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IoT-Based Fire Detection System Using a Flame Detector and Arduino Uno R4 Wi-Fi

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***Abstract*— Based on data from the DORS POLRI application, a total of 935 fire incidents were recorded from January to October 7, 2024. The locations with the highest frequency of fires were residential areas, with 704 reported cases. These data indicate the need for a fire detection security system capable of providing early warning as a risk-mitigation measure to prevent casualties during fire incidents.The system designed in this study is based on the Internet of Things (IoT) and is equipped with a notification feature that sends alerts to a Telegram bot when the sensor detects the presence of fire. The results of this study show that even after reducing the sensor sensitivity 33the sensor still performs adequately in detecting fire. It can detect real fire at a distance of 35 cm and can still detect light from a bulb at a distance of approximately 95 cm. However, the sensor is unable to detect paraffin fire at a distance of 10–50 cm because the infrared wavelength emitted by paraffin is outside the detectable range of the sensor. Additionally, the sensor cannot detect virtual fire or light from a mobile phone flashlight because these light sources do not emit infrared radiation that matches the operating characteristics of the sensor.Thus, the system has been proven effective in detecting fire and sending automatic real-time notifications to Telegram, enabling users to respond quickly when there is a potential fire hazard.**

***Index Terms*— Fire, Flame Detector, IoT, Paraffin.**

I. INTRODUCTION

Fire is a major threat to the environment, industry, public facilities, and human life. The losses caused by fire include damage to property and assets, and in severe cases, can lead to casualties [1] According to experts, fire is defined as the presence of unwanted or uncontrolled flames [13]. Fires can occur at any time and are unpredictable [14]; therefore, to prevent major losses, a fire detection security system with early warning capabilities is required to mitigate fire risks [8].

In fire detection systems, flame detectors or flame sensors are often chosen because of their fast detection capability in identifying fire occurrences [5][6] and their adjustable sensitivity. These sensors typically detect light emissions within the infrared (IR) or ultraviolet (UV) spectrum and immediately send a signal when a flame is detected.

According to data from the DORS POLRI application, there were 935 fire incidents recorded from January to October 7, 2024. The locations most frequently affected were residential areas (704 incidents), shops (63), offices (29), schools (17), warehouses (16), and others (106) [2]. This data shows that the risk of fire remains relatively high, necessitating a reliable early detection system to minimize material losses and casualties.

Previous research by Denny and Budy (2022), titled "Prototype of a Fire Detection Device Using a Flame Sensor and MQ-2 Based on Arduino Uno," explains that the flame detector was able to detect fire at a distance of 5–25 cm, triggering an alarm and activating an LED indicator [3]. Furthermore, in the study conducted by Dian et al., titled "Arduino-Based Fire Detection System Using a Flame Detector and MQ-2 Sensor," the test results showed that the flame detector could detect fire at distances ranging from 5 cm to 40 cm. At a distance of 5 cm, the average detection time was approximately 0.57143 seconds; at 10 cm it was 1.5714 seconds; at 20 cm it was 8 seconds; at 30 cm it was 13 seconds; and at 40 cm it was 9 seconds [4]. Another study conducted by Rima et al. demonstrated that the flame detector was capable of detecting the presence of fire at distances from 20 cm up to 250 cm [12]. In the study conducted by Ruibing and Dhirtiman, a fire detection method using CNN is presented, making the fire detection system more efficient and effective [16].

The system is designed based on the Internet of Things (IoT) and is equipped with real-time notification delivery to a Telegram bot when the flame detector sensor detects the presence of fire. In addition, the system sends information regarding water availability in the storage tank using an ultrasonic sensor. With the integration of Telegram notifications, users can easily receive status updates [9][10] and monitor environmental conditions in real time without being physically present at the location. The system is also equipped with a water pump that activates automatically when fire is detected and stops operating once the fire is no longer detected.

II. METHODOLOGY

The methodology used in this study is the prototype development method, followed by direct testing of the system. The testing phase was conducted 3–5 times for each test component. The test components consisted of a yellow bulb, phone flashlight, virtual fire, real fire, and paraffin. The testing distance for each component ranged from 5 cm to ±95 cm. During testing, the flame detector was brought close to each test component at predetermined distances to observe the sensor's response.

