CHAPTER 1

PREAMBLE

1.1 BACKGROUND

House fires poses a significant threat to safety and property, with incidents often occurring during the night or when occupants are not present to respond. In such scenarios, fire can spread rapidly, leading to extensive damage before it is detected. Additionally, traditional firefighting methods pose considerable challenges particularly in situations where fire sources are inaccessible or temperatures reach levels dangerous to human responders. The nature of these incidents combined with the inherent risks associated with human involvement underscores the need for autonomous solutions in fire detection and suppression.

Traditional firefighting relies heavily on human intervention which although effective is time-sensitive and limited by the physical dangers firefighters face. Entry into burning buildings handling high temperature areas and navigating through potentially explosive materials create an environment where any delay can have devastating consequences. Moreover as fire can obstruct escape routes, trapped individuals face further risks. A significant improvement in fire management requires systems that can operate autonomously, accessing the source of the fire and initiating suppression methods without delay or exposure to risk.

The rapid advancement in robotics, sensor technology, and wireless communication has opened the door to new possibilities in autonomous firefighting. Robotics in particular offers an alternative approach to fire safety enabling remote operation and risk-free deployment in hazardous environments. By integrating smart sensors, robotic systems can detect the presence of fire assess its intensity and initiate counter measures promptly. The advent of wireless modules and smart phone integration provides an added advantage allowing for real-time control and feedback even in situations where human operators are not physically present.

This project introduces a smart firefighter robot, designed specifically for defense and security applications, to autonomously detect and extinguish fires. This system integrates both autonomous and remote-controlled features to ensure adaptability and precision in response. The robot employs a wifi module for communication with a mobile phone, enabling users to direct its movements and monitor its actions.

In terms of fire detection, the robot is equipped with multiple sensors, which may include flame, smoke, and temperature sensors to comprehensively detect fire conditions. Upon identification, the robot activates its onboard extinguishing mechanism, which may include a water sprayer or chemical suppressant depending on the fire type. This autonomous capability allows for immediate action minimizing fire spread and providing an additional layer of protection in situations where manual intervention is delayed or impossible.

Beyond its practical applications in firefighting, this project demonstrates the broader potential of robotics in emergency response. By reducing human exposure to dangerous environments, robots can play a critical role in managing disasters efficiently and effectively. The smart firefighter robot while targeted for home and industrial use exemplifies the evolving role of robotics in enhancing public safety and resilience against fires. As this technology advances it is anticipated that such systems will not only improve firefighting outcomes but also set a foundation for the adoption of robotics across other emergency response scenarios, contributing to safer, more resilient communities.

1.2 MOTIVATION

Residential fires pose a significant threat to lives, property, and the environment, particularly when they occur at night or in empty homes. The risks associated with traditional fire fighting methods are magnified by factors such as inaccessible fire sources, high temperatures, and the presence of volatile materials, all of which can delay response times and put both occupants and firefighters in danger. In many cases, fires escalate quickly, and manual intervention becomes less effective as the situation worsens.

This project is motivated by the need to improve fire detection and response times, reduce human exposure to fire hazards, and create a more effective means of fire suppression, especially in high-risk environments. The integration of robotics into fire management can revolutionize the way fires are handled by enabling autonomous operation in situations where human presence is impractical or too dangerous. By developing a smart fire fighter robot, this project aims to provide a solution that can rapidly detect and suppress fires, even in areas that are difficult to reach or too hazardous for human intervention.

The motivation lies in the potential for enhancing safety and efficiency in emergency situations. With the ability to operate autonomously combined with real-time monitoring and remote control, the robot can act swiftly to detect and address fire outbreaks, reducing the risk of damage and loss.

Moreover, by removing human operators from immediate danger, the project aligns with the broader goal of safeguarding both lives and property in fire-prone areas. The development of this technology not only represents an advancement in fire safety but also paves the way for future innovations in autonomous emergency response systems, offering greater reliability and efficiency than current manual fire fighting methods.

1.3 OBJECTIVES OF WORK

- **Fire Detection:** Accurately detect the presence of fire using sensors.
- **Fire Suppression:** Extinguish fire effectively using mechanisms such as water pumps, CO2 extinguishers, or chemical agents.
- **Autonomous Navigation:** Navigate autonomously in a predefined area or dynamic environment to locate and approach the fire source.
- **Remote Monitoring:** Provide real-time visuals of the affected area using onboard cameras for remote observation and decision-making.
- **Alert System:** Notify nearby personnel or the central system via audible alarms, visual signals or communication modules like GSM.
- **Visual Monitoring:** Utilize the ESP32 CAM to capture images or stream video for real-time visual feedback during a fire event.

