IoT-based Unmanned Ground Vehicle for Firefighting Applications

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Abstract **This paper deals with developing an unmanned fire extinguishing robot with an SMS alert feature. The firefighting robot with SMS alert contributes to the field of fire safety by providing an efficient and proactive approach to detecting and suppressing fires. The robot is equipped with a sensor that detects CO levels in that affected area and in addition it can detect other poisonous gases in the area under surveillance. One can also estimate the quality of gas in that affected area using this. The air quality can be detected and done onboard, while the flame sensor alongside a smoke sensor is used to detect the fire. MATLAB is the simulation tool used. This firefighting robot with an SMS alert presents an innovative solution for enhancing fire safety in indoor environments. By integrating autonomous fire detection, navigation, fire suppression mechanisms, and real-time SMS alerts the robot improves response time and minimizes risks associated with fire incidents.**

Keywords —Flame Sensor, IoT, MQ7 Sensor, Node MCU, Robocar Kit, Simulink

I. INTRODUCTION

Disasters like fires have the potential to cause property and human casualties. Although fighting fires is their primary responsibility, firefighters frequently face significant risks when putting out fires. Unmanned fire extinguishing is a solution to this problem; it automatically places extinguishing duties as soon as it detects a flame and sends out an SMS notice as soon as the incident occurs. To provide a much safer atmosphere for rescue operations, the data about atmospheric CO levels is also sent to the appropriate higher authorities. Technological advancements can help firefighting because fire extinguishment procedures have high barriers and risks [1]. A novel approach to autonomous extinguishing of indoor fires inside a building by a Micro-scale Unmanned Aerial Vehicle (MAV) is also implemented [2]. The reference [3] discusses a low-cost and highly versatile microcontroller used for various applications which include wireless communication, IoT (Internet of Things) devices, home automation, robotics, embedded systems, etc[5][6][8].

The goal of creating an autonomous firefighting robot is to protect the lives of firemen who are tasked with putting out fires and saving people inside buildings. The integration of CO level and timely SMS notifications improves project efficiency and contributes to a safer rescue operation environment.

This work intends to put in place an autonomous firefighting system to protect the lives of firefighters by spotting fires early on, putting them out, reporting incidents to higher authorities, and supplying information about the concentration of poisonous gases, particularly CO, which is thought to pose a serious threat to human life.

The creation of a system that can detect a flame in three forward directions and put out a fire using water from a reservoir is part of the work's scope. Along with detecting the flame, an instant SMS alarm is sent to higher authorities. Additional features can be added based on the fire factor, and different extinguishing components can be added based on the barriers the movement must overcome. Various featured movements can also be applied. Their main goal is to make firefighters safer by lowering their risk of fire occurrences.

The second section deals with the design of the proposed system along with the circuit diagram, hardware, and software requirements. The third section deals with the implementation and obtained results.

II. DESIGN OF THE PROPOSED SYSTEM

The LM293D motor driver, the gas sensor, and the flame sensor make up the three primary parts of the block diagram for the IoT-powered autonomous firefighting robot. It is seen in Figure 1. The flame sensor that is attached to the node MCU locates the source of the fire and provides the water pump with a digital signal. Using centrifugal force, this pump draws water from the reservoir and notifies the owner via phone.

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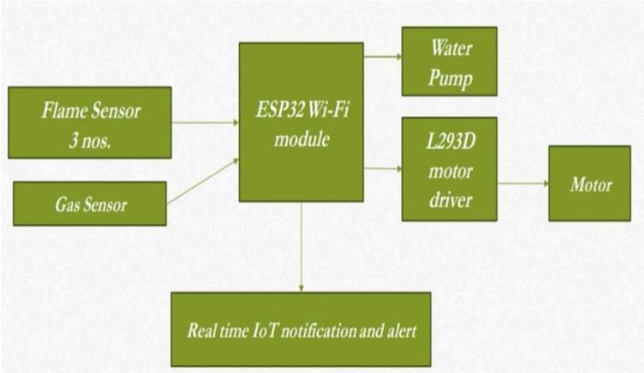

Figure 1 Block Diagram of Unmanned Ground Vehicle for Firefighting

In tandem, the LM293D motor driver is turned on, enabling DC motors to move in a direction detected by the flames to assist the robot's wheels. The owner receives a notice about the CO levels on their phone via the gas sensor, which is a CO level sensor connected to the Node MCU.

A. HARDWARE REQUIREMENTS

A pair of DC Gear Motors, motor wheels, universal castor and modules, four battery holders, and the necessary brackets, screws, and nuts are typically included in a robot car kit [9]. Eight pins on each side of the 16-pin L293D integrated circuit are used to operate a motor. Each motor has two INPUT pins, two OUTPUT pins, and one ENABLE pin. L293D has two H-bridges in it. The simplest circuit for managing a motor with a low current rating is the H-bridge. An 18650 battery has a 1200 mA capacity and is a Li-ion rechargeable battery. Up to 1000 cycles of charging and discharging an 18650 cell can be performed with little loss of battery capacity. They have a long battery life, are safe to use, and are beneficial to the environment.