The research stages began with the creation of a system block diagram aimed at identifying the main components used and the interconnections between them. This block diagram provides an overview of the system's workflow, from the input to the output stage.

Next, a system flowchart was created to illustrate the detailed logic flow of the system, describing how the system operates—from the fire detection process and water availability check to the activation of the pump and alarm. The subsequent stage involved hardware design, which included assembling key components such as the Arduino Uno R4 WiFi, flame sensor, ultrasonic sensor, LCD, water pump, indicator LEDs, and buzzer. All components were connected according to the previously designed block diagram.

Following this, the software design stage was carried out by writing a program for the Arduino to control the entire system operation—from reading sensor data to managing outputs and displaying information on the LCD. Once the hardware and software were integrated, direct testing of the system was conducted to ensure that all components functioned as intended. The testing involved simulating the presence of fire and observing the system's response to this condition.

The results of these tests were then used to evaluate the performance and effectiveness of the developed automatic fire detection system prototype.

A. Block Diagram

The first stage of this research is the development of a block diagram, which is a diagram that illustrates the workflow and the main components of a system [15]. This block diagram is used to show the components that will be used and how they are interconnected within the system. The system is designed based on the components shown in Block Diagram 1.1. The main components used include the Arduino Uno R4 WiFi, flame detector, ultrasonic sensor, red LED, blue LED, pump, buzzer, and LCD.

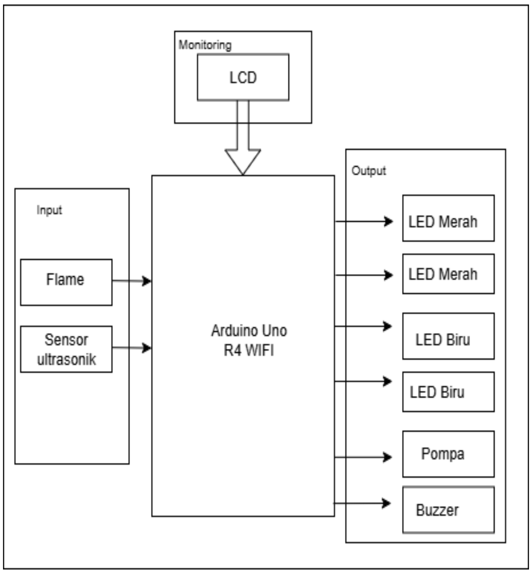

Fig. 1. Block Diagram System

The system detects the presence of fire. When a fire is detected, the water nozzle automatically opens and sprays water. In addition, the system is equipped with an ultrasonic sensor to detect the water level in the tank, and the monitoring results are displayed on the LCD, making supervision easier.

The following is an explanation of the block diagram for the design of the fire detection system:

1. Power Supply – Functions as the main power source that provides voltage and electric current to operate all system components.
2. Arduino Uno WiFi – Serves as the central controller (microcontroller) that processes data from the sensors and controls the output responses such as LEDs, buzzer, and pump, as well as sends information to Telegram in real time.
3. I2C Module – Used as a communication interface between the Arduino and the LCD to make pin usage more efficient and simplify data transmission to the display.
4. LCD – Displays system information such as fire detection status, object distance from the ultrasonic sensor, and pump condition.
5. Flame Detector – Detects the presence of fire based on the intensity of infrared light emitted by the flame.
6. Ultrasonic Sensor – Measures the water level in the storage tank.
7. Red LED – Acts as an indicator when fire is detected or when the water level is low.

Blue LED – Serves as an indicator that no fire is detected or that the condition is safe.

8. Pump (Actuator) – Functions to spray water when the system detects fire.
9. Buzzer – Serves as an audible alarm to provide a warning when fire is detected.
10. Telegram – Used to receive notifications or information sent by the Arduino.