1.4 PROBLEM DEFINATION

House fires present a significant safety risk, especially when they occur at night or when occupants are absent, often resulting in delayed response times and increased potential for property damage and loss of life. Traditional firefighting methods, while effective, face substantial limitations due to hazardous conditions, inaccessible fire sources, and high temperatures that endanger both occupants and emergency responders. Furthermore, these challenges can lead to restricted access to the fire, delayed response, and exposure to volatile materials, creating an environment where even slight delays can have catastrophic consequences.

The need for a solution that can autonomously detect, assess, and respond to fires, particularly in environments where human intervention is limited or unsafe, is increasingly critical. This project addresses this issue by developing a smart firefighter robot that operates autonomously to detect and extinguish fires. Designed for defense and security applications, the robot aims to enhance fire response efficiency and safety by allowing remote monitoring and control.

1.5 ORGANIZATION OF REPORT

This project work report is organized into six chapters

- The **chapter 1** presents brief introduction about fire fighting robot motivation, objectives and problem statement in the present context.
- The **chapter 2** explains the existing literature on fire fighting robot through Different techniques.
- The **chapter 3** gives the brief introduction about software requirement specification and methodology of fire fighting robot.
- The **chapter 4** presents the system design and architecture.
- The **chapter 5** presents implementation of project.
- The **chapter 6** deals with the result and discussion of the project.
- The **chapter** 7 deals with the conclusion limitations and future scope of the project.

CHAPTER 2

LITERATURE SURVEY AND REVIEW

2.1 INTRODUCTION

Literature survey on fire fighting robot discuss how these robots can help fire fighters by reducing the risk of their lives and operating in environments that are out of reach for humans. The goal of a fire fighting robot is to detect fires, assist firefighters, reduce the risk, improve efficiency and also effectively combat fires without requiring direct human intervention.

2.2 LITERATURE REVIEW

Table shows the summary of comparison of various techniques used during the implementation of fire fighting robot for human safety. Here different author yields different techniques such as arduino IOT, deep learning and software program.

Sl. no	Author	Title	Year	Functions	Results	Scope
1	Monica P Suresh,V R Vedha Rhythesh, J Dinesh, K Deepak, J Manikandan	An Arduino Uno Controlled Fire Fighting Robot for Fires in Enclosed Spaces.	2022	The robot developed consists of three elements which is the hardware, electronic interfacing circuits, and software program. The robot has four battery operated motor.	By using such robots, fire identification and rescue activities can be done with greater accuracy and securely.	Although there is a lot of scope for improvement, this could be a first step in developing a complete fire-fighting robot that could also rescue victims.

2	Xiangke Tian Chao Meng Junyu Ma,Baocong Ma, Yuhan Wang, Wenkang Chen.	Research on Structure and Fire Control System of Fire Fighting UAV Based on Polymer Gel Fire Bomb.	2022	In view of the existing problem that high-rise building fire can not be timely good control, as well as the search and rescue difficulties to the fire scene trapped personnel, design and improvement to the UAV is compolished .	Using gel fire bombs to cover objects in the fire, the spread of the fire is controlled.	Personnel in the fire is searched and rescued and relief materials is dropped using sensors.
3	Md. Aowrongajab Uaday, Md. Nazmul Islam Shuzan,Saffa nShanewaze , Rakibol Islam Rakib; Hasan	The Design of a Novel Multi-Purpose Fire Fighting Robot with Video Streaming Capability	2019	In this work we introduce a novel design of a multi-purpose fire-fighting robot which, with the help of a streaming video camera attached to it, transmits live video.	The robot can be mobilized and directed to the spot of the fire and throw water at the fire. It uses RF signal .	It can effectively reduce the human risk of fire-fighting operation. The design of the robot is cost effective, which makes it especially attractive.
4	Yanying Cheng, Chunjie Mou, Ke Chen, Hui Bai,Liu,Yuch un Zhang	Experimen tal Study on Fire Extinguish ing Effect of Water-	2019	In recent years, the frequent fire accidents of public transport vehicles have resulted in the	The system can put out fire quickly and efficiently. Moreover, it	The system can put out fire quickly and efficiently. Moreover, it can effectively reduce

