"DEVELOPMENT OF AN INTELLIGENT IOT BASED FIRE EXTINGUISHING ROBOT"

A Project Report Submitted to
Rajiv Gandhi Proudyogiki Vishwavidyalaya

Towards Partial Fulfillment for the Award of
Bachelor of Engineering in *Computer Science Engineering*

Submitted by:

Durgesh Sharma (0827CS181072)
Harshala Gaikwad (0827CS181087)
Kartavya Verma (0827CS181103)

Guided by:

Prof. Narendra Pal Singh Rathore
Associate Professor CSE AITR, Indore

Acropolis Institute of Technology & Research, Indore
Jan - June 2021

EXAMINER APPROVAL

The Project entitled **"DEVELOPMENT OF AN INTELLIGENT IOT BASED FIRE EXTINGUISHING ROBOT"** submitted by **Durgesh Sharma (0827CS181072), Harshala Gaikwad (0827CS181087), Kartavya Verma (0827CS181103)** has been examined and is hereby approved towards partial fulfillment for the award of **Bachelor of Technology degree in Computer Science discipline**, for which it has been submitted. It understood that by this approval the undersigned do not necessarily endorse or approve any statement made, opinion expressed or conclusion drawn therein, but approve the project only for the purpose for which it has been submitted.

(Internal Examiner) **(External Examiner)**

Date: **Date:**

GUIDE INTERACTION

This is to certify that the work embodied in this project entitled **"Development Of An Intelligent IoT Based Fire Extinguishing Robot"** submitted by **Durgesh Sharma (0827CS181072), Harshala Gaikwad (0827CS181087), Kartavya Verma (0827CS181103)** is a satisfactory account of the bonafide work done under the supervision of **Prof. Narendra Pal Singh Rathore**, Associate Professor, AITR, Indore is recommended towards partial fulfillment for the award of the **Bachelor of Technology (Computer Science)** degree by Rajiv Gandhi Proudyogiki Vishwavidhyalaya, Bhopal.

(Project Guide) **(Project Coordinator)**

STUDENTS UNDERTAKING

This is to certify that project entitled **"Development Of An Intelligent Iot Based Fire Extinguishing Robot"** has developed by us under the supervision of **Prof. Narendra Pal Singh Rathore .** The whole responsibility of work done in this project is ours. The sole intension of this work is only for practical learning and research.

We further declare that to the best of our knowledge, this report does not contain any part of any work which has been submitted for the award of any degree either in this University or in any other University / Deemed University without proper citation and if the same work found then we are liable for explanation to this.

Durgesh Sharma (0827CS181072)

Harshala Gaikwad (0827CS181087)

Kartavya Verma (0827CS181103)

Acknowledgment

We thank the almighty Lord for giving me the strength and courage to sail out through the tough and reach on shore safely.

There are number of people without whom this projects work would not have been feasible. Their high academic standards and personal integrity provided me with continuous guidance and support.

We owe a debt of sincere gratitude, deep sense of reverence and respect to our guide and mentor **Prof. Narendra Pal Singh Rathore,** Associate Professor, AITR, Indore for his motivation, sagacious guidance, constant encouragement, vigilant supervision and valuable critical appreciation throughout this project work, which helped us to successfully complete the project on time.

We express profound gratitude and heartfelt thanks to **Prof. Narendra Pal Singh Rathore**, AITR Indore for his support, suggestion and inspiration for carrying out this project. I am very much thankful to other faculty and staff members of CS Dept, AITR Indore for providing me all support, help and advice during the project. We would be failing in our duty if do not acknowledge the support and guidance received from **Dr. SC Sharma**, Director, AITR, Indore whenever needed. We take opportunity to convey my regards to the management of Acropolis Institute, Indore for extending academic and administrative support and providing me all necessary facilities for project to achieve our objectives.

We are grateful to **our parent** and **family members** who have always loved and supported us unconditionally. To all of them, we want to say “Thank you”, for being the best family that one could ever have and without whom none of this would have been possible.

Durgesh Sharma (0827CS181072), Harshala Gaikwad (0827CS181087), Kartavya Verma (0827CS181103)

Executive Summary

Fire Extinguishing Robot

This project is submitted to Rajiv Gandhi Proudyogiki Vishwavidhyalaya, Bhopal (MP), India for partial fulfillment of Bachelor of Engineering in Computer Science and Engineering branch under the sagacious guidance and vigilant supervision of **Prof. Narendra Pal Singh Rathore**.

The project is based on Internet Of Things (IOT). In the project, Arduino software is used, which is open-source software that makes it easy to write code and upload it to the Arduino Uno. It is used for detecting and extinguishing fire real time. It uses IR Flame Sensor to detect environmental fire, Motor drive to navigate the robot to reach the fireplace and water pump to extinguish fire. The purpose of this project is to implement 'Fire Fighting Robot' in the college in real-time.

Key words: Arduino UNO, IR Flame Sensors, Motor driver, Water Pump

“Where the vision is one year, cultivate flowers;

Where the vision is ten years, cultivate trees;

Where the vision is eternity, cultivate people.”

- Oriental Saying

List of Figures

List of Tables

List of Abbreviations

Abbr1: IOT- Internet Of Things

Abbr2: IR–InfraRed

Abbr3: I/O- input/output

Abbr4: LDR- Light Dependent Resistor

Abbr5: DC- Direct Current

Abbr6: BLDC- Brush Less Direct Current

Abbr7: IDE- Integrated Development Environment

Abbr8: BO- Battery Operated

Abbr9: HW- Hi-Watt

Abbr10: PC- Personal Computer

Abbr11: RAM- Random Access Memory

Abbr12: IC- Integrated Circuit

Abbr13: MHz- MegaHertz

Abbr14: USB- Universal Serial Bus

Table of Contents

Chapter 1. Introduction

Introduction

Fire causes tremendous damage and loss of human life and property. Recently, in order to cope with such catastrophic accidents, research on fire-fighting robots has been carried out in many countries. Our project, Fire Fighting 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.

It is sometimes impossible for fire-fighting personnel to access the site of a fire because of explosive materials, smoke, and high temperatures. In such environments, fire-fighting robots can be useful. The key features of our system are to provide surveillance of fire so that major fire accidents can be prevented and loss of human lives gets minimized.

1. 1 Overview

The project is based on detecting the fire and extinguishing it in real-time. In this, we intend to build a system that could extinguish a small flame by sensing and moving to the location itself. IR Flame Sensors are used to sense the surrounding environment (for instance for the level of temperature) and identify the fireplace.

A system is made in such a way that it detects the surrounding fire and extinguishes them. The key feature of our system is to provide surveillance of fire so that major fire accidents can be prevented and loss of human lives gets minimized.

1.2 Background and Motivation

According to National Crime Records Bureau (NCRB), it is estimated that more than 1.2 lakh deaths have been caused because of fire accidents in India from 2010-2014. In the event of a fire breakout, to rescue people and to put out the fire we are forced to use human resources which are not safe. With growing lifestyle and duties, people are becoming more negligent. This negligence can turn a minor spark into a huge accident, putting various lives at stake. To the worst case of accidents, fire causes heavy loss both financially and by taking lives. Though such accidents are a result of carelessness, but the consequences are very disturbing. If the root cause, i.e, the source of fire can be detected and put off beforehand, then such consequences can be avoided. Therefore by inventing such a device that automatically senses and extinguishes the fire at an early stage can be of great importance

1.3 Problem Statement and Objectives

The growing world population is bringing involuntary problems together. Fires are among the most important of these problems. In the event of a fire breakout, to rescue people and to put out the fire we are forced to use human resources which are not safe. To the worst case of accidents, fire causes heavy loss both financially and by taking lives. Therefore by inventing such a device that automatically sense and extinguish the fire, humans as well as property can be saved at higher rate with minimum damage caused by the fire.

Thus, the system implemented has the following objectives:

1. Objective 1: To design and implement a robot that can automatically sense fireplace and extinguish fire without human intervention so that live loss can be reduced.

2. Objective 2: To design and development firefighting robot at low cost.

1.4 Scope of the Project

- The firefighting robot will have future scope that it can work with firefighters, which greatly reduce the danger of injury to victims.

Fig 1.4.1 Firefighter along with robot extinguish the fire

- Camera and Video transmission can be added.
- It is an innovative work in the field of robotics that operates towards a sensible and obtainable access to save the lives and prevents the danger to property

Fig 1.4.2 Robot extinguish the fire to prevent the danger to property and lives

1.5 Team Organization

- **Durgesh Sharma :**

  Gathered ideas and worked on project selection. I developed a detailed project plan to track progress of the project activities, surveyed the various resources and developed presentations and other related documents. I coded the project at initial stage. I have also gathered the hardware requirement and done the testing of individual parts of the robot. I have contributed in documentation, reports, research paper and other design related diagrams (UML diagrams). Posters and animation videos were developed by me.

  Attended and contribute to all sessions, meetings and activities as required.

- **Harshala Gaikwad :**

  Along with doing preliminary investigation and understanding the limitations of current system, I studied about the topic and its scope and surveyed various research papers related to the Fire Fighting task and the technology that is to be used.

  I have also gathered the hardware requirement and done the testing of individual parts of the robot. I have also worked on the design part of the project (designs the UML diagrams). Documentation part is also the work done by me in this project.

- **Kartavya Verma :**

  I investigated and found the right technology and studied in deep about it. For the implementation of the project, I collected the hardware and build the model for it. Implementation logic for the project objective and coding of internal functionalities is also done by me. Also, I worked on coding part to train the robot.

1.6 Report Structure

The project ***Fire Extinguishing Robot*** is primarily concerned with the **Fire Control in real-time** and whole project report is categorized into five chapters.

Chapter 1: Introduction- introduces the background of the problem followed by rationale for the project undertaken. The chapter describes the objectives, scope and applications of the project. Further, the chapter gives the details of team members and their contribution in development of project which is then subsequently ended with report outline.

Chapter 2: Review of Literature- explores the work done in the area of Project undertaken and discusses the limitations of existing system and highlights the issues and challenges of project area. The chapter finally ends up with the requirement identification for present project work based on findings drawn from reviewed literature and end user interactions.

Chapter 3: Proposed System - starts with the project proposal based on requirement identified, followed by benefits of the project. The chapter also illustrate software engineering paradigm used along with different design representation. The chapter also includes block diagram and details of major modules of the project. Chapter also gives insights of different type of feasibility study carried out for the project undertaken. Later it gives details of the different deployment requirements for the developed project.

Chapter 4: Implementation - includes the details of different Technology/ Techniques/ Tools/ Programming Languages used in developing the Project. The chapter also includes the different user interface designed in project along with their functionality. Further it discuss the experiment results along with testing of the project. The chapter ends with evaluation of project on different parameters like accuracy and efficiency.

Chapter 5: Conclusion - Concludes with objective wise analysis of results and limitation of present work which is then followed by suggestions and recommendations for further improvement.

Chapter 2. Review of Literature

Review of Literature

In today's era firefighting is a dangerous issue. Detecting the fire and extinguishing it is a dangerous job and that puts lives of fire fighters at risk. There are number of fire accidents in which fire fighter had to lose their lives in the line of duty each year throughout the world. Increase in the number fire accidents are due to expanding human population and growing industrialization. The physical limitations of humans to deal with these kinds of destructive fires make fire extinguishing a complicated task. The use of fire-fighting robots can reduce the errors and the limitations that are faced by human fire fighters.

2.1 Preliminary Investigation

2.1.1 Current System

- The current methods applied in firefighting are inadequate and inefficient relying heavily on humans who are prone to error, no matter how extensively they have been trained.
- A recent trend that has become popular is to use robots instead of humans to handle fire hazards. This is mainly because they can be used in situations that are too dangerous for any individual to involve themselves in.

