SDM COLLEGE OF ENGINEERING AND TECHNOLOGY, Dharwad-580002

(An autonomous Institution affiliated to Visvevaraya Technological University, Belgaum-590018)

Department of Electrical and Electronics Engineering

Minor Project Phase 1 [22UEEL505] Report entitled

"AUTOMATIC FIRE FIGHTING SYSTEM"

Submitted by

Akash C Hadimani 2SD22EE003
Akshay Hiremath 2SD22EE004
Amogh Gadag 2SD22EE005
Anilkumar Katti 2SD22EE006

Students of 5th Semester
Under the guidance of
Dr.Shekhappa Ankaliki

Department of Electrical and Electronics Engineering

Academic year 2024-25

S.D.M. College of Engineering &Technology Dharwad – 580002
(An autonomous Institution affiliated to Visvesvaraya Technological University, Belagavi-590018)

Department of Electrical and Electronics Engineering

CERTIFICATE

This is to certify that,

Name	USN
Mr. Akash Hadimani	2SD22EE003
Mr. Akshay Hiremath	2SD22EE004
Mr. Amogh Gadag	2SD22EE005
Mr. Anilkumar Katti	2SD22EE006

Students of 5th Semester have satisfactorily completed the **Minor Project Phase-1 [22UEEL505]** entitled **"Automatic Fire-Fighting System"** submitted to the **Department of Electrical and Electronics Engineering, SDM College of Engineering and Technology, Dharwad – 580 002**, for the partial fulfillment of the Degree.

Prof. (Project Guide), **Dept. of EEE,** **SDMCET, Dharwad - 02**	**Dr. S. G. Ankaliki,** **Prof & Head, Dept. of EEE,** **SDMCET, Dharwad - 02**	**Dr. R.L.Chakrasali,** **Principal,** **SDMCET, Dharwad - 02**

Examiner – 1	Examiner – 2
Name: _____	**Name:** _____
Designation: _____	**Designation:** _____
Affiliation: _____	**Affiliation:** _____
Signature with Date: _____	**Signature with Date:** _____

ACKNOWLEDGEMENT

Firstly, we would like to praise the almighty for his grace to bless us with this project and forgiving us the confidence to complete it successfully.

To express our hearty thanks to Principal**, Dr. Ramesh .L. Chakrasali** of our college, for his constant motivation regarding our Project work.

We express our gratefulness to **Dr. Shekhappa Ankaliki**, Head of the Department, Department of Electrical and Electronics Engineering, for providing us kind advice during the development of the project.

Our hearty thanks to our guide **Dr. Shekappa Ankaliki**, Department of Electrical and Electronics Engineering, for her constant support and guidance offered to us during the course of our project by being one among us.

We express our thanks to our project coordinator prof. Megha Shidenur Department of Electrical and Electronics Engineering, for constant support and guidance offered to us during the course of our project by being one among us.

We are committed to place our heartfelt thanks to our all teaching and non-teaching staff members, friends, family members and all the noble hearts that gave us immense encouragement towards the completion of our project.

ABSTRACT

We see new inventions and discoveries being made every single week. Be it in medical science, commercialization, globalization, defence warfare or digital advancements. Increasing infrastructural marvels also increases concerns about basic safety measures like fire protection. In this study, we have designed a prototype for a firefighting robot and discussed ways in which it can be useful to fire fighters during fire safety drills.

TABLE OF CONTENT:

CHAPTER 1: CONCEPTION OF THE PROJECT

1.1 INTRODUCTION:

Humans are progressing at an unprecedented rate in the growing world of technologies and infrastructure. The number of high-rise buildings and towers that can be seen today is a testament to that fact. Such buildings are made with a lot of thought processes behind them. With such big structures, ensuring the safety of all the individuals inside those buildings is paramount. Onsite engineers pay special attention towards ensuring that the building passes all the necessary safety checks. Besides that, they must ensure timely maintenance of all the safety measures. Large buildings, towers, flyovers, etc. require electricity for their respective functionalities. Any abnormality in normal working conditions in these places can very easily lead to a fire, which is one of the most common threats that is being faced. The fire, if caused, can either be small or big depending upon the extent of fault/failure in the system. However, mitigating the fire, no matter how big or small, is very necessary. Fire fighters put their life on the line to doze off the fire as quickly as they possibly can. However, there are certain spots in a specific area which are difficult for even the Fire fighters to reach as they are life threatening. In such situations, a small and mobile robot can be useful. It can get into spaces where humans can't and try to limit the extent of the fire to some extent. And this is the major objective behind this study, which is to ease the operations of Fire fighters in extinguishing the fire using portable robots or robotic cars. Nowadays, robotic design and machinery have become very important in helping humans. The firefighting robot was implemented to help humans in hazardous situations. A firefighting robot is capable of extinguishing fire with the help of powered electronic sensors. Our project report reports the design of a small automatic fire-extinguishing robot. The fire-fighting robot is enabled to search the fire for an area of specific dimensions with the help of flame sensors commanded by Arduino uno.