		based Fixed Fire Extinguishing System in full-Scale Bus Cabin		scrapping of vehicles, catastrophic property losses and casualties, which had drawn widespread concern of people and society for public safety.	can effectively reduce temperature and concentration of toxic and harmful gases in the cabin after the fire.	temperature and concentration of toxic and harmful gases in the cabin after the fire. It could obviously improve the fire protection capacity.
5	Ya-Zhou Jia,Ji-Shun Li,NanGuo,Qi-Su Jia,Bo-Feng Du,Chang-Ye Chen.	Design and Research of Small Crawler Fire Fighting Robot.	2018	In view of the special working conditions and personal safety of firefighters in public places, houses and other fire scenes, the virtual prototype technology was used to conduct in-depth research on small crawler fire-fighting robots.	Research shows that the small crawler fire-fighting robot has high detection intelligence and structural reliability, which is of great significance to the fire-fighting operations.	The overall design scheme of the fire-fighting robot is proposed, and the independent suspension system with good shock absorption performance is designed. The explosion-proof waterproof shell of the special fire-fighting robot is developed, which realizes the accurate detection

6	P Anantha Raj, M Srivani	Internet of Robotic Things Based Autonomous Fire Fighting Mobile Robot.	2018	This paper proposes the idea of including the autonomous firefighting mobile robot in the traditional fire safety IoT system to perform early firefighting action.	This robot reaches fire location by using path planning algorithm and performs firefighting action	In the meantime, fire safety officers can do better plan to handle the fire accident by watching the video sent by the firefighting robot.
7	Shiva Mittal, Manish Kumar Rana, Mayank Bhardwaj, Meenakshi Mataray, Shubham Mittal	CeaseFire: The Fire Fighting Robot.	2018	This paper presents CeaseFire - the robot developed to serve firefighting crews in real-time situations. The development aims to reduce the risk	The merits of design include ease of handling, quick on initiation and long range remote controllability.	Its quick and efficient response to test situations demonstrates its reliability of usage in real world cases.
8	Kazuhiro Takahagi, Tomoyuki Ishida, Satoshi Noda, Akira Sakuraba, Noriki Uchida,Yoshi takaShibatas.	Proposal of the Fire Fighting Support System for the Volunteer Fire Company	2015	In this research, we built the fire fighting support system for supporting the fire fighting of the volunteer fire company. This system is the mobile application .	By using this system, the fire corps volunteers can confirm the fire fighting water sources.	Therefore, this system can expect a big effect from the fire fighting of the volunteer fire company, since the fire fighting water sources around the fire site.

9	Xu Fang, Zhang Di, Wang Jun.	Fire Safety Management Information System Design for Key Social Organizations.	2014	This paper introduces the design and implementation of the fire safety management information systems of the networked key organizations	The fire supervision, administrative authorities so as to improve the fire safety management	To extend the functions of fire remote monitoring control system, and promote fire prevention and control capability of the whole community
10	YanliZhang, Hongzhang Jin; Nuo Jia,Aili Zou.	Cascading failure evalution of ship fire-fighting system.	2013	According to the characteristics of ships, this paper in brief presents a cascading failure definition and cascading failure mechanism of ship fire-fighting system.	Combined with the internal and external environment of ship fire-fighting system, a evalution index system of cascading failure is established.	It finds more important evaluation index through a total weight order. This research provides a theoretical basis for failure prevention and safety management work of ship fire fighting system.
11	Jin-Qiang Ma; Jun-Jing Tian	Study of City Fire Fighting Long-Distance Intelligent Monitoring System. Based on	2010	According to the construction requirements of the city fire fighting remote monitoring system,	this paper applies the Agent technology to the intelligent monitoring system	This system is suitable for key unit of fire fighting, and has its directed behavior, and strong adaptability to the environment.

2.3 GAPS IN EXISTING RESEARCH

Identifying gaps in existing research on firefighting robots involves analyzing current technologies, methods, and challenges. Here are some key points:

1. Technical Gaps

Autonomous Navigation: Limited research on efficient path-planning algorithms in dynamic fire environments with obstacles.

Sensor Integration: Insufficient work on integrating multi-modal sensors (thermal, gas, infrared) for real-time fire detection and mapping.

Communication: Lack of robust communication systems for maintaining connectivity in hazardous environments.

2. Fire Detection and Suppression

Fire Identification Accuracy: Limited research on differentiating between real flames and false positives (e.g., sunlight reflections).

Fire Suppression Mechanisms: Few studies on adaptive suppression techniques, such as varying water pressure or using alternative extinguishing agents.