2.2 Limitations of Current System

The limitations of these are as follows:

- At the economic front, it is not feasible to have a person who continuously monitors the environment. Also this is inadequate and inefficient relying heavily on humans who are prone to error, no matter how extensively they have been trained.
- The primary risk of current system is that of personal physical injury. Firefighters are susceptible to burns, smoke inhalation and crush injuries from collapsing structures. They can suffer from heat exhaustion, as well as long-term job-related illnesses such as asthma, persistent coughing, heart disease, cancer and lung damage.
- It is not possible for a person to stand for 24 hours and keep monitoring the environment but our system can be used 24X 7.
- When a CCTV camera is used, person is required to monitor the particular place continuously but in our system this can be done automatically in real-time.

2.3 Requirement Identification and Analysis for Project

Significant work has been done in the field of Fire Fighting Robot; however, it is not easy to achieve desired results. The review of literature leads to draw certain major findings which are as under:

1. Tawfiqur Rakib, M. A. Rashid Sarkar [4] proposed a fire fighting robot model which consists of a base platform made up of 'Kerosene wood', LM35 sensor for temperature detection, flame sensors to detect the fire and a water container of 1 litre capacity which is made up of a strong

cardboard that makes it water resistant. The robot has two wheels for its movement.

2. Saravanan P., Soni Ishawarya [5] proposed a model which uses Atmega2560 micro-controller and in which the robot is divided into three basic units according to their functions which are as locomotive unit, fire detecting unit and extinguishing unit. Each unit performs their task in order to achieve the desired output of extinguishing fire. The locomotive unit is used for the movement of the robot and to avoid the obstacles with the help of four IR and four ultrasonic sensors. The fire detecting unit is used to detect fire using LDR and temperature sensor. The extinguishing unit is used to extinguish the fire using water container and BLDC motor. The robot also has a bluetooth module that is connected with the smartphones in order to navigate it in the proper direction.

3. S. Jakthi Priyanka,R. Sangeetha [6] proposed an android controlled fire fighting robot which uses Arduino UNO R3. The robot consists of gas sensor for fire detection, gear motor and motor drive for the movement of robot, a bluetooth module to connect the robot with the android device and to control the robot with the smartphone as well. Water pump and sprinkler is also used in this. To instruct the Arduino UNO open source software which is Arduino IDE is required to code and to implement that code in Arduino UNO.

4. In our project, we develop a robot that is able to locate and extinguish fire in a given environment. The goals of the project is
    - To increase safety associated with firefighting.
    - To create a way to check for fires without involving human beings directly such that they are not exposed to any threats.
    - To be capable of traversing an area without any concerns about inhaling smoke or burning at any point during the exploration

- Decrease the time taken to traverse a map with potential fire

2.3.1 Conclusion

This chapter reviews the literature surveys that have been done during the research work. The related work that has been proposed by many researchers has been discussed. The research papers related to firefighting robots from 2005 to 2020 have been shown which discussed about different methods and algorithm to identify objects.

Chapter 3. Proposed System

Proposed System

3.1 The Proposal

The proposal is to deploy a system which can automatically identify fire and extinguish it without human intervention in real-time, in order to reduce life losses. This would improve the efficiency of fire fighters and also prevent them from risking human lives.

It can used in record maintaining rooms where fire can cause loss of valuable data.

3.1.1 Benefits of the Proposed System

The current system had a lot of challenges that are overcome by this system:

- **Economic:** The proposed system is economic as there will not be any person required to keep monitoring the environment. Also we are using IR flame sensors instead of photodiode which reduces the cost.
- **Real-Time Observation:** The fire can be detected and extinguish with the help of sensors and motors in real-time.
- **Man Power:** It does not require any person (firefighters) or their efforts in extinguishing the fire. It will reduce the risk of injury for firefighters and decreases the loss in terms of lives and property.
- **24 x 7 Monitoring:** Fire Fighting System implemented does not require the person to stand 24 hrs. Our robot will continuously

monitor the environment.

3.2 Block Diagram

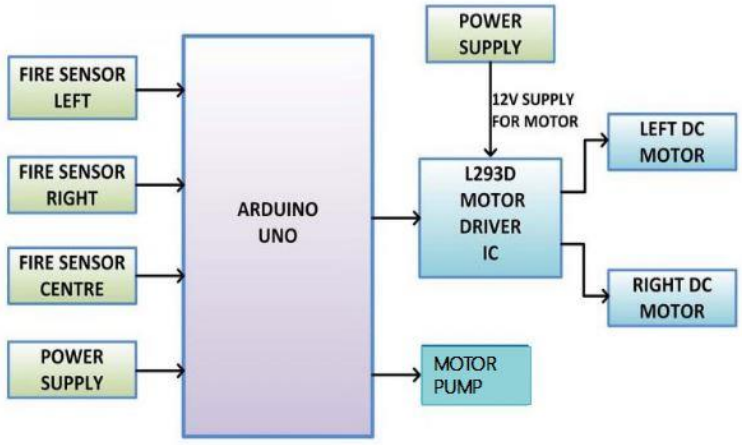


Figure 3-1: Block Diagram

Fig 4.2.1 shows the block diagram of firefighting robot which consists of three IR flame sensors as the input of the system. Arduino UNO is used as a micro-controller that connects other components. L293D Motor driver is used to drive motors and is capable of running two DC motors (Left DC motor and Right DC motor) at the same time

3.3 Feasibility Study

A feasibility study is an analysis of how successfully a system can be implemented, accounting for factors that affect it such as economic, technical and operational factors to determine its potential positive and negative outcomes before investing a considerable amount of time and money into it.

3.3.1 Technical

The project is a complete IOT based embedded application. The main technologies associated with it are:

- Software
  - Arduino
- Languages
  - C++
- Hardware
  - BO Motor
  - Servo Motor
  - Motor Driver
  - Breadboard, Connecting wires
  - Flame Sensor
  - Submersible pump
  - Arduino UNO

Each of the technologies are freely (software's) and easily (hardware's) available and the technical skills required are manageable. Time limitations of the project development and these technologies are synchronized.

Initially the robot of the project is for domestic use, but for later implementation it will be enhanced with sufficient features for broad use.

From this it's clear that the project Fire Extinguishing Robot is technically feasible.

3.3.2 Economical

Being an IOT based application Robot will have an associated hardware cost (in Indian Rupees).

1. Arduino UNO --> 400/-
2. DC motors & wheels --> 415/-
3. Jumper Wire --> 50/-
4. Servo motor sg90 --> 120/-
5. L293D IC --> 40/-
6. L293D Driver Module --> 180/-
7. Mini Breadboard (170 points) --> 80/-
8. Flame sensor --> 360/-
9. Mini submersible water pump --> 145/-
10. HW 9V battery --> 80/-

For flame detection keeping an eye on economic feasibility, IR flame sensors are used instead of photo-diode sensor which stretches the cost.

The system will follow the freeware software standards no cost will be charge from the potential customers.

From these it's clear that project FIRE EXTINGUISHING ROBOT is economical feasible.

3.3.3 Operational

The main motto of our system is to reduce the manual efforts of fire fighters and automating their task with the help of firefighting robots. Firefighting robot helps in automatically sensing the fire with the help of IR Flame Sensors and is connected to Arduino UNO, which control the movement of Motor drive that helps the robot to reach the fireplace and extinguishes it with the pumping mechanisms to reduce the lives loss.

Our system (Fire Fighting Robot) is able to do that accurately

and efficiently making the system operationally feasible.

3.4 Design Representation

Fig 3.4 shows the design representation of firefighting robot which consists of three IR flame sensors as the input of the system (Arduino UNO). Arduino UNO is used as a micro-controller that connects other components. L293D Motor driver is connected to Arduino Uno and is used to drive motors and is capable of running two DC motors (Left DC motor and Right DC motor) at the same time. When system detects the fire, robot with the use of these motors move towards the fire location and extinguishes it with the help of water pump. The pump is placed on the top of a servo motor so that we can control the direction in which the water has to be sprayed.

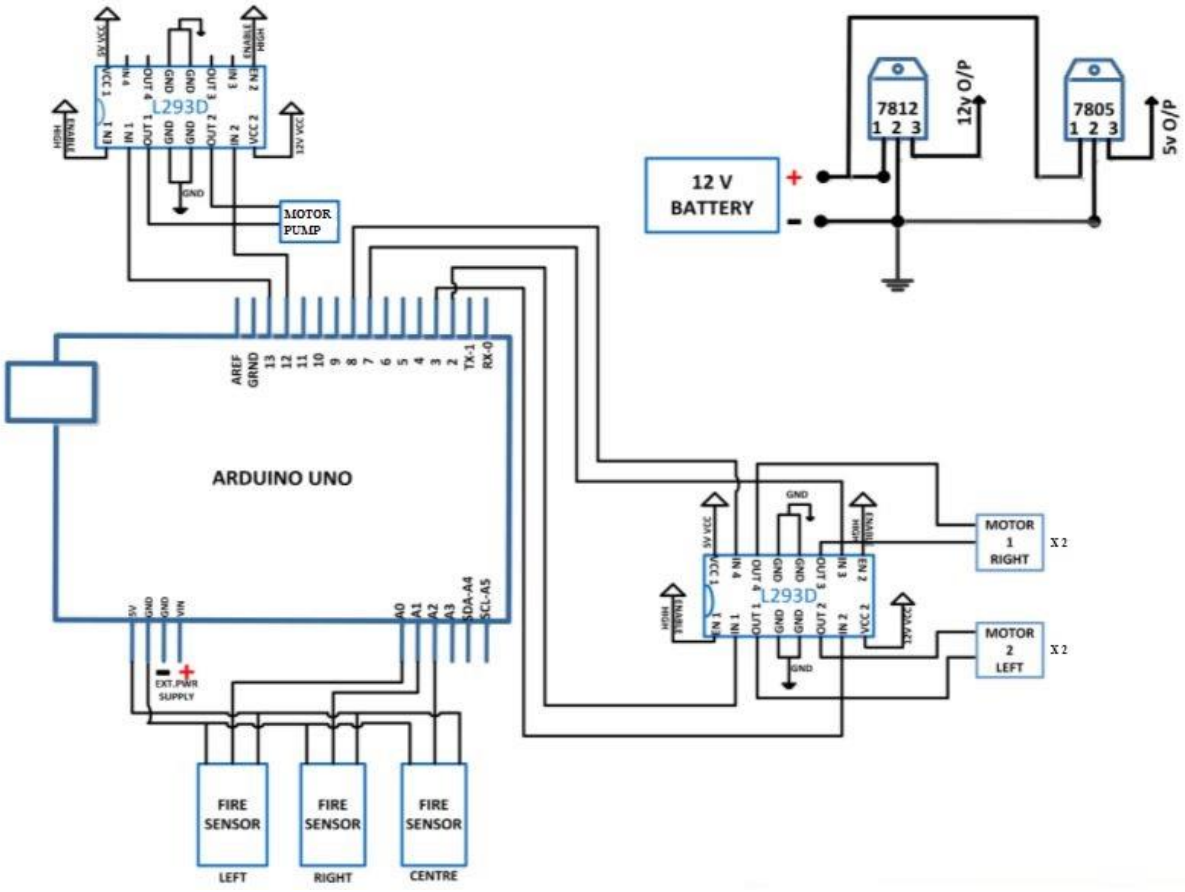


Fig 3-2 Circuit Diagram of Fire Extinguishing Robot

3.5 UML DIAGRAMS

A UML diagram is a diagram based on the UML (Unified Modeling Language) with the purpose of visually representing a system along with its main actors, roles, actions, artifacts or classes, in order to better understand, alter, maintain, or document information about the system.