This 18650 battery cell holder is designed to transport, store, and maintain your lithium-ion battery in an ideal, secure position. The plastic case has a single mounting hole in the middle that allows us to attach it to any surface with 3mm screws. The ESP32 is a single-chip, 40 nm TSMC super low power Wi-Fi and Bluetooth combination semiconductor. It operates at 2.4 GHz. The industry's most integrated Wi-Fi + Bluetooth solution, the ESP32 requires fewer than ten external components. Filters, power management modules, low noise receive amplifiers, power amplifiers, and antenna switcher balun are all included in the ESP32 [3][7][10].

As a result, the total solution takes up very little space on the printed circuit board (PCB). The ESP32 is intended for Internet of Things (IoT) and wearable electronics applications. It has several characteristics of the latest low-power devices, such as dynamic power scaling, power modes, and fine-resolution clock gating. The flame sensor measures wavelengths between 760 and 1100 nm from the light source to detect flame. The flame may be detected with a 600-degree detection angle and at a distance of 100 cm. This sensor produces either an analog or digital signal as its output.

The sensitivity of the MQ-7 gas sensor to carbon monoxide is high. The sensor is inexpensive, versatile, and capable of detecting a variety of gases including CO [4]. The MQ-7 CO Carbon Monoxide Coal Gas Sensor Module measures the amount of CO in the atmosphere and provides an analog voltage as a result.

B. SOFTWARE REQUIREMENTS

A block diagram environment for model-based design and multidomain simulation is called Simulink®. It facilitates continuous testing and verification of embedded systems, automatic code generation, simulation, and system-level design. When given a collection of inputs, a Simulink® function is a computational unit that determines a set of outputs.

III. IMPLEMENTATION AND RESULTS

The circuit shows how the signal is input to the MQ7 smoke sensor and flame sensors, which are then converted. The output is then received by the L293D motor drivers, which power the pumps and motors that spray water in the direction of the fire that has been detected. By tethering the registered device, an SMS alarm is sent to the appropriate authorities as soon as the sensors detect a flame. Using the parts included in the Robot Car kit, the vehicle is put together and connected. The robot automobile is equipped with three flame sensors and a MQ7 gas sensor.

The flame sensors are positioned in the middle of the vehicle, as well as to the right and left of the vehicle. The top surface of the robot car houses the main circuit, as shown in the circuit diagram. All of the components are connected to the ESP32 WROOM using jumper wires. In Figure 2, the circuit schematic is displayed.

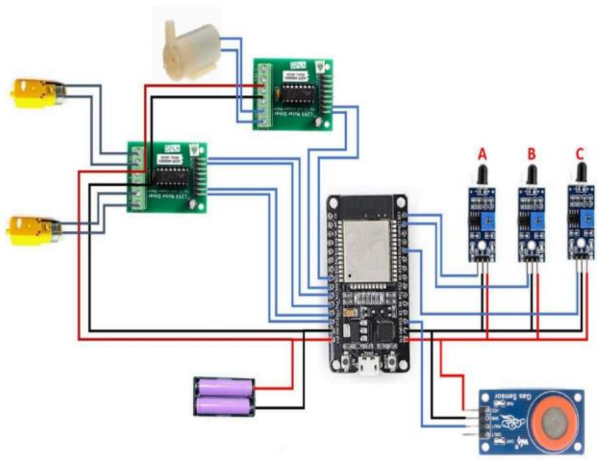

Figure 2 Circuit Diagram

The surface of the robot car also carries a small container with water where the water pump has a connection with the circuit. The mini water pump pumps water outwards

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whenever it detects fire through a pipe that is connected to the water pump.