3. Environmental Adaptability

Extreme Conditions: Minimal focus on robots capable of withstanding high temperatures, toxic gases, and collapsing structures.

Terrain Navigation: Lack of research on mobility solutions for rough, uneven terrains such as forests and multi-story buildings.

4. Power Management

Energy Efficiency: Insufficient exploration of energy-saving technologies for extended missions.

Power Sources: Limited advancements in sustainable and long lasting power sources for continuous operation.

2.4 HOW THE PROJECT ADDRESSES THIS GAP

1. Navigation and Path Planning

Research Gap: Limited algorithms for path planning in dynamic fire environments.

Project Solution: Develop with real-time obstacle fire-source localization using infrared sensors.

2. Sensor Integration and Data Fusion

Research Gap: Insufficient multi-sensor data fusion for accurate fire detection.

Project Solution: Integrate and flame sensors using sensor fusion techniques to improve accuracy.

3. Communication in Hazardous Environments

Research Gap: Lack of robust communication in extreme fire conditions.

Project Solution: Implement a communication network between the robot and control center.

5. Environmental Adaptability

Research Gap: Difficulty in operating in high-temperature, toxic, and uneven terrains.

Project Solution: Design a heat-resistant robot chassis with rugged for improved mobility

6. Power Management

Research Gap: Limited exploration of long-lasting power systems.

Project Solution: Use high-capacity batteries with smart energy management systems.

7. Human-Robot Interaction

Research Gap: Poor user interfaces and limited decision support.

Project Solution: Develop a user-friendly control interface with real-time monitoring

2.5 SUMMARY

Firefighting robots can transport equipment, direct water or fire-retardants, and assess danger zones with thermal imaging. These capabilities free up emergency teams to focus on high-priority tasks, optimizing intervention times and minimizing fire spread. Firefighting robots can transport equipment, direct water or fire-retardants, and assess danger zones with thermal imaging. These capabilities free up emergency teams to focus on high-priority tasks, optimizing intervention times and minimizing fire spread.

CHAPTER 3

METHODOLOGY

3.1 APPROACH

To be used efficiently all computer software needs certain hardware components or other software resources to be present on a computer. These prerequisites are known as (computer) system requirements and are often used as a guideline as opposed to an absolute rule. Most software defines two sets of system requirements: minimum and recommended. With increasing demand for higher processing power and resources in newer versions of software, system requirements tend to increase over time. Industry analysts suggest that this trend plays a bigger part in driving upgrades to existing computer systems than technological advancements. The system design process partitions the requirements to either hardware or software systems. It establishes overall system architecture. Software design involves representing the software system functions in a form that may be transformed into one or more executable programs. The design process is as shown in involves developing several models of the system at different levels of abstraction. The design process is divided into software design and hardware design.

3.2 TOOLS AND TECHNOLOGY

The most common set of requirements defined by any operating system or software application is the physical computer resources also known as hardware

3.2.1 HARDWARE REQUIREMENT

A hardware requirements list is often accompanied by a hardware compatibility list especially in case of operating systems. The following sub-sections discuss the various aspects of hardware requirements.

ESP8266 NODE MCU

Fig 3.1 ESP8266 NODE MCU

The ESP8266 which is a highly integrated chip designed for the needs of a new connected world. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

ESP8266 has powerful on-board processing and storage capabilities that allow it to be integrated with the sensor and other application-specific devices. The ESP8266 NODEMCU development board a true plug-and-play solution for inexpensive projects using Wi-Fi.

MOTOR DRIVER

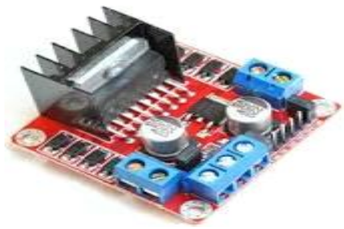

Fig 3.2 Motor Driver

Motor Driver is a high power motor driver perfect for driving DC Motors and Stepper Motors. It uses the popular L298 motor driver IC and has an onboard 5V regulator which it can supply to an external circuit. It can control up to 4 DC motors or 2 DC motors with directional and speed control. This motor driver is perfect for robotics and mechatronics projects and perfect for controlling motors from microcontrollers, switches, relays, etc. Perfect for driving DC and Stepper motors for micro mouse line following robots, robot arms, etc.