3.5.1 Use Case Model:

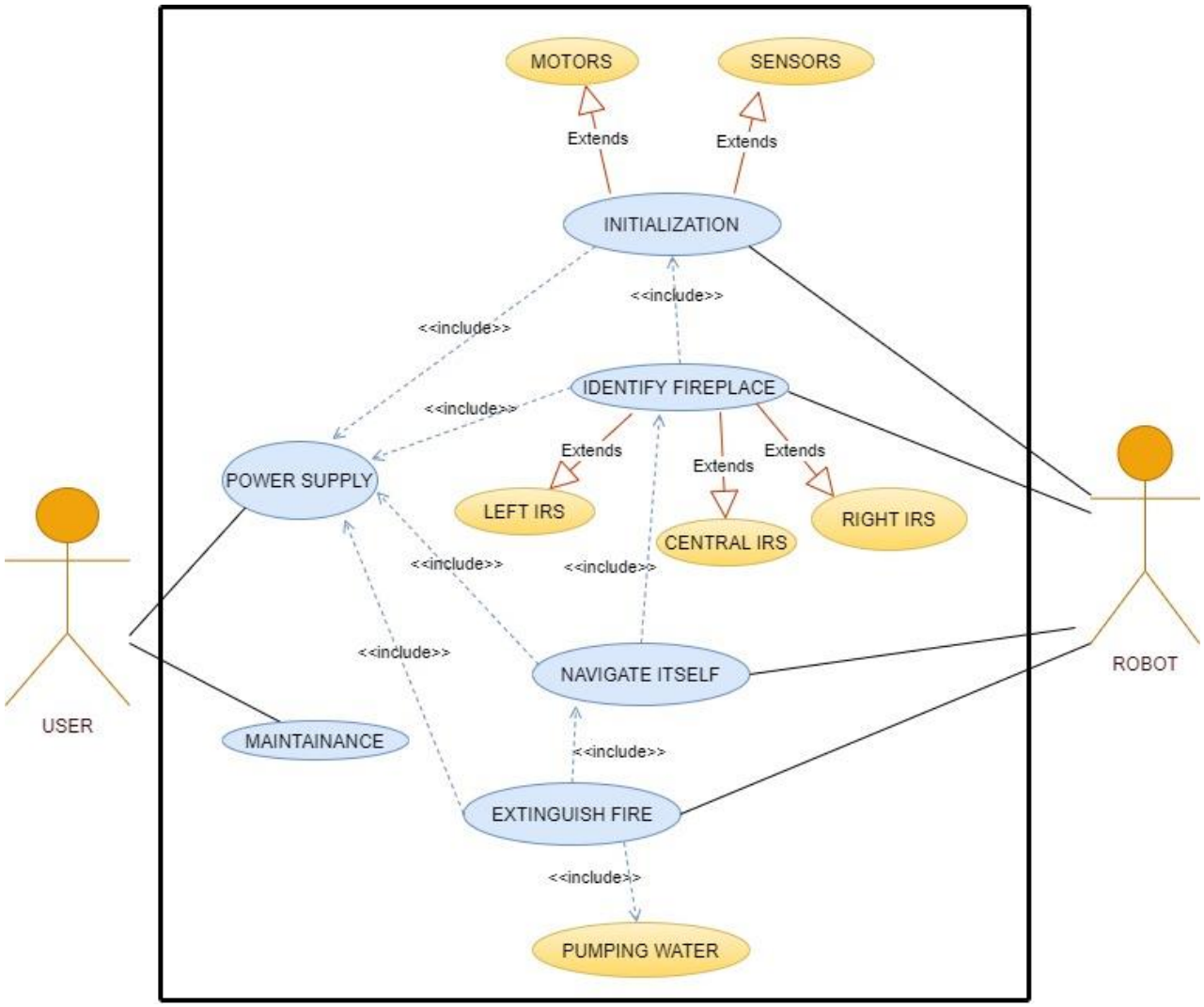


Fig 3-3 Use Case Diagram

3.5.1.1 Use Case Description

- **Use case Name: Power Supply**
  - **Actors: User**
    - ✓ Brief Description

  This use case describes how the user turns on or off the robot using power supply.
  - **Priority:**
    - ❖ Without power supply, the robot is non-functional.
  - **Status:**
    - ❖ Electricity can be supplied.
  - **Pre-Conditions:**
    - ❖ None
  - **Post-Conditions:**
    - ❖ If the use case was successful, the robot sensors get initialized and the robot functions properly. If not, the system state is unchanged.
  - **Extension Points:**
    - ❖ None.
  - **"Used" Use cases:**
    - ❖ None

- **Use case Name: Maintainance**
  - **Actors: User**
    - ✓ Brief Description

  This use case describes how the user maintains the robot for smooth and efficient functions.
  - **Priority:**
    - ❖ Without proper maintainance, the robot is non functional or may not perform the tasks as needed.
  - **Status:**
    - ❖ Maintainance can be done manually.

- **Pre-Conditions:**
  - ❖ None
- **Post-Conditions:**
  - ❖ If the use case was successful,the robot works in an efficient manner. If not, the system state is unchanged.
- **Extension Points:**
  - ❖ None.
- **"Used" Use cases:**
  - ❖ None

- **Use case Name: Initialization**
  - **Actors: Robot**
    - ✓ Brief Description

    This use case describes how the robot initialize its sensors on getting power supply.
  - **Priority:**
    - ❖ Without initializing sensors, the robot is unable to detect fire.
  - **Status:**
    - ❖ Can be initialized when robot is supplied electricity.
  - **Pre-Conditions:**
    - ❖ Robot should be turned on.
  - **Post-Conditions:**
    - ❖ If the use case was successful, the robot sensors detect the fire using flame sensors. If not, the system state is unchanged.
  - **Extension Points:**
    - ❖ Motors
    - ❖ Sensors

    They get initialized during the process so that further actions can be carried out.
  - **"Used" Use cases:**
    - ❖ Power supply

- **Use case Name: Identify fireplace**
  - **Actors: Robot**
    - ✓ Brief Description

  This use case describes how the robot detects fire using various fire detection sensors namely IR sensors. Mainly we are using three IR sensors for fire detection.

  - **Priority:**
    - ❖ Without identifying the fire place, the robot cannot navigate to the desired fire breakout location.
  - **Status:**
    - ❖ Flame sensors can be used to identify the fireplace.
  - **Pre-Conditions:**
    - ❖ Sensors must be initialized.
    - ❖ Electricity must be supplied.
    - ❖ Motors should be initialized.
  - **Post-Conditions:**
    - ❖ If the use case was successful, the robot sensors get activated and directs the robot to the location where fire is been detected. If not, the system state is unchanged.
  - **Extension Points:**
    - ❖ Left IR sensor
    - ❖ Right IR sensor
    - ❖ Central IR sensor
  - **"Used" Use cases:**
    - ❖ Power supply
    - ❖ Initialize sensors

- **Use case Name: Navigate itself**
  - **Actors: Robot**
    - ✓ Brief Description

This use case describes how the robot navigates itself to the fireplace once its sensors detects the flames.

- **Priority:**
  - ❖ Without navigation to the fire breakout location, it is not possible to extinguish fire.
- **Status:**
  - ❖ Navigation is possible once the flame sensors detects the fire..
- **Pre-Conditions:**
  - ❖ Electricity supply
  - ❖ Initialization of sensors
  - ❖ Identification of fireplace
- **Post-Conditions:**
  - ❖ If the use case was successful, the robot is able to extinguish fire. If not, the system state is unchanged.
- **Extension Points:**
  - ❖ None.
- **"Used" Use cases:**
  - ❖ Power supply
  - ❖ Initialize sensors
  - ❖ Identify fireplace

- **Use case Name: Extinguish Fire**
  - **Actors: Robot**
    - ✓ Brief Description

This use case describes how the robot extinguishes fire after reaching to the fire-breakout location .

- **Priority:**
  - ❖ Without extinguishing fire, the purpose of robot is not fulfilled.
- **Status:**
  - ❖ Fire can be extinguished once its location is been detected and the robot reaches to that location.

- **Pre-Conditions:**
  - ❖ Electricity supply must be given.
  - ❖ Sensors should be initialized.
  - ❖ Fireplace should be detected
  - ❖ Fire place should be reached.
  - ❖ Pumping action is to be achieved.
- **Post-Conditions:**
  - ❖ If the use case was successful, the robot extinguishes fire and thus is able to prevent huge flames of fire.If not, the system state is unchanged.
- **Extension Points:**
  - ❖ None.
- **"Used" Use cases:**
  - ❖ Power supply
  - ❖ Initialize sensors
  - ❖ Identify fireplace
  - ❖ Navigate itself

