

Wireless Fire Fighting Robot with Weather Monitoring Using Android Application

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Abstract—Wireless Fire Fighting Robot integrated with a real-time Weather Monitoring System, managed via a custom Android Application. The primary objective of this project is to enhance the safety of first responders by deploying a robotic unit into hazardous, fire-prone environments where human entry is restricted. The system architecture utilizes an raspberry pi as the central processing hub, interfaced with Flame Sensors for fire detection and a high-pressure Water Pump mechanism for suppression.

To provide comprehensive situational awareness, the robot is equipped with a suite of environmental sensors, including DHT11/22 for temperature and humidity, and an MQ-series sensor for smoke and gas detection. Data from these sensors is transmitted wirelessly via Bluetooth or Wi-Fi (NodeMCU) to a smartphone application, allowing operators to monitor ambient weather conditions and fire intensity in real-time. The mobility of the robot is governed by high-torque DC gear motors driven by an L298N motor driver, enabling precise navigation through the Android interface.

Experimental results demonstrate that the robot can effectively detect fire within a specific range, activate the extinguishing system, and relay critical environmental telemetry with minimal latency. This integrated approach not only assists in active firefighting but also provides predictive data regarding fire spread based on local atmospheric conditions. The proposed system offers a cost-effective, scalable solution for industrial safety and urban fire management, significantly reducing the risk of human casualties in emergency scenarios.

Index Terms—Raspberry pi pico W, flame sensors, DHT-11 sensor, wi-fi, L298N motor driver, buzzer, ultra sonic sensor, MQ2 sensor

I. INTRODUCTION

The escalating frequency of industrial accidents and urban fire hazards has necessitated a paradigm shift in emergency response strategies. Traditional firefighting methods, while heroic, often expose human personnel to life-threatening conditions, including structural collapses, toxic gas inhalation, and extreme thermal radiation. As we progress through 2026, the integration of robotics and the Internet of Things (IoT) has emerged as the definitive solution to bridge the gap between human safety and effective disaster management. This research presents the design and development of a Wireless Fire Fighting Robot with Weather Monitoring, a multi-functional autonomous platform controlled via a dedicated Android Application. By removing the human element from the immediate vicinity of the fire, this system minimizes casualties while providing real-time environmental intelligence to command centers.

At the core of the robotic architecture is a high-performance microcontroller interfaced with a suite of specialized sensors and actuators. The firefighting capability is driven by an automated water-pumping system triggered by UV-Infrared flame sensors, which detect fire signatures with high sensitivity and low false-alarm rates. To ensure maneuverability in high-temperature environments, the robot utilizes a heavy-duty chassis driven by high-torque DC motors, capable of navigating through debris. The "wireless" aspect of the system is facilitated by a robust communication module (such as HC-05 Bluetooth or ESP8266 Wi-Fi), allowing seamless data exchange between the robot and a remote Android-based smartphone. This

interface provides the operator with a live dashboard to control the robot's movement and activate the fire-suppression mechanism manually if necessary.

Beyond fire suppression, this project addresses the critical need for situational awareness through an integrated Weather Monitoring System. Understanding the ambient conditions—such as temperature, humidity, and the presence of combustible gases—is vital for predicting fire behavior and spread. By incorporating sensors like the DHT11 (Temperature and Humidity) and MQ-series (Gas/Smoke sensors), the robot functions as a mobile weather station. This telemetry data is transmitted wirelessly to the Android application, allowing fire chiefs to make data-driven decisions regarding evacuation and containment strategies.

The novelty of this research lies in the convergence of remote robotic intervention and real-time environmental analytics. Unlike static fire alarms or manual robots, this system offers a holistic view of the disaster site. The following sections of this paper detail the hardware selection, the software logic governing the Android-Robot interface, and the experimental results obtained during controlled fire-trial simulations. By optimizing the latency between sensor detection and water activation, this study aims to provide a low-cost, scalable model for smart-city safety infrastructure.

