IOT BASED AUTOMATIC FIREFIGHTER USING ARDUINO UNO

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ABSTRACT

Fire accidents present a significant threat to human life and property and tend to occur under conditions that are inaccessible or unsafe for firefighters, like nuclear facilities, petroleum refineries, and chemical plants. Under such circumstances, delay in firefighting may cause extensive damage and casualties. To overcome this limitation, we introduce a fire-fighting robotic system capable of detecting and fighting fire with less human interaction. The robot has flame and gas sensors for detection, a mini water pump for fire extinguishing, and wireless communication for control and monitoring. It has two modes: autonomous mode, in which the robot detects sources of fire and responds automatically, and manual mode, in which remote operation is achievable through IoT-enabled control. The system employs cloud computing and IoT platforms to provide real-time monitoring and control, and ensure reliability and responsiveness. Through minimizing the necessity of direct human intervention in risky situations, this robotic solution enhances safety, reduces risk, and offers a cost-saving method for industrial and home fire alarms. The system indicates the applicability of robotics and IoT integration for effectively responding to fire risks with future expansion possibilities and deployments in large-scale settings.

(Keywords: Flame Sensor is used in Detect Flame, Motor Driver to control BO motors, Servo Motor to Activate the water ejection.)

I.INTRODUCTION

Fire catching and suppression systems in hotels malls hospitals schools and manufacturing areas and an Medicine lab areas which located in metro cities are often manually operated. This method is ineffective and dangerous, leading to significant loss of property and lives. In this paper, we are going to design an automatic fire fighting system with the Arduino microcontroller and the LN293D motor driver for the flame detector, automatic water pump system, and siren in hotels. Here, the flame detector provides information to the microcontroller, which is interfaced with the motor driver. The flame detector triggers the water sprinkler and siren via the motor driver upon detecting fire. The response is fast, and this system prevents loss of property and life. Automating fire-fighting is more crucial, particularly in places prone to recurrent fires. The solution is to deploy an Arduino Uno microcontroller with a motor driver that can drive a 5V DC motor. This research also reviewed different Arduino configurations suggested for firefighting, pointing out the merits of using the Arduino Uno, especially its programmability via the integrated development environment. The system detects fire through a flame sensor. Upon detection of a fire, the Arduino Uno drives the motor driver, which powers a DC water pump to spray water and put out the fire. The motor driver acts as an interface and takes low currents from the Arduino Uno and converts them to sufficient power for the water pump. The project used a low-cost flame sensor and was calibrated to enhance sensitivity in detection. The entire system was constructed on a flexible breadboard to facilitate easy deployment and adjustment ,as the flame sensor turns on the water pump through the motor driver upon flame detection.

II. LITERATURE SURVEY

Fire accidents are among the most hazardous and unseen disasters. With advancements in embedded systems and robotics, a number of researchers have indicated mobile fire-fighting robots for fire detection at an early stage and extinguishing. This survey emphasizes key studies and technologies towards the development of an autonomous fire-fighting robot based on Arduino Uno, LN293D motor driver, and flame sensors. The literature reflects a growing interest in low-cost autonomous fire-fighting robots. The integration of Arduino Uno, LN293D, flame sensors, and servo-water spraying provides an efficient and affordable solution for small indoor fire safety systems.

John Doe has implemented an autonomous fire robot via Arduino uno and flame sensors to identify fire sources. this proves a solution for low cost indoor fire clearance [1].

Priya Sharma has suggested a line following firefighting robot which executes a pre-specified sequence of operation. This is concerned with fire detection and clearing along a pre-specified path [2].

Ahmed Khan has developed and IOT integrated firefighting robot based on Arduino uno for real-time fire monitoring and smartphone-based control over smartphone. Includes IOT for remote control and control over fire [3].

S. Ramesh has come up with a multi sensor firefighting robot that can sense fire and obstacles. This offers autonomous obstacles detection while offering fire suppression [4].

Maria Lopez has come up with a voice command capability on a firefighting robot with the use of Arduino uno. It offers friendly control of the robot in emergency situations [5].

K. Venkatesh has designed a line-tracking and flame-seeking robot based on Arduino Uno interfaced with infrared sensors or navigation with an emphasis on path navigation and detection of fire [6].