3.5.2 Activity Diagrams:

1. Power Supply:

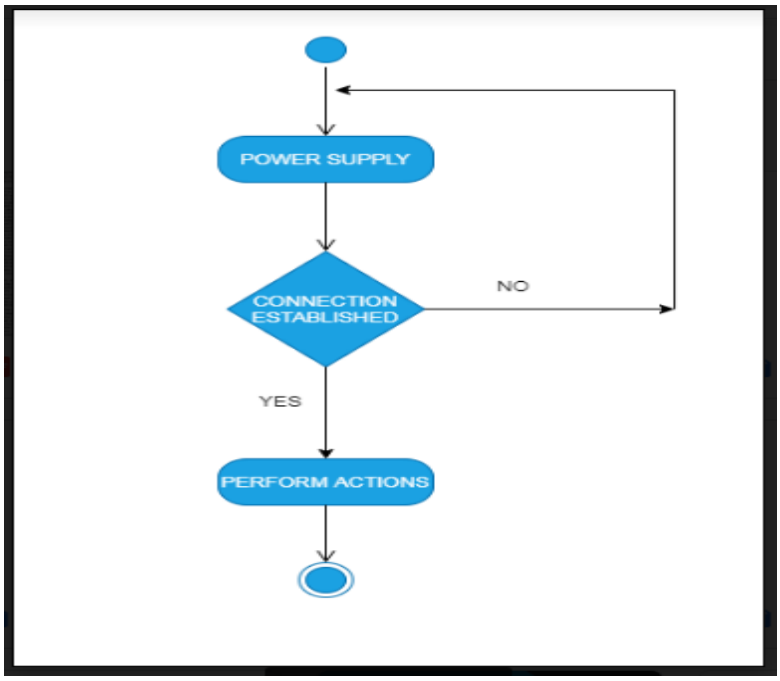


Fig 3-4 Power Supply

2. Initialization:

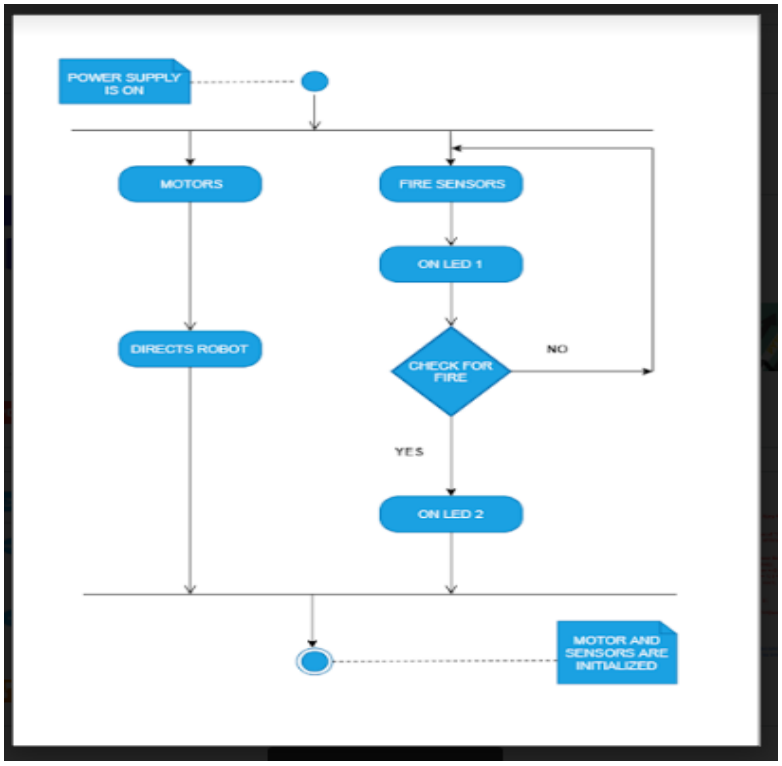


Fig 3-5 Initialization

3. Identify Fireplace:

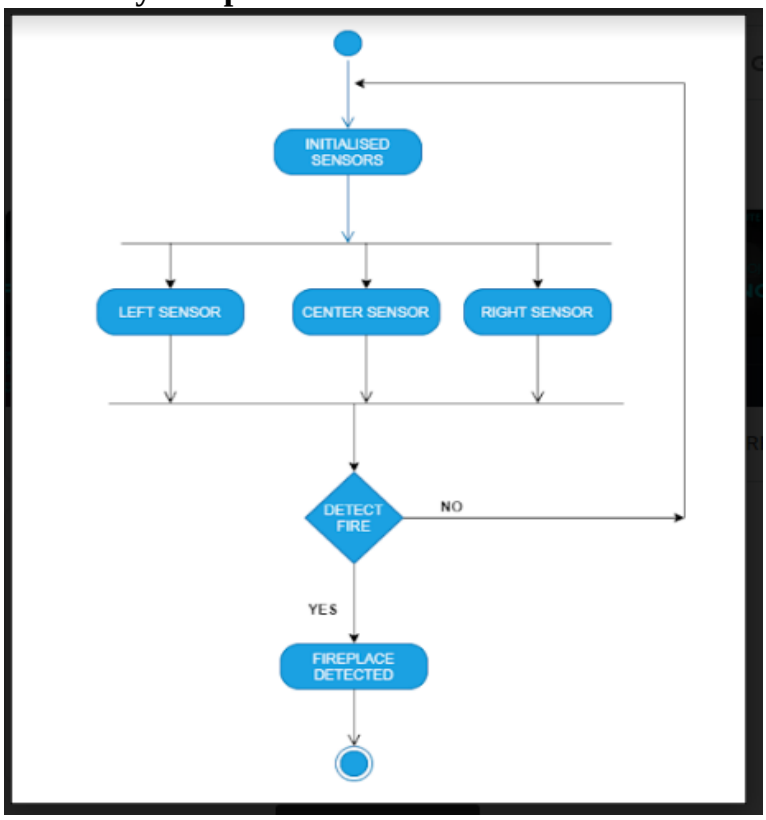


Fig 3-6 Identify Fireplace

4. Navigate Itself:

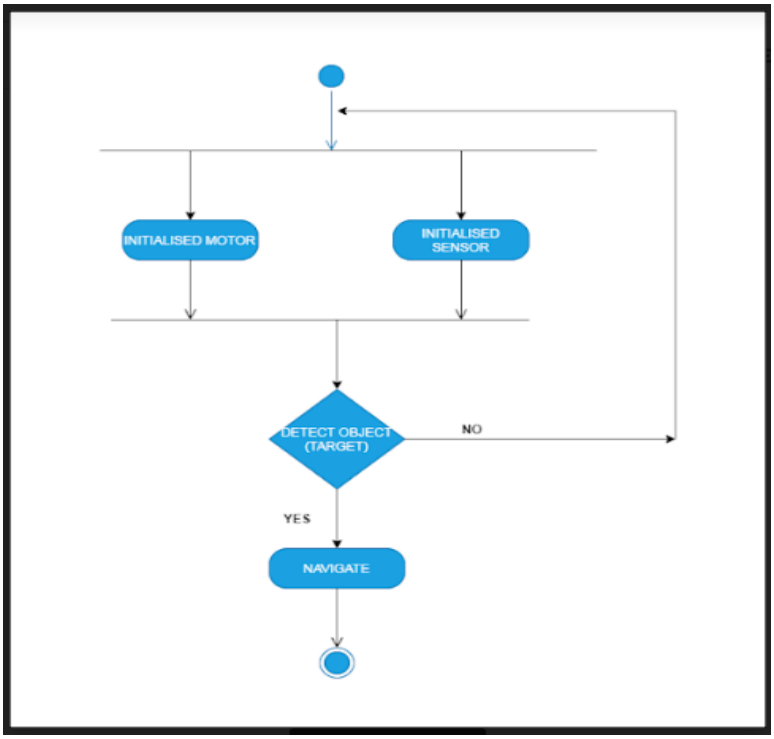


Fig 3-7 Navigate Itself

5. Extinguish Fire:

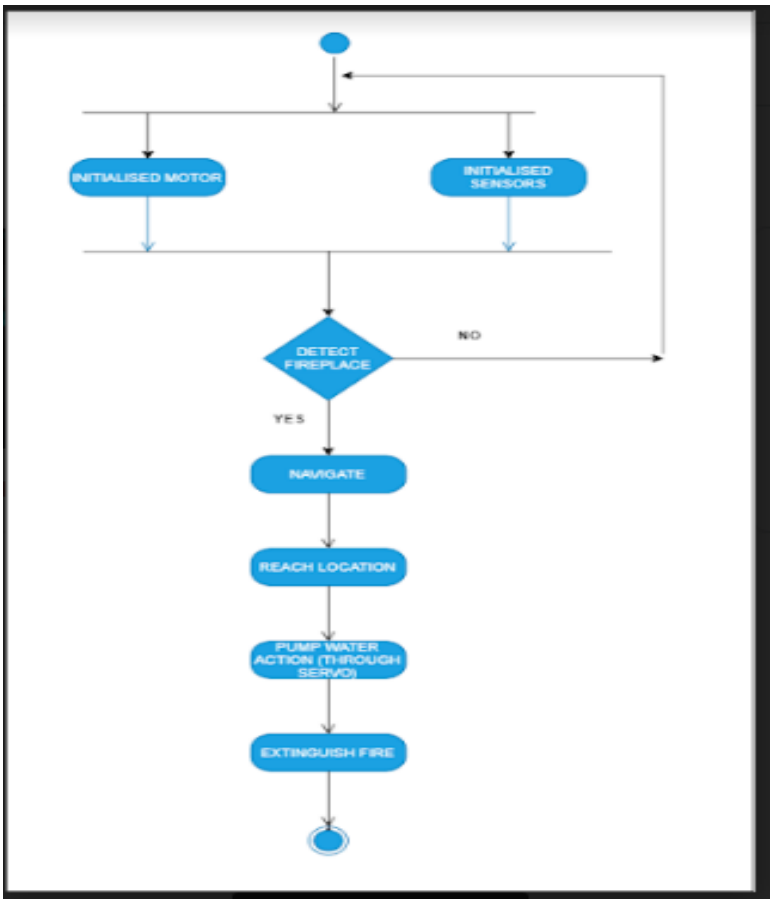


Fig 3-8 Extinguish Fire

3.5.3 Sequence Diagrams:

1. Power Supply and Maintenance:

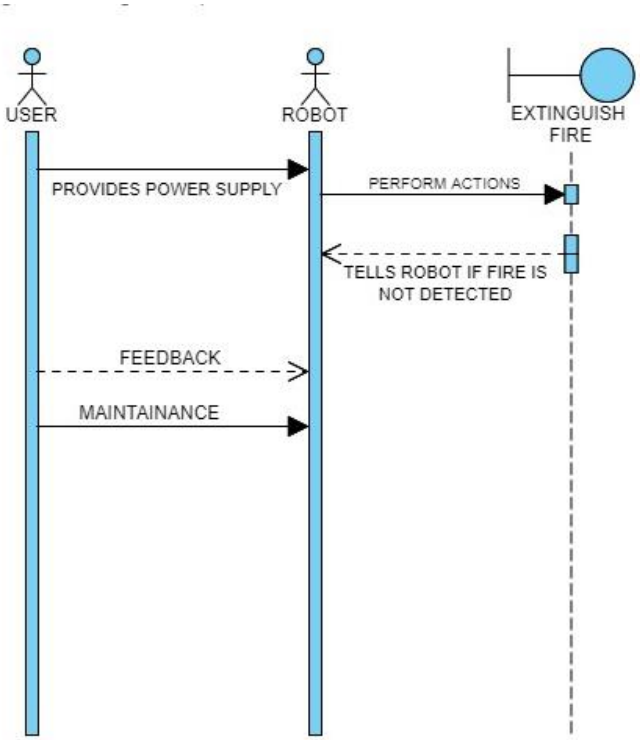


Fig 3-9 Power Supply and Maintenance

2. Initialization:

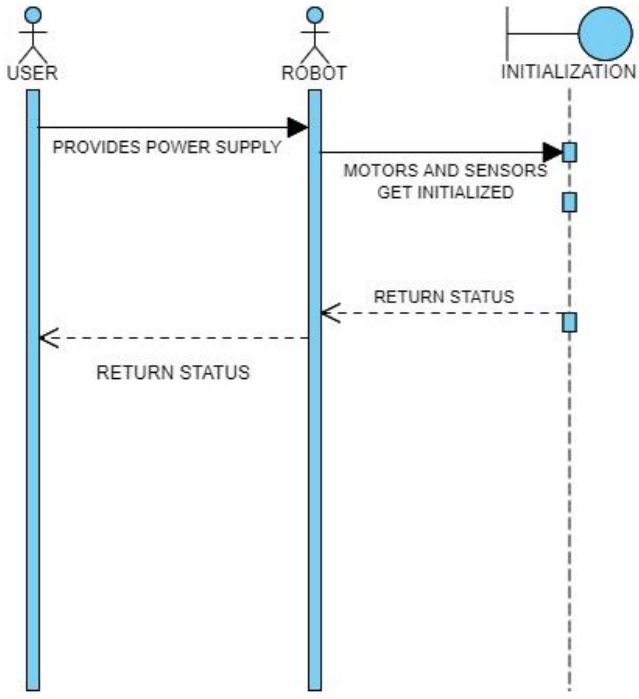


Fig 3-10 Initialization

3. Identification of Fireplace:

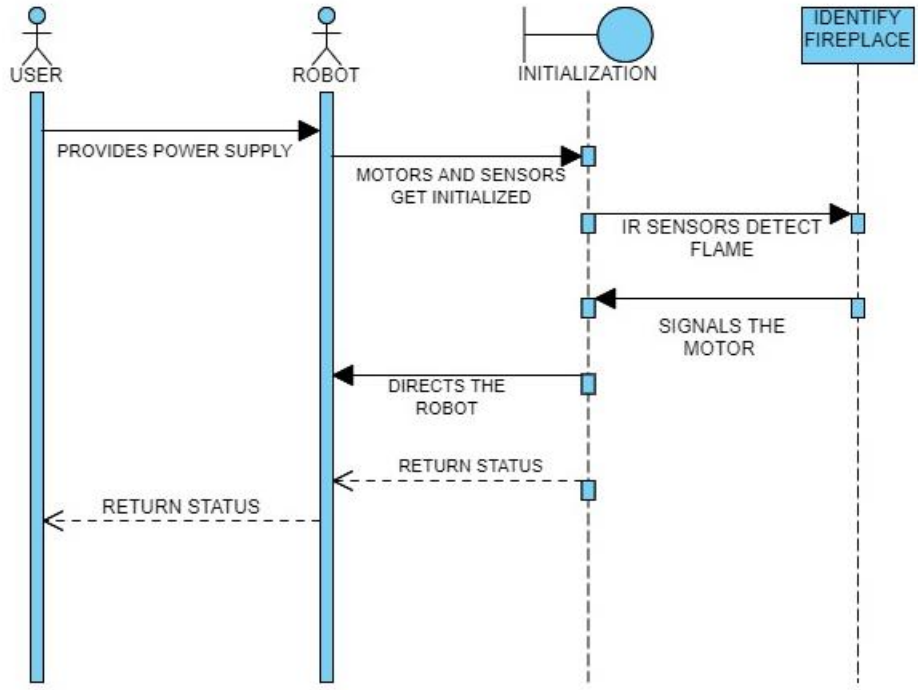


Fig 3-11 Identification of Fireplace

4. Navigation and Extinguishing Fire:

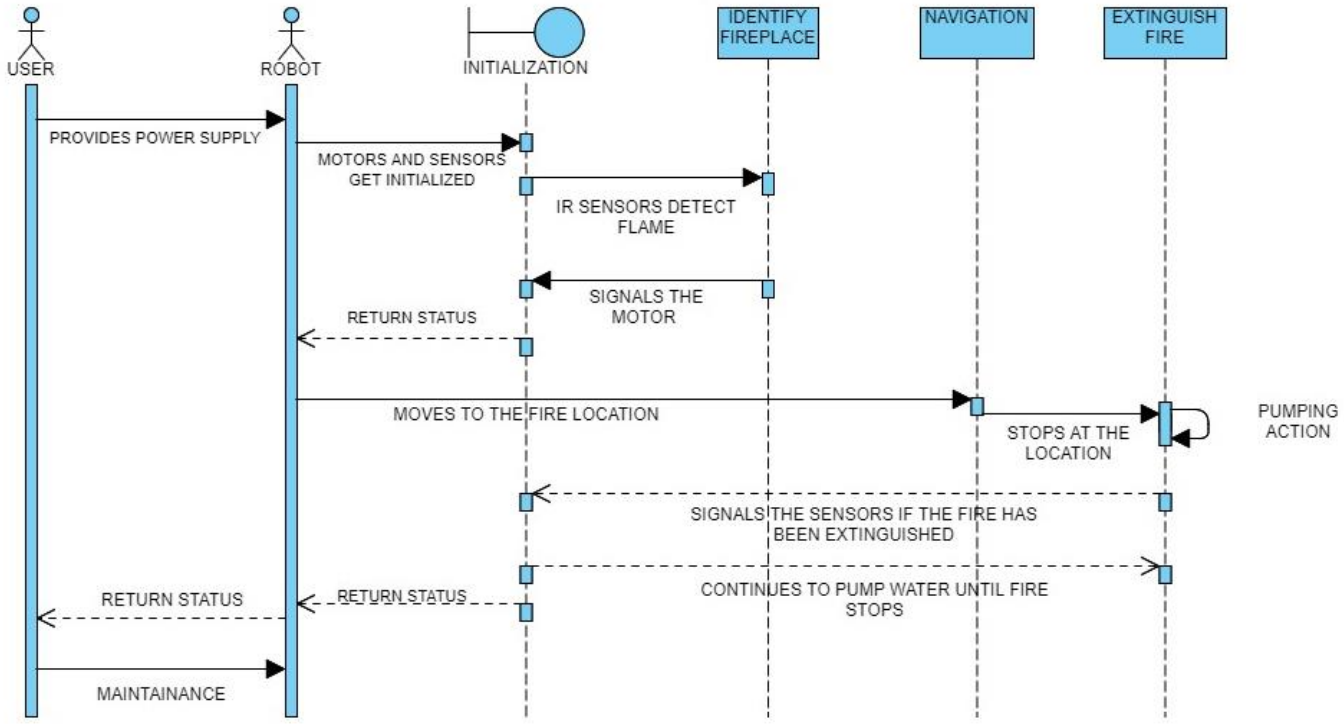


Fig 3-12 Navigation and Extinguishing Fire

3.5.4 E-R Diagram:

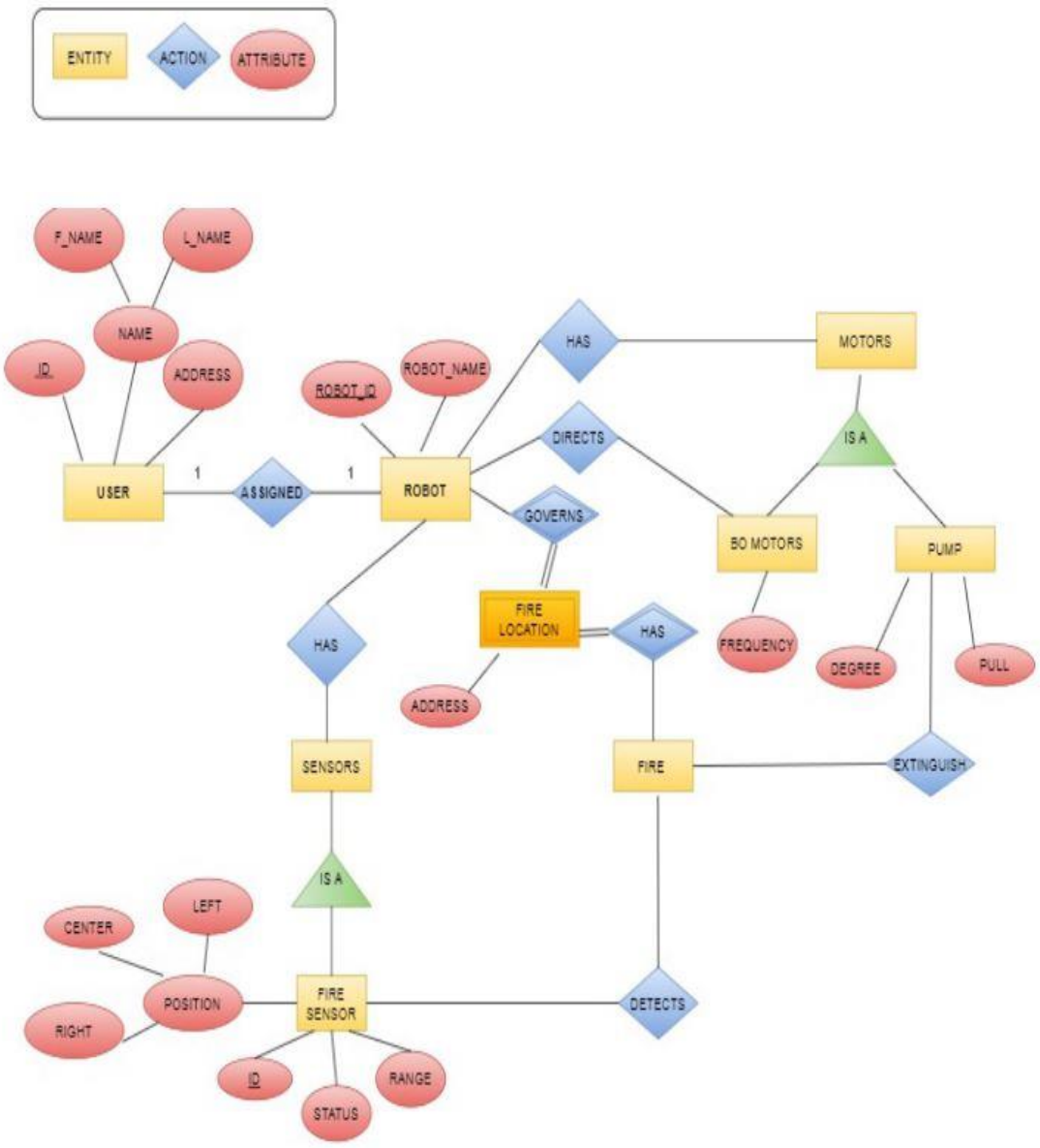


Fig 3-13 E-R Diagram

3.5.5 Class Diagram:

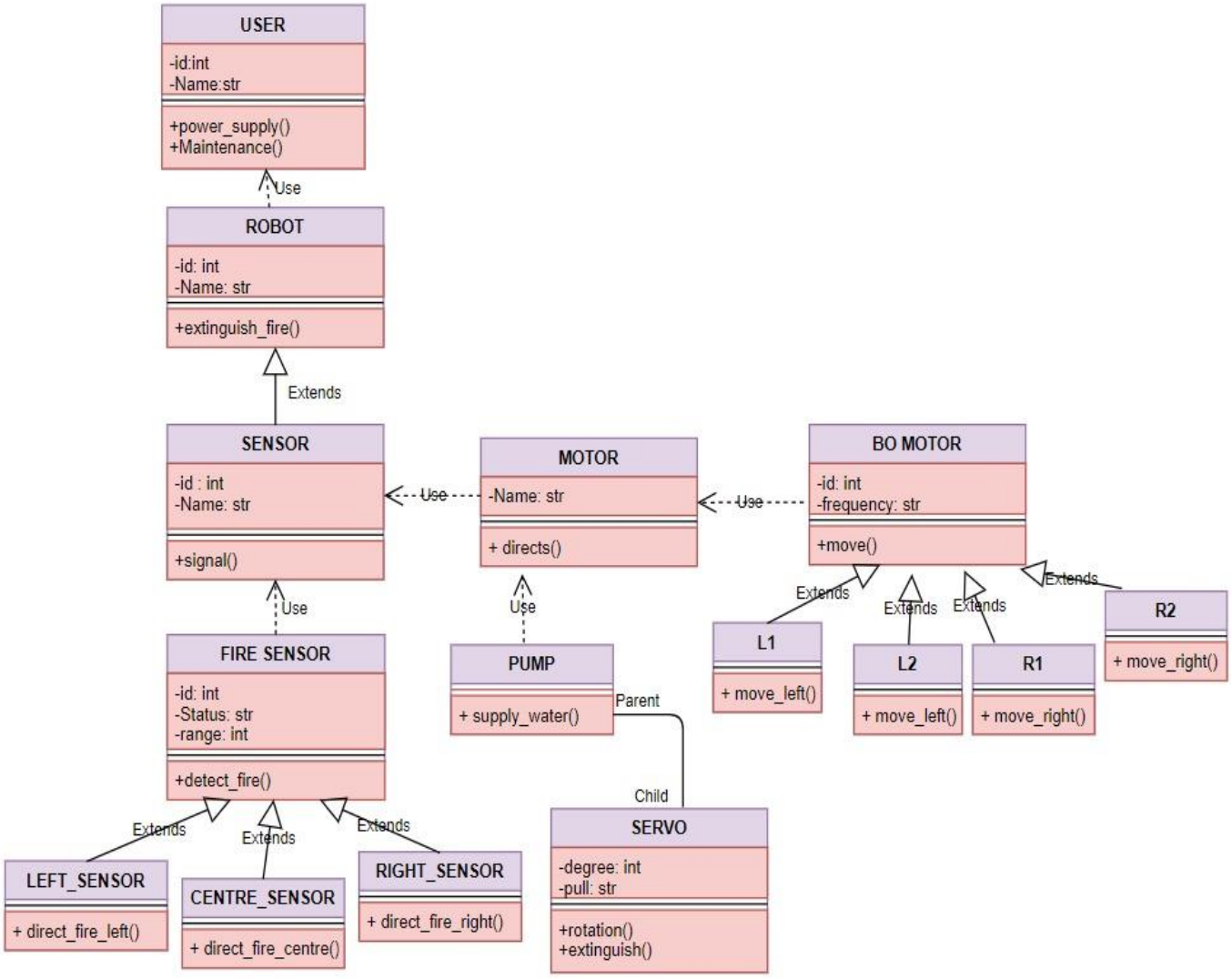


Fig 3-14 Class Diagram

3.5.6 Data Flow Diagrams:

1. Level 0:

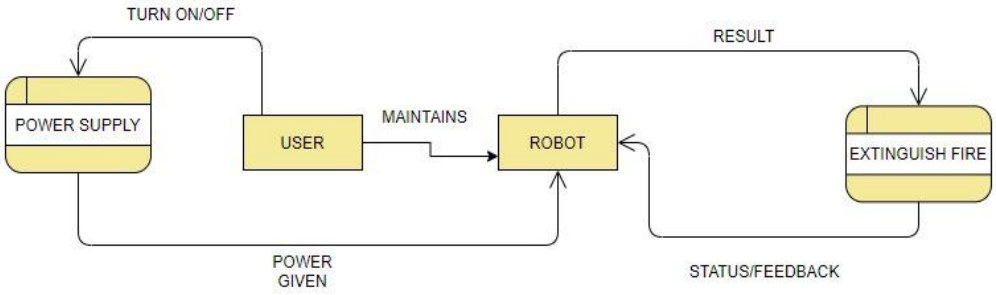


Fig 3-15 Level 0 DFD

2. Level 1:

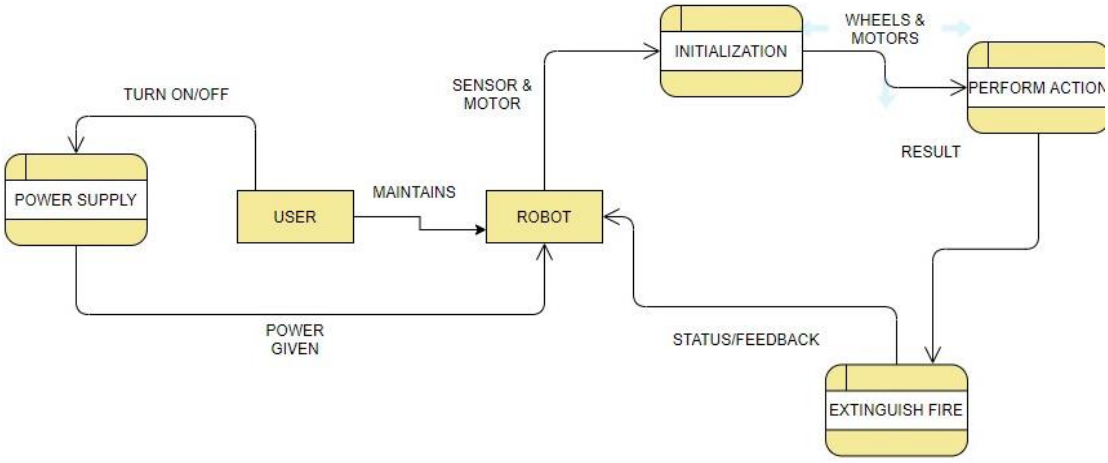


Fig 3-16 Level 1 DFD

3. Level 2:

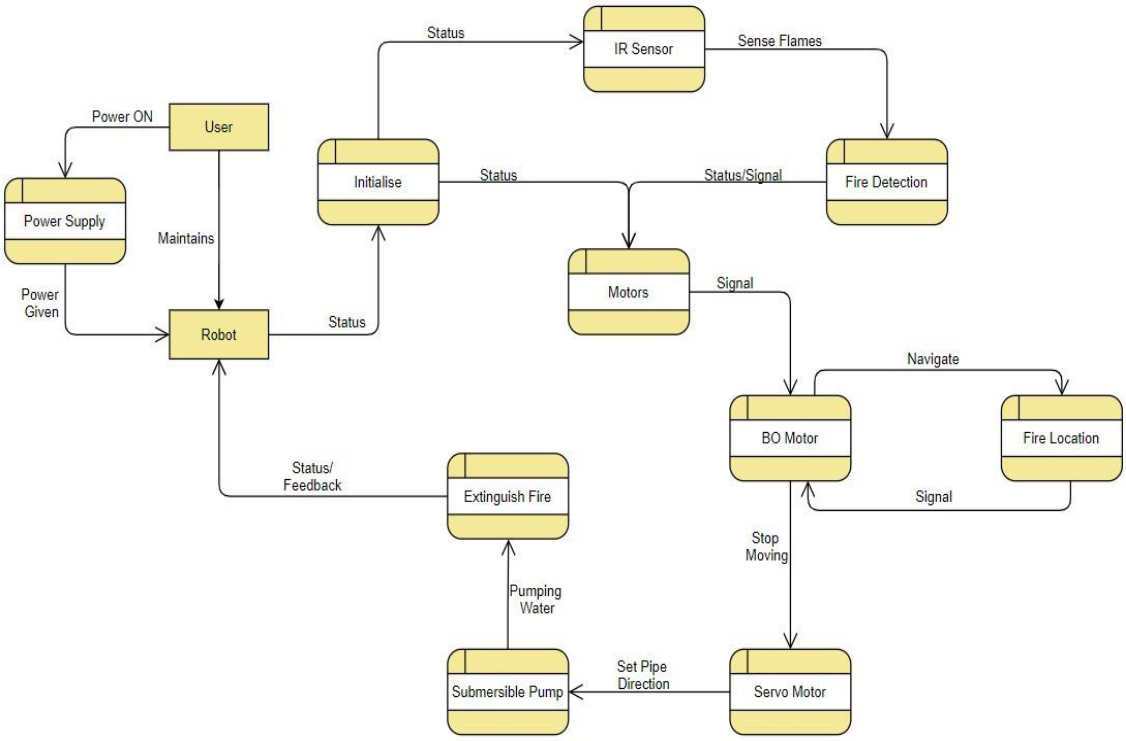


Fig 3-17 Level 2 DFD

3.6 Deployment Requirements

There are various requirements (hardware and software) to successfully deploy the system. These are mentioned below:

3.6.1 Hardware

1. Servo Motor-
    - Pull: 1.8-2kg
    - Voltage: 4.8 to 6 V.
    - Degree: 180°

2. Motor Driver-
    - L293D Module
3. Mini Breadboard-
    - 170 tie points
4. Jumper Wires-
    - Male to male
    - Male to female
    - Female to Female.
5. BO Motor (300 rpm)
6. Laptop (64 bit)
7. PC Processor : CORE i7+
8. PC RAM : 8GB+
9. Batteries
10. Sensors -

No.	Sensor	Function
1.	Left IR sensor	Sense flame in left direction.
2.	Right IR sensor	Sense flame in right direction
