PROJECT IV: Flame Detection

Introduction

Fire hazards remain a significant concern in residential, commercial, and industrial environments, often resulting in severe damage and loss. Traditional fire detection and suppression systems are typically reactive and may suffer from delayed response times, thereby increasing the potential for fire escalation. To address these challenges, we have designed and implemented an automated flame detection and extinguishing system that provides an immediate and effective response to fire outbreaks. Our system comprises highly sensitive flame sensors, an Arduino Uno R3 for real-time data processing, and a motorized water dispensing unit. Upon detecting a flame, the sensors relay the information to the microcontroller, which processes the data and activates the motor to release water directly onto the flame. This rapid intervention is crucial in preventing the spread of fire and minimizing damage. By integrating cutting-edge sensing technologies with automated response systems, this project aims to significantly improve fire safety measures. The research contributes to the advancement of intelligent fire prevention systems, showcasing the potential for innovative solutions in enhancing safety and reducing fire-related risks.

Components

- Hardware
    - Arduino Uno R3
    - Liquid Crystal Display (LCD)
    - Servo Motor
    - 9V Battery
    - Water Motor
    - Water pipe – 1 foot
    - Flame Sensor
    - 4-pin Relay Module
    - Buzzer
    - Resistor
    - Breadboard
    - Jumper Wires

- LED: Red and Green

- Software
    - Arduino Uno IDE

Working

This IoT project works with the help of multiple hardware components including: Arduino Uno R3, Flame Sensor, Relay Module, Liquid Crystal Display (LCD), Battery, and motors.

The Arduino Uno R3 is a microcontroller board based on the ATmega328P. It features 14 digital input/output pins, 6 analog inputs, and a USB 2,0 type-B connection for programming and power. The board operates by reading inputs (like light on a sensor), processing the data, and controlling outputs (like turning on an LED). It's widely used for prototyping and educational purposes in electronics and programming.

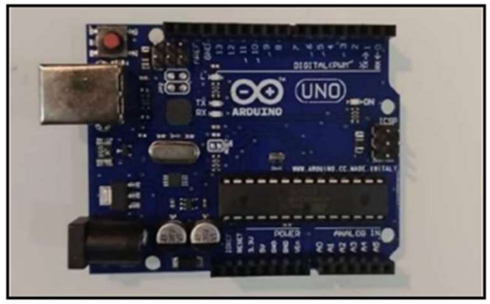

Figure 4.1: Arduino Uno R3

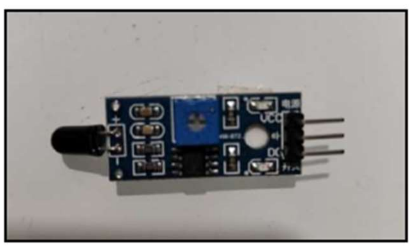
Figure 4.2: Flame Sensor

Flame sensors are crucial components in safety systems, detecting the presence of flames in various applications. They operate by sensing infrared radiation emitted by flames, triggering alarms or safety protocols. They are used in industries from aerospace to household appliances, flame sensors play a vital role in preventing fire hazards. Their reliability in quickly detecting flames helps in timely response and mitigation of fire risks. Advanced versions integrate with automated systems, enhancing overall safety and efficiency in diverse environments.

The 4-pin smart relay module is a versatile electronic component used to control high-voltage devices with low-voltage signals. It features six pins: VCC, GND, four pins (for four relay modules), and the other side consists of Normally open (NO), normally closed (NC) and COM (common) pins. The module can be integrated with microcontrollers like Arduino and Raspberry Pi, making it ideal for IoT projects. It allows for the remote control of

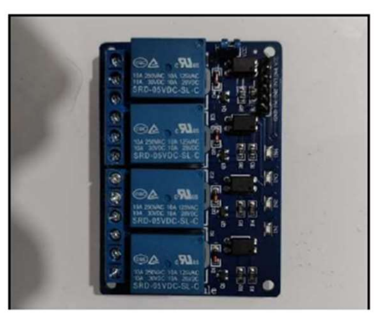
Figure 4.3: 4-way relay module

appliances, lights, and other electrical devices. With built-in optocouplers, it provides isolation and protects the controlling device from voltage spikes and surges.

