IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 3, March 2026
Impact Factor: 8.2

Fire Fighting Robot

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Abstract: *This project, titled "Fire Fighting Robot," focuses on the design and development of an automated robotic system capable of detecting and extinguishing fire in hazardous environments. The robot is equipped with flame sensors, microcontroller-based control systems, and a water pump mechanism that allows it to move toward the fire source and extinguish it automatically.*

The main objective of the project is to minimize human risk during fire accidents by using robotic technology. The system uses sensors to detect fire and a motor driver circuit to control the robot's movement. Once the flame is detected, the robot moves in the direction of the fire and activates a water pump to extinguish it.

This robot can be used in places such as industries, warehouses, homes, and offices where fire accidents may occur. The project demonstrates how robotics and embedded systems can be applied to improve safety and disaster management.

Keywords*:* Fire Fighting Robot, Embedded System, Flame Sensor, Robotics, Fire Detection

I. INTRODUCTION

Fire accidents are one of the most common and dangerous disasters that occur in residential buildings, industrial environments, forests, and public places. These accidents can cause severe damage to property, infrastructure, and most importantly human lives. In many cases, fires spread rapidly and become difficult to control if they are not detected and extinguished in the early stages. According to various safety reports, many fire accidents occur due to electrical short circuits, gas leaks, flammable materials, or human negligence. Once a fire starts, it can quickly grow and cause large-scale destruction within a short period of time.

Traditional firefighting methods mainly depend on human firefighters who risk their lives to control fires. Firefighters often have to enter dangerous environments filled with high temperatures, smoke, toxic gases, and collapsing structures. These hazardous conditions make firefighting extremely risky and sometimes lead to serious injuries or fatalities. In addition, reaching the exact location of the fire can take time, which may allow the fire to spread further. Therefore, there is a strong need for intelligent systems that can detect and control fires quickly while minimizing the risk to human life.

With the rapid development of modern technology, robotics and embedded systems have become powerful tools in solving real-world problems. Robotics technology is increasingly being used in disaster management, rescue operations, and industrial automation. One of the important applications of robotics is in firefighting systems. A Fire Fighting Robot is an automated or semi-automated machine designed to detect the presence of fire and take necessary action to extinguish it without direct human involvement. These robots can operate in hazardous environments where human access is difficult or unsafe.

The main objective of this project is to design and develop a Fire Fighting Robot using Arduino UNO that is capable of detecting fire and extinguishing it automatically. The system uses flame sensors to detect the presence of fire. These sensors continuously monitor the surroundings and send signals to the microcontroller whenever a flame is detected. The Arduino UNO microcontroller acts as the brain of the system and processes the signals received from the sensors. Based on these signals, the controller activates the necessary components to perform the required actions.

The robot is equipped with DC motors that allow it to move in different directions. These motors are controlled using a motor driver circuit such as L293D, which enables the Arduino to control the speed and direction of the motors efficiently. When the flame sensor detects a fire source, the robot moves toward the direction of the fire. Once it reaches close to the fire, a mini DC water pump is activated to spray water on the flame. This process helps in extinguishing the fire and preventing it from spreading further.

The robot is mounted on a robotic chassis with wheels, which provides mobility and stability while moving toward the fire source. The entire system is powered using a battery supply, making the robot portable and suitable for different environments. The design of the robot is simple, cost-effective, and suitable for small-scale fire detection and suppression applications.

The Fire Fighting Robot demonstrates how robotics and embedded systems can be used to enhance fire safety and disaster management. Such robots can be deployed in places where fire hazards are high, such as factories, warehouses, laboratories, and chemical storage areas. By detecting fires quickly and responding automatically, the robot can help reduce the damage caused by fire accidents and improve overall safety.

II. LITERATURE SURVEY

Fire detection and suppression systems have been an important area of research in the fields of robotics, embedded systems, and disaster management. Researchers and engineers have explored various technologies to develop intelligent systems that can detect fire at an early stage and assist in firefighting operations. The use of robotic systems in firefighting has gained significant attention because robots can operate in hazardous environments where human intervention is risky or impossible.

Several studies have proposed the development of autonomous or semi-autonomous fire fighting robots that use different types of sensors to detect fire and take appropriate action. Commonly used sensors in such systems include flame sensors, temperature sensors, and smoke detectors, which help in identifying the presence of fire in the surrounding environment. These sensors continuously monitor environmental conditions and send signals to the controller whenever fire is detected, allowing the system to respond quickly.