1.2 MOTIVATION:

The motivation behind this project is that firefighter's death. Many firefighters are struggling to perform their duty which causes much death while on a mission and the circumstances related to each incident. Firefighters are our heroes and our sense of security in times of trouble. They put themselves on dangerous situations to protect us. At present, the world is moving toward the use of technologies software and hardware.

1.3 BACKGROUND:

1. **Smart City Integration:** The robot could serve as part of a smart city infrastructure, automatically coordinating with IoT-enabled fire alarms and sprinklers to enhance urban fire safety systems.
2. **Rugged Terrain Application:** Designed to operate in challenging terrains like forests, mines, or mountains, the robot can aid in preventing wildfires or addressing underground fires.
3. **Industrial Fire Specialist:** Built to combat chemical or electrical fires in industries where conventional firefighting methods are unsuitable or dangerous for humans.
4. **Historical Preservation:** Aimed at protecting heritage sites, the robot could navigate delicate structures without causing further damage while extinguishing fires.
5. **Warehouse and Storage Protector:** The robot could be deployed in warehouses to mitigate the risk of fire damaging valuable inventory, especially in high-temperature storage areas.
6. **Educational Tool:** As a demonstration project, it can teach students how to integrate hardware and software to solve real-world problems.
7. **Nighttime Rescue Robot:** Equipped with thermal imaging cameras and night-vision capabilities, it can operate in dark or low-visibility environments to detect and extinguish fires.
8. **Compact Home Assistant:** A smaller version designed for residential use to tackle household fires before they escalate into larger incidents.
9. **Disaster Relief Partner:** Operates in post-earthquake or flood scenarios where fire hazards are prevalent due to broken gas lines or electrical short circuits.
10. **Environmentally Friendly Design:** Utilizes eco-friendly extinguishing agents and solar-powered systems to align with sustainable practices while performing its duties.

1.4 LITERATURE SURVEY:

1. **J. Reinhart V. Khandwala (2003**), it was all discussed about design and the implementation of the fire-fighting robot. The key design elements of the robot to be discussed include: the assembly and construction of the robot hardware, the processing algorithm based on the sensor's response, and the navigation algorithm that will enable the robot to find an efficient path in and out of the house model.
2. **Miller, Lynette,** the construction of each component of the robot that is intended to locate and put out a minor fire represented by a light emitting diode in a model home was discussed by **Daniel**

Rodriguez (2017). This essay will discuss every element of the robot, starting with the start signal and moving on to the robot platform, line following, room finding, and, finally, fire detection.

3. According to **Sahil S. Shah (2013),** an embedded system was used to construct a FIRE FIGHTING ROBOT. We'll create and test a robot that can put out a fake house fire. It must be capable of independently moving around a simulated floor layout while aggressively looking for a flame. The robot can even serve as a fire extinguisher in an emergency and a path guider in regular circumstances. In the future, robots that can locate fires before they get out of control will dramatically reduce the danger of injury to victims. The outcome demonstrates that employing the embedded system does really result in greater efficiency.
4. Four flame sensors were used in the firefighting robot's fire detection system design by Sai Prasanna, **M.V.D. Prasad (2013)**, and sensor-based programming was used to programme the fire detection and fighting technique. Four thermistors/flame sensors that continuously track temperature are built inside the firefighting robot. A buzzer sounds to alert everyone in the industry and the neighbouring fire station to the possibility of a fire mishap if the temperature rises beyond the predetermined threshold value. This is done using the GSM module that is attached to the device.
5. In the College of Engineering**, American International University - Bangladesh, Swati A. Deshmukh (2015)**, explained the fire detection system employing sensors and programmed the fire detection and fighting technique.