WATER PUMP

Fig 3.3 Water Pump

Water Pump is an ideal non submersible pump for variety of liquid movement application. It has enough pressure to be used with nozzle to make spray system. The pump can handle heated liquids up to a temperature of 80°C and when suitably powered can suck water through the tube from up to 2m and pump water vertically for up to 3m.The pump is also capable of pumping air, though when pumping air the pump is quite noisy in comparison.

RELAY MODULE

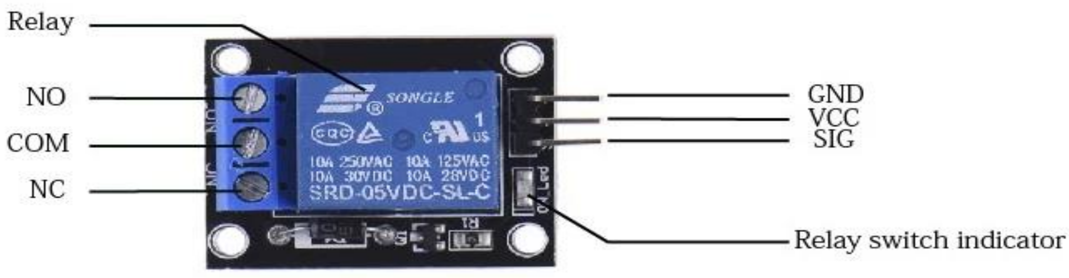

Fig 3.4 Relay Module

A relay module is an electrically operated switch that allows the control of a high-voltage or high-current device using a low-voltage signal. Typically, a relay module consists of one or more relays support circuitry like diodes for flyback protection and isolation terminals or connectors for easy integration into circuits.

BATTERY

Fig 3.5 Battery

This 2600mAh Lithium-Ion Battery it comes with a rated voltage of 3.7 volts and a capacity of 2600mAh. It is a single cell compact and powerful battery cell with 2600mAh capacity. It is very convenient to install in your project to fulfill the 3.7 Volt requirement with high capacity. The battery terminals can use in any compatible battery adapter/holder or it can be permanently soldered to your applications power source wires.

IR SENSOR

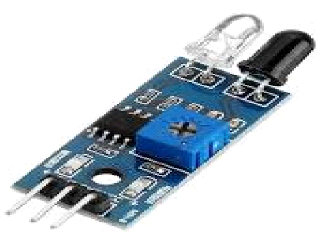

Fig 3.6 IR sensor

Infrared Obstacle Avoidance IR Sensor Module (Active Low) has a pair of infrared transmitting and receiving tubes. When the transmitted light waves are reflected back, the reflected IR waves will be received by the receiver tube. The module features a 3 wire interface with Vcc, GND and an OUTPUT pin on its tail. It works fine with 3.3 to 5V levels. Upon hindrance/reflectance, the output pin gives out a digital signal (a low-level signal). The onboard preset helps to fine-tune the range of operation the effective distance range is 2cm to 80cm.

ESP32 CAM

Fig 3.7 ESP32 Cam

The ESP32 CAM WiFi Module Bluetooth with OV2640 Camera Module 2MP For Face Recognization has a very competitive small-size camera module that can operate independently as a minimum system with a footprint of only 40 x 27 mm a deep sleep current of up to 6mA and is widely used in various IoT applications. It is suitable for home smart devices, industrial wireless control, wireless monitoring, and other IoT applications.

This module adopts a DIP package and can be directly inserted into the backplane to realize rapid production of products, providing customers with high-reliability connection mode, which is convenient for application in various IoT hardware terminals.

GSM

Fig 3.8 GSM

This GSM Module Micro SIM Card Core Board Quad-band TTL Serial Port with the antenna, in this module two antennas have been included which can be integrated into a great number of IoT projects. You can use this module to accomplish almost anything a normal cell phone can SMS text messages, make or receive phone calls, connecting to the internet through GPRS, TCP/IP, and more! To top it off, the module supports quad-band GSM/GPRS network, meaning it works pretty much anywhere in the world.

BUCK CONVERTER

Fig 3.9 Buck Converter

A buck converter or step-down converter is a DC-to-DC converter which decreases voltage while increasing current from its input (supply) to its output (load). It is a class of switched mode power supply. Switching converter (such as buck converters) provide much greater power efficiency as DC-to-DC converters than linear regulator, which are simpler circuits that dissipate power as heat but do not step up output current. The efficiency of buck converters can be very high, often over 90%, making them useful for tasks such as converting a computer's main supply voltage.

