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Bluetooth Control Fire Fighting Robot & Pick and Place Arm

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Abstract: ***Fire accidents are a major cause of loss of life and property, particularly in hazardous environments where human intervention is risky. This paper presents the design and implementation of a Bluetooth Controlled Fire Fighting Robot integrated with a Pick and Place Robotic Arm. The system is developed using an Arduino Uno microcontroller, flame sensor, DC motors, and a water pump mechanism for automatic fire detection and extinguishing. Additionally, the robot can be manually controlled through a smartphone using an HC-05 Bluetooth module, allowing safe remote operation.***
The integrated pick and place robotic arm is designed using servo motors and multiple joints, enabling precise and efficient handling of objects. This enhances the system's capability for automation tasks such as material handling, packaging, and assembly. The combination of firefighting and object manipulation functions makes the system versatile and cost-effective.
Overall, the proposed system improves safety, reduces human effort, and increases operational efficiency. It is suitable for applications in industries, laboratories, and other environments requiring quick response and automation.
Keywords: HC-05 Module, Bluetooth Controlled Robot, Industrial Automation, Remote Control Robotics. Intelligent Robotics.

I. INTRODUCTION

Fire accidents are one of the major causes of loss of life and property around the world. In many situations, it is very dangerous for firefighters to directly enter areas affected by fire. To reduce human risk and improve safety, robotic technology can be used to detect and extinguish fires. A Bluetooth controlled firefighting robot is an innovative system designed to detect fire and extinguish it automatically or through remote control.

This robot is designed using a microcontroller such as the Arduino Uno which controls all the functions of the robot. The system uses a flame sensor to detect the presence of fire. When the sensor detects a flame, the robot moves towards the fire source and activates a small water pump to extinguish it. The robot movement and water pump operation can also be controlled using a smartphone through Bluetooth communication.

The Bluetooth communication is achieved using the HC-05 Bluetooth Module which connects the robot to a mobile phone. Through a mobile application, the user can control the robot's direction such as forward, backward, left, and right. This allows the robot to reach areas that may be dangerous or inaccessible to humans.

The robot uses DC motors for movement and a motor driver to control the speed and direction of the motors. The entire system is powered by a rechargeable battery, making the robot portable and easy to operate. The robot can be used in small industries, laboratories, homes, and other environments where early fire detection and quick action are required. Automation plays a very important role in modern industries repetitive tasks such as picking up objects and placing them at different locations. These tasks can be performed more efficiently and accurately using robotic arms. A pick and place robotic arm is a mechanical device designed to automate the movement of objects from one position to another.

The robotic arm works with the help of multiple motors and joints that allow movement in different directions. The arm is controlled using a microcontroller such as the Arduino Uno which sends signals to motors to control the movement of each joint. Servo motors are commonly used in robotic.

The robotic arm usually consists of several parts including the base, shoulder, elbow, wrist, and gripper. Each part is controlled by a servo motor which allows the arm to rotate and move with high precision. The gripper is used to pick up objects and place them in a desired location.

Pick and place robotic arms are widely used in industries such as manufacturing, packaging, assembly lines, and material handling. They help increase productivity, reduce human effort, and improve accuracy. These robotic systems can work continuously without fatigue, making them highly efficient for repetitive tasks.

II. LITERATURE REVIEW

Fire-fighting robots have gained significant attention in recent years due to their potential to reduce human risk in hazardous environments. Various researchers have explored different control mechanisms, sensing technologies, and robotic designs to enhance the efficiency and reliability of such systems.

Pathak et al. (2017) [1] developed a fire-fighting robot controlled remotely using an Android application. Their system utilized wireless communication to allow users to navigate the robot and extinguish fire from a safe distance. The study highlighted the effectiveness of mobile-based control systems but was limited by dependence on manual operation and lack of autonomy.

Khambalkar et al. (2025) [2] proposed a hybrid system incorporating both autonomous and manual control via Bluetooth. This approach improved flexibility, allowing the robot to operate independently in certain scenarios while still enabling human intervention. However, Bluetooth communication restricts operational range, making it less suitable for large-scale environments.