1.5 PROBLEM STATEMENT:

Fire disaster is one of the dangerous problems that can lead to heavy loss both financially and by taking lives. Sometimes it becomes difficult for fighters to access the site of a fire because of explosive materials, smoke, and high temperatures. Such situations risk the lives of fire fighters too. In such environments, fire-fighting robots can be useful. This Fire Extinguishing Robot is based on IOT Technology. In Fire Extinguishing Robot, we intend to build a system that could extinguish a small flame by sensing and moving to the location itself. Sometime delay in the arrival of fire fighters leads to numerous consequences. The Fire Extinguishing robot continuously monitors the environment and extinguishes it without delay.

1.6 OBJECTIVES:

1. To find fire in the region vulnerable to disasters.
2. Lowers the amount of devastation and labour effort put out by humans, as well as the harm done to human life.

3. To utilize flame sensors to detect fire.
4. To automatically put out a fire when one is detected.

1.7 WORKING PRINCIPLE:

The fire fighter robot is equipped with flame sensors that continuously monitor the environment for any signs of fire. Once fire is detected, the robot moves towards the fire sources by comparing sensor data. It uses ultrasonic sensor to avoid obstacles during navigation. Upon reaching the fire, the water pump is activated, and water is sprayed to extinguish the fire. The robot can operate autonomously, requiring no human intervention, thus making it an effective tool in mitigating fire hazards in a controlled environment.

1.8 FEATURES:

1. **Fire Detection**: Equipped with flame sensors to accurately detect the presence and direction of a fire.
2. **Temperature Monitoring**: Uses temperature sensors to assess heat intensity and identify potential fire zones.
3. **Autonomous Navigation**: Capable of moving independently in hazardous environments using obstacle detection sensors and motor control.
4. **Fire Suppression**: Includes a small water tank and pump system to extinguish small-scale fires.
5. **Compact and Durable Design**: Built to withstand heat and navigate confined spaces effectively.
6. **Rechargeable Power Supply**: Operates on a rechargeable battery, ensuring sustained performance during emergencies.
7. **User-Friendly Interface**: Easy to operate and monitor, making it suitable for educational and practical applications.

1.9 APPLICATIONS:

1. **Fire Rescue Operations**:

- **Industrial Facilities**: Useful in factories or warehouses where fires may be difficult to reach.
- **Residential Buildings**: Provides an additional layer of fire safety in homes, especially in high-risk areas.

2. **Search and Rescue**:

- **Disaster Scenarios**: Assists in locating and extinguishing fires in disastrous areas or during building collapses.

3. **Automated Safety Systems**:

- **Monitoring and Maintenance**: Can be integrated into building safety systems to provide real-time fire monitoring and response.

4. **Educational Tools:**

- **STEM Education**: Provides a hands-on learning experience for students and enthusiasts interested in robotics and fire safety technology.

1.10 ADVANTAGES:

1. **Enhanced Safety:**

- **Reduced Human Risk**: The robot can operate in hazardous environments, minimizing the risk to human firefighters.
- **Remote Operation:** Can be controlled remotely or operate autonomously, ensuring safety during dangerous conditions.

2. **Efficiency**:

- **Rapid Response**: The robot can quickly navigate to and address fires, especially in confined or complex environments.
- **Consistent Monitoring**: Continuous operation without fatigue allows for persistent fire detection and management.

3. **Effective Cost**:

- **Lower Operational Costs**: Reduces the need for extensive human resources in high-risk situations.
- **Prototyping and Development**: Provides a cost-effective platform for developing and testing firefighting technologies.

4. **Versatility:**

- **Adaptable to Various Environments**: Suitable for different settings, from industrial sites to residential areas.
- **Multi-Sensor Integration**: Uses multiple sensors for comprehensive fire detection and obstacle navigation.

1.11 DISADVANTAGES:

1. **Limited Fire Extinguishing Capacity**:

- **Small Fires Only**: The water pump system may not be sufficient for larger or more intense fires.
- **Limited Water Supply**: The effectiveness depends on the size of the water tank or bottle.

