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Intelligent Firefighting and Alert Automation

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ABSTRACT

Fire accidents pose significant threats to both human lives and properties across various settings, ranging from residential buildings and corporate offices to educational institutions and medical facilities. In this comprehensive review, we propose an integrated solution for fire detection, suppression, and alerting by combining an autonomous fire-fighting robot and a synchronized alert system. Our primary aim is to design a self-directed robot capable of swiftly identifying and extinguishing fires in real-time while simultaneously notifying relevant stakeholders and occupants. the fire-fighting robot seamlessly interfaces with a comprehensive alert system. This system rapidly disseminates notifications to relevant stakeholders, including building occupants, security personnel, and firefighting authorities. Leveraging diverse communication channels such as SMS, email, and auditory alarms, the alert system ensures timely communication, enhancing evacuation protocols and improving firefighting coordination.

Keywords :- Fire-fighting robot, Arduino Mega 2560, Flame sensor, C- Language

I. INTRODUCTION

Fire incidents have the potential to cause profound devastation, resulting in the loss of both life and property. The repercussions often include extensive damage and the possibility of irreversible disabilities. While firefighters are indispensable in responding to such emergencies, their role comes with significant risks, particularly in hazardous and infectious environments. Addressing the diverse spectrum of fire-related accidents, ranging from actual fires to instances of smoke and leaks of flammable gases, this study presents a unified solution.Central to this solution is the development of a fire detection robot that seamlessly integrates SMS and call alert functionalities. These features are designed to rapidly notify registered phone numbers associated with the location of the affected building. Beyond just alerting occupants, the robot also assumes an active role in autonomous fire suppression efforts.The detection of fires is achieved through the strategic deployment of flame and smoke sensors.

This study underscores the transformative potential of an advanced autonomous system in fire management. The robot excels in pinpointing fire-prone areas and executing fire suppression through the utilization of stored water resources. In cases where the initial fire

suppression proves insufficient, the robot takes a proactive stance by promptly sending SMS alerts and initiating phone calls to the registered numbers. This mechanism not only aids in alerting individuals but also facilitates their active involvement in firefighting endeavors.

Real-world fire scenarios underscore the unpredictable nature and severity of such incidents, which can transpire at any moment and in any location. The resulting consequences encompass damage to structures, human lives, and vital natural resources like forests. It is pertinent to note that fatalities can arise not only from direct exposure to flames but also from the inhalation of toxic smoke and gases. In response to these formidable challenges, this study proposes the implementation of an automated fire fighting robot.

Equipped with a trio of highly sensitive flame sensors, the robot capitalizes on an Arduino-based control system to efficiently detect fires. Moreover, the robot's operational capacity is reinforced by its onboard water reservoir, ensuring a consistent supply of extinguishing water as required.

Upon activation, the robot engages in purposeful random movement within the designated premises. In the event of a fire detection triggered by the flame sensors, the robot swiftly embarks on firefighting actions, employing its water-based suppression system. Concurrently, the robot engages in communication with the designated registration number, promptly transmitting alerts concerning the ongoing fire incident. Upon arriving at the scene of the fire, the robot executes a cautious approach by halting at a safe distance. It then initiates a targeted fire suppression process, leveraging its specialized water-based mechanism. These actions are coupled with notifications dispatched to the registered number, promoting effective collaboration in tackling the fire emergency.

II. Literature Survey

In recent years, the field of robotics has gained significant traction, driven by diverse designs and technological advancements. The motivation behind our fire extinguisher design stems from the aspiration to emulate human-like efficiency in combating fires, swiftly sensing fire outbreaks and responding promptly to minimize property damage and loss of life.

Several projects have explored the utilization of predefined paths or tracking lines for robots to navigate as they work towards fire suppression. Meanwhile, other designs incorporate ultrasonic sensors. Nevertheless, it's important to note that simulating these designs often presents challenges when transitioning to real-time applications. From a thorough review of various projects, certain objectives guided our selection of an optimal technique for efficient fire management: remote control through wireless technology and the integration of a primary sensor—the Flame sensor. This choice was motivated by the sensor's exceptional fire detection capabilities and the significance of fire pumps.