As can be seen in Fig. 1 there is information about 3 parts that communicate with each other. The first part is the remote control block. There is Blynk IoT which functions as a controller and monitor carried out by the greenhouse owner and there is also Gmail which functions to receive sensor reading reports by the greenhouse owner and also functions to send messages that the system is in error to the greenhouse technician. The second part is the software block. There is Arduino IDE which functions to enter code into ESP32 and there is also Blynk Cloud which functions as a virtual communication intermediary between ESP32 and Blynk IoT and Gmail. The third part is the hardware block. There is ESP32 as the control center and main control system, there is a BH1750 sensor, DHT22 sensor, and soil moisture sensor, there is also a stepper motor actuator, lights, foggers, and water pumps.

B. *Design System*

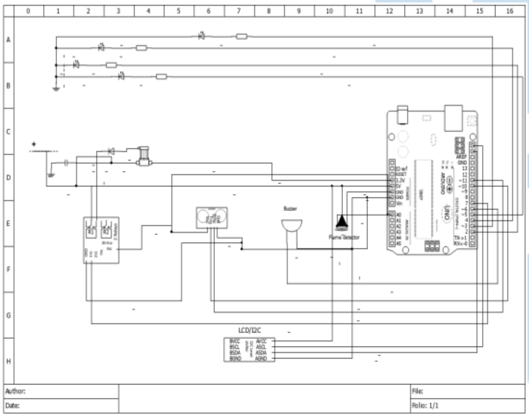

Fig. 2. Design System

The system design illustrates how the components are configured in the automatic fire detection system. This system uses an Arduino Uno as central control. The Arduino will control and process data from the sensors, then control the pump that will discharge water and display information in real time on the display. The system operation is as follows:

1. When the circuit is powered on, this is indicated by LED 1 (blue) and the display will show “Fire: Safe”.
2. When the fire sensor (KY-026) detects a flame, LED 2 (red) and the buzzer will activate, and the display will show “Fire: Danger”.
3. Then the 5 V DC pump is activated and pumps water from the tank to the predetermined fire point.
4. When the fire is extinguished, LED 2 (red) becomes inactive and the 5 V DC pump stops until it is activated again if another fire danger is detected.
5. LED 1 (blue) turns on again and the display returns to the indication “Fire: Safe”.
6. The ultrasonic sensor (HC-SR04) on the water tank functions as the water level reader.
7. The display shows two indications:
   a. Water tank: High / Normal / Low / Empty
   b. Water level: 0–100%

   Notes:
   • High: water > 80% – 100%
   • Normal: water > 40% – < 80%
   • Low: water < 40%
   • Empty: no water
8. If the tank level shows “Low” on the display, the pump will not activate and LED 2 (red) will light.

To build this design, several components are required, as listed in the following table.

TABLE I. LIST COMPONENT OF PROTOTYPING

No	Component	Quantity
1	Arduino Uno R4 WiFi	1
2	LCD + I2C Module	1
3	Flame Detector	1
4	UltrasoniC Sensor	1
5	Pump	1
6	Jumper Wires	± 30
7	Buzzer	1
8	Red LED	2
9	Blue LED	2

C. *Flowchart*

The following is an illustration of the system’s operation. In the flowchart above, there are two conditions. The first condition occurs when the sensor detects fire. In this case, the sensor sends a signal to the Arduino to activate the buzzer as an early warning of fire. The Arduino then turns on the pump, which draws water from the reservoir to extinguish the fire. At the same time, the red LED lights up to indicate that fire is still detected, while the blue LED turns off. Fire information is also displayed on the LCD. The second condition occurs when no fire is detected. In this situation, the buzzer is turned off, the red LED goes off, and the blue LED turns back on. The LCD then displays information indicating that no fire is detected.