Naik et al. (2022) [3] introduced a voice-controlled fire-fighting robot, integrating speech recognition for command input. This innovation enhanced user interaction and accessibility, especially in emergency situations. Despite its advantages, the system's performance may degrade in noisy environments, which are common during fire incidents.

Preetham et al. (2023) [4] designed a fire-fighting robot equipped with sensors for fire detection and suppression. Their work focused on automation using temperature and flame sensors, enabling the robot to detect and extinguish fire without human intervention. However, the system lacked advanced navigation capabilities for complex terrains.

Similarly, Bhosle et al. (2022) [5] presented a fire-fighting robot emphasizing cost-effectiveness and practical implementation. Their design incorporated basic fire detection sensors and a water-spraying mechanism. While economical, the system had limitations in precision and adaptability in dynamic fire conditions.

An important foundational contribution by Pack (2004) [6] discussed interdisciplinary design approaches in fire-fighting mobile robotics. This work emphasized the integration of mechanical design, control systems, and sensor technologies, laying the groundwork for modern fire-fighting robotic systems. It also highlighted the importance of education and collaborative design in robotics development.

In addition to fire-fighting systems, several studies have explored robotic manipulation using Bluetooth control, which can be integrated into fire-fighting robots for enhanced functionality. Manjunatha et al. (2022) [8] developed a Bluetooth-controlled pick-and-place robot using Arduino, demonstrating efficient wireless control for object handling tasks. Their work provides a basis for incorporating robotic arms into fire-fighting robots.

Anandh et al. (2021) [9] implemented a robotic arm for pick-and-place operations via Bluetooth, focusing on precision and control. This system demonstrated the feasibility of remote manipulation, which can be extended to handling hazardous materials during fire emergencies.

III. METHODOLOGY

A. Problem Definition

Fire accidents are very dangerous and can cause serious damage to life and property. In many situations, it is difficult for humans to reach the fire location quickly because of high temperature, smoke, and low visibility. Entering such areas can be risky and may lead to injuries. Small fires in homes, laboratories, offices, and industries can spread rapidly if they are not controlled at the right time In addition to fire hazards, there is also a need to handle or remove small objects from dangerous areas without direct human contact. Traditional firefighting methods require human effort and can take more time, which may delay the response during emergency situations. Therefore, there is a need for a system that can reduce human involvement and improve safety. To solve this problem, a Bluetooth controlled firefighting robot with a pick and place arm is developed. This robot can move into risky areas, detect fire, extinguish it using a water pump, and also handle small objects safely using a robotic arm.

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Fig. 1 Robot's Schematic Picture

B. Problem planning and Designing the Robot

Design conceptualization of robot The robot is designed based on a compact and mobile chassis capable of navigating through different environments. The structure consists of a four-wheel drive system powered by DC motors, which provides stability and manoeuvrability. A water container and pump mechanism are mounted on the robot to facilitate fire extinguishing. Additionally, a robotic arm is installed on the platform to perform pick and place operations. The entire system is controlled using a microcontroller, which acts as the central processing unit, coordinating all sensors, actuators, and communication modules. The design ensures that the robot remains lightweight, efficient, and capable of performing multiple tasks simultaneously. Fire detection system To enable fire detection capabilities, the robot is equipped with flame and smoke sensors that continuously monitor the surrounding environment. These sensors detect the presence of fire based on infrared radiation and gas concentration levels. When fire is detected, the sensor sends a signal to the microcontroller, which processes the input and confirms the presence of fire. This detection system ensures timely identification of fire hazards and improves the responsiveness of the robot in critical situations.