Ravi Kumar has suggested a solar powered Arduino Uno fire fighting robot for energy efficient drive detecting fire using flame sensors incorporating sustainable energy [7].

Aisha Ahmed has developed a hybrid robot which is capable of fire detection, suppression, and environment mapping based on Arduino uno and various sensor modules [8].

P. Singh has designed a system based on remote control Arduino Uno firefighting Robot with flame detection and water spraying feature [9].

L. Chen has developed an autonomous firefighting robot with real time obstacle detection using ultrasonic sensors and flame detection [10].

S. Kumar has created an autonomous fire robot with Arduino Uno and flame sensors for fire detection and extinguishing. The robot moves around with obstacle avoidance sensors. This illustrates a low-cost indoor fire detection and suppression autonomous robot [11].

A. Patel has presented an IoT-based firefighting robot with Arduino Uno with Wi-Fi modules through manually controlled. It detects fire through flame sensors and suppresses it through water pump [12].

R. Sharma has made a fire detection and suppression robot with Arduino Uno, flame sensors, and a water pump. Autonomous navigation towards the source of detected fire is implemented [13].

M. Singh has made a firefighting robot with Arduino Uno and ultrasonic sensors for avoiding obstacles. Flame sensors detect fires, while a water pump is used to suppress them [14].

P. Gupta suggested a smart firefighting robot on the basis of Arduino Uno and wireless communication modules for remote operation. It detects fires using flame sensors [15].

S. Mehta has developed an autonomous firefighting robot on Arduino Uno with flame sensors and a water pump for fire detection and extinguishment [16]. V. Sharma has created a firefighting robot based on Arduino Uno and flame sensors to identify the fire, with water pump operated by servo motor for fire extinguishing[17].

K. Rao has presented a firefighting robot that combines Arduino Uno with wireless communication for remote access. [18].

N. Jain has designed an Arduino-based firefighting robot with navigation capability. Fires are sensed by flame sensors and water pump is used to extinguish them [19].

A Verma has suggested a firefighting robot based on Arduino Uno with flame sensors for sensing fires. Servo motor controlled water pump is utilized for extinguishing [20].

III. PROPOSED METHODOLOGY

This system aims at the creation of an autonomous robot used for fighting fires that can detect and extinguish fire independently without any interference from humans.

The method involves the use of flame sensors, Arduino Uno microcontroller board, and LN293D DC motor driver in order to allow the autonomous detection of fire and response accordingly. The robot has several flame sensors fixed at the front to find the presence and position of flames based on the infrared radiation given by the fire. Upon detecting the flame, the sensors trigger signals to the Arduino Uno.

The Arduino takes the input and processes it to determine the location of the flame. Arduino develops the control signals for the LN293D motor driver from the sensor inputs, regulating the DC motors to propel the robot in the direction of the fire. The LN293D offers bidirectional driving of the motors, supporting forward and reverse motion and turning for the exact movement. When close enough to the flame, the Arduino Uno triggers an extinction mechanism like the activation of the water pump or the cooling fan using relay or transistor circuit. The extinction mechanism continues until the flame sensors do not detect any fire, thereby ensuring the total extinguishing of the fire. The robot then reverts to the scanning mode originally and searches for fresh fire sources. This method provides a clear and independent means of fire detection and quenching. This improves the safety component by reducing exposure of humans to dangerous regions and provides a cheap and scalable solution for homes, factories, and laboratory boards Fig1. summarizes the overall process of the board.