3.	Central IR sensor	Sense flame in forward direction.

Table 3.1: Sensors used

3.6.2 Software:

Arduino:

Arduino, natively, supports a language that we call the Arduino Programming Language, or Arduino Language. This language is based upon the Wiring development platform, which in turn is based upon Processing, which if you are not familiar with, is what p5.js is based upon. It's a long history of projects building upon other projects, in a very Open Source way. The Arduino IDE is based upon the Processing IDE, and the Wiring IDE which builds on top of it.

When we work with Arduino we commonly use the Arduino IDE (Integrated Development Environment), a software available for all the major desktop platforms (macOS, Linux, Windows), which gives us 2 things: a programming editor with integrated libraries support, and a way to easily compile and load our Arduino programs to a board connected to the computer.

The Arduino Programming Language is basically a framework built on top of C++. You can argue that it's not a real programming language in the traditional term, but I think this helps avoiding confusion for beginners.

A program written in the Arduino Programming Language is called sketch. A sketch is normally saved with the .ino extension (from Arduino).

Chapter 4. Implementation

Implementation

To rescue people from fire breakout and to put out the fire we are forced to use human resources which are not safe. To the worst case of accidents, fire causes heavy loss both financially and by taking lives. Therefore by inventing such a device that automatically sense and extinguish the fire, humans as well as property can be saved at higher rate with minimum damage caused by the fire.

4.1 Technique Used

4.1.1 Design Structure