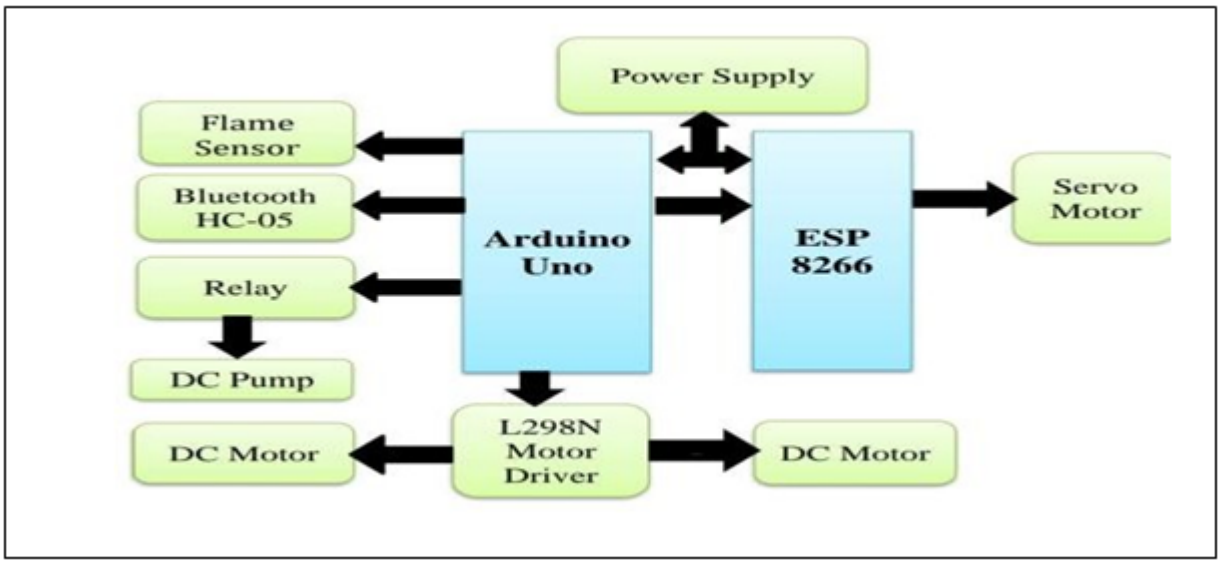

Fig. 2 Block Diagram

C. Proposed System Architecture

The proposed system is designed using an Arduino Uno, ESP8266 Wi-Fi module, sensors, and motor control components to enable automated fire detection and response operations. The system integrates both hardware and communication modules to achieve efficient monitoring and control.

Initially, a regulated power supply unit provides the required operating voltage to all system components, including the Arduino Uno, ESP8266 module, sensors, relay module, and motor driver. The Arduino Uno serves as the central processing unit, responsible for acquiring sensor data, processing inputs, and controlling output devices.

A flame sensor is employed to detect the presence of fire. Upon detecting a flame, the sensor transmits a signal to the Arduino Uno. Based on this input, the Arduino triggers a relay module, which activates a DC water pump to suppress or extinguish the fire. This ensures an immediate automated response to fire hazards.

The system also incorporates a Bluetooth HC-05 module to enable short-range wireless communication. Through this module, users can manually monitor and control the system using a mobile device. Commands sent via Bluetooth are received by the Arduino and executed in real time, allowing manual override when necessary.

For motion and mechanical operations, an L298N motor driver is used. The motor driver receives control signals from the Arduino and drives DC motors accordingly. It facilitates proper control of motor direction and speed, ensuring reliable system movement.

Additionally, the ESP8266 module provides IoT functionality by enabling Wi-Fi connectivity. It communicates with the Arduino Uno and allows data transmission over the internet, thereby supporting remote monitoring and control of the system. This enhances accessibility and enables users to supervise system status from distant locations.

A servo motor is interfaced with the ESP8266 for precise angular positioning. This can be utilized to direct water flow towards the detected fire source or to adjust system components dynamically.

Overall, the system operates by continuously monitoring environmental conditions through sensors, processing the data via the Arduino Uno, and controlling actuators such as pumps and motors. The integration of automatic operation (sensor-based) and manual/remote control (Bluetooth and Wi-Fi-based) ensures flexibility, reliability, and efficient fire management.