2. **Power Constraints:**

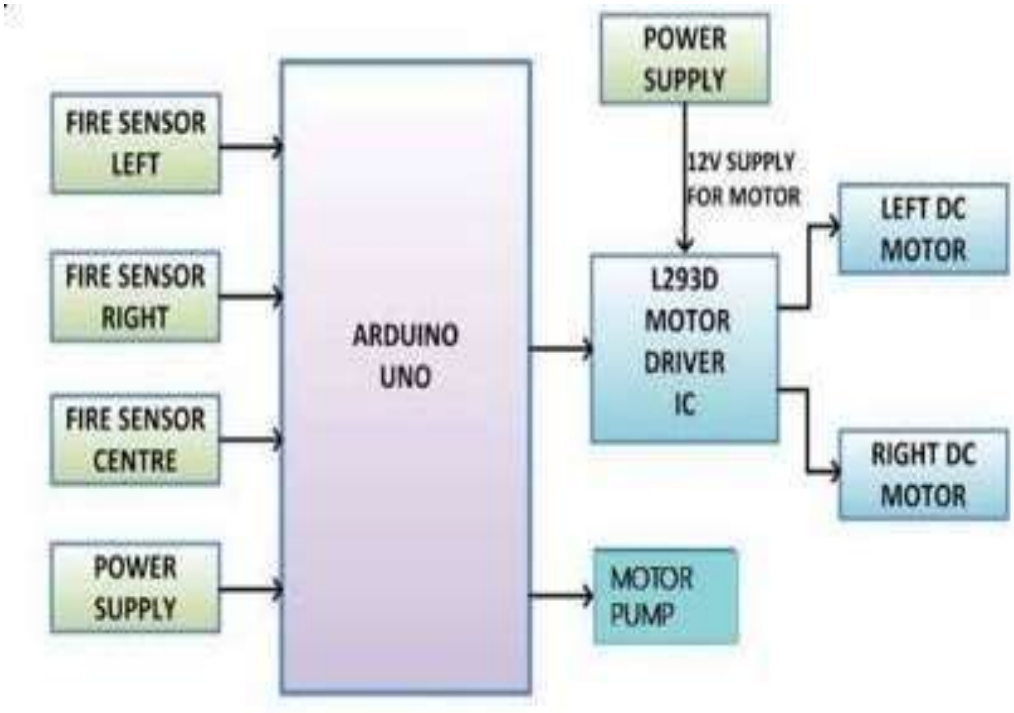
- **Battery Life:** Limited by battery capacity, which affects the duration of operations and may necessitate frequent recharging or battery replacement.
- **Power Consumption**: The robot's various components, including motors and the water pump, can drain power quickly.

1.12 METHODOLOGY:

As a means of battling flames in hazardous or unreachable areas, firefighting robots are growing in popularity. These remotely controlled robots are safer for firefighters to work with since they may be outfitted with a range of sensors and instruments to aid in the detection and extinguishment of flames. The Arduino is one of the most widely used platforms for robotic firefighting. The Arduino microcontroller is an excellent option for both engineers and enthusiasts since it is user-friendly and reasonably priced. For the Arduino, there are several libraries that may be used to control sensors, motors, and other devices. The Arduino is used in many different types of robots that battle fires.

CHAPTER 2: DESIGN OF THE PROJECT

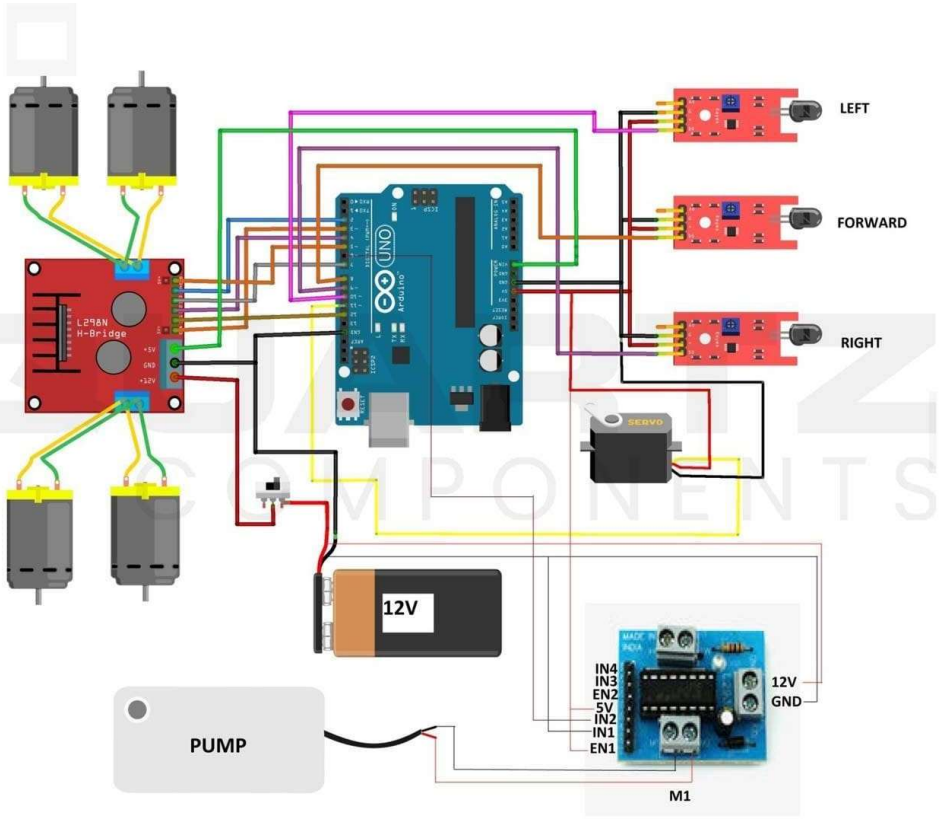
2.1 BLOCK DIAGRAM:



Fig(a).Overall block diagram of the system.

The fig.(a) shows block diagram of an Automatic Fire-Fighting System consists of several key components working together to detect and extinguish fires. A Power Supply energizes the system, while Fire Detection Sensors (e.g., flame or smoke sensors) monitor the environment and send signals to the Microcontroller, which processes the data. Based on this, the Motor Driver controls the Locomotion System (e.g., DC motors) to move the robot toward the fire. The Fire Extinguishing System (e.g., water pump or CO_2 dispenser) is then activated to suppress the fire. An optional Communication System can send alerts or updates, and a Feedback Mechanism ensures the fire is completely extinguished.

2.2 CIRCUIT DIAGRAM:



Fig(b).Circuit diagram of the system.

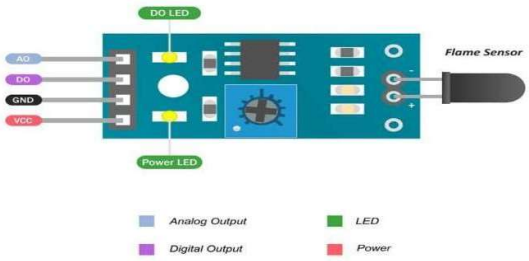
The fig.(b) shows circuit diagram of the Automatic Fire-Fighting System includes an Arduino microcontroller, flame sensors, a motor driver, DC motors, a pump, and a 12V battery. Flame sensors (left, forward, right) detect fire and send signals to the Arduino, which processes the data to control the motor driver and guide the DC motors for robot movement. The pump, controlled by the Arduino, activates to spray water and extinguish the fire. The 12V battery powers the entire system, ensuring seamless operation of sensors, motors, and the pump.

2.3 COMPONENTS REQUIRED:

1. ARDUINO UNO:

The Arduino Uno is a popular microcontroller board based on the ATmega328P chip. It features 14 digital input/output pins, including 6 PWM outputs, and 6 analog inputs for connecting sensors and actuators. The board runs on a 5V power supply and can be powered via USB or an external power source. It has a 16 MHz crystal oscillator for precise timing. The Uno is programmed using the Arduino IDE, which simplifies coding in a C/C++-based language. It supports easy prototyping with plug-and-play components. With extensive community support, it's ideal for beginners and hobbyists. Common uses include IoT, robotics, and home automation projects.

2. FLAME SENSOR:

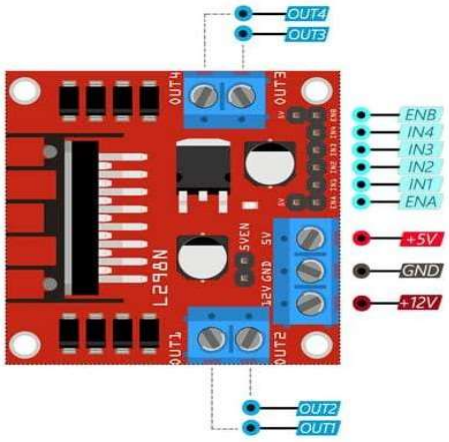


A flame sensor is a device used to detect the presence of fire or flames by sensing infrared (IR) or ultraviolet (UV) light. It typically operates at a wavelength of 760 nm to 1100 nm for detecting fire emissions. The sensor outputs either an analog or digital signal, making it easy to integrate with microcontrollers like Arduino. Flame sensors are fast and responsive, capable of detecting flames from a distance of up to 1 meter. They often include an adjustable sensitivity potentiometer for precise tuning. These sensors are widely used in safety systems, fire alarms, and robotics. They require a 3.3V or 5V power supply to operate effectively.