Each sensor on the robot operates under the control of an Arduino, facilitating coordination and synchronized responses. Augmenting the sensor suite, the robot incorporates a water tank, ensuring a ready supply of extinguishing agent in the event of a fire. During operation, the robot's movement is characterized by random exploration of the environment. Once the flame sensors detect a fire, the robot initiates a sequence of actions. It redirects itself toward the source of the fire, simultaneously triggering a warning message dispatched to a registered phone number associated with the location. Upon reaching the site of the fire, the robot strategically halts at a safe distance and engages its fire suppression mechanism, which employs water as the primary extinguishing agent. Simultaneously, it alerts the registered phone

number, fostering an integrated approach to fire management.

III. Problem Formulation/Identification

- A fire outbreak at Pune's Marigold IT Park resulted in the injury of 20 people and the rescue of 40 individuals.
- In a significant Dhayari fire incident, workshops housed in tin sheds were completely destroyed, necessitatinga massive response effort.
- An incident involving a fire in a commercial building led to the successful rescue of 225 individuals.
- A fire outbreak within a PNB branch in Delhi's Karol Bagh was reported, fortunately without any injuries.
- Tragedy struck in TN's Cuddalore district as a man accidentally set his house on fire while attempting to pourpetrol on himself, leading to 5 fatalities.
- The fire occurrence at Mumbai's Breach Candy Apartment on May 27, 2023
- A blaze in Dharavi's Kamala Nagar ravaged nearly 100 shanties, underlining the vulnerability of such communities to fire incidents.

IV. The design of the firefighting robot

Flame detectors stand as prominent automatic detection methods, emulating human vision by operating in the infrared, ultraviolet, or a combined spectrum. These devices detect radiant energy in the range of approximately 400 to 700 nanometers, serving as indicators of flammable conditions. A specific application of flame sensor technology involves fire detection, triggering an SMS alert to a registered phone number [1].

The foundational components of our firefighting robot center around three flame sensors that maintain continuous temperature monitoring. Upon identifying a fire, the robot immediately dispatches an SMS notification to the registered phone number. the robot elevates the response level by placing a call—a fire alarm—to the registered number. This facilitates manual intervention and remote control to avert further damage and promptly extinguish the fire [2].

The versatile application of this firefighting robot extends to forest fire detection and mitigation. In the event of a fire outbreak, the robot undertakes the dual tasks of fire suppression and notifying a registered phone number. This proactive approach aids in containing the fire and preventing its escalation [3].

Incorporating a target-driven obstacle avoidance model, the robot's mobility employs fuzzy theory, integrating sensor data to govern its speed and navigate toward the designated destination [4]. The flame sensor, a compactand highly efficient component, plays a pivotal role in the robot's decision-making process [5].

The electronic circuitry features essential components such as the Arduino Mega 2560 microcontroller, Flame sensor, Sim 800L GSM cellular chip, MQ 2 Sensor for smoke and combustible gas detection, Relay Module for electrical device control, LM 2596 Buck Converter for voltage regulation, Servo sg 90 for actuation, and a Mini Water pump (5v) for fire

suppression. The hardware also encompasses Bo Moter, Wheel X 4 for robotic locomotion, 18650 Battery X 2 as a rechargeable power source, Mini Breadboard for circuit prototyping, and jumper wires for electrical connections. Refer to Table 1 for a comprehensive list of the electrical components integral to the circuit design.

Table 1. Hardware Components for Circuit Design

Sr. No.	Component	Features and Functionality
1.	Arduino Mega 2560	Microcontroller board with ATmega2560
2.	Flame sensor	Detects flames or infrared radiation
3.	Sim 800L	GSM cellular chip for communication

4.	MQ 2 Sensor	Smoke and combustible gas detection
5.	Relay Module	Controls electrical devices on or off
6.	LM 2596 Buck Convert er	Steps down voltage and drives load under 3A
7.	Servo sg 90	Micro servo motor used in hobbyist and DIY projects
8.	Mini Water pump (5v)	Uses suction to pump and release water
9.	Bo Moter, Wheel X 4	Components for building robots and vehicles
10.	18650 Battery X 2	Rechargeable lithium battery of 3.7 volts
11.	Mini Breadboard	Small breadboard with adhesive backing
12.	Jumper Wire	Electric wire for connecting remote circuits on printed circuit boards

V. The architecture of the Alert Automation

The design of the firefighting robot comprises two key components, each contributing to the overall functionality. The mechanical aspect, depicted in Figure 1, forms the first part of the design. Concurrently, the second part involves software design, realized through the utilization of the SketchUp. software—a versatile 3D modeling tool employed across a spectrum of domains, including architectural, interior design, and civil and mechanical engineering.