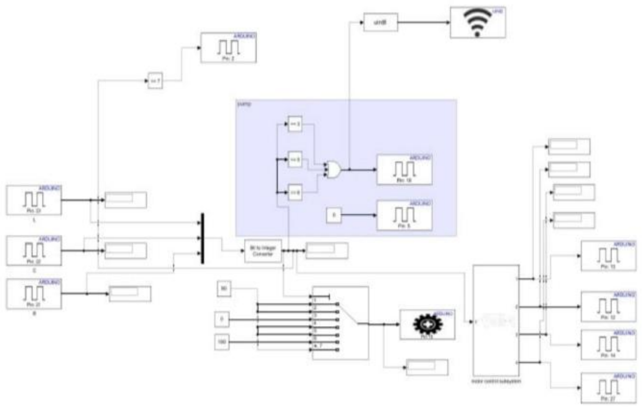

Fig. 3 Simulink Model

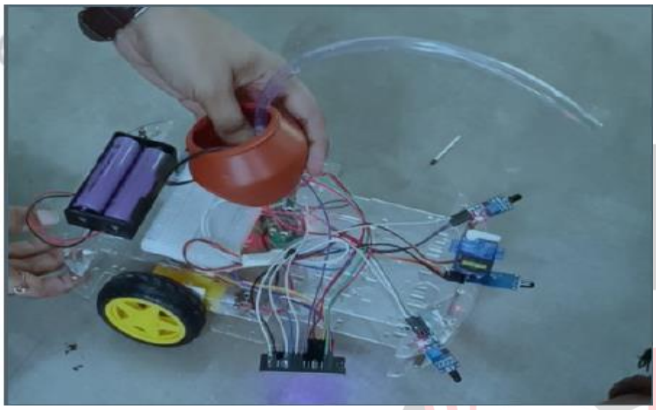

Fig. 4 Working Model of the Proposed System

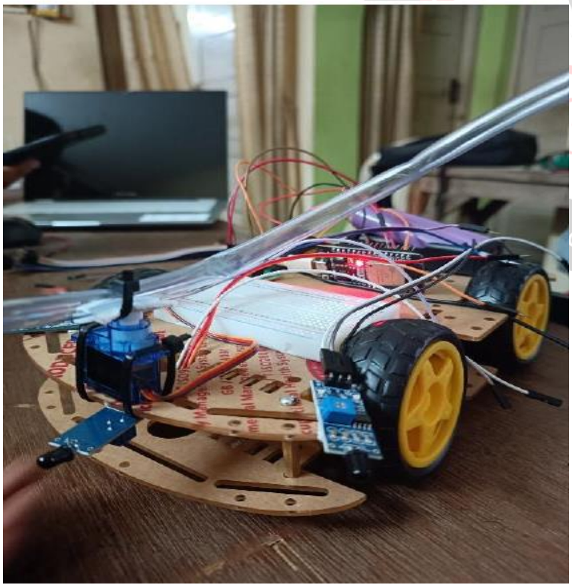

Fig. 5 Servo Motor Rotation

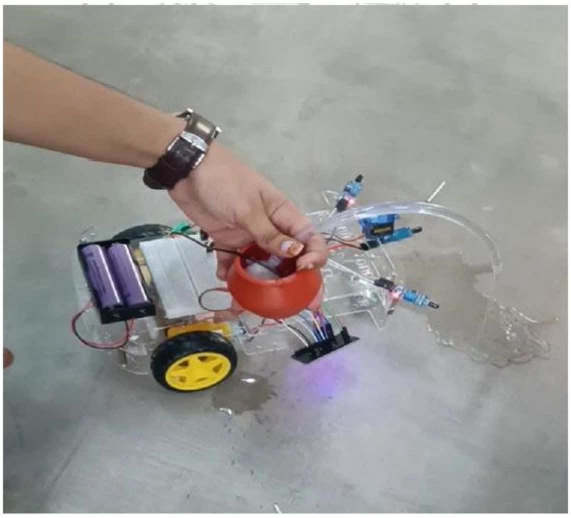

Fig. 6 Fire Extinguishing Using the Unmanned Vehicle

With its four wheels, the robot car—which is made up of a circuit and a water container—can travel in a direction that detects flames and shoots water through a water pipe in the direction of the fire. The circuit modeled in MATLAB is deployed into the ESP32 WROOM via a USB cable following each circuit connection and component assembly. The ESP32 WROOM, which has a MATLAB-modeled circuit deployed into it, receives information, or input, whenever the flame sensors are positioned in three distinct directions to detect flame. Figure 3 displays the Simulink deployment model.

The L293D motor drivers, which are attached to the robot wheel's shaft and the little water pump, will turn on as soon as the ESP board learns about the flame. When the motor driver is turned on, the pump and the robot wheel are also turned on. As a result, when a flame is detected, the robot car travels in the direction that is detected while the pump concurrently shoots water through the pipe to put out the fire. The circuit operates following the logic that was applied throughout the MATLAB Simulink circuit modeling process. The working model's various stages are seen in Figures 4, 5, and 6.

IV. CONCLUSIONS AND FUTURE SCOPE

An inventive way to improve the fire safety environment indoors is the autonomous firefighting robot with SMS alert and CO level alert project. The robot reduces fire incident risks and speeds up reaction times by combining autonomous fire detection, navigation, fire suppression systems, and real-time SMS warnings. All things considered, the firefighting robot with SMS alert advances the field of fire safety by offering a proactive and effective method of spotting and putting out flames. It is simpler to develop and implement with MATLAB Simulink.

The suggested idea can be expanded in the future by utilizing different types of sprinklers to automatically put

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out the fire according to the type of fire that happened. An extremely sophisticated variation of this autonomous firefighting robot is the wall-climbing robot. Additionally, based on the situation, one may be able to use their crawling ability for effective locomotion. An upgraded robot version may also provide additional IoT features.

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