BUZZER

Fig 3.10 Buzzer

Here buzzer is used for alarming purpose, whenever the fire is detected detecting then thebuzzer will start buzzing here the buzzer used is piezoelectric buzzer. Whenever smoke sensor senses smoke, it reduces its resistance and due to this decreases in resistance, voltage across the base of the transistor increases. Now when the voltage at the base terminal of transistor become more than or equal to 0.70v then transistor turns on and buzzer alsostarts buzzering.

3.2.2 SOFTWARE REQUIREMENT

Software requirements deal with defining software resource requirements and prerequisites that need to be installed on a computer to provide optimal functioning of an application.

¬ Arduino

¬ Window OS

Arduino software (IDE)

The software used by the Arduino is Arduino IDE. The Arduino IDE is a cross platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring project. It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. There is typically no needto edit make files or run programs on a command-line interface. Although building on command-line is possible if required with some third-party tools such as Ino.

Fig 3.11 Arduino

Embedded C

Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

3.3 WORKFLOW

The design methodology for the smart firefighter robot focuses on integrating fire detection, autonomous navigation, and remote control capabilities to ensure an efficient, responsive, and safe firefighting solution.

Remote control of the robot is achieved through a WiFi module connected to a mobile phone application, allowing users to guide the robot in real-time and respond based on live feedback. Additionally the extinguishing mechanism a water sprayer or chemical release system is activated upon fire detection targeting the source directly to minimize fire spread.

A system involving components such as an ESP8266 microcontroller, ESP32 CAM, GSM module, fire sensor, motors, a pump, and a power supply. The system likely serves as an automated device for fire detection and control, possibly sending alerts via GSM and capturing visuals via the ESP32 CAM.

Power Management

Use a buck converter to regulate the voltage from the battery and supply power to all components. Ensure the power requirements of the ESP8266, GSM module, ESP32 CAM, and other components are met without overloading.

Fire Detection

Connect the fire sensor to the ESP8266 to detect fire incidents. Program the ESP8266 to continuously monitor the sensor's output.

Response to Fire

If fire is detected activate the buzzer via an output pin of the ESP8266 to provide an audible alert, Start the pump using a relay to spray water in the affected area and Control motors (via the motor driver) for specific movements.

Alert Mechanism

Use the GSM module to send an SMS or call to a predefined mobile number with details of the incident. Ensure proper communication protocols are implemented between the ESP8266 and GSM module.

Visual Monitoring:

The ESP32 CAM captures images or streams video when a fire is detected and Send visuals to a server or mobile app if needed.

The combination of autonomous fire detection, real-time monitoring, and mobile-controlled maneuverability creates an effective, user-friendly robotic system tailored to enhance fire safety in various settings.

3.4 SUMMARY

The chapter is gives the information about the software and hardware components used in fire fighting robot module. The system design process partitions the requirements to either hardware or software systems and this system involving components such as an ESP8266 microcontroller, ESP32 CAM, GSM module, fire sensor, motors, a pump, motor driver and a power supply.

