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FIRE FIGHTING ROBOT WITH SMS AND CALL ALERT

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Abstract:

Fire incidents are among the most dangerous threats facing both human life and property along with the natural surroundings, and one of the major reasons for the increased losses associated with fires is the slow process of fire detection and fire extinguishing. This work describes the project of a Fire-Extinguishing Robot with SMS and Call Notification. It is a robot featuring a number of devices used for flame and smoke detection, autonomous movement, water-based extinguishing, and SMS notification through GSM. In particular, there are two basic mechanisms responsible for detecting fire: a flame detector and an MQ2 smoke detector. After detecting the fire, the robot will figure out the fire source thanks to the Arduimo Uno microcontroller and motor-driven robot movement. Once the robot arrives at the fire, the servomotor will activate fire nozzle and a water pump to extinguish the fire while the robot will also send an SMS and make a call by using the SIM800L GSM module. This work positions its design in the broader context of the literature of IoT and GSM-based fire-fighting research and mentions five articles relevant to this research with regards to emergency alert systems, GSM-controlled firefighting robots, NodeMCU systems, mesh fire alarm systems, and IoT-based surveillance robots. Based on this literature review, the work presents its design regarding hardware and software components, methods, modules, its functional parameters, strengths and weaknesses, and prospects of the project.

Keywords: Fire Fighting Robot, Internet of Things (IoT), Arduino UNO, Flame Sensor, MQ2 Smoke Sensor, GSM Communication, SIM800L, SMS Alert, Autonomous Navigation, Emergency Response System

1. INTRODUCTION

Fires are one of the biggest threats to human life and property, as well as to the environment. Conventional fire safety solutions (smoke detectors, fire extinguishers) present reactive systems, which recognize the fire threat, but demand the presence of a human being to act upon it. The impossibility of reaching the fire, the presence of poisonous gases that make it impossible for a person to enter the area, or the delay of a few seconds in extinguishing it become the biggest disadvantages of the traditional fire safety systems.

In view of advances in embedded systems, low cost sensors and machine-to-machine communication, it is possible to bridge the said gap by means of autonomous robotic systems. The Internet-of-Things based robotic system Fire Fighting Robot with SMS and Call Alert developed in this research paper was designed specifically for the purpose of reducing the gap between the detection of fire and extinguishing of fire while alerting the remote user at the same time. The robot consists of a flame sensor and MQ2 gas smoke sensor for detection of fire, an Arduino UNO microcontroller for making decisions, a motor-driven wheel base for movement towards the source of fire autonomously, a water pump activated by a servo for suppressing fire and finally a SIM800L GSM module for remote communication using SMS text message and voice calls.

This paper is an extension of the original project proposal synopsis to a full research paper. This will entail referring to five articles related to fire safety and IoT robotics – those addressing large-scale fire public-safety warning architecture, autonomous fire fighting robots that use GSM technology, smart fire-fighting systems controlled by NodeMCU, fire-alarm system using Mesh network, and the application of IoT robotics for surveillance.

1.1 Contribution of the Work:

The main focus of this research is the implementation of three functions: fire detecting, mobile fire fighting, and sending emergency messages over GSM. These functions are of the same aim in low-cost robotic system. The system is different from conventional alarm systems as it combines fire detection, fire suppression and remote communications capabilities in one system. The prototype demonstrates that the integration of these functions is effective in case of small fires.

1.2 Comparison with Conventional Fire Alarm Systems

Feature	Traditional Alarm System	Proposed Fire Fighting Robot
Fire Identification	Yes	Yes
Smoke Identification	Yes	Yes
Automatic Movement	No	Yes
Automatic Water Suppression	No	Yes
SMS Notification	Typically Limited	Yes
Call Notification	Generally Restricted	Yes
Manual Intervention	Required for Fire Suppression	Reduced
Mobile Response to Fire	No	Yes

2. STATEMENT OF THE PROBLEM

Fire accidents cause major and sometimes irreparable harm to life and property. In many practical scenarios, it is neither feasible nor safe to have humans intervene in case of a fire outbreak. Conventional fire alarm systems are restricted only to the function of signaling an alarm and do nothing else themselves, leaving all the responsibilities of firefighting to human beings.