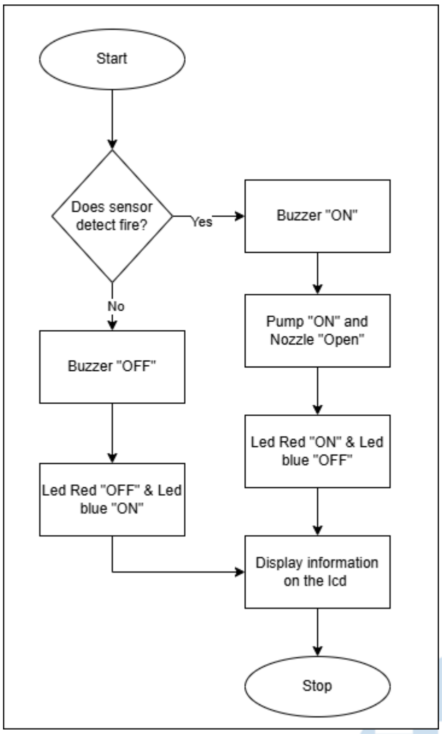

Fig. 3. Design System

III. Result and Analysis

In the system circuit, all components are shown working together to detect the presence of fire and automatically spray water as an initial fire suppression step.

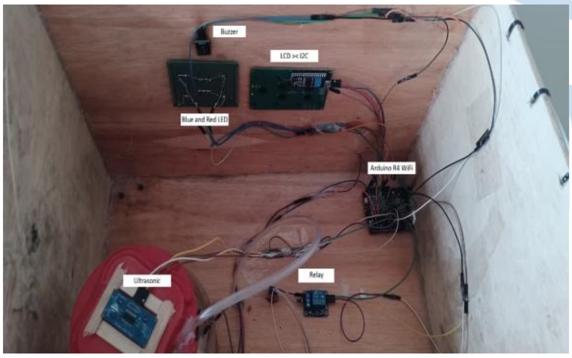

Fig. 4. Component System

Figure 4 shows the overall layout of the system inside the control box. Several main components can be seen, including the Arduino Uno R4 WiFi, flame sensor module, ultrasonic sensor, LCD, water pump, and the connecting cables between components.

The ultrasonic sensor is installed on the lid of the water tank to detect the water level or availability. The water pump is connected to the tank and functions to automatically draw and spray water when the system detects the presence of fire.

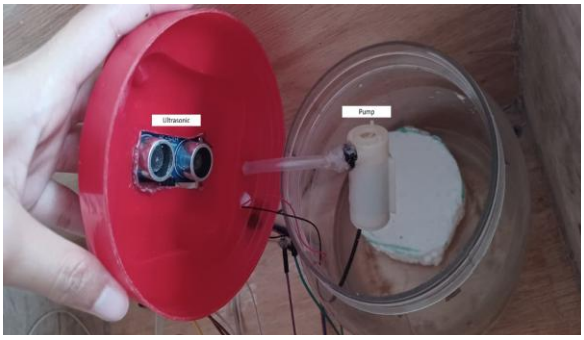

Fig. 5. Ultrasonic Sensor and Pump

From Figure 5 the ultrasonic sensor is installed at the top of the water container (tank). This sensor works by emitting ultrasonic waves and receiving their reflections from the water surface, allowing the Arduino to determine whether the water is still available or has run out. The system also includes a pump that functions to draw water automatically when a fire is detected.

Fig. 6. Flame Detector and Hose

At the bottom section, there is a hose and a flame detector. This part shows the hose end and the nozzle where water from the pump is discharged. It becomes active when the flame detector detects fire, allowing water to be sprayed directly onto the heat source area.

Fig. 7. LCD, LED, and Buzzer

It shows the front view of the system box, which includes an LCD screen, several LED indicators, and a buzzer.

Fig. 8. Display Telegram Bot

The following is the display of the Telegram bot, which shows information about water availability, pump status, and fire conditions in the automatic fire detection system. This bot sends notifications whenever there is a change in the system's state, such as the pump being activated or deactivated, fire being detected or not, and the water level in the storage tank.