CHAPTER 4

SYSTEM DESIGN

4.1 BLOCK DIAGRAM

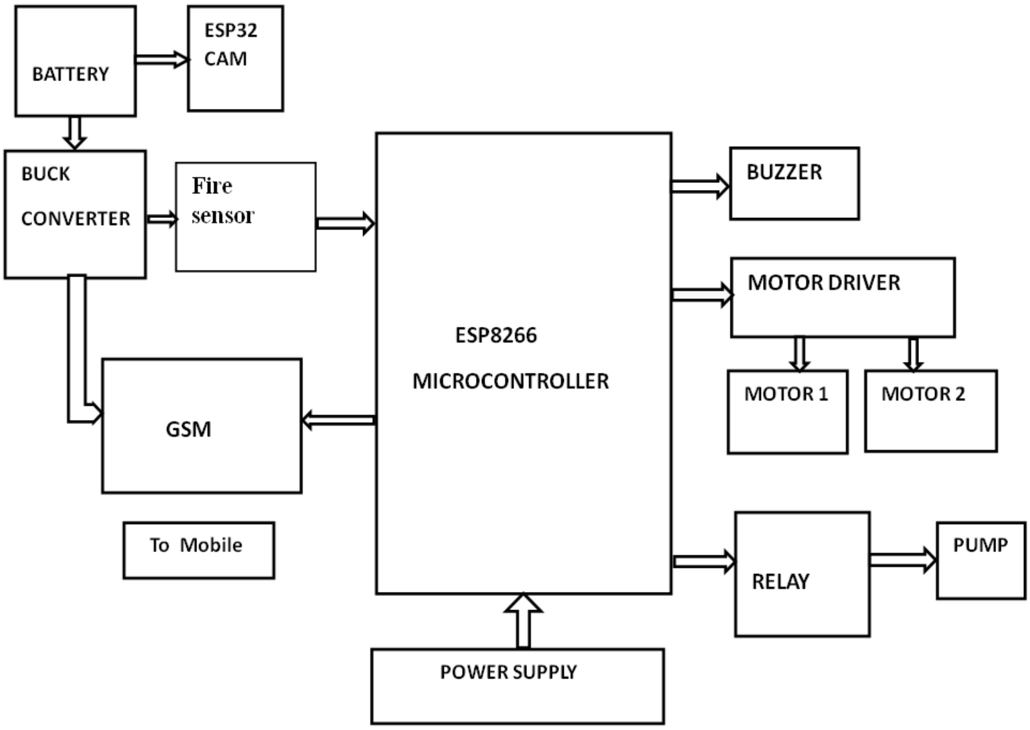

Fig 4.1 Block Diagram

The fire-fighting robot in the above figure is designed to detect and extinguish fires autonomously while ensuring real-time monitoring and alerting. The system is powered by a rechargeable battery connected to a buck converter for efficient power distribution to components. Fire detection is achieved using a fire sensor, which sends signals to the ESP8266 microcontroller upon detecting flames or heat. The microcontroller controls a relay to activate a pump for extinguishing the fire and a buzzer for alerting nearby personnel. It also drives motors via a motor driver to enable mobility, allowing the robot to navigate toward the fire. For monitoring, an ESP32 CAM module streams real-time visuals, while a GSM module sends fire alerts to mobile devices. The system incorporates obstacle avoidance to ensure smooth navigation in dynamic environments. All operations are powered by an integrated power supply system, ensuring the robot is reliable and energy-efficient during firefighting missions.

4.2 FLOW CHART

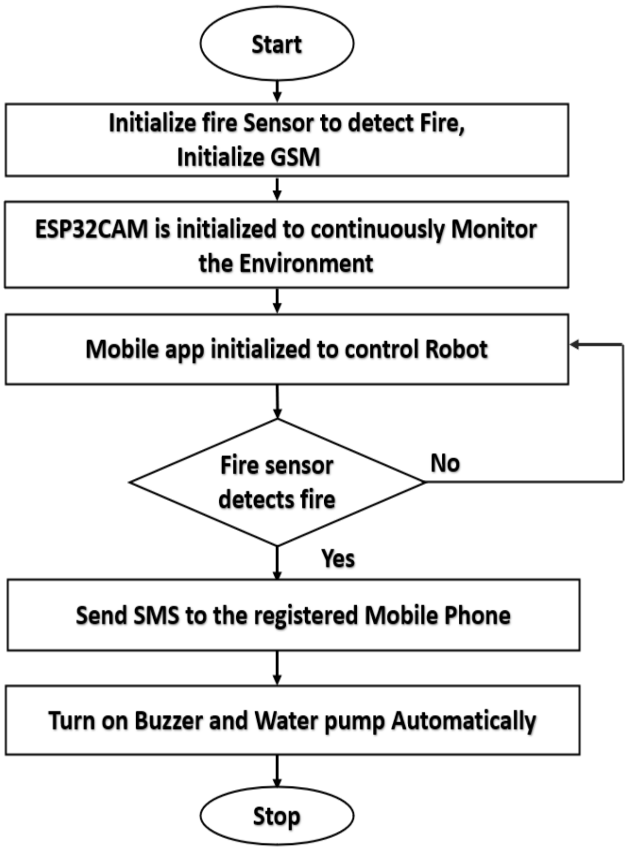

Fig 4.2 Flow Chart

4.3 ARCHITECTURE

The firefighting robot is designed to autonomously detect and extinguish fires. It consists of an ESP8266 microcontroller at its core, interfaced with several modules and components. A fire sensor detects the presence of fire, and the data is processed by the microcontroller. For visual monitoring an ESP32-CAM module is integrated, which can transmit video feeds. Power to the system is supplied via a battery, which is regulated by a buck converter to provide appropriate voltage levels. Communication with a mobile device is facilitated by a GSM module, allowing alerts and updates to be sent remotely. The robot employs motor drivers to control two motors, enabling its movement. When a fire is detected, the system activates a pump through a relay to extinguish the fire, while a buzzer provides an audible alert. The entire system is powered by a dedicated power supply circuit ensuring.