The specific issues that fuel the need for this research are:

- Latency in reaction to the fire event due to the delay caused by human observations and actions.
- Threat to human firefighters entering dangerous, smoky, and/or unstable environments.
- The inability to monitor unattended locations such as warehouses, laboratories, and server rooms.
- The lack of an immediate fire suppression system within existing alarm systems.
- Damage caused by escalating costs of delays between ignition, detection, and suppression.

The issues discussed above have led to the realization of the necessity of a robotic system with intelligence, which can be able to identify fire, move to where it is, suppress it on its own, and alert a user at a distant location.

3. OBJECTIVES AND SCOPE OF THE PROJECT

3.1 Objectives

- Designing and implementing a robot that can work independently without any need for constant human supervision.
- Detection of fire and smoke presence through the use of a flame sensor together with the MQ2 gas/smoke sensor.
- Enabling the robot to move towards the fire source using wheel base under control of the motor driver.
- Extinguishing the detected fire through the use of a water pump with a nozzle controlled by a servo.
- Sending SMS alerts to the mobile number of the registered user immediately after detecting the fire.
- Making an emergency call using the GSM module as an alternative alert method.
- Increasing safety in the environment where the robot is deployed.

3.2 Scope

The suggested system will be used in applications where there is a need for constant monitoring by humans, which is difficult, or situations where the danger posed to the human responders is too high. Some typical application environments include domestic and office spaces, research labs, libraries, workshops, small industrial units, and schools. The project will be considered as a part of the broader concept of smart safety infrastructure and emergency response engineering using IoT, and not as an alternative to professional fire-fighting services.

4. LITERATURE REVIEW

The approach to designing an IoT-based fire safety system described herein is based on recent research conducted on IoT-enabled and GSM-enabled fire safety systems. In total, five articles related to this field were analyzed for the purposes of informing the current design approach.

4.1 Public-safety alert architecture using IoT and large-scale distributed heterogeneous sensors

Zhang, Zhang, and Sun (2025) present the architecture of an IoT-based real-time public-safety alerting and emergency response solution that involves using a combination of heterogenous sensors (gas, fire, vibration, and biometric sensors), edge computing nodes (e.g., Raspberry Pi and ESP32), and cloud platforms (AWS IoT and Firebase). The prototype of this system has been tested in four cases: fire, traffic accident, gas leak, and medical distress. In all the cases tested within a smart city simulation environment, the system demonstrated less than 450 milliseconds alert latency time, over 95 percent detection accuracy, scalability to over 12,000 concurrent connected devices, and 99.1 percent successful alert delivery rate.

4.2 Autonomous firefighting robots using GSM technology

In their research, Rony et al. (2026) describe a fire-fighting robot that is autonomous and uses the Arduino Nano controller, which uses flame and temperature sensors for detection of the presence of fire, an L298N motor driver for differential movement of the robot, a water pump actuator driven by servomotor for fire suppression, and finally the SIM800L GSM module to make notifications through SMS and calls from a distant location. In their experiments, they succeeded in having an accuracy of detection of about 97 percent, a response time of 1.32 seconds on average, and operational efficiency of about 95 percent. This architectural implementation bears the most similarity to the present system and the use of GSM as a means of communications instead of Wi-Fi or Bluetooth (whose range is limited) directly aids our communication scheme.

4.3 NodeMCU-based smart firefighting robots

Nivash et al. (2023) describe a NodeMCU (ESP32)-controlled smart firefighting robot that combines flame, gas, PIR, and temperature/humidity sensors 4.3 Smart firefighting robots using NodeMCU

In their recent paper, Nivash et al. (2023) propose a smart firefighting robot controlled by NodeMCU (ESP32), which features flame, gas, PIR, and temperature-humidity sensors along with a built-in camera and ultrasonic obstacle avoidance, as well as a wireless connection to a cloud server and companion app for Android. The authors provide a solution capable of working in both autonomous mode and under joystick control and showcase how a more robust set of sensors may enhance situational awareness, although being dependent on the availability of the local Wi-Fi network. The current approach relies on a similar concept of sensors, although preferring GSM to Wi-Fi.