In this section, the prototype of robotic system is presented, in which it consists of IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, rubber wheels, processor, and communication module for exchanging data between the fire-fighting robot and Arduino software. Fig 4.1.1 shows the basic prototype of our firefighting robot. The robot carries four main functions: First, it initializes itself i.e. its sensors gets initializes as the power is supplied. Second, robot sense the surrounding environment (for instance for the level of temperature) and identify the fireplace. Third, robot sends the navigating information and starts to navigate itself towards the fireplace. Fourth, finally the robot starts to extinguish the fire with the help of servo motors and submersible water pump.

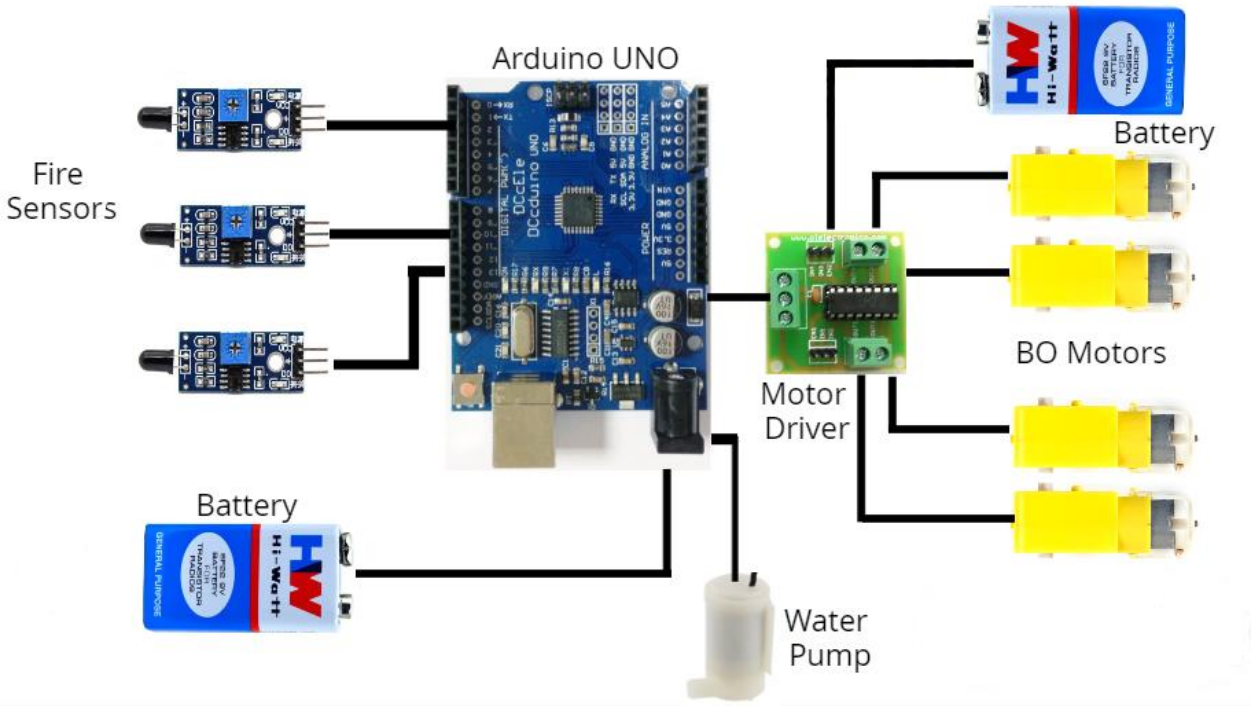


Figure 4-1 : Design of Fire Extinguishing Robot

4.1.2 Hardware Implementation

The hardware part is one of the vital parts in the development of firefighting robot. It includes Arduino UNO, IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, and rubber wheels. Fig 4.2.1 shows the block diagram of firefighting robot which consists of three IR flame sensors as the input of the system. Arduino UNO is used as a micro-controller that connects other components. L293D Motor driver is used to drive motors and is capable of running two DC motors (Left DC motor and Right DC motor) at the same time.

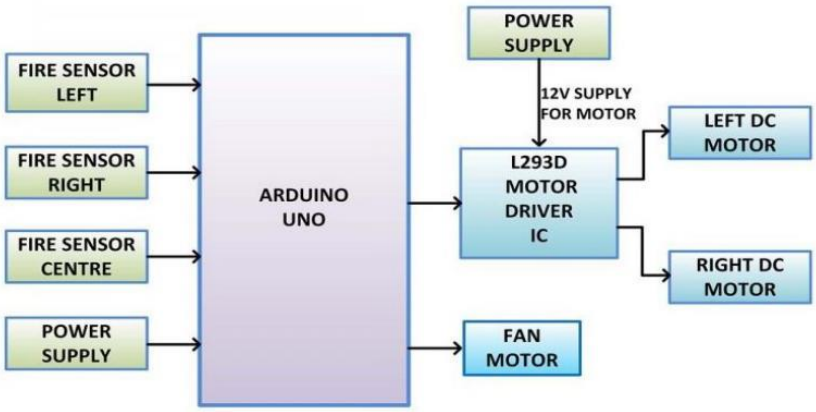


Fig 4.2.1 : Block Diagram of Fire Fighting Robot

4.2 HARDWARE USED:

1. ATmega328P IC(Arduino UNO):

Fig 4.2.1 Arduino UNO

Fig 4.2.2 shows the Arduino UNO board. The Arduino UNO Micro-controller board based on the ATmega328P. The ATmega328P is good platform for robotics application. Thus the real time fire extinguishing can be performed. It has 14 digital I/O pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the micro-controller.

2. IR Flame Sensor:

Fig 4.2.3 shows the IR Flame Sensor. The flame sensor detects and responses to the presence of fire or flame. The module is based on the IR receiver and basically detects the presence of flammable gases likes nitrogen, hydrogen, carbon mono oxide. The signal detection capacity is adjustable. Our project contains three flame sensors.