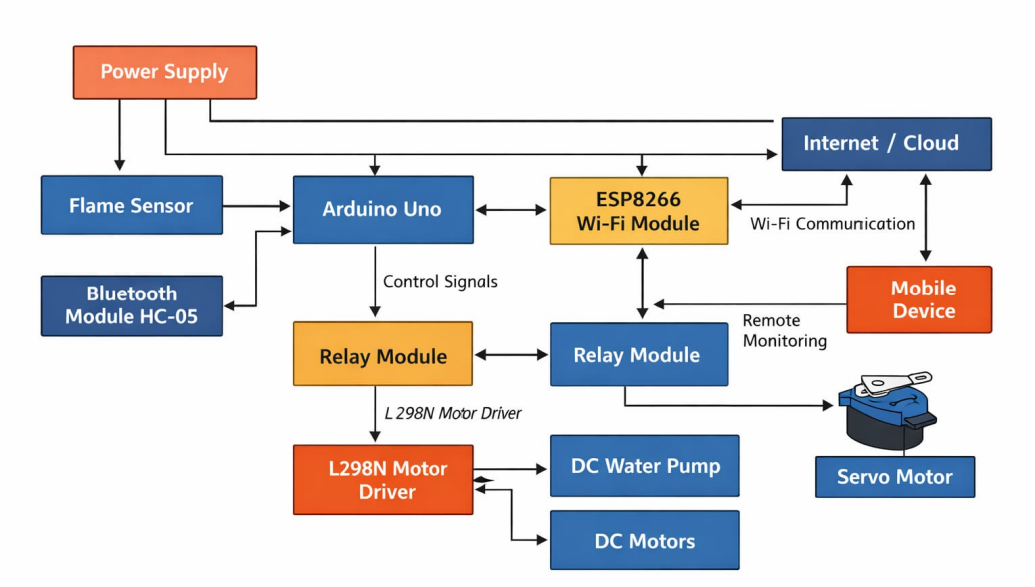

Fig. 3 Proposed System Architecture

IV. RESULTS AND DISCUSSION

The developed system, "Bluetooth Controlled Fire Fighting Robot & Pick and Place Arm," was successfully implemented and tested under different operating conditions. The robot demonstrated effective performance in both manual (Bluetooth-based) and automatic (sensor-based) modes.

During fire detection tests, the flame sensor accurately detected fire within a short response time. Upon detection, the Arduino Uno triggered the relay module, activating the DC water pump to extinguish the flame. The response time of the system was observed to be minimal, ensuring quick action in emergency situations.

The Bluetooth HC-05 module enabled reliable communication between the robot and the mobile device within a typical range of 8–10 meters. The user was able to control robot movement and arm operations smoothly, with negligible delay.

The pick-and-place arm, integrated with servo motors, showed precise angular movement and was capable of handling lightweight objects efficiently. The L298N motor driver provided stable control of DC motors, ensuring smooth navigation of the robot.

Additionally, the ESP8266 module enabled IoT-based monitoring, allowing system status updates to be transmitted over the internet. This enhanced the system's capability for remote supervision.

Overall, the system achieved:

1) Efficient fire detection and suppression
2) Stable wireless communication via Bluetooth
3) Accurate object handling using the robotic arm
4) Reliable motor control and system integration

V. FUTURE SCOPE

The proposed system can be further enhanced with the following improvements:

1) Integration of advanced sensors
2) Implementation of computer vision
3) Autonomous navigation
4) Use of GPS module
5) Mobile application development
6) Machine Learning integration
7) Enhanced robotic arm design
8) Use of water mist or fire extinguishing chemicals

9)

Fig. 4 Future Scope

VI. CONCLUSION

This paper presented the design and implementation of a Bluetooth Controlled Fire Fighting Robot integrated with a Pick and Place Arm. The system successfully combines fire detection, firefighting mechanisms, wireless control, and robotic manipulation into a single platform.

The integration of Arduino Uno, flame sensor, relay-controlled water pump, Bluetooth HC-05 module, ESP8266, and motor driver enables both autonomous and manual operation. The robot effectively detects fire and responds promptly while also allowing users to control movement and object handling remotely.

The pick-and-place arm enhances the functionality of the system by enabling it to perform additional tasks such as object handling in hazardous environments. The proposed system is cost-effective, easy to implement, and suitable for real-time applications.