4.4 IoT-based mesh fire-alerting systems

Al Hasani et al. (2022) have designed a mesh fire-alerting system, which is an IoT-based fire alerting system consisting of multiple nodes based on the ESP8266 platform that have a carbon dioxide sensor, methane sensor, flame sensor, smoke detector, humidity detector, and a temperature sensor. The fire-alarm system works using a mesh network and sends data to the main Raspberry Pi-based node via a 4G LTE module using MQTT protocol. The experimental results of the prototype reveal that fire alerting can be done with an average end-to-end delay of about 20 seconds. They have demonstrated that not only a mobile robot but also a fixed-sensor network is able to provide rapid multi-channel fire alerts through SMS and calls.

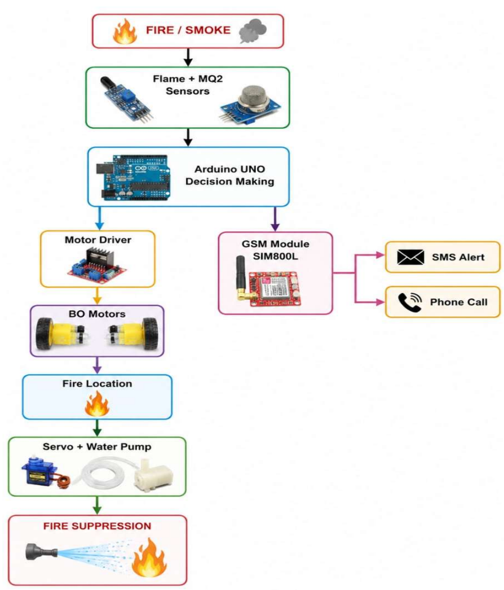
4.5 IoT-Driven Robotic Surveillance Systems

In this category, Mamun et al. (2022) discuss an IoT-driven robotic car with a live video stream using an Arduino microcontroller, an ESP8266 Wi-Fi shield, and a camera, designed for surveillance purposes more than firefighting. While this robotic car cannot extinguish fires, it can be used as a model for future development, where there could be integration of a camera on the fire-fighting robot for live video viewing of the fire scene.

4.6 Literature Review Summary

Through all these five works, three common themes come up which influence the design of our project. Firstly, using both flame and gas/ smoke sensors together works better compared to using any one of the two types independently. Secondly, using GSM technology to communicate is an improvement over Wi-Fi or Bluetooth since the former will be less affected by fires in places where the local networks cannot survive. Lastly, having autonomous mobility alongside automatic suppression is important in decreasing the reaction time lag in alarm only systems.

SYSTEM ARCHITECTURE



5. THE EXISTING SYSTEM AND ITS FLAWS

The fire-safety systems which are most frequently used currently comprise of smoke detectors and audible alarm devices. Though relatively cheap and popular, they suffer from a number of flaws, namely:

- They can only give an alarm signal and do not perform any actions themselves.
- The process of extinguishing fire must be conducted by a human being.

- They do not have a remote communication channel to communicate with a person who is located outside of the premises.
- They cannot perform fire suppression actions themselves.
- The total response time from ignition till extinguishment is quite long, because all the steps that follow detection require a human being to come into the room.

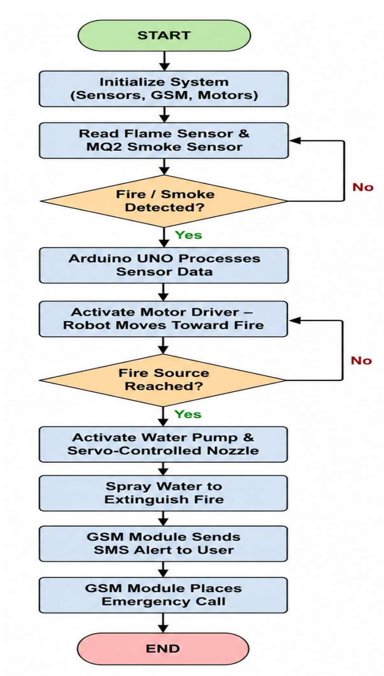
This list of flaws serves as the primary reason for the need of the suggested system.