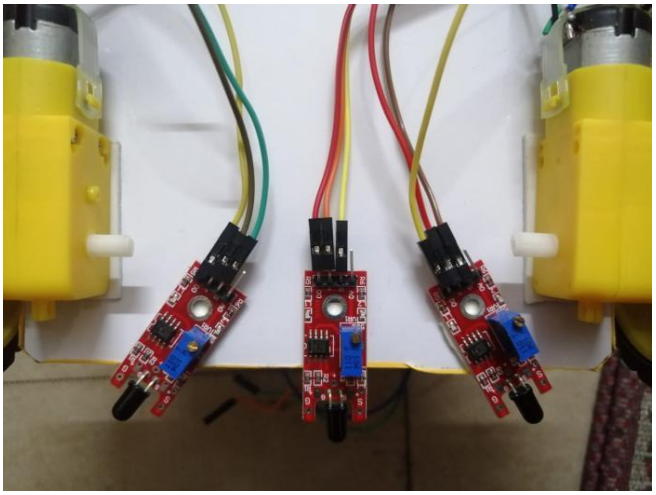


Fig 4.2.2 IR Flame Sensor

3. L293D Motor Driver:

Fig 4.2.4 shows the L293D Motor Driver. L293D is a typical Motor Driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction.

Fig 4.2.3 L293D Motor Driver

4. Servo Motors:

Servo Motors are electronic devices that are mainly used for providing specific velocity and acceleration. Fig 4.2.5 shows the Servo Motors.

Fig 4.2.4 Servo Motor

5. Submersible Water Pump:

Fig 4.2.6 shows the Submersible Water Pump. Submersible Water Pump is ideal for making automatic watering system using Arduino. The water pump is an important part of the robot as it will pump water to extinguish the fire.

Fig 4.2.5 Submersible Water Pump

6. BO Motors:

Fig 4.2.7 shows the BO Motor. BO Motor is a dual shaft motor having 300rpm.It converts electrical energy into mechanical energy. It is an alternative to our metal gear DC motors. Our robot uses four dual shaft

motors.

Fig 4.2.6 BO Motor

4.3 Language Used

Arduino language is used in the system due to the following characteristics :

What language is Arduino?

Arduino code is written in C++ with an addition of special methods and functions, which we'll mention later on. C++ is a human-readable programming language. When you create a 'sketch' (the name given to Arduino code files), it is processed and compiled to machine language.

Simple :

The Arduino ecosystem is comprised of a diverse combination of hardware and software. The versatility of Arduino and its simple interface makes it a leading choice for a wide range of users around the world from hobbyists, designers, and artists to product prototypes.

Free and Open Source :

Both beginners and experts have access to a wealth of free resources and materials to support them. Users can look up information on how to set up their board or even how to code on Arduino. The open source behind Arduino has

made it particularly friendly to new and experienced users. There are thousands of Arduino code examples available online. In this post, we'll take you through some basic principles of coding for Arduino.

Arduino IDE :

The Arduino Integrated Development Environment (IDE) is the main text editing program used for Arduino programming. It is where you'll be typing up your code before uploading it to the board you want to program. Arduino code is referred to as sketches.

Extensive Libraries :

In Arduino, much like other leading programming platforms, there are built-in libraries that provide basic functionality. In addition, it's possible to import other libraries and expand the Arduino board capabilities and features. These libraries are roughly divided into libraries that interact with a specific component or those that implement new functions.

To import a new library, you need to go to Sketch > Import Library

4.4 Screenshots:

The Following are the screenshot of the result of the project:

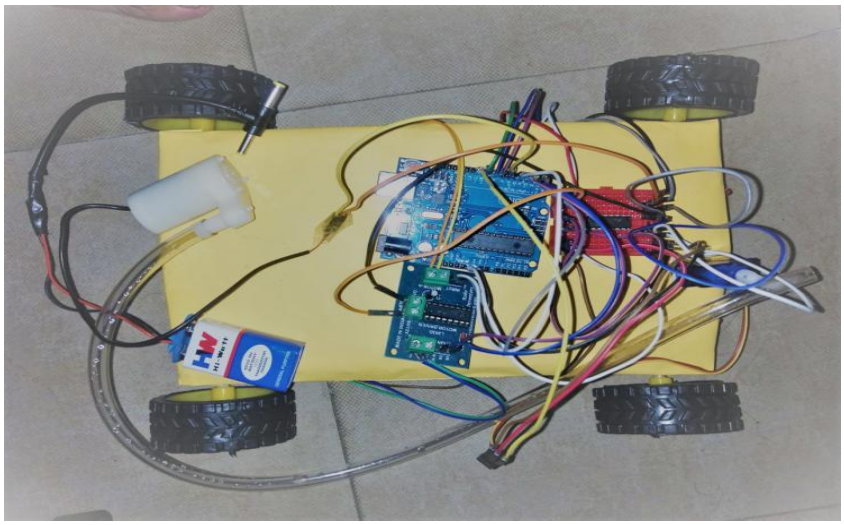


Figure 4.3.1 : Screenshot 1

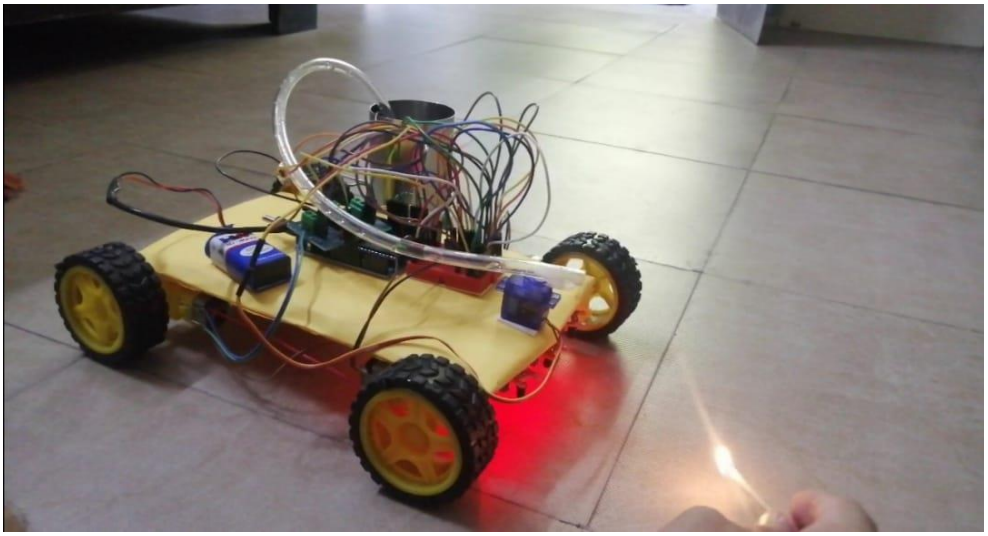


Figure 4.3.2: Screenshot 2

4.5 Testing

Testing is the process of evaluation of a system to detect differences between given input and expected output and also to assess the feature of the system. Testing assesses the quality of the product. It is a process that is done during the development process. .

4.5.1 Strategy Used

Tests can be conducted based on two approaches –

- Functionality testing
- Implementation testing

The testing method used here is Black Box Testing. It is carried out to test functionality of the program. It is also called ‘Behavioral’ testing. The tester in this case, has a set of input values and respective desired results. On providing input, if the output matches with the desired results, the program is tested ‘OK’, and problematic otherwise.

4.5.2 Test Case and Analysis

TEST CASE: 1

Test Case ID	TC001
Test Case Summary	Individual testing of hardware parts to check their functionality.
Test Procedure	Testing of BO Motors, Fire Sensors and water pump is done.
Expected Result	All sensors and motors must be in functional condition.
Actual Result	All sensors and motors worked properly.
Status	Pass

Table 4.1 : Test Case 1

TEST CASE 1 OUTPUT:

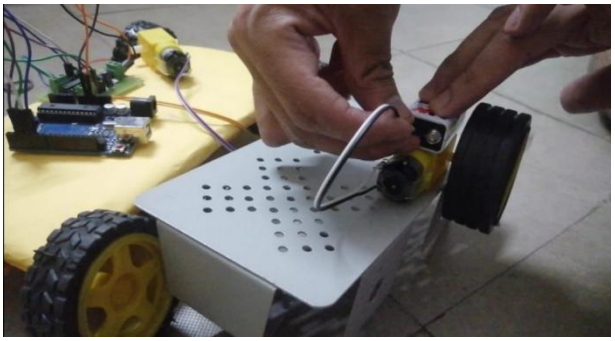


Figure 4.4.1 : Motor Testing

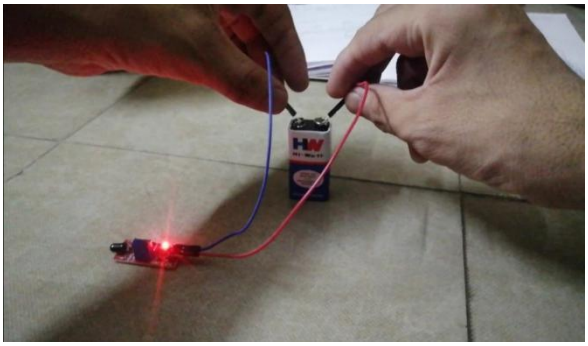


Figure 4.4.2 : Fire Testing

Figure 4-12 : Test Case 1 Output

TEST CASE: 2

Test Case ID	TC002
Test Case Summary	Testing of robot whether it will detect fire or not after assembling.
Test Procedure	Place the robot at a certain place from the fire breakout point.
Expected Result	Fire sensor must activate and send the signals to Arduino UNO.
Actual Result	Fire is detected by the fire sensors.
Status	Pass

Table 4.2: Test Case 2

TEST CASE: 3

Test Case ID	TC003
Test Case Summary	Testing of robot whether it will move in the direction of fire breakout point after detecting fire.
Test Procedure	Place the robot at a certain place from the fire breakout point.
Expected Result	Robot will reach the fire breakout point after detecting fire.
Actual Result	Robot reaches the fire breakout point after detecting fire.
Status	Pass

Table 4.3 : Test Case 3

TEST CASE 2 & 3 OUTPUT:

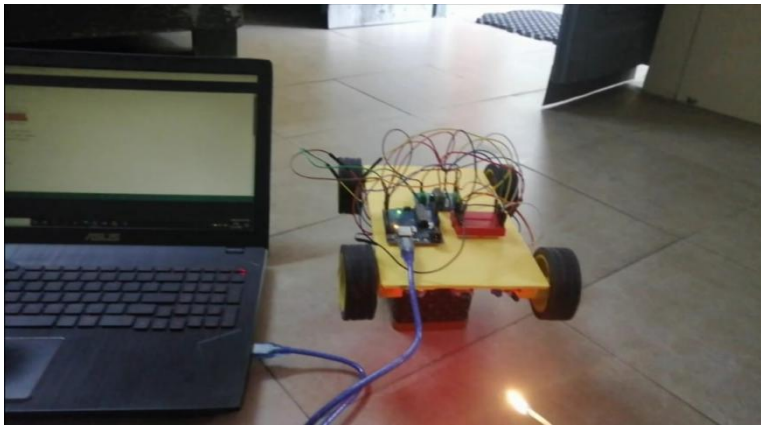


Figure 4.4.3 : Test Case 2 &3 output

TEST CASE: 4

Test Case ID	TC004
Test Case Summary	Testing of robot whether it will extinguish the fire or not after reaching the fire breakout point.
Test Procedure	Place the robot at a certain place from the fire breakout point.
Expected Result	Robot will reach the fire breakout point after detecting fire and water pump will start and extinguish the fire.
Actual Result	Robot extinguishes the fire as expected.
Status	Pass

Table 4.4 : Test Case 4

Chapter 5 Conclusion

Conclusion

5.1 Conclusion

Fire causes tremendous damage and loss of human life and property. For handling such fire breakouts we depend upon fire fighters. Detecting the fire and extinguishing it is a dangerous job, it may harm the life of fire fighters too. It is sometimes impossible for the fire fighter to access the sight of fire because of explosive materials, smoke and high temperature. Fire fighters may suffer from heat exhaustion and various diseases such as asthma, persistent coughing, heart disease, cancer and even lung damage. Also it may be difficult for fire fighters to continuously monitor the environment and extinguishing it in initial stage before it turned into huge damage.

