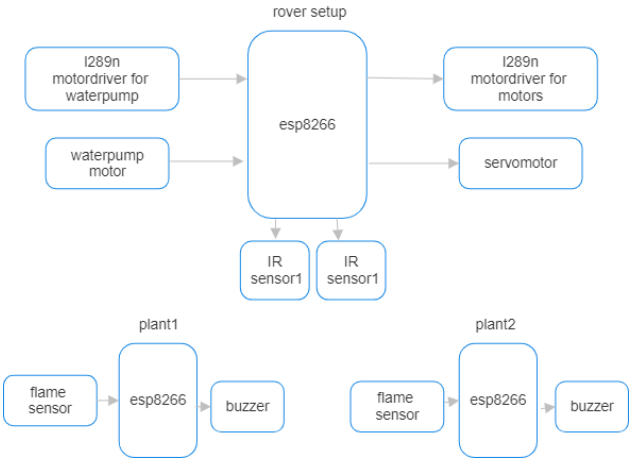

Figure 1. Block diagram

A.ESP8266(NODE MCU):

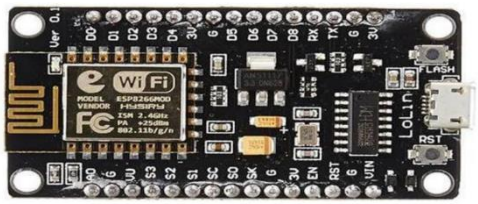

Figure 2.ESP8266

The ESP8266 is a powerful and versatile Wi-Fi module that has gained immense popularity in the world of electronics and IoT (Internet of Things) projects. Equipped with GPIO (General Purpose Input/Output) pins, the ESP8266 allows for seamless integration with various sensors, actuators, and other peripherals, making it ideal for a wide range of applications. These pins enable the ESP8266 to communicate with other digital devices, read sensor data, control outputs, and even interface with displays or other communication protocols. With its low cost, small form factor, and easy programmability, the ESP8266 has become a staple in DIY electronics and professional projects alike, empowering creators to bring their ideas to life with ease. Whether you're building a smart home device, a weather station, or a remote-controlled gadget, the ESP8266's pins provide the flexibility and connectivity needed to make it happen. In addition to its GPIO pins, the ESP8266 also features other essential capabilities that enhance its functionality. It boasts built-in Wi-Fi connectivity, allowing seamless integration into wireless networks for remote monitoring, data logging, and control applications. Moreover, its onboard processing power and memory enable it to run complex algorithms and handle data processing tasks efficiently. With support for various programming languages and development environments like Arduino and MicroPython, the ESP8266 offers a user-friendly platform for both beginners and experienced developers to create innovative IoT solutions. Its popularity has led to a vibrant community of enthusiasts who continually contribute libraries, tutorials, and projects, further expanding its capabilities and potential applications. Overall, the ESP8266 with its pins is a versatile and cost-effective solution for powering a diverse range of IoT projects, from home automation and environmental monitoring to industrial automation and beyond.

B .FlameSensor:

Figure 3.FlameSensor

A flame sensor is a crucial component in fire detection and safety systems, designed to detect the presence of flames or fire. It works by detecting the infrared radiation emitted by flames, allowing it to swiftly identify the onset of a fire even in low-light conditions. Typically, a flame sensor consists of a photodetector that converts infrared light into an electrical signal, which is then processed by a control unit. This signal triggers an alarm or activates safety protocols to mitigate the risk of fire damage or injuries.

C .Servomotor:

Figure 4.Servomotor

A servo motor is a type of rotary actuator that allows precise control of angular position, velocity, and acceleration. It consists of a motor coupled with a feedback mechanism, typically a potentiometer or an encoder, which provides information about the motor's current position. This feedback loop enables the servo motor to accurately maintain its position even under varying loads or external disturbances. The operation of a servo motor is controlled by sending it a PWM (Pulse Width Modulation) signal, which determines the desired position or velocity. The servo motor then adjusts its output shaft accordingly to reach and maintain the specified position. By varying the width of the PWM signal, the desired position or speed of the servo motor can be finely adjusted.