Thus, the system proves to be a reliable solution for fire safety applications, industrial automation, and rescue operations.

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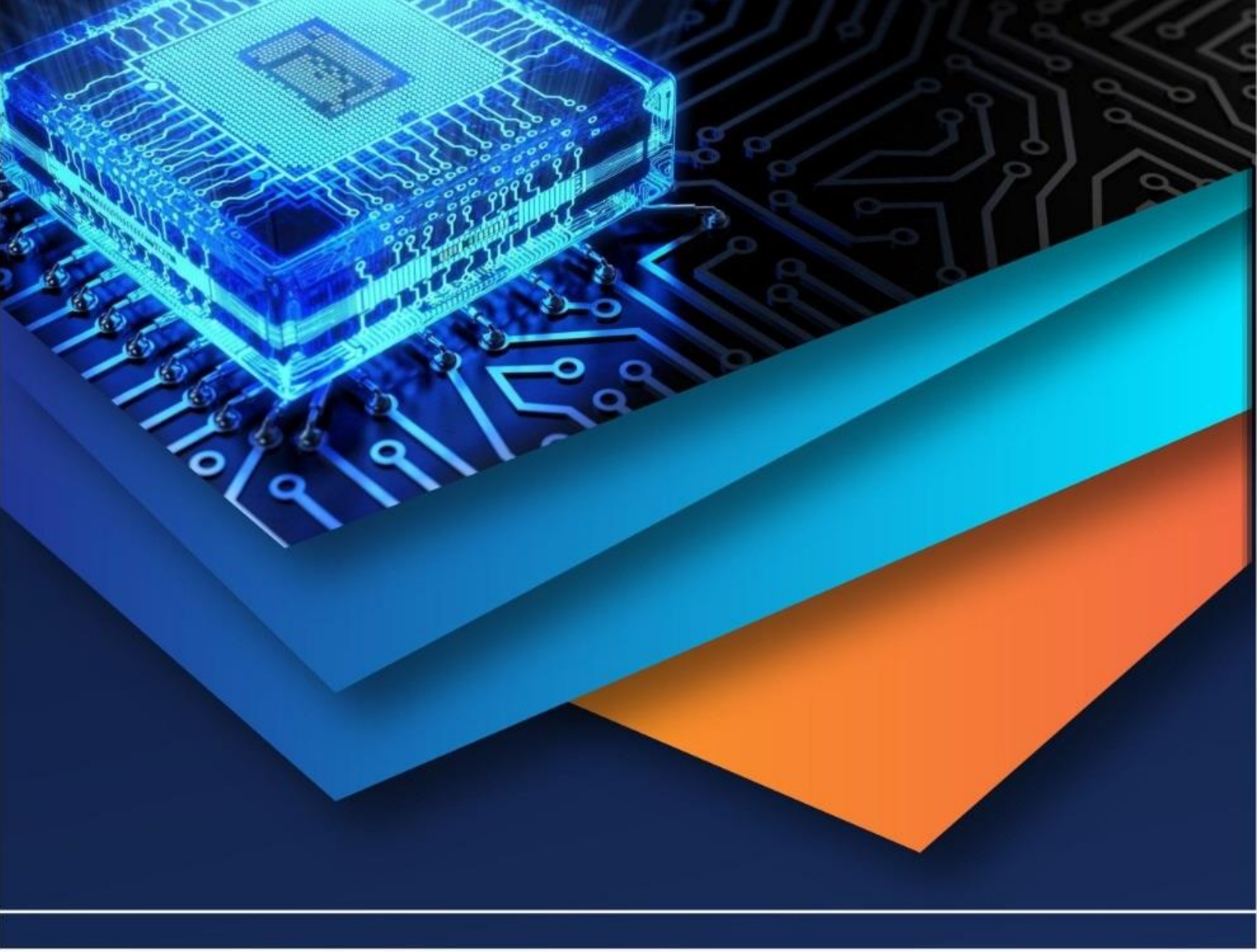

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