3. SERVO MOTOR:

A **servo motor** is a rotary actuator used for precise control of angular position, velocity, and acceleration. It consists of a motor, a position sensor, and a control circuit. Servo motors typically operate on **4.8V to 6V** and are controlled using PWM (Pulse Width Modulation) signals. They can rotate within a specific range, often **0° to 180°**, or continuously for specific models. Compact and easy to use, they are ideal for robotics, RC vehicles, and automated systems. The position of the servo is controlled by the duration of the PWM signal sent from a microcontroller like Arduino. Servo motors are reliable, efficient, and widely used in precision tasks.

4. L298 MOTOR DRIVER:



The L298 motor driver is a dual H-bridge motor driver IC used to control the speed and direction of DC and stepper motors. It operates at a voltage range of 5V to 46V and can handle a maximum current of 2A per channel. The IC has two channels, allowing it to control two motors simultaneously. It features logic inputs to control motor direction and an enable pin for PWM speed control. The L298 is often used with microcontrollers like Arduino for robotics and automation projects. It has built-in protection diodes to safeguard against voltage spikes. Its compact design makes it ideal for motor control in various applications.

5. **CHASSIS:**The physical frame of the robot that supports and houses all components.
6. **BO MOTORS:** Provides movement and propulsion for the robot.
7. **5-9 V WATER PUMP+ PIPE:** Pumps water to extinguish fires.
8. **WATER TANK/BOTTLE:** Stores the water supply for the pump.
9. **3.7 V BATTERIES (18650):** Powers the Arduino and other electronic components (ensure they are connected in a suitable configuration to achieve the desired voltage and capacity).

10. **JUMPER WIRES:** Connects various components to the Arduino and each other.
11. **TIP-122 TRANSISTORS:** Used to control the high current required for the water pump.
12. **1K RESISTORS:** Used to limit current flow in certain parts of the circuit (e.g., for the base of the TIP-122 transistor).

CHAPTER 3: IMPLEMENTATION OF THE PROJECT

3.1 WORKING:

The heart of the firefighting robot is the Arduino UNO microcontroller board. The connections from the flame sensors, L298N motor driver, L293D motor driver, pump as well as Servo motor are all made to the respective pins on the Arduino Uno board. Fig. shows the Circuit diagram of the fire- fighting robot. The wheels of the robot are driven by an L298N motor driver while the pump is driven by the L293 motor driver. The connections of the Servo motor are made to the Arduino. The Servo rotates at the specific angles set by programming in the Arduino IDE. Under normal conditions when there is no fire, the robot can move freely avoiding obstacles on its path due to the ultrasonic sensor which is employed. The sensor detects the distance with the help of the ultrasonic waves and then the robot decides the trajectory for itself, whether to move towards the left, right, forwards or backwards. The angle at which the ultrasonic sensor rotates to detect obstacles is adjustable and can be modified in the Arduino IDE and re-uploaded to the Arduino Uno microcontroller board as per our requirements. The fire-fighting robot is programmed in such a way that when any kind of obstacle is sensed by the robot with the help of the ultrasonic sensor, the robot analyses the best path of movement and moves towards it. Example: When the motor decides to make a right turn owing to obstacles in its path, then the wheels on the left-hand side of the robot are programmed to rotate in a clockwise motion while the wheels on the right-hand side of the motor are programmed to rotate in an anticlockwise motion. Similarly, when the robot decides to make a left turn, then the wheels on the right-hand side of the robot rotate in a clockwise motion while the wheels on the left-hand side of the robot rotate in an anticlockwise motion. When the flame sensor detects the presence of fire, anywhere near, then they are activated as per the code that is written in the Arduino IDE. As a result of which, it pauses the wheels and then activates the pump. The pump then sends water through a pipe mounted over the Servo. The Servo motor then equally spreads the water at the site of the fire through the pipe within the angle specified in the code. The angle at which the servo rotates is adjustable and can be modified as per requirement by making changes in the code where the angle of rotation for the same is defined. International Journal of Trend in Scientific Research and Development @ www.ijtsrd.com eISSN: 2456-6470 @ IJTSRD | Unique Paper ID – IJTSRD55111

| Volume – 7 | Issue – 2 | March-April 2023 Page 710 Once the fire is dozed away completely, the pump stops and the robot is again set in motion. The firefighting robot will start operating again by detecting obstacles on its way and it will move forward. When the flame sensors sense fire ahead of it then the entire process of pumping out water to extinguish the fire is repeated again. And the fire- fighting robot in a working state.