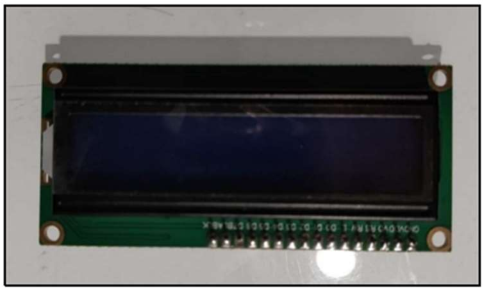
Figure 4.4: LCD front

Liquid Crystal Displays (LCDs) are ubiquitous in electronic devices, offering a clear and visually sharp interface for displaying information. Utilizing the light-modulating properties of liquid crystals between polarized electrodes, LCDs produce images with high contrast and low power consumption. They are commonly used in devices such as digital clocks, calculators, and consumer electronics like smartphones and televisions. LCDs are preferred for their thin profile, light weight, and ability to display information in various lighting conditions, making them versatile for both indoor and outdoor applications. As technology advances, LCDs continue to evolve with improved resolution, colour reproduction, and energy efficiency, maintaining their status as a cornerstone of modern display technology. Normally, the LCD consists of 8 pins, however, for this project The LCD used in this project consists of four: SDA, SCL, Vcc and GND. The potentiometer present on the board helps to adjust the brightness of the LCD.

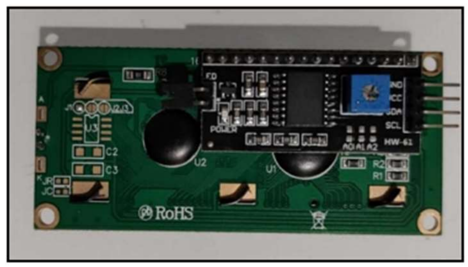

Figure 4.5: LCD back


Figure 4.6: Servo Motor

A servo motor is an electric motor coupled with a sensor for position feedback, allowing precise control of angular or linear position, velocity, and acceleration. It works by receiving a control signal that dictates the desired position and using the feedback sensor to adjust the motor's movement accordingly. The motor's internal circuitry continually corrects any deviations from the target position. Servo motors are widely used in robotics, CNC machinery, and automated manufacturing.

A water motor, commonly known as a water pump, is an essential device that moves water from one location to another, often used in agriculture, industry, and residential settings. It operates by converting electrical or mechanical energy into hydraulic energy, enabling efficient water distribution for irrigation, drainage, and household water supply. Modern water motors are designed for energy efficiency and durability, ensuring reliable performance in various conditions. By automating water transport, they significantly reduce manual labour and enhance productivity. Overall, water motors play a crucial role in managing water resources and supporting sustainable practices across different sectors.

Figure 4.7: Water motor

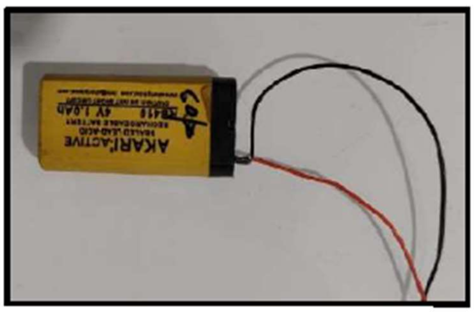

Figure 4.8: 9V Battery

Batteries are portable energy storage devices that convert chemical energy into electrical energy through electrochemical reactions. They power a vast array of devices, from small electronics like smartphones and laptops to larger applications such as electric vehicles and grid storage systems. Their ability to store energy efficiently and deliver it steadily over time has made them indispensable in modern life. Batteries come in various chemistries, each offering different characteristics in terms of capacity, voltage, cycle life, and environmental impact. Continuous advancements in battery technology aim to improve energy density, charging speed, and overall lifespan, addressing the growing demand for sustainable energy solutions worldwide.

Code

The Arduino Uno R3 needs to be programmed to focus on detecting the flame and thereby performing a necessary series of tasks. The code that is used to program the Arduino is shown in the figure below:

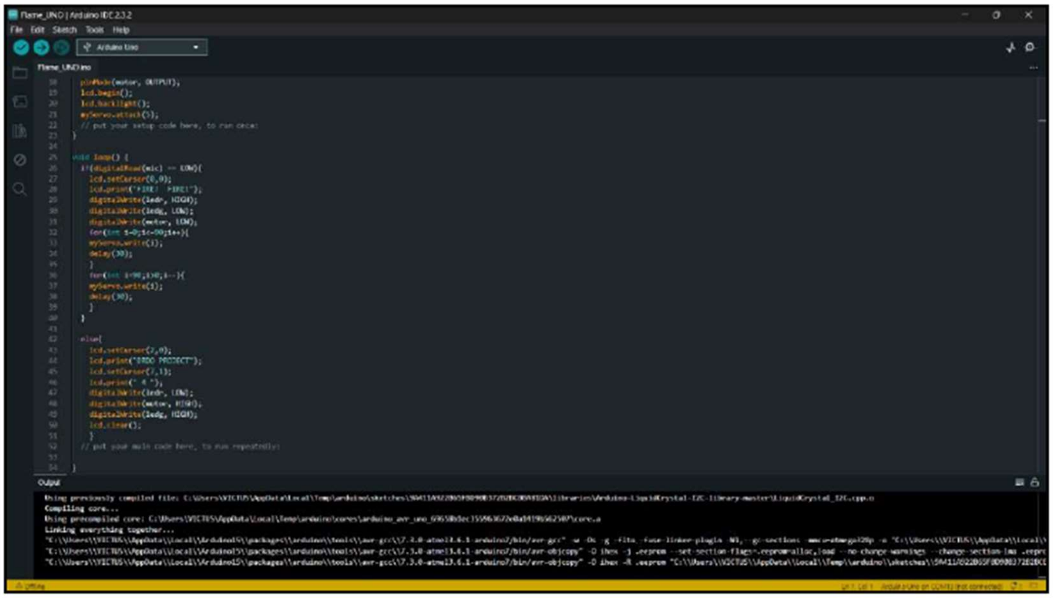

Figure 4.9: Program Code

Block Diagram

The hardware connections are shown in the block diagram below:

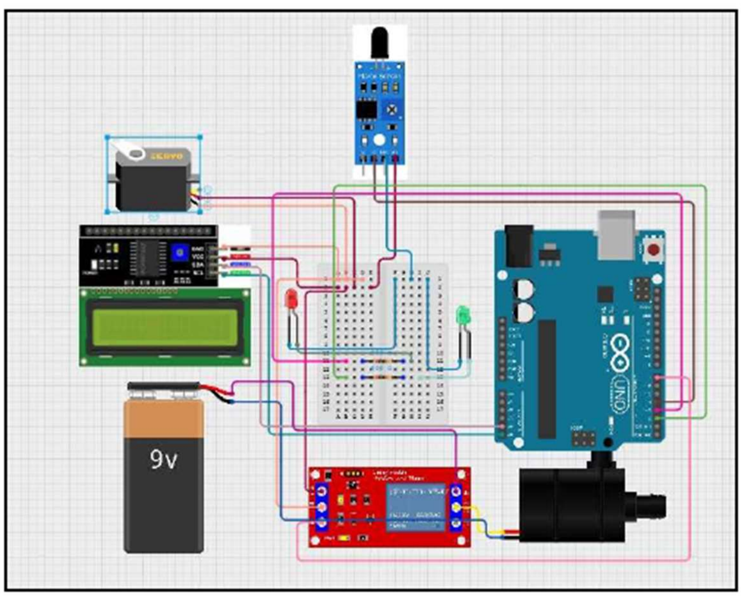

Figure 4.10: Block Diagram

Connections

All the components mentioned above are connected in accordance with the block diagram as shown in the figure above. This section provides further details of the pin connections.

Firstly, the liquid crystal display (LCD) has four connecting pins, namely the Ground, Vcc, SDA and SCL. The ground pin is connected to the ground in the breadboard and the Vcc is connected to 5 V input Vcc pin in the Arduino R3 board. The SDA pin reads the data and is connected to the A4 pin and the SCL pin acts as a clock and is connected to the A5 pin of Arduino Uno R3 board respectively.

Then, the flame sensor has three pin connections: Ground, Vcc and Output. The Ground of the flame sensor is connected to the ground of the breadboard, the Vcc is connected to a 3V Vcc on the breadboard and the Output pin is connected to pin 4 of Arduino Uno R3 board. The 4V battery has a red (positive) and a black (negative) wire. The positive end is connected to the relay module whereas the negative wire is connected to the negative wire of the water motor.

Furthermore, we have the water motor which consists of positive and negative wires as well. The positive is connected to the relay module, at the NO pin beside the common pin and NC pins whereas the negative is connected to the negative of the 9V battery. The positive of the 9V battery is connected to the common pin of relay module. The servo motor consists of three pins that are represented by brown, red and yellow wires. The brown wire is Ground, the red is Voltage input and the yellow wire is connected to the pin number 5 in the digital pins of Arduino Uno R3.

Overall, the connections shown in the above block diagram are explained in this section in detail.