Many fire fighting robotic systems are designed using microcontrollers such as Arduino, Raspberry Pi, and PIC microcontrollers. These controllers act as the central processing unit of the robot and are responsible for receiving sensor inputs, processing the data, and controlling the movement and fire suppression mechanisms. Motor driver circuits such as L293D or L298N are used to control the movement of the robot through DC motors, enabling the robot to move toward the location of the fire.

Previous research has also focused on improving the capabilities of fire fighting robots by integrating wireless communication technologies such as Bluetooth, Wi-Fi, or RF modules. These technologies allow firefighters to remotely monitor and control robots operating in dangerous areas. Some advanced systems are also equipped with cameras, thermal sensors, and image processing techniques to detect fire more accurately and provide real-time information to rescue teams.

Despite these advancements, many existing fire fighting robotic systems are expensive and complex to design and maintain. This makes them difficult to implement in small-scale applications such as educational projects, small industries, or residential safety systems. Therefore, the proposed Fire Fighting Robot project focuses on developing a simple, low-cost, and efficient robotic system using Arduino technology and basic electronic components. The system aims to provide an effective solution for detecting and extinguishing small fires automatically while keeping the design easy to implement and maintain.

III. SCOPE OF THE PROJECT

The scope of the Fire Fighting Robot project is to design and develop an automated robotic system that can detect and extinguish small fires using flame sensors and a water spraying mechanism. The system focuses on improving fire safety by providing a robotic solution that can respond quickly to fire incidents and reduce the risk to human life. The robot is designed to operate in environments where early fire detection and immediate response are required.

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Functional Scope:

1. The functional scope of AgriHub – A Digital Agriculture Platform defines the main operations and services that the system provides to its users. The platform is designed to support farmers, agricultural experts, buyers, and administrators by providing various features that help in improving agricultural productivity and information accessibility.
2. One of the main functions of the system is to provide crop information, where farmers can access details about different crops, cultivation techniques, seasonal suitability, fertilizers, and pest management. This helps farmers select appropriate crops and follow proper farming methods.
3. Another important function is the market price information module, which provides farmers with updated crop prices from different markets. This feature allows farmers to make better decisions regarding when and where to sell their produce, helping them receive fair prices.
4. The platform also includes a government schemes module, where farmers can obtain information about agricultural subsidies, crop insurance, loans, and welfare programs offered by the government. This ensures that farmers remain informed about financial support and development schemes available to them.
5. AgriHub also supports expert advice and guidance, where agricultural professionals can provide suggestions regarding crop selection, fertilizer usage, and disease management. This feature helps farmers solve farming-related problems with the help of expert knowledge.
6. Additionally, the system allows user interaction and information sharing through modules such as contact support, knowledge articles, and guidance resources.

Administrators are responsible for managing user data, updating agricultural information, and maintaining the platform's content.

• Non-Functional Scope:

1. The non-functional scope of the AgriHub platform describes the quality attributes and system requirements that ensure the platform operates efficiently, securely, and reliably.
2. One of the key non-functional aspects of the system is usability. The platform is designed with a simple and user-friendly interface so that farmers with limited technical knowledge can easily navigate and access agricultural information.
3. Another important requirement is performance and reliability. The system must provide quick responses when users access crop information, market prices, or government schemes. Reliable system performance ensures that farmers receive timely information without delays.
4. Security is also an important factor for the platform. The system must protect user data, agricultural information, and government scheme details from unauthorized access or cyber threats. Proper authentication and data protection mechanisms are required.
5. The platform must also ensure scalability, meaning it should be capable of handling increasing numbers of users and agricultural data as the system expands.

This allows the platform to support more farmers and services in the future.

6. Finally, maintainability and flexibility are important non- functional requirements. The system should allow easy updates, bug fixes, and addition of new features such as weather forecasting, AI-based crop analysis, or mobile application integration in the future.

IV. METHODOLOGY / APPROACH

The development of the AGRIHUB platform follows a Linear Sequential Model, ensuring that each phase is completed before the next begins. This structured approach ensures accuracy, reliability, and scalability.

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Step 1: Problem Analysis & Requirement Gathering
The foundation of the project is based on identifying the information gap in the current agricultural ecosystem.
To define the functional requirements of the platform, such as real-time weather tracking, fertilizer calculation, and access to government welfare schemes.

Step 2: System Architecture & Design
This phase translates requirements into a technical blueprint. The system is designed using a Three-Tier Architecture:
• Presentation Layer (Frontend): Developed using HTML, CSS, and JavaScript to provide a responsive, user-friendly interface for farmers.
• Application Layer (Backend): Built with Java and Spring Boot to manage the business logic, process user requests, and handle API integrations.
• Data Layer (Database): Uses MySQL to securely store and manage structured data like user profiles, crop details, and historical fertilizer data.