6. PROPOSED SYSTEM

The system under consideration will incorporate the use of a fire-fighting robot that integrates fire detection, automatic navigation, water-based suppression and communication using GSM in one embedded system. This working procedure follows a total of seven steps, namely:

- The flame sensor detects infrared radiation present in the open flames from the environment continuously.
- The MQ2 sensor senses the presence of any smoke and combustible gases in the environment continuously as another validating parameter.
- The data received by the sensors is then analyzed by the microcontroller which confirms the occurrence of the fire event.
- The occurrence of the fire event makes the motor driver and DC motors move the robot towards the fire.
- Once the fire has been detected, the servo motor positions the nozzle and the water pump is actuated to direct the water on the flames.
- The SIM800L GSM module sends out a message about the event through an SMS message to a pre-specified mobile number.

This is shown in the flow chart of the system working in figure 2 below.



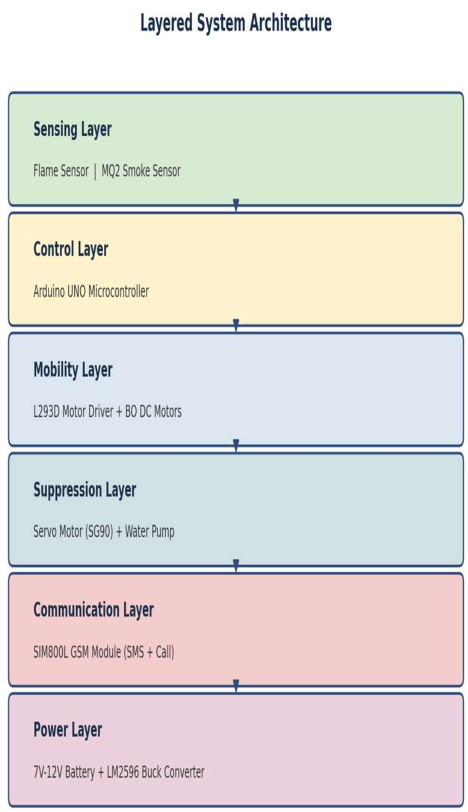
Operational flowchart of the Fire Fighting Robot with SMS and Call Alert.

6.1 Strengths of the Recommended Firefighting System

- Quick and automatic reaction without delay from human observation or any human actions.
- Increased safety of occupants and firefighters because the robot moves into the hazardous area instead of the human being.
- Completely automated process from detecting fire to suppressing it without requiring any actions from an operator.
- Remote surveillance using SMS and voice call notifications in case of fire incidents.
- Low energy consumption in comparison with systems that require constant human presence at the workplace.

7. SYSTEM ARCHITECTURE AND MODULES

The whole system architecture is divided into six functional layers, starting from environment sensing to human notification remotely. The layered structure of the whole architecture is illustrate



Layered system architecture of the proposed robot.

7.1 Fire Detection Module

The fire detection module monitors the surroundings for the presence of any fire or smoke. This module consists of a flame sensor that detects the presence of infrared radiation emanating from an open flame as well as a MQ2 smoke sensor that detects the presence of smoke particles and flammable gases. By using both sensors together, chances of errors occurring through either individual sensors get minimized.

7.2 Control Module

The Arduino UNO controller makes up the heart of the decision-making capability of the robot. The Arduino UNO controller continuously queries the fire detection module to make a decision about the occurrence of a fire using a threshold-based decision rule.

7.3 Mobility Module

The movement of the robot is done through the use of BO-type DC motors through the L293D motor driver IC, thus enabling the control of speed and direction by the Arduino UNO via low-power digital control signals. The robot moves towards the position where the fire outbreak occurs.

7.4 Fire Extinguishing Module

After detecting the position of the fire outbreak, this module will operate a water pump, which uses an SG90 servo motor to direct the stream from the nozzle to the fire before extinguishment takes place.

7.5 Communication Module

The SIM800L GSM module is used for two-way communication without using a network. When the fire is detected, the module sends an SMS and automatically calls the registered phone number.

7.6 Power Supply Module

This module consists of a battery pack with voltages between 7V and 12V, which will be converted into appropriate voltages by the LM2596 buck converter for use by the Arduino UNO, motor driver, servo motor, water pump, and GSM modules.