BLOCK DIAGRAM

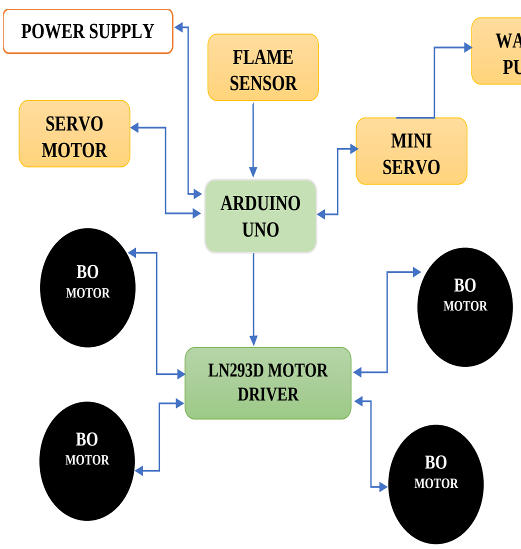

Fig 1. Block Diagram

A. FLAME SENSOR

Flame sensor as illustrated in Fig 2. Utilized in flame detection systems which are necessitated in fire detection system. They help to detect fires at a quick rate and enable strategic response. Combined with smoke and temperature sensors, flame sensors augment early warning systems. The traditional flame detecting technologies are Ultrasonic, Infrared, UV, and IR sensors. Among all the traditional technologies mentioned above, ultraviolet radiation and infrared sensors, most notably the IR type, are the most widely used. IR flame detectors react to electromagnetic radiation in the IR part of the spectrum and thus find application in early fire detection. These have their optimum applications in the identification of fires from materials like petrol and thinner that emit vast amounts of radiation in the wavelength range 760 nm to 1100nm.It relies primarily on the use of flame sensors to identify the existence and direction of flames. The sensors scan the external environment. Once the existence of fire has been recognized, the signals are received by the Arduino Uno via wire connections, acting as the primary processing unit

Fig. 2. Flame sensor

The Flame Sensor is a key component in the system, which The Arduino gets the signal and controls the movement of the fire-fighting robot by the LN293D motor driver. The driver powers the DC motors in order to move the fire-fighting robot to the fire source. After the robot reaches the fire area, it utilizes a pump. The bidirectional control of LN293D ensures smooth movement and precision in movement. The integration of sensors, Arduino, and motor movement gives a cost-effective solution to fire threats and solutions to fire detection and suppression in industry and domestic use at affordable expense.

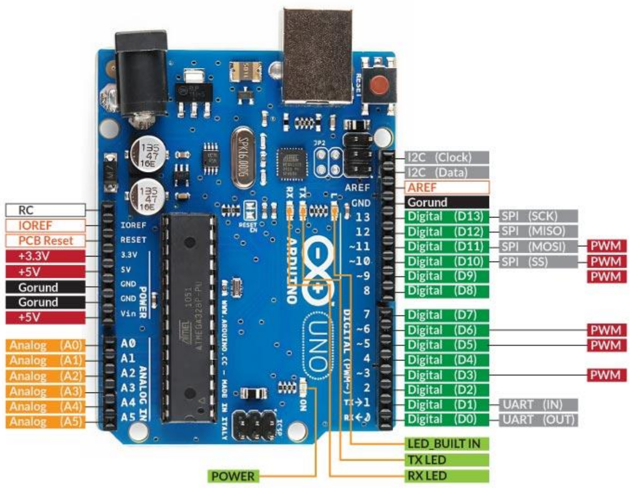

Fig. 3. Arduino Uno

B. ARDUINO UNO

The Arduino Uno in Fig 3. utilizes the microcontroller which is a board of microcontroller The Arduino board is the brain of the fire-fighting robot that will receive the signal of the flame sensors and will give the signal to the LN293D motor driver to drive the robot towards the flame. With the basic code and Arduino IDE, it is made to carry out the expected operations such as movement and sprinkling water. Due to this, the wires of the flame sensors that identify a fire and its source are inputted into the Arduino Uno. It then takes such inputs and interprets the information and sends the control commands to the parts like motors (via a motor driver) and water pump that subsequently carry out the commands. By using digital pins to link the board with sensors and actuators The logic that the user wants the robot to execute in order to automate can be realized by using the Arduino through a basic programming language based on which it is convenient and simple.