TABLE II. FLAME DETECTOR TESTING

No	Test Experiment	Distance	Result	
			Yes	No
1	Yellow Bulb	± 95 cm	√	
		80 cm	√	
		70 cm	√	
		60 cm	√	
2	Phone Flashlight	15 cm		√
		10 cm		√
		5 cm		√
3	Virtual Fire	15 cm		√
		10 cm		√
		5 cm		√
4	Real Fire	35 cm	√	
		25 cm	√	
		20 cm	√	
5	Paraffin	50 cm		√
		40 cm		√
		30 cm		√
		25 cm		√
		10 cm		√

In the experimental results shown in Table 2, with the sensor sensitivity set to 33, it was found that the flame detector sensor exhibits different sensitivity levels to various light sources. In the first experiment using a yellow bulb, the sensor was able to detect light at a distance of up to approximately 95 cm and continued to detect it at closer distances (80 cm, 70 cm, and 60 cm). This indicates that the sensor is quite sensitive to yellow light because the intensity and spectrum of the bulb's light fall within the detectable range of the sensor.

In the second and third experiments, using a phone flashlight and virtual flame, the sensor failed to detect any light sources even at very close distances (5–15 cm). This occurs because the light emitted by a phone flashlight and a virtual flame (on a screen) does not contain the infrared components characteristic of real fire, resulting in no response from the sensor.

In the fourth experiment, using a real flame source, the sensor successfully detected fire up to a distance of 35 cm, indicating that the sensor effectively detects the infrared radiation emitted by actual flames. However, in the fifth experiment, the paraffin flame could not be detected even at a distance of 10 cm. This is because the infrared (IR) wavelength range that the flame sensor can detect is between 760 nm and 1,100 nm [5], while the infrared wavelength range of paraffin flame is between 2,500 nm and 25,000 nm [7][11].

IV. CONCLUSION

Based on the results of the design and testing, the automatic fire detection system using a flame detector based on Arduino Uno R4 WiFi was able to function properly as expected. The system can detect fire using the flame detector, and the water pump is automatically activated to extinguish the fire. Once the fire is extinguished, the water pump stops operating automatically. In addition to the flame sensor, the system is also equipped with an ultrasonic sensor installed on the water tank, which measures the water level and displays it in real time on the LCD, while also sending information to a Telegram bot, allowing users to monitor the system remotely.

The test results also show that the flame detector has high sensitivity to real fire and light bulb sources, even when the sensitivity level is reduced to 33. However, the flame detector is less responsive to virtual fire, phone flashlight, and paraffin flame, because the infrared wavelength of paraffin fire lies outside the IR wavelength range that can be detected by the flame detector.

Thus, this system has proven to be effective in detecting fire and providing automatic real-time notifications via Telegram, enabling users to respond quickly when there is a potential fire hazard.

REFERENCES

[1] G. A. Rimbawan and M. A. Nur, "Nilai Kerugian Ekonomi Lingkungan Akibat Kebakaran Hutan dan Lahan Gambut di Kota Banjarbaru," *JIEP: Jurnal Ilmu Ekonomi dan Pembangunan,* vol. 4, pp. 25-39, 2021. DOI: 10.20527/jiep.v4i1.3540

[2] PUSIKNAS (Pusat Informasi Kriminal Nasional)," 18 Oktober 2024. [Online]. Available: https://pusiknas.polri.go.id/detail_artikel/kebakaran_paling_banyak_terjadi_di_perumahan. [Accessed 15 Oktober 2025].

[3] D. A. Nugraha and B. Satria, "Prototype Alat Pendeteksi kebakaran Menggunakan Sensor Flame dan MQ-2 Berbasis Arduino Uno," *IJCS: Indonesian Journal of Computer Science,* vol. 11, pp. 936-944, 2022. DOI: https://doi.org/10.33022/ijcs.v11i3.3102

[4] D. Indriani, M. Subhan and E. Rahmawati, "Sistem Alarm Kebakaran Berbasis Arduino Menggunakan Flame Detector Dan Sensor MQ-2," *Jurnal Pedagogos : Jurnal Pendidikan STKIP Bima,* vol. 3, pp. 16-23, 2021. DOI: https://doi.org/10.33627/gg.v3i2.509

[5] Zulkifli, M. Muhallim, Hasnahwati, "Pengembangan Sistem Alarm dan Pemadaman Kebakaran Otomatis Menggunakan Internet of Things," JITET (Jurnal Informatika dan Teknik Elektro Terapan), vol. 13, no. 3, pp. 2444-2460, 2024. DOI: http://dx.doi.org/10.23960/jitet.v12i3.4774.