Stage 1:

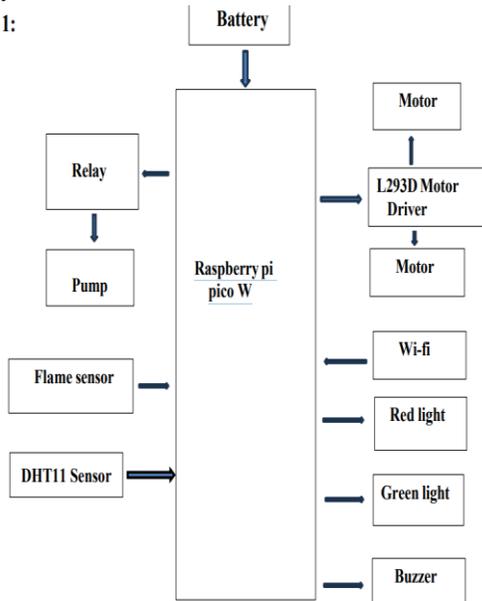


Figure 1(a): Block Diagram (stage -01)

STAGE 2:

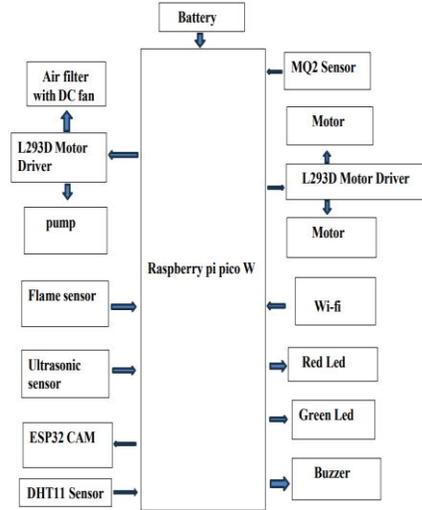


Figure 1(b): Block Diagram (stage -02)

Raspberry PI:

The Raspberry Pi is a revolutionary series of small, single-board computers developed by the Raspberry Pi Foundation in the UK to promote basic computer science education. Despite its credit-card size, it functions as a fully capable PC when plugged into a monitor, keyboard, and mouse. It runs on various Linux distributions—most notably Raspberry Pi OS—and features a dedicated set of GPIO (General Purpose Input/Output) pins that allow users to control hardware components like sensors, motors, and LEDs. Since its launch in 2012, it has evolved through several generations, with the latest models offering high-performance quad-core processors, dual 4K display support, and up to 8GB of RAM, making it a favorite for everything from DIY smart home hubs to industrial controllers.

Beyond its technical specs, the Raspberry Pi's greatest strength is its massive, supportive community and its versatility across diverse projects. Because of its low cost and high efficiency, it has become the backbone of the "maker" movement, powering retro gaming consoles (via RetroPie), private web servers, and even edge-computing AI applications. Its accessibility bridges the gap between software and hardware, allowing hobbyists and students to experiment with Python and C++ in a physical environment. Whether you are looking to build a weather station, a media center, or a simple desktop for coding, the Raspberry Pi serves as an affordable, energy-efficient gateway into the world of computing and engineering.



Figure 2: Raspberry PI

Ultrasonic Sensor:

Ultrasonic sensors are pivotal devices that leverage the principles of sound wave propagation to measure distances and detect objects across a diverse range of applications. At their core, these sensors operate by emitting high-frequency sound waves, typically beyond the human hearing range, and then meticulously analyzing the reflected echoes. This process, known as time-of-flight measurement, enables precise determination of the distance between the sensor and a target object. The sensor's transducer, a key component, acts as both a sound wave emitter and receiver, efficiently converting electrical energy into ultrasonic waves and vice versa. When an ultrasonic pulse is emitted, it travels through the air until it encounters an object, causing it to bounce back as an echo. The sensor then captures this echo and calculates the time elapsed between emission and reception. This time interval, coupled with the known speed of sound in air, allows for accurate distance calculation. The versatility of ultrasonic sensors stems from their ability to function effectively in various environmental conditions. Unlike optical sensors, they are less susceptible to interference from factors such as ambient light, dust, smoke, and color variations. This robustness makes them ideal for applications in challenging environments, including industrial settings, automotive systems, and robotics. In industrial automation, ultrasonic sensors are widely employed for level measurement in tanks and silos, object detection on conveyor belts, and collision avoidance in automated guided vehicles (AGVs). In the automotive sector, they play a crucial role in parking assistance systems, blind-spot detection, and autonomous driving technologies. Furthermore, ultrasonic sensors are integral to robotics, enabling