Servo motors come in different sizes and power ratings to suit various applications.

D.L289n Motor Driver:

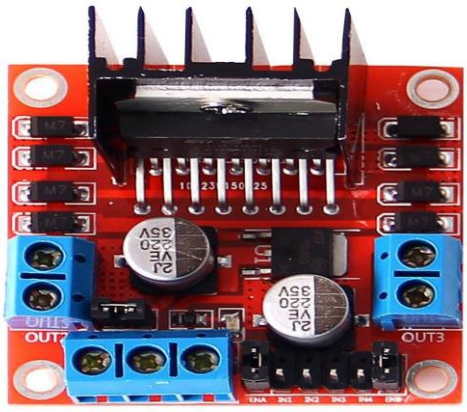

Figure 5.L289n Motor Driver

The L298N motor driver is a versatile and widely-used integrated circuit renowned for its robustness and efficiency in driving DC motors and stepper motors. Equipped with dual H-bridge circuits, it can effectively control the speed and direction of two motors independently. With a maximum operating voltage of 46V and a peak current of 2A per bridge, this driver is suitable for a wide range of applications, from small robotics projects to larger industrial systems. Its built-in protection features such as thermal shutdown and overcurrent detection ensure reliable operation under various conditions. Additionally, its straightforward interfacing and compatibility with microcontrollers make it a preferred choice for hobbyists and professionals alike in the realm of electromechanical control systems.
Furthermore, the L298N's convenient pinout layout simplifies connection to microcontrollers and external control circuits, enhancing its versatility and ease of use. Its robust design and built-in diodes for freewheeling protection contribute to its reliability in demanding applications, ensuring stable motor operation over extended periods. With its wide adoption and ample documentation available, the L298N remains a go-to choice for engineers and hobbyists seeking a reliable motor control solution.

E.Buzzer:

Figure 6.Buzzer

Buzzer, a common electromechanical component, serves various purposes across different applications. It produces audible alerts or tones through the vibration of a piezoelectric element when an electric current passes through it. Available in various sizes and configurations, buzzers range from simple passive components emitting a single tone to more complex ones with integrated circuitry for generating different frequencies and patterns. Commonly used in alarm systems, timers, and electronic devices, buzzers provide essential auditory feedback in scenarios where visual cues may be insufficient or impractical. Their simplicity, low cost, and reliability make them indispensable in numerous everyday and industrial applications.

In conclusion, the autonomous vehicle designed for fire detection and extinguishing incorporates a meticulously engineered mechanical structure to ensure optimal performance and reliability in firefighting operations. The chassis, crafted from lightweight yet durable materials

such as aluminum or carbon fiber, provides a robust foundation for the vehicle, supporting its propulsion and stability systems. Two large rear wheels, coupled with a front castor wheel, facilitate smooth movement and maneuverability across various terrains. The integration of fire sensors on the front section enables early detection of fire outbreaks, while a centrally positioned water tank supplies water for extinguishing fires through a spraying mechanism. A line follower system guides the vehicle autonomously towards fire-affected areas, while a buzzer provides audible alerts upon fire detection. Communication components enable seamless data transmission to a cloud platform and mobile app for real-time monitoring and alerting. Additionally, protective enclosures safeguard sensitive electronic components from environmental factors, ensuring operational integrity. Overall, the careful selection and integration of materials in the mechanical structure contribute to the effectiveness and efficiency of the autonomous firefighting vehicle, enhancing safety and mitigating fire hazards in diverse environments.