[6] J. Ryu and D. Kwak, "Flame Detection Using Appearance-Based Pre-Processing and Convolutional Neural Network," *MDPI,* no. Computing and Artificial Intellegence, pp. 1-14, 2021. DOI: https://doi.org/10.3390/app11115138

[7] "Pharmacopeial Forum," [Online]. Available: https://www.drugfuture.com/Pharmacopoeia/usp38/data/v38332/usp38nf33s2_c854.html. [Accessed 16 October 2025].

[8] S. F. Razi, A. Mardiyanto and S. Y. Widianti, "Implementasi Sistem Peringatan Dini Kebakaran Berbasis IoT (Internet of Things) Pada Gedung Sekolah Muhammadiyah Lhokseumawe," *Proceeding Seminar Nasional Politeknik Negeri Lhokseumawe,* vol. 8, pp. 110-115, 2025. URL: https://e-jurnal.pnl.ac.id/semnaspnl/article/view/6897/4765

[9] D. R. Juliandi, J. Karman and R. , "Perancangan Sistem Bot Alert Telegram Sebagai Notifikasi Deteksi Serangan Ping of Death Berbasis Snort," *RESOLUSI : Rekayasa Teknik Informatika dan Informasi,* vol. 5, pp. 49-57, 2024. DOI: 10.30865/resolusi.v5i1.2168

[10] M. H. Azhari, R. and B. A. Prakosa, "Rancang Bangun Dan Pemanfaatan Notifikasi Telegram Pada Alat Penyewaan Power Bank," *Jurnal Pendidikan dan Teknologi Indonesia (JPTI),* vol. 4, pp. 313-324, 2024. DOI: https://doi.org/10.52436/1.jpti.450

[11] A. Y. Ramadhan, "Rancang Bangun Simulasi Otomatisasi Pembersih Sightglass Untuk Meningkatkan Akurasi Flame Detector Pada Burner Heater", Politeknik Industri Petrokimia Banten, 2025.

[12] R. T. Aldisa, F. N. Karel and M. Aldinugroho, "Sistem Peringatan Dini Kebakaran Dengan Flame Sensor dan Arduino Uno R3," *JURNAL MEDIA INFORMATIKA BUDIDARMA,* vol. 6, no. 1, pp. 453-458, 2022. DOI: 10.30865/mib.v6i1.3499

[13] V. Haristianti, M. . A. W. Linggasani, S. N. Sabatini and D. Hartabela, "PROTEKSI RISIKO KEBAKARAN DI PERUMAHAN STUDI KASUS: PERUMAHAN BARU DI KELURAHAN CIGADUNG, BANDUNG," *Jurnal Arsitektur Zonasi,* vol. 2, no. 1, pp. 1-11, 2019. DOI: http://10.17509/jaz.v2i1.15061

[14] A. Cahyadi, F. Lestari and A. Kadir, "ANALISIS TINGKAT RISIKO BENCANA KEBAKARAN WILAYAH JAKARTA BARAT, PROVINSI DKI JAKARTA," *PREPOTIF Jurnal Kesehatan Masyarakat,* vol. 6, no. 1, pp. 467-477, 2022. DOI: https://doi.org/10.31004/prepotif.v6i1.3651

[15] F. Maulana, M. Orisa and H. Z. Zahro, "KLASIFIKASI DATA PRODUK MEBEL ANEKA JAYA MENGGUNAKAN METODE K-NEAREST NEIGHBOR BERBASIS WEB," *JATI (Jurnal Mahasiswa Teknik Informatika),* vol. 5, no. 2, pp. 460-466, 2021. DOI: https://doi.org/10.36040/jati.v5i2.3782

[16] R. Shi and D. Vaikuntan, "Recent Advances in Flame Detection Using Convolutional Neural Networks: A Review," *Journal of Computer Technology and Software,* vol. 4, no. 1, 2025. DOI: https://doi.org/10.5281/zenodo.14785303.