8. HARDWARE AND SOFTWARE REQUIREMENTS

8.1 Hardware Requirements

Component	**Function**
Arduino UNO	Central microcontroller and decision-making unit
Flame Sensor Module	Fire detection using infrared sensors
MQ2 Smoke Sensor	Smoke and combustible gas detection
SIM800L GSM Module	Sends SMS alerts and makes emergency phone calls
Water Pump	Fire extinguishing using water
Servo Motor (SG90)	Directing the suppression nozzle
L293D Motor Driver	Controlling DC drive motors

BO Motors	Driving the robot
LM2596 Buck Converter	Voltage regulation
Battery (7V–12V)	Main power supply
Jumper Wires / Breadboard	Circuit construction and connectivity

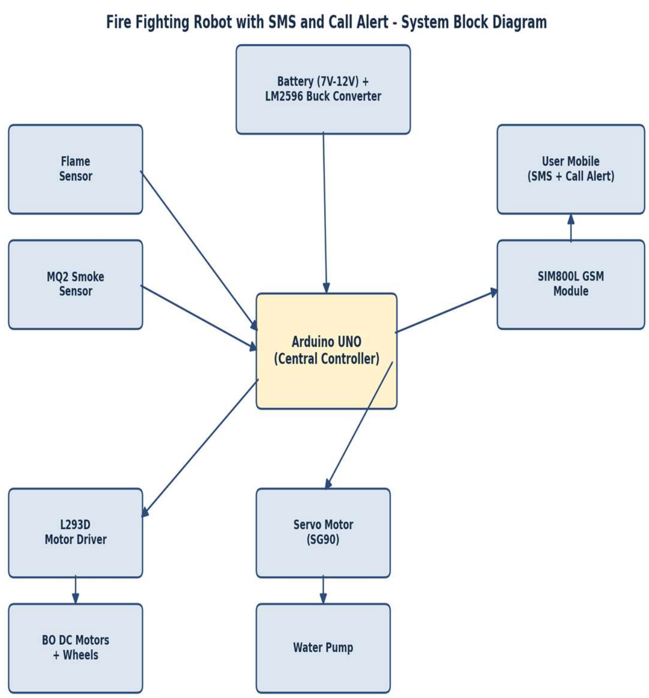
8.2 Software Requirements

- Arduino IDE software to write and load the firmware onto the board.
- Either C or C++ language for the firmware programming code.
- Windows operating system as the host environment.

9. METHODOLOGY

The entire hardware connections of the proposed robot are given in Figure 1 where the flame and MQ2 sensors provide information to the Arduino UNO, which then controls the L293D motor driver (which controls the DC motors, the servo motor, the water pump, and the SIM800L GSM). Power is provided

by the battery and the LM2596 buck converter.



Hardware block diagram of the Fire Fighting Robot with SMS and Call Alert.

Operation-wise, the firmware code used on the Arduino UNO continuously polls and takes inputs from the flame sensor and the MQ2 sensor at equal time periods. In the case where the flame sensor and MQ2 sensor give input to the Arduino firmware that conditions are right for a fire to occur, then the firmware changes its status from monitor mode to response mode. When in response mode, the motor driver is told to make the robot travel to the supposed direction of fire and to keep going until the reading from the flame sensor tells the robot that it has gotten close enough to the fire location. After this, the servo motor makes sure that the nozzle is aimed properly and the relay switch is used to start the water pump. While all of this is happening, the Arduino UNO sends AT commands to the SIM800L module and sends an SMS along with initiating an emergency voice call to the preset phone number.

10.RESULTS AND DISCUSSION

The prototype has been built and incorporated into a wheeled robot platform according to the hardware architecture described in this article. The prototype photo presents the Arduino UNO control unit, the sensors mounted in the front, motorized wheel unit, water storage tank, see-through water delivery pipe, suppressor nozzle, power and control electronics, and cabling. This implementation proves that various detection, mobility, suppression, and communication systems can form a compact firefighting robot that can be operated by students.

Because the work done is more of a prototype demonstration than a laboratory benchmark, the results are given in the form of functional observations. All numerical characteristics like detection efficiency, exact time needed for response, and water consumption should be reported following their confirmation in repeated laboratory tests.