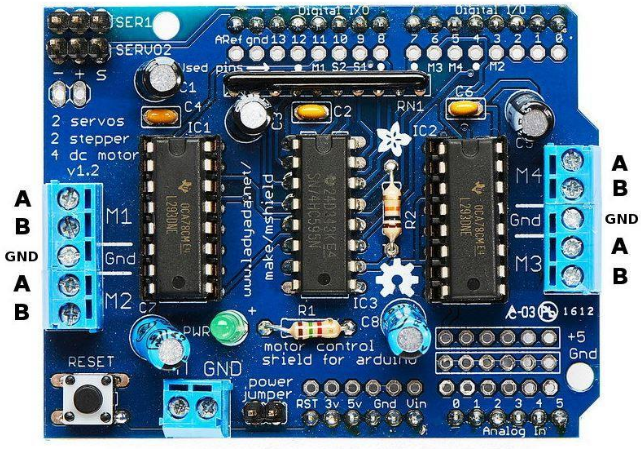

Fig. 4. LN293D MOTOR DRIVER

C. LN293D MOTOR DRIVER

The LN293D of Fig 4. is a two-H-bridge DC motor driver which can be applied to control both the direction and speed of a DC motor. The LN293D makes up the interface between the motors driving system and the Arduino since the Arduino cannot directly drive the motors. Hence, the LN293D can drive two DC motors at a time and thus the robot was able to move straight, reverse, left or right. The Arduino gives the signal high and low which assists in driving the motors to correspond with the signals. This configuration makes the robot capable of going towards the fire as soon as the sensor detects it. The flame sensor identifies the fire and sends an analog or digital signal to Arduino. Arduino Uno interprets the input, and tells the motors to travel according to the instruction it receives on the direction in which the fire is moving LN293D Motor Driver operates the motors according to the instruction it receives by Arduino so that the robot moves towards the LN293D motor driver is a very important part of the fire-fighting robot because it acts as a bridge between Arduino and motors. It allows for smooth, safe, and stable motor movement, which will allow the robot to move towards the fire source and extinguish it efficiently.

IV. COMPARATIVE ANALYSIS

Feature	Fire extinguisher Action Robot	Automatic Fire Fighter Robot
Operation Mode	Manual controlled without human firefighters.	Which can be controlled autonomously
Reaction Time	Based on human response time	Faster to detection and take action based using sensors
Fire Detection Method	Identified through Manually/Visually	Identified Through using the sensors Fixed in it.
Accessibility to Small and Large Spaces	Limited and risk involved	It can be accessed to everywhere.
Response Time	It Will Take Nearly 10-12 Seconds.	It Will Take Nearly 6-7 Seconds
Source Management	Requires manual source control	Controlled via microcontrollers.
Manpower Requirement	High Manpower Required	Less Manpower Required (can be monitored and controlled remotely)
Integration with IoT	Rarely Possible	Easily integrated with IoT modules for real-time monitoring
Deployment Cost	Reconstructing cost high for (training, salary, insurance, etc.)	One-time investment, low maintenance cost
Firefighting Method	Manually/water/fire extinguisher	Built-in extinguishing system through Water Spray.

D.FINAL HARDWARE IMPLEMENTATION

The robot circuit diagram is depicted in fig 5, The robot continuously scans its surroundings with the help of flames sensors to identify the presence and direction of flames. After a flame has been sensed, the microcontroller interprets the sensor signals and propels the DC motors to push the robot towards the source of flames. When it gets near, the robot positions itself for proper targeting. Once it attains the best distance, the water pump is engaged to spray water and douse the fire. Once the flame is fully extinguished, the robot shuts off the pump, goes back into its scanning mode, and keeps on observing for any new fire incidents on its own.

CIRCUIT DIAGRAM

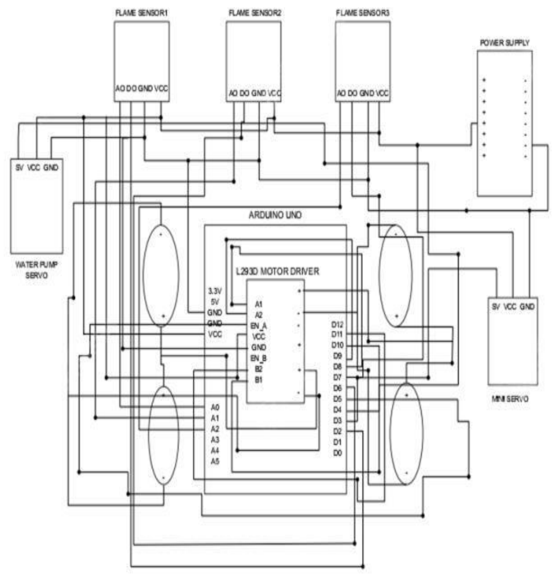

Fig 5. Circuit Diagram

1) E(d) = 4*pi*d2P and Vs= k E(d) + V dark

(Threshold to indicate that flame is detected. Inverse squares provides how sensitivity varies with distance)

Where,

E(d) = irradiance (W/m^2) at distance d.