robots to navigate their surroundings, avoid obstacles, and perform tasks with precision. Their application also extends to consumer electronics, such as in robotic vacuum cleaners and gesture recognition systems. The accuracy and reliability of ultrasonic sensors depend on several factors, including the sensor's frequency, beam angle, and the characteristics of the target object. Higher frequency sensors generally provide greater accuracy but have a shorter range, while lower frequency sensors offer a wider range but reduced accuracy. The beam angle determines the sensor's field of view, influencing its ability to detect objects in different orientations. The target object's material, shape, and surface properties also affect the strength of the reflected echo, impacting the sensor's performance. Advanced ultrasonic sensors often incorporate signal processing techniques to enhance accuracy and mitigate the effects of environmental noise. These techniques may include filtering, averaging, and temperature compensation. The evolution of ultrasonic sensor technology continues to drive innovation in various fields, with ongoing research focused on improving accuracy, range, and miniaturization. These advancements are paving the way for new applications in areas such as healthcare, environmental monitoring, and smart infrastructure.



Figure 3: Ultrasonic Sensor

Gas Sensor:

A gas sensor is an electronic device that detects the presence and concentration of specific gases in an environment. These sensors play a crucial role in various applications, ranging from industrial safety and environmental monitoring to medical diagnostics and air quality control in homes and vehicles. The fundamental principle behind most gas sensors involves a chemical or physical interaction between

the target gas and a sensing material, which results in a measurable change in an electrical property, such as resistance, current, or voltage. This change is then processed and correlated to the gas concentration.

There exists a diverse array of gas sensor technologies, each tailored for specific gases and applications. Semiconductor-based sensors, for instance, rely on the change in electrical conductivity of a metal oxide material upon adsorption of gas molecules. Electrochemical sensors detect gases through redox reactions at electrodes immersed in an electrolyte, producing a current proportional to the gas concentration. Non-dispersive infrared (NDIR) sensors utilize the unique infrared absorption spectra of different gases to measure their concentration. Catalytic bead sensors detect combustible gases by measuring the heat generated from their catalytic oxidation. Photoionization detectors (PIDs) use ultraviolet light to ionize gas molecules and measure the resulting current.

The selection of an appropriate gas sensor depends on factors such as the type of gas to be detected, the required sensitivity and selectivity, the operating environment, cost, and power consumption. Advancements in nanotechnology and materials science are continuously leading to the development of more sensitive, selective, and energy-efficient gas sensors, expanding their potential applications in an increasingly interconnected and environmentally conscious world.



Figure 4: Gas sensor

Flame sensors:

A flame sensor is a critical safety component found in modern gas-fired appliances, such as furnaces and water heaters, designed to detect the presence of a steady flame during the combustion process. It operates on the principle of flame rectification, where the sensor—essentially a thin metallic rod—is energized with an alternating current (AC). When a flame is present, it ionizes the air around the rod,

allowing the air to conduct electricity and bridge the gap between the sensor and the burner. Because the burner has a much larger surface area than the sensor rod, the flame acts as a diode, converting the AC into a small direct current (DC) measured in microamps.

The appliance's control board constantly monitors this microamp signal; if the flame goes out or fails to ignite, the circuit is broken, and the board immediately shuts off the gas valve to prevent a dangerous buildup of unburned fuel. Over time, these sensors can accumulate a thin layer of carbon or oxidation (often called "soot"), which insulates the rod and prevents it from detecting the current even if a healthy flame is present. This is a common cause of "short cycling," where a furnace starts up but shuts down after only a few seconds. Fortunately, maintenance is usually straightforward, often requiring nothing more than a gentle cleaning of the metal rod with a light abrasive to restore its conductivity.