10.1 Prototype Implementation

The prototype consists of an Arduino UNO as the main control unit, with the fire detection sensors being connected to it for control purpose. The robot body serves to carry the traction motors and the fire extinguishing system. There is a water tank built into the base and linked to the water pump by a tube so the water can go to the fire through the nozzle. The sensors mounted on the front of the robot gives the good field of view of the fire.

The water storage area is separated from the electronics, so that the electronics are not directly exposed to the water. The prototype is constructed in a way that allows creating the entire system using inexpensive elements and components**.**

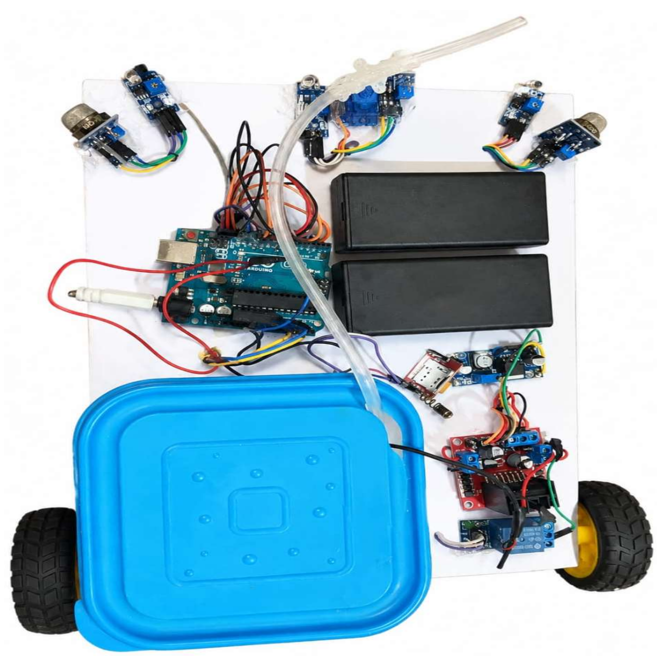


Figure 4. Developed prototype of the Fire Fighting Robot with water-suppression assembly.

10.2 Functional Results

Subsystem	Test / Observation	Prototype Result	Status
Fire Detection	**Flame/smoke sensors exposed to fire-related conditions.**	**The sensors provide the necessary input for the Arduino-based fire detection and decision-making logic.**	**Functional at the prototype level**
Robot Movement	**Motor control commands applied to the drive system.**	**The wheeled platform performs forward, reverse, and turning operations through the motor driver stage.**	**Functional at the prototype level**
Water Suppression	**Pump and water delivery path tested.**	**Water is stored inside the robot and delivered through the transparent tube to the nozzle.**	**Functional at the prototype level**
Nozzle Orientation	**Servo-controlled nozzle assembly operated.**	**The suppression nozzle can be directed toward the intended fire location.**	**Functional at the prototype level**
GSM Alarm	**Communication module integrated with the controller.**	**The system provides SMS and voice-call alert functionality; however, actual delivery time depends on SIM availability, signal strength, and network conditions.**	**Requires repeated field testing**
Power System	**Battery and regulated power supply connected to the system.**	**The battery and regulator arrangement supplies power to the robot's electronic circuits and actuators.**	**Functional at the prototype level**

10.3 Discussion

The tested prototype illustrates the main benefit of the concept: fire suppression is integrated within one platform instead of using just a fixed alarm. As soon as the initial fire is detected using the sensors, Arduino UNO can control the movement of the robot, position the nozzle, activate the water pump, and send notifications about the fire. This means that there is less requirement for the rescue team to be present during the initial moments of fire.

The placement of the water storage and pump displayed in the prototype allows it to work for small and localized flames. However, its limited tank size and pump output suggest that the robot should be treated more as an early warning system rather than a substitute for professionally trained firefighters.

The arrangement of sensors offers a practical yet inexpensive option, though the readings of sensors depend on the environmental conditions, smoke levels, flammable gases, and the location of the flame. The use of flame detection along with smoke/gas detection increases the accuracy of the decisions made compared to relying upon a single sensor, however, the calibration of thresholds must be done experimentally for the specific conditions.

The GSM module offers the remote alarming feature for the user that allows receiving notifications when the person is not close to the robot, but the performance of GSM alarming depends on the cellular coverage, availability of the SIM, stability of the power, and the congestion of the network. Thus, the reliability of SMS and call messages should be tested through a number of trials and cannot be assumed based only on the hardware characteristics.