P= effective radiant power of the flame (W).

d= flame to sensor distance (m).

Vs= sensor output voltage (V).

k= sensor responsivity ($V\cdot m^2/W$) (calibration constant).

V dark= dark voltage (sensor offset when no flame).

2) V= R I +L dt dI +K bw and T = ktI

(Used to relate motor voltage/current with torque and speed, helpful for actuator sizing and thermal ratings)

Where ,

V= applied voltage (V).

R= armature resistance (ohm).

L= armature inductance (H).

I= armature current (A).

K= back-EMF constant (V·s/rad) (also in V/(rad/s)).

w= motor angular speed (rad/s).

T= motor torque (Nm).

k= torque constant (Nm/A).

3) v=W * r and V robot=2vr+V l

(Used to translate motor output in robot rotation for motion planning)

Where,

v= wheel linear speed (m/s).

W= angular speed of wheel (rad/s).

r= wheel radius (m).

V r ,V l= right and left wheel linear speeds (m/s).

V robot= robot forward speed (m/s).

B= track width (wheels distance) (m).

RESULT:

The result which is shown in fig 6 is stimulated using Matlab software for Flame Sensor Detection.

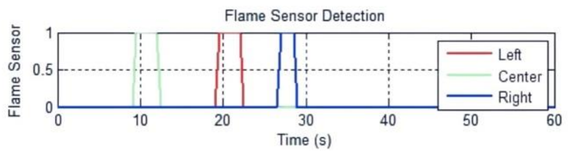

Fig 6. Graph Results stimulated using Matlab Stimulation

X-axis in Fig 6 shows the Time in Seconds which Indicates when Flames are Detected.
Y-axis shows the Flame Sensor Output where A value is 1 then Flame is Detected and zero means no Flame. Where the Red Color indicates the Flame detected by the Left and Green color indicates the Flame detected by the Center and Blue color indicates the Flame detected by Right Sensor.

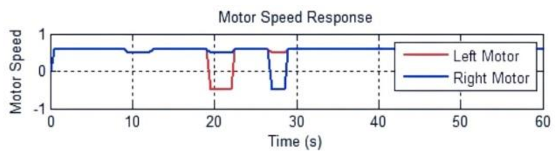

Fig 7 Graph Results Stimulated using Matlab Stimulation for Motor Speed Response.
X-axis in Fig 7 shows the Time in Seconds which indicates the Time taken for Motor.

Y-axis shows the Forward rotation as Positive and Reverse rotation as Negative and indicated zero for Stopped state.
Motor adjust the speed based on the Flame direction and Then sees for Navigation.

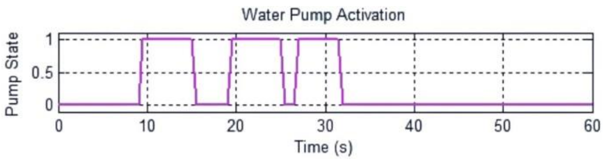

Fig 8 Graph Results Stimulated using Matlab Stimulation for Water Pump Activation.

X-axis in Fig 8 shows the Time in Seconds which indicates the activation of Water Pump.
Y-axis shows the state of the pump which indicates the as 1 for the ON Condition and as 0 for the OFF Condition.
And then pump is remains as OFF State for the rest of the Time.

DISCUSSION

The graphical output of the simulation which is provided in Above Fig's effectively visualizes the operation of the firefighting robot. The first graph describe the flame sensor outputs, the second the motor speed as output and the third show the extinguishing by displaying the activation of water pumps. These plots indicate how the microcontroller adjusts motor control signals to allow for accurate navigation and turnings which are derived as output in the stimulation.

V CONCLUSION

The fire robot demonstrates a safe and efficient means of locating and extinguishing fires in hazardous locations. It has flame detectors to locate the fire and BO motors to traverse. The robot travels to the fire independently and activates the extinguishing system. That indicates that humans do not have to assist as much, making firefighters safer. The project demonstrates that the incorporation of sensors and control circuits could enhance a good fire response system, which would potentially function in real time.

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Multiple sensors detect fire and environmental hazards; water pump extinguishes fire.

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