IV.FLOW CHART AND EXPLANATION

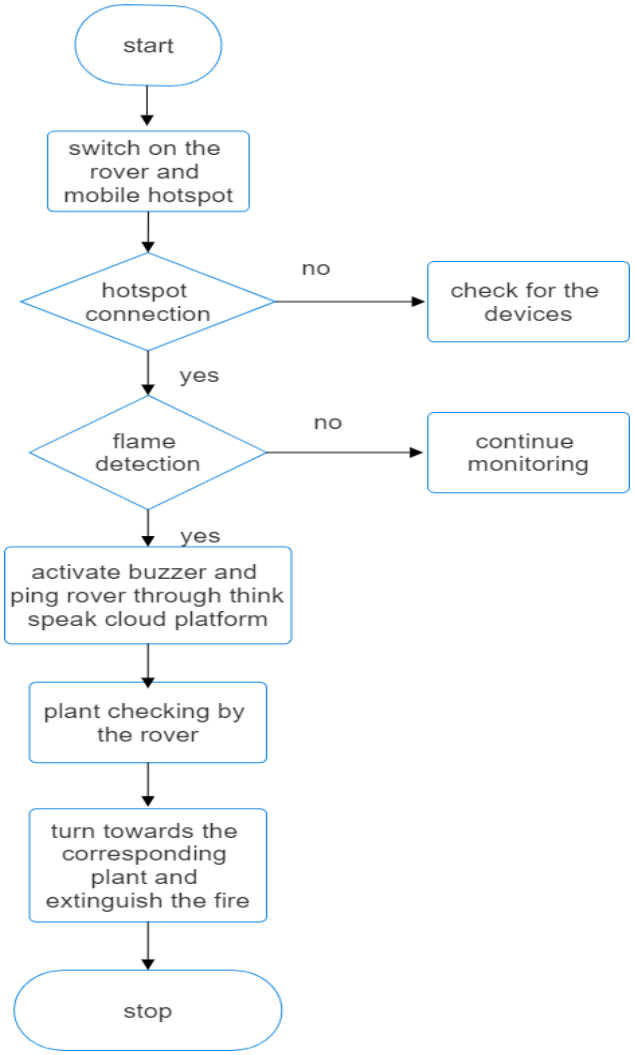

Figure 7.Flow chart

The flowchart outlines the process of initiating the rover and mobile hotspot, ensuring all three NodeMCUs are connected to the hotspot. Upon flame detection, a buzzer is activated, and a message is sent to the rover via ThingSpeak. Depending on whether the message indicates Plant 1 or Plant 2, the rover moves to the corresponding destination, activating the pump and spraying water to nurture the plants.

A. Rover Description

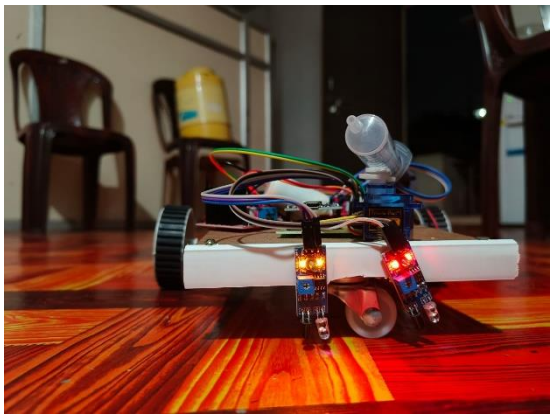

Figure 8. Circuit Description

The IR sensors namely the left IR and right IR sensor and the servo motor are given Vcc and Gnd commonly. The input pins of the IR sensors are connected to digital pins D5,D6 of esp8266.The PWM pin of the servomotor SG90 is also connected to the D8 pin of esp8266.The pins of IN1, IN2, IN3 and IN4 respectively of the L293D Motor Driver Module are also connected to D0,D1,D2,D3. The OUT1, OUT2, OUT3 and OUT4 pins of the Motor Driver Module are connected to the Left and the Right DC motor respectively.
Another L293D motor driver is used for pumping water. OUT1,OUT2 pins are given to motor pump and IN1,IN3 are connected to D7,GND

V. ALGORITHM

Following steps are followed for the programming of the robot to detect and extinguish fire