Ultimately, it can be concluded that the results of the model show that the idea proposed in the concept is possible at the prototype scale. The main accomplishment is that everything in the project consists of the principles of combining other devices for sensing, moving, suppressing water, and alerting the end user. However, the investigation is required in terms of finding the quantitative detection precision, time for navigating, suppression success rates, battery life, and GSM notification delays.

10.4 Result Summary

The presented prototype confirms that the required main modules for executing the operation of an autonomous firefighting robot have been physically integrated. The prototype can perform all sequential activities of the system, which are sensing a fire condition, controlling the robot motion, bringing the water to the fire location, and establishing the remote connection. Therefore, the prototype serves as a working proof of the low-cost fire emergency reaction system.

It is necessary to differentiate between the performances observed from the prototype functionality and the quantitative results. The picture and the prototype construction indicate that the necessary hardware is available, but they do not guarantee any evaluation of such accuracy of detection, reaction speed, or rate of GSM delivery.

10.5 Testing and Evaluation

“Testing of the developed prototype should follow multiple rounds of control tests to ensure testing efficiency of all modules and the whole system. Testing should include fire detection, smoke detection, robot movement and nozzle position maintenance, water pump operation, SMS sending, and emergency call activation. Several trials should take place at various distances from the flame source and in different environmental conditions. The parameters to be measured can involve detection accuracy, response time, suppression time, GSM notification delay, and battery life.”

Testing and Performance Evaluation of the Proposed System

Parameter	Testing Method	Result/Observation
Flame Sensor Detection	Position a flame at various distances from the sensor	Note success of fire detection
Smoke Sensor Detection	Generate controlled smoke near the sensor	Note sensor response and activation
Robot Navigation	Perform forward, reverse, left, and right movements	Note reliability and accuracy of movement
Water Suppression System	Test on a small controlled flame	Note time required to extinguish the flame
SMS Alert	Trigger a fire condition	Note time required to send SMS notification
Phone Call Alert	Trigger a fire condition	Note time required to initiate the emergency call
Battery Performance	Operate the complete system continuously	Note total operating duration

11. LIMITATIONS

- Limitations arise due to the capability of the onboard water tank and pump to suppress the fire, thereby making the firefighting solution applicable for small and infantile fires only.
- Limitations can occur due to high-density smoke, high temperatures, and rough terrain since all these factors affect the efficiency of the sensors and movement of the robot, which is also seen as a problem in other similar firefighting robots.
- There is always a delay of some seconds in the notification process in GSM communication.
- The use of batteries for power leads to the limitation of continuous runtime, as well as battery replacement and recharge limitations.

12. SAFETY ISSUES

The prototype is designed to be shown in demonstrations and for initial fire response activities. Testing must be done in a safe and controlled environment with small and controlled fire sources, which means that no electrical or electronic components can be watered or come into direct contact with water, in addition the battery, motor and GSM must function according to their specifications.

13. CONCLUSION

The Fire Fighting Robot with SMS and Call Alert is an IoT-based security system which is capable of detecting fire automatically, moving to the location of the fire, extinguishing the fire without any human intervention, and alerting the registered user through SMS as well as automated voice call. By combining flame and smoke detection, mobile locomotion, water-based suppression system, and GSM-based communication into one single embedded system, the proposed system provides a solution to the basic limitation associated with traditional fire alarm systems that lacks any automatic corrective measure. The proposed system stands out against the other related literature such as IoT-based public safety architecture, GSM-based firefighting robots, NodeMCU-based firefighting systems, mesh network fire alerting systems, and IoT-based robotic surveillance system as a cost-effective and GSM-enabled system which can be used in homes, offices, laboratories, and small industries.

14. FUTURE SCOPE

- Incorporation of mobile applications for real-time monitoring and manual control of the robot.
- Use of GPS technology for pinpointing the location of the robot during the fire incident.
- Monitoring and data collection in the cloud using edge-cloud framework discussed in the public safety literature.
- Fire prediction with the help of artificial intelligence using historical data from the sensors for predicting any chances of fire even before the fire incident takes place.
- Use of cameras for real-time video surveillance.

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