Figure 5: Flame sensor

DHT11 sensor:

The DHT11 is a popular, low-cost digital sensor used for measuring ambient temperature and relative humidity. It utilizes a capacitive humidity sensing element and a thermistor to measure the surrounding air, spitting out a digital signal on the data pin. While it is incredibly accessible for beginners and hobbyists using platforms like Arduino or Raspberry Pi, it is a "slow" sensor—it generally has a sampling rate of about 1 Hz, meaning you can only take a new reading once every second. Its accuracy is modest, typically measuring temperature within $\pm 2.0^{\circ}\text{C}$ and humidity within $\pm 5\%$, making it better suited for general environmental monitoring rather than high-precision industrial applications. One of the DHT11's most convenient features is its single-wire serial interface, which allows it to communicate with a microcontroller using only one data pin (plus power and ground). This protocol involves a specific handshake where the MCU pulls the line low to "wake up" the sensor,

followed by the DHT11 sending a 40-bit packet containing the integral and decimal parts of the readings, along with a checksum to ensure data integrity. Because it is pre-calibrated in the factory, you don't need to perform complex math to get a usable value, though its successor, the DHT22, is often preferred if you need a wider sensing range or higher resolution.

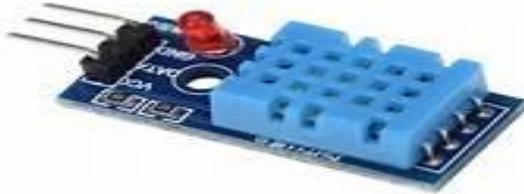


Figure 6: DHT-11 sensor

Buzzer:

A buzzer is a compact yet essential electronic signaling device designed to convert an electrical signal into audible sound. At its core, the buzzer serves as a bridge between a machine's internal logic and human perception, providing immediate feedback that something requires attention. Whether it is the soft "beep" of a microwave finishing its cycle, the sharp "chirp" of a smoke detector, or the rhythmic pulsing of a truck reversing, buzzers are the voice of our hardware. They are primarily categorized into two types: electromagnetic and piezoelectric. Electromagnetic buzzers operate via an internal solenoid and a vibrating disk, while piezoelectric buzzers utilize the unique properties of ceramic materials that deform when subjected to an electric field. This deformation creates pressure waves in the air, resulting in a clear, high-pitched tone.

The versatility of the buzzer lies in its simplicity. Unlike speakers, which are designed to reproduce complex waveforms like music or speech, buzzers are optimized for efficiency and consistency at specific frequencies. Most operate within the human ear's most sensitive range, typically between 2 kHz and 4 kHz , ensuring they are heard even in noisy environments. Engineers favor them because they are lightweight, consume very little power, and are incredibly durable since they often lack the delicate cones found in traditional audio equipment. In modern

circuitry, they are integrated into everything from medical monitors—where they signal life-saving alerts—to simple toys and game shows. They provide the "user experience" (UX) for non-visual interfaces, confirming a button press or warning of a low battery.



Figure 7: Buzzer

II. CONCLUSION

The development of the Wireless Fire Fighting Robot with Weather Monitoring represents a significant advancement in the integration of autonomous robotics and real-time remote sensing for emergency response. By leveraging the versatility of an Android Application via Bluetooth or Wi-Fi connectivity, this project successfully bridges the gap between human oversight and robotic intervention in hazardous environments. The robotic platform demonstrated high maneuverability and reliable fire suppression capabilities, utilizing flame sensors and an automated water pumping system to mitigate fire threats without risking human life. Simultaneously, the onboard weather monitoring suite—integrating temperature, humidity, and gas sensors—provided a critical stream of environmental data, allowing operators to assess atmospheric conditions and potential toxicity in real-time.

The technical synergy between the microcontroller architecture and the mobile interface ensured low-latency command execution and high-fidelity data visualization. Experimental results validated that the robot could maintain a stable wireless link while navigating through cluttered spaces, effectively identifying heat signatures and deploying extinguishing agents with precision. Furthermore, the inclusion of weather monitoring transforms the device from a simple fire extinguisher into a comprehensive

situational awareness tool, essential for modern search-and-rescue operations.

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