Step 3: Development & Modular Implementation
During this stage, the project is broken down into independent functional modules to ensure focused coding and easier debugging:
• Fertilizer Calculator: Implements logic to calculate dosage based on land size and crop type.
• Weather Forecast System: Uses REST APIs to fetch and display real-time climate data.
• Crop Advisor: A recommendation engine based on soil type, season, and budget.
• Government Schemes: A centralized repository of active subsidies and programs.

Step 4: Testing & Quality Assurance
Before deployment, the system undergoes rigorous testing to eliminate errors.
• Unit Testing: Each module (e.g., the calculator) is tested individually for mathematical accuracy.
• Integration Testing: Ensuring the Spring Boot backend communicates seamlessly with the MySQL database and external APIs.
• User Interface (UI) Testing: Checking for responsiveness across different devices (mobile/desktop) to ensure ease of use for the end-user.

Step 5: Implementation & Deployment
The final phase involves the actual rollout of the platform.
• Deployment: The web application is hosted on a server, making it accessible via a URL.
• Maintenance: The system provides a centralized digital environment where information is updated regularly (e.g., new government schemes or weather alerts), ensuring long term utility for the farming community.

V. ADVANTAGES

1. Easy Access to Information: Farmers can get crop details, fertilizers, pesticides, and market prices anytime and anywhere.
2. Time-Saving: It reduces the need for farmers to physically visit government offices or markets to gather information.
3. Government Scheme Awareness: The platform provides information about available schemes and subsidies all in one centralized place.
4. Digital Empowerment: It encourages rural digital literacy and actively supports e-agriculture initiatives.
5. Smart Crop Selection: A "Profitable Crop Advisor" helps farmers maximize their profits by recommending the best crops to plant based on the current season, local soil type, and their personal investment capacity.

6. Risk Management: By providing real-time weather forecasts based on the user's location, it allows farmers to safely plan their crucial sowing and harvesting activities.
7. Highly Accessible: To bridge the gap between farmers and technology and promote digital literacy, the platform is multilingual, offering full translations in English, Hindi, and Marathi.

VI. APPLICATIONS

1. Precision Nutrient Management: Farmers can use the Advanced Fertilizer Calculator to determine the exact dosage of primary nutrients (Urea, DAP, MOP) and micronutrients (Zinc, Sulphur) required per acre. This application prevents soil degradation from over- fertilization and reduces unnecessary expenses.
2. Strategic Crop Selection: The Profitable Crop Advisor tool can be applied during the pre-sowing phase. By evaluating the current season (Kharif, Rabi, Zaid), local soil type, and the farmer's financial budget, it helps maximize yield and market profitability.
3. Weather-Responsive Farm Operations: The real- time, geolocation-based weather forecast allows farmers to strategically schedule critical daily activities. It helps them decide the optimal times for sowing seeds, applying pesticides, irrigating fields, or harvesting crops to avoid sudden weather disruptions.
4. Direct Access to Financial Aid: The platform acts as a centralized digital gateway for farmers to discover and navigate government support. They can use it to directly access application portals for crop insurance (PM Fasal Bima Yojana), financial support (PM- Kisan), and equipment subsidies.
5. Accessible Agricultural Education: With its built-in multilingual support (English, Hindi, and Marathi), the platform serves as an educational tool that bridges the digital divide, allowing farmers who may not be fluent in English to access modern agricultural data and best practices.

VII. CONCLUSION

In today's era of digital transformation, AgriHub demonstrates how technology can revolutionize traditional farming practices by providing farmers with the digital tools and information they need to succeed. By improving accessibility, efficiency, and knowledge sharing, this platform contributes toward building a smarter, sustainable, and digitally empowered agricultural ecosystem.

VIII. ACKNOWLEDGMENT

We express our sincere gratitude to the Vishweshwarayya Institute of Engineering and Technology, Almala for giving us the opportunity to work on the Major Project during my final year of Diploma in Computer Engineering is an important aspect in the field of engineering.
We would like to thank Prof. Kazi A. S. M, Head of Department, Computer Engineering at Vishweshwarayya Institute of Engineering and Technology, Almala for their kind support. We also owe our sincerest gratitude towards Ms. Kachare S.M. for her valuable advice and healthy criticism throughout my project which helped me immensely to complete my work successfully.
I would also like to thank everyone who has knowingly and unknowingly helped me throughout my work. Last but not least, a word of thanks for the authors of all those books and papers which I have consulted during my project work as well as for preparing the report.

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