Hardware Connections

The hardware look of the entire system is shown in the figure below:

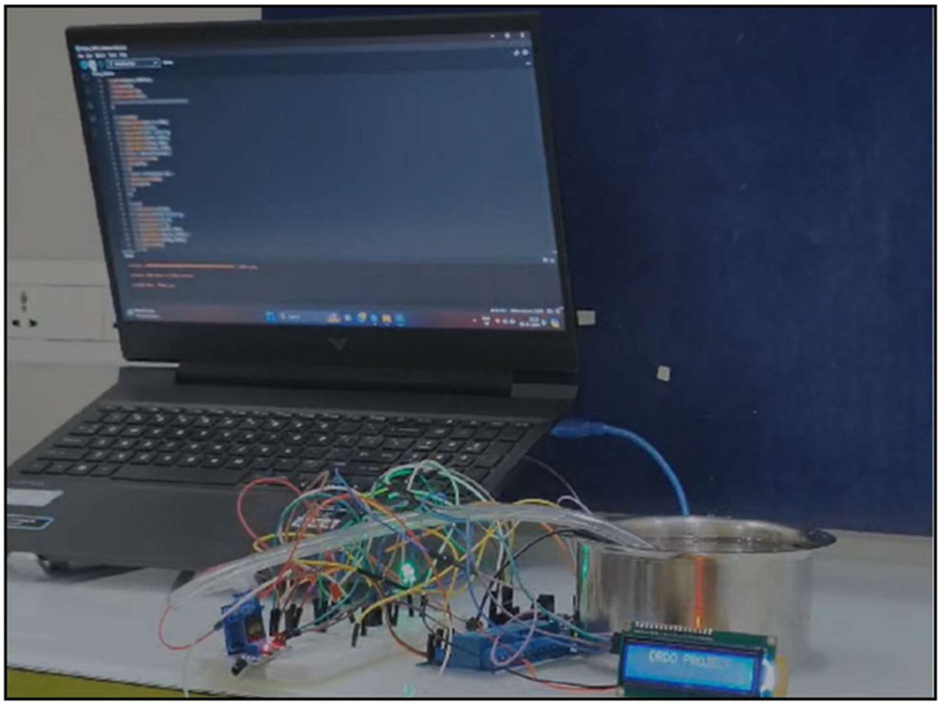

Figure 4.11: Hardware Connections

Result

The code is uploaded onto the Arduino Uno R3 board with the help of a USB type-B wire. All the connections are set and the system is tested. To test the system, a matchbox was used to light fire, and the result mush showcase “FIRE! FIRE!” on the LCD, play a buzzer and also spray water onto the fire. Otherwise, in case of no fire, the system displays “DRDO PROJECT 4” on the LCD. The output is shown below:

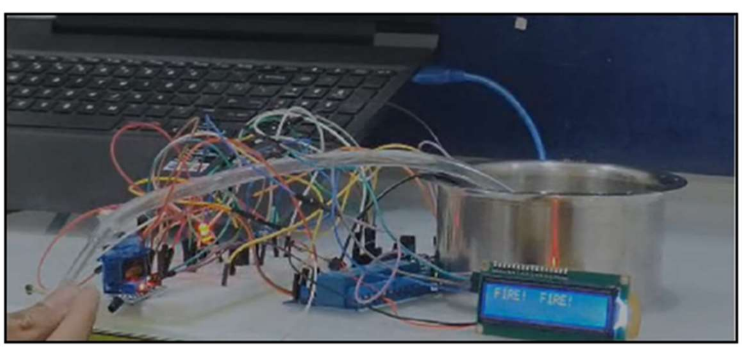

Figure 4.12: LCD Output

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Figure 4.13: Water motor extinguishing the fire

Figure 4.12 shows the display of FIRE! FIRE! On the LCD screen when there is a match lit near the flame sensor and Figure 4.13 shows water trying to extinguish the fire, The pipe moves in the direction of the fire and sprays water on it.

Conclusion

This project presents a significant advancement in fire safety through the development of an automated flame detection and extinguishing system. By integrating sensitive flame sensors with a motor-driven water dispensing mechanism, the system provides rapid and effective responses to fire incidents. Experimental results confirm its reliability and efficiency in detecting and extinguishing flames quickly, minimizing fire spread and damage.

The success of this system underscores the potential of IoT and automated technologies in enhancing safety measures. Future improvements could focus on scalability, additional sensors, and enhanced water dispensing mechanisms. This project highlights the importance of ongoing research and innovation in developing smarter, more responsive fire safety solutions to protect lives and property.