Our project aids to share out the burden of fire fighters in firefighting task. It aims to build a real time firefighting robot which moves in a constant speed, identify the fire and then extinguish it with the help of pumping mechanism. The detection and extinguishing was done with the help basic hardware components attached with the robot. Firstly, IR Flame sensors are used for the detection of fire. Secondly, BO Motors and Rubber wheels are used to navigate the robot to reach the fireplace. Finally, the robot extinguishes the fire with the help of submersible water pump and servo motors. Our Fire Fighting Robot is also beneficial for continuously monitors the environment so that fire can be

extinguishing at the initial stage and results in less damage to life and property.

For future enhancement to our current project, additional features can be added onto the system namely it can work with the firefighters, which greatly reduce the danger of injury to victims; Camera and Video transmission can be added; obstacle avoidance can be added; image processing technique can be added to analyze fire source in accordance with flame sensors; wireless communication module can be added using cloud technology.

5.2 Limitations of the Work

- It is not used to put out large fires :

  As to make the robot portable and light in weight,this robot is small in size so it cannot be used for large fire breakouts. It is mainly designed for the residential apartments, offices and small houses, to avoid any chances of large fire-breakout by extinguishing the fire at the early stage.

- It cannot leave outside for long period of time due to battery life :

  This robot working fully depends upon the battery we used in order to activate all the hardware components that are required to detect and extinguish the fireplace. Therefore due to its battery life it cannot the put outside for long period of time.

- It cannot work beyond the limit :

  As mentioned in above point the robot working fully depends upon the battery. And as we know that battery has certain limit upto which it can

provide power to the components due to which our robot will be able to work upto certain limit.

5.3 Suggestion and Recommendations for Future Work

- The advents of IOT with revolutionize the information system and computing technologies.

- For future enhancements additional features can be integrated onto the system namely:

    - Obstacle avoidance
    - Image processing technique to analyze fire source in accordance with flame sensors.
    - Using cloud technology for wireless communication module.

Bibliography

1. 1.http://www.iosrjournals.org/iosr-jce/papers/Vol18-issue6/Version-5/U180605113119.pdf

2. https://www.researchgate.net/publication/317610964_Fire_Extinguishing_Robot

3. https://www.researchgate.net/publication/332415751_F2R_AN_ARDRUINO_BASED_FIREFIGHTING_ROBOT

4. [4] 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.

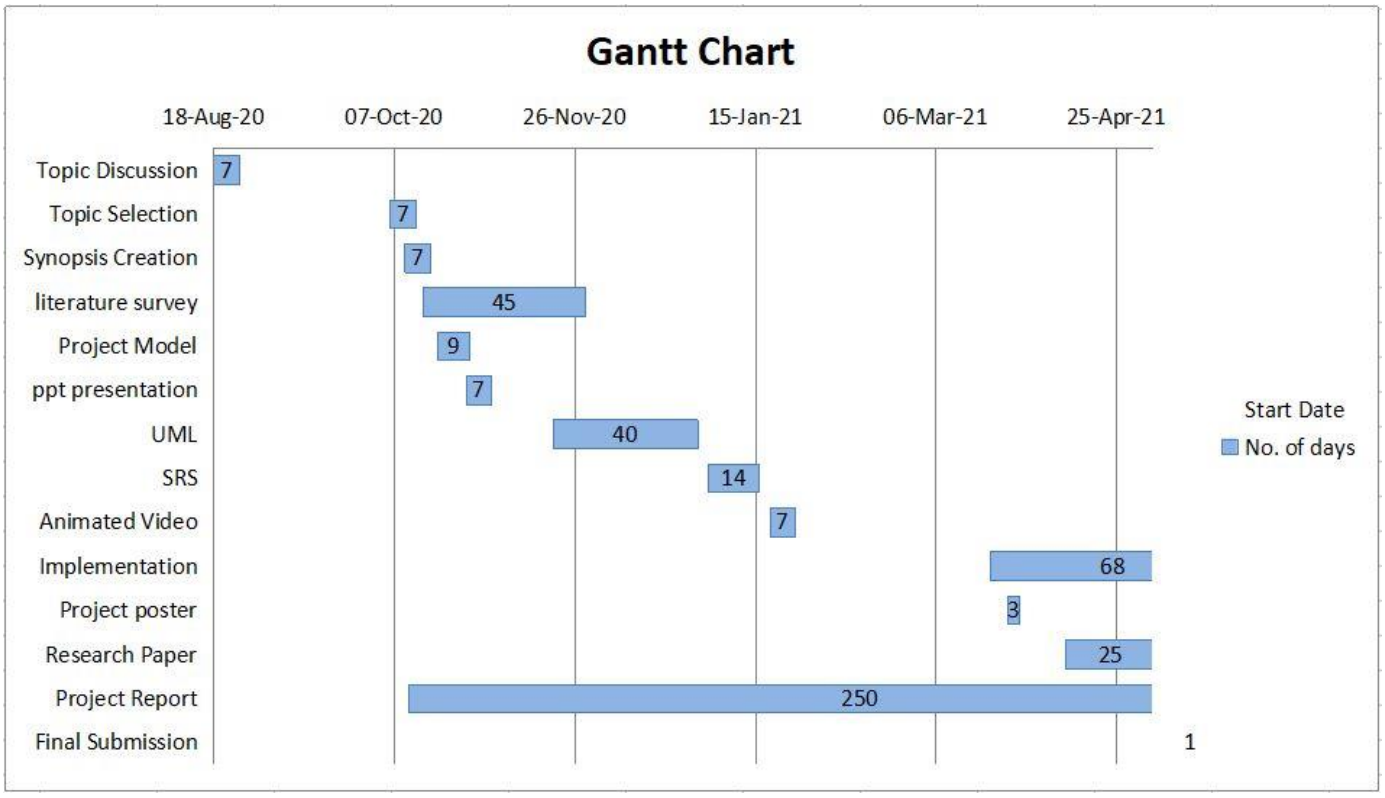
5. [5] Saravanan P. ,Soni Ishawarya Android controlled intergrated semi autonomous fire fighting robot.Ineternational journal of innovative science Engg. and Technology 2015.

6. [6] S. Jakthi Priyanka,R. Sangeetha Android controlled firefighting robot Ineternational journal of innovative science Engg. and Technology ,Volumn 3, 2017.

Project Plan

Gantt Chart

Topic	Start Date	No. of days
Topic Discussion	18-Aug-20	7
Topic Selection	06-10-2020	7
Synopsis Creation	10-10-2020	7
literature survey	15-10-2020	45
Project Model	19-10-2020	9
ppt presentation	27-10-2020	7
UML	20-11-2020	40
SRS	02-01-2021	14
Animated Video	19-01-2021	7
Implementation	21-03-2021	68
Project poster	26-03-2021	3
Research Paper	11-04-2021	25
Project Report	11-10-2020	250
Final Submission	05-05-2021	1



Appendix-1

Guide Interaction Sheet

Date	Discussion	Action Plan
18.08.2020	Discussion on various project ideas and choosing the appropriate technology for project.	Fire Extinguishing Robot was decided as the title of our project and we chose IOT(Arduino) technology .
06.10.2020	Discussion on the technology to be used for object detection in real-time	Arduino were finalized
10.10.2020	Discussion of the creation of synopsis of the project.	Gathering of information for synopsis creation
15.10.2020	Suggestions on how to do a literature survey and preliminary investigation on the topic.	Many research papers were read, understood and their abstract were to be written.
19.10.2020	Discussion about the project model and it's implementation.	Using Arduino and other hardware tools, we decided to start our implementation.
23.10.2020	Discussion on the objective of the project.	Suggestions were given by the guide to achieve the objective of project.
27.10.2020	Discussion on creating the documentation and presentation part for our project.	Making of presentation was started.
08.11.2020	Correction and updation in the presentation part of our project.	Correction in presentation was made.
20.11.2020	Checking and correction of Use Case Diagram.	Studying and making of Use Case Diagram was started.
15.12.2020	Discussion on Activity and Sequence Diagrams.	Studying and making of Activity & Sequence Diagram was started.

24.12.2020	Discussion on Class, E-R & Data Flow Diagrams.	Studying and making of Class, E-R & Data Flow Diagrams was started.
02.01.2021	Discussion on SRS Document.	Decided to write the SRS document with proper format.
19.01.2021	Discussion on Animated Video of our Project.	Started to make the animated video of our project.
01.02.2021	Correction and updation in Animated Video of our Project.	Changes in video were done.
26.02.2021	Discussion on Synopsis and gathering of material for our project.	Started making synopsis document with proper format.
10.03.2021	Discussion on further changes in presentation of our project.	Changes in power-point presentation was done.
21.03.2021	Discussion on implementation of our project.	Basic testing of all hardware components were done.
26.03.2021	Discussion on project poster.	Creation of poster was started.
11.04.2021	Discussion on Research Paper of our project.	Decided to write the research paper.
20.04.2021	Discussion on project report.	Decided to write the content and integrate it in the proper format of the report.
24.04.2021	Discussion on project documentation.	Modification and changes in project documents if required.

Table 4-5 : Guide Interaction Table

Appendix-2

Source Code

```
#include <Servo.h>
Servo myservo;
int pos = 0;
boolean fire = false;
/*-------defining Inputs------*/
#define Left_S 9      // left sensor
#define Right_S 10      // right sensor
#define Forward_S 8 //forward sensor
/*-------defining Outputs------*/
#define LM1 2       // left motor
#define LM2 3       // left motor
#define RM1 4       // right motor
#define RM2 5       // right motor
#define pump 6
void setup()
{
  pinMode(Left_S, INPUT);
  pinMode(Right_S, INPUT);
  pinMode(Forward_S, INPUT);
  pinMode(LM1, OUTPUT);
  pinMode(LM2, OUTPUT);
```

```
  pinMode(RM1, OUTPUT);
  pinMode(RM2, OUTPUT);
  pinMode(pump, OUTPUT);
  myservo.attach(11);
  myservo.write(90);
}
void put_off_fire()
{
    delay (500);
    digitalWrite(LM1, HIGH);
    digitalWrite(LM2, HIGH);
    digitalWrite(RM1, HIGH);
    digitalWrite(RM2, HIGH);
   digitalWrite(pump, HIGH); delay(500);
    for (pos = 50; pos <= 130; pos += 1) {
    myservo.write(pos);
    delay(10);
  }
  for (pos = 130; pos >= 50; pos -= 1) {
    myservo.write(pos);
    delay(10);
  }
  digitalWrite(pump,LOW);
  myservo.write(90);
```

```
    fire=false;
}
void loop()
{
   myservo.write(90); //Sweep_Servo();
    if (digitalRead(Left_S) ==1 && digitalRead(Right_S)==1 &&
    digitalRead(Forward_S) ==1)
    //If Fire not detected all sensors are zero
    {
    //Do not move the robot
    digitalWrite(LM1, HIGH);
    digitalWrite(LM2, HIGH);
    digitalWrite(RM1, HIGH);
    digitalWrite(RM2, HIGH);
    }
    else if (digitalRead(Forward_S) ==0) //If Fire is straight ahead
    {
    //Move the robot forward
    digitalWrite(LM1, HIGH);
    digitalWrite(LM2, LOW);
    digitalWrite(RM1, HIGH);
    digitalWrite(RM2, LOW);
    fire = true;
    }
```

```
    else if (digitalRead(Left_S) ==0) //If Fire is to the left
    {
    //Move the robot left
    digitalWrite(LM1, HIGH);
    digitalWrite(LM2, LOW);
    digitalWrite(RM1, HIGH);
    digitalWrite(RM2, HIGH);
    }
    else if (digitalRead(Right_S) ==0) //If Fire is to the right
    {
    //Move the robot right
    digitalWrite(LM1, HIGH);
    digitalWrite(LM2, HIGH);
    digitalWrite(RM1, HIGH);
    digitalWrite(RM2, LOW);
    }
delay(300); //Slow down the speed of robot
     while (fire == true)
     {
      put_off_fire();
     }
}
```