1.Start
2.Switch on the rover and mobile hotspot
3.if hotspot is not connected, check for the devices
4.if hotspot is connected now start monitoring the area for flame
5.if flame is not detected, continue the process of monitoring
6.if flame is detected , then activate buzzer and ping rover through think speak cloud platform
7.Now check for the plant to which rover should move
8.Turn towards the corresponding plant and extinguish fire
9.Stop

V. WORKING CONCEPT

The vital component of this robot is Esp8266(NodeMCU),but for sensing the line follower the rover is built with IR Sensor Module, the rover is shown below

A. Working

Firstly, the system is instructed to power up the rover and activate the mobile hotspot, laying the foundation for seamless communication and data transmission. Subsequently, a thorough check is conducted to ascertain the status of the hotspot connection. If the system successfully establishes a connection, it progresses to the critical phase of flame detection, marking a pivotal moment in the operational sequence. Conversely, in the event of a failed connection, the system promptly shifts focus towards troubleshooting and examining the connectivity of associated devices, ensuring no stone is left unturned in the pursuit of a stable network connection. This meticulous approach underscores the system's commitment to robust communication infrastructure, essential for real-time monitoring and response mechanisms.

In parallel, the flame detection process unfolds with precision and vigilance, leveraging sophisticated sensors and algorithms to identify any signs of combustion within the monitored area. Should the system detect the presence of a flame, it initiates a swift and decisive response, signaling the rover to transmit pertinent data through the ThinkSpeak Cloud Platform.

Figure 9.Message to the mobile phone fire Occurred from plant1

After sending message to the mobile phone through an app the rover also receives the message and it moves towards the plant1 till the location reaches and therefore,after going there the motor pump and the servo motor gets on and through the silicon pipe the water flows and sprinkles on fire occurring place with the help of servomotor which slows moves from left to right and the buzzer also ring along with the water flow So that the concerned people can take immediate action and take further steps in order to extinguish the fire in an appropriate way

Figure 10.Message to the mobile phone fire Occurred from plant2

After sending message to the mobile phone through an app the rover also receives the message and it moves towards the plant1 till the location reaches and therefore,after going there the motor pump and the servo motor gets on and through the silicon pipe the water flows and sprinkles on fire occurring place with the help of servomotor which slows moves from left to right and the buzzer also ring along with the water flow So that the concerned people can take immediate action and take further steps in order to extinguish the fire in an appropriate way

This seamless integration of detection and response mechanisms underscores the system's adaptability and efficiency in mitigating potential fire hazards. Moreover, the rover is mobilized to navigate towards the location of the detected flame, where it promptly engages in firefighting efforts, safeguarding the surrounding environment from the threat of escalating fires. This proactive approach exemplifies the system's capability to not only detect but also autonomously respond to emergent situations, ensuring the safety and security of the monitored area.

VI. ANALYSIS

The main purpose was to develop a prototype robot, which underwent iterative modifications in both design and code to achieve the desired functionality. Through a series of trials, adjustments were made to the robot's sensors to optimize their effectiveness in detecting fires at varying distances. Initially designed for use in flat terrain, where sensor performance remained optimal, further enhancements were implemented

to enable the robot to operate effectively in challenging and rugged environments. This evolution highlights the adaptability and versatility of the robot, transforming it from a specialized tool for specific conditions to a capable asset capable of navigating diverse terrains and addressing a broader range of firefighting scenarios.

VII. SCOPE AND LIMITATIONS

This research is about making a prototype robot that can detect and put out fires. We can make it better by adding GSM and GPS to the ESP8266(NodeMCU). With GSM, the robot can text the nearest fire station its location from GPS. The flame sensors can't detect fires from far away, and the robot can only spray water within 50 to 60 centimeters. Also, it might struggle in rough landscapes. This robot is best for homes because of how it's built[6].

VIII. CONCLUSION

The prototype met its goals, but it does have some limitations, as we mentioned earlier. However, when the conditions are right, it works smoothly without any problems. By adding more features like ultrasonic sensors, gas sensors, a display, GPS, and GSM modules, we can make the robot usable in real-life situations[7].

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