Figure 1. Design of the Alert Automation

a. Connection between Components

Tumerous interconnections are established between components and the Arduino microcontroller, facilitated by the deployment of jumper wires. This intricate web of connections binds all equipment to the Arduino board, ensuring seamless integration and operation, as illustrated in Figure 2.

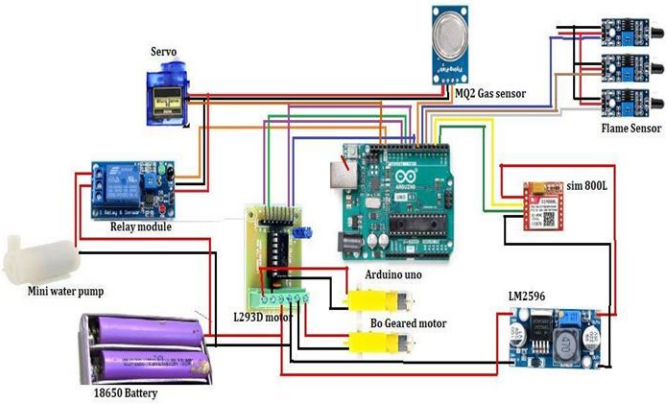

Figure 2. The connection between components and Arduino.

VI. Arduino Software

The fire fighting robot's operations are governed by the Arduino software. Arduino programming transcends programming languages, as it involves a compiler that generates binary machine code from any chosen programming language. The Arduino Project offers the Arduino Integrated Development Environment (IDE)—a cross-platform tool coded in Java. This IDE

accommodates code written in C and C++, featuring specific conventions for code management. When the fire fighting robot detects a fire, it promptly initiates an alert sequence through interaction with the Arduino software. The robot leverages the SIM800L module to convey fire alerts via a SIM card. To enable this functionality, the Arduino is configured to receive signals from the Sim 800L module. Upon fire detection, the Arduino IDE triggers a multi-step process. It commences by sending an SMS notification to the registered phone number through the software interface. Subsequently, if the fire's temperature surpasses a certain threshold, the Arduino proceeds to initiate a phone call alert.

There are several objectives to make this project as following:-

- This project encompasses a range of objectives aimed at creating an effective firefighting solution
- Develop and implement an autonomous or manually operated firefighting robot with the capability toextinguish fires.
- Detect fire outbreaks within disaster-prone regions, enabling timely intervention.
- Promptly suppress fires upon detection to minimize their spread and associated damage.
- Alleviate the demand for human labor and mitigate the extent of destruction caused by fires.
- Design and construct a cost-effective Fire Fighting robot, promoting accessibility and affordability.
- Devise a robot equipped with obstacle avoidance mechanisms, fire detection capabilities, and fire suppressionfunctionality.
- Safeguard human lives, particularly firefighters who face hazardous conditions while battling fires, by reducingexposure to danger.
- Pinpoint the precise origin of fire outbreaks, facilitating swift response and containment.
- Outline an intelligent fire detection system through the insights provided in this paper .
- Comprehend the underlying principles governing the operation of fire detection systems, enhancing knowledgewithin the field.

VII. CONCLUSION

The successful implementation of an automated firefighting robot, guided by programmed instructions, demonstrated its efficacy in fire detection and suppression. The robot's construction aligned with initial design objectives and underwent refinements to address evolving needs and enhancements. To accommodate the limited available supply voltage ports from Arduino, components such as sensors, the SIM 800L module, and relays were sequentially connected and soldered onto the PCB, ensuring optimal operational conditions.

The development of coding through the Arduino software facilitated comprehensive control and coordination of the robot's functions. The availability of a robust software library expedited project realization, bolstered by real-time simulations. It is noteworthy that the firefighting robot's design, alongside the proposed enhancements presented here, holds the potential to bolster the accuracy of firefighting systems, providing crucial support to human efforts.

The concept of this fire fighting robot holds substantial promise for diverse applications, signifying its viability and adaptability across various contexts.

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