3.2 STEPS INVOLVED IN THE PROCESS:

1. **Start**
2. Initialize pins and sensors.
3. Read sensor values (s1, s2, s3).
4. **If fire detected**:

- Activate pump.
- Move toward the fire.

5. **If no fire detected**:

- Perform obstacle avoidance.

6. Repeat steps 3–5.
7. **Stop**.

3.3 ALGORITHM:

The following algorithm explains the working of the fire-fighting robot:

1. **Initialization**:
- Configure pins for IR sensors, motors, servo, and pump in the setup() function.
- Initialize serial communication for debugging and monitoring sensor values.
2. **Read Sensor Data**:
- Continuously read values from the IR sensors (ir_R, ir_F, ir_L) using analog Read() to determine fire direction and proximity.
3. **Decision-Making Logic**:
- **If fire is detected by the right sensor (s1 < 250)**: Activate the pump and move the robot forward toward the fire source.
- **If fire is detected by the front sensor (s2 < 350)**: Activate the pump and move the robot forward to extinguish the fire.
- **If fire is detected by the left sensor (s3 < 250)**: Activate the pump and move the robot forward.
- **If no fire is detected**: Perform obstacle avoidance or random movement:
- **If s1 detects an obstacle**, reverse and turn right.
- **If s3 detects an obstacle**, reverse and turn left.Otherwise, move forward.
4. **Control Motors**:

- Use motor control pins (in1, in2, in3, in4) to move forward, backward, or turn based on sensor data and decision logic.

5. **Activate Pump**:

- When fire is detected, activate the pump by setting the respective pin high.

6. **Repeat**:

- Continuously monitor sensors and adjust movements to locate and extinguish fires in real-time.

CHAPTER 4 : RESULTS OF THE PROJECT.

4.1 CONCLUSION:

This paper gives a detailed mechanism about the real time industrial fire-fighting mobile robot that can move through a model structure, sense the occurrence of fire accident continuously, intimates the respective personnel and then extinguish it with the help of pumping mechanism. Thus if any fire accident occurs, the robot will first warn the people in accident prone area by blowing a buzzer and then start throwing the water immediately in the direction where the temperature and smoke is recorded to be maximum. The results show that the proposed fire-fighting robot prototype is successfully implemented.

4.2 FUTURE SCOPE:

In the present condition the motion of our robot can be controlled only up to certain distance. It can be extended and improved by using a more robust and long ranged communication system. Presently our robot has a water tank and pump to extinguish a fire. It can be extended to a real fire extinguisher by replacing the water tank by a carbon dioxide carrier which can enable to extinguish the fire of all types. We have used asbestos in the body of our robot to protect the internal components and circuit. The performance of robot can be improved by using more effective heat reflector for the body of robot. The camera can also be modified by using heat resistant glass. The robot can also a fully automated to detect the obstacles and handle them as well. Selection and Dimensioning.

4.3 REFERENCE:

[1] https://www.researchgate.net/publication/35 0996142_Fire_Fighting_Robot

[2] http://www.ijareeie.com/upload/2017/march/ 175_ERTW_20_1517_V2_--_AL

[3] https://www.ijraset.com/researchpaper/fire-extinguisher-robot

[4] https://ijesc.org/upload/95db8f76a7fc5e5d

[5] https://ijesc.org/upload/95db8f76a7fc5e5d2a261af531451ffe.Fire%20Fighting%20Robot%20for%20Disaster%20Management.

[6] https://ijcrt.org/papers/IJCRT_185446.pdf

[7] Tawfiqur Rakib, M. A. Rashid Sarkar, “Design and fabrication of an autonomous firefighting robot with multi sensor fire detection using PID controller”, ICIEV Volumn 23 issue-1 JUNE 2016.

[8] Saravanan P. ,Soni Ishawarya, “Android controlled intergrated semi-autonomous firefighting robot”, Ineternational journal of innovative science Engg. and Technology 2015.

[9] S. Jakthi Priyanka,R. Sangeetha, “Android controlled firefighting robot”,Ineternational journal of innovative science Engg. and Technology ,Volumn 3, 2017.