CHAPTER 5

IMPLEMENTATION

5.1 CODE

```
#define BLYNK_TEMPLATE_ID "TMPL3HASggrcZ"
#define BLYNK_TEMPLATE_NAME "project"
#define BLYNK_AUTH_TOKEN "tNhRKVIVJrMLfC4yimo9uKku6VHcS_hC"
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
#include <SoftwareSerial.h>//Library used to
String str="";
SoftwareSerial serial2(D7, D8);  // create
char auth[] = BLYNK_AUTH_TOKEN;
char ssid[] = "Abcd"; //Enter your WIFI name
char pass[] = "12345678"; //Enter your WIFI passowrd

//Motor PINs
#define IN1 D0
#define IN2 D1
#define IN3 D2
#define IN4 D3
#define Pump D5
int buz= D4;
int fire = D6;
bool forward = 0;
bool backward = 0;
bool left = 0;
bool right = 0;
bool pump =0;
void setup() {
Serial.begin(9600);
Serial.begin(9600);
```

```
 pinMode(IN1, OUTPUT);
 pinMode(IN2, OUTPUT);
pinMode(IN3, OUTPUT);
pinMode(IN4, OUTPUT);
pinMode(Pump, OUTPUT);
digitalWrite(Pump,HIGH);
pinMode(buz,OUTPUT);
digitalWrite(buz,LOW);
pinMode(fire,INPUT);
Blynk.begin(auth, ssid, pass);
}
BLYNK_WRITE(V0)
 {
  forward = param.asInt();
}
BLYNK_WRITE(V1)
{
  backward = param.asInt();
}
BLYNK_WRITE(V2)
{
  left = param.asInt();
}
BLYNK_WRITE(V3) {
  right = param.asInt();
}
BLYNK_WRITE(V4) {
  pump = param.asInt();
}
void smartcar()
{
 if (forward == 1)
 {
 carforward();
```

```
 Serial.println("carforward");
 }
else if (backward == 1)
{
   carbackward();
   Serial.println("carbackward");
 } else if (left == 1) {
   carturnleft();
   Serial.println("carfleft");
  } else if (right == 1) {
   carturnright();
   Serial.println("carright");
  }
   else if (forward == 0 && backward == 0 && left == 0 && right == 0)
 {
   carStop();
   Serial.println("carstop");
  }
 }

void pumpState()
{
   if (pump == 1)
{
digitalWrite(Pump,LOW);
Serial.print("pump on");
delay(1000);
  }
else
{
   digitalWrite(Pump,HIGH);
  }
}
void loop()
```

```
{
  Blynk.run();
  smartcar();
  pumpState();

  int fireVal= digitalRead(fire);
  if(fireVal==0)
{
    digitalWrite(Pump,LOW);
     digitalWrite(buz,HIGH);
     sendSMS();
     digitalWrite(buz,LOW);
  }
else
{
    digitalWrite(Pump,HIGH);
    digitalWrite(buz,LOW);
  }
}
   void carforward()
{
  digitalWrite(IN1, LOW);
  digitalWrite(IN2, HIGH);
  digitalWrite(IN3, LOW);
  digitalWrite(IN4, HIGH);
}
  void carbackward()
{
  digitalWrite(IN1, HIGH);
  digitalWrite(IN2, LOW);
  digitalWrite(IN3, HIGH);
  digitalWrite(IN4, LOW);
}
  void carturnleft()
```

```
{
  digitalWrite(IN1, LOW);
  digitalWrite(IN2, HIGH);
  digitalWrite(IN3, HIGH);
  digitalWrite(IN4, LOW);
}
  void carturnright()
{
    digitalWrite(IN1, HIGH);
    digitalWrite(IN2, LOW);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, HIGH);
}
   void carStop()
{
    digitalWrite(IN1, LOW);
    digitalWrite(IN2, LOW);
    digitalWrite(IN3, LOW);
    digitalWrite(IN4, LOW);
}
   void sendSMS()
{
    str = String ("Fire detetected");
    serial2.println("AT+CMGF=1");    //Sets the GSM Module in Text Mode
    delay(1000);  // Delay of 1000 milli seconds or 1 second
    serial2.println("AT+CMGS=\"+919535599391\"\r"); // Replace x with mobile number
    delay(1000);
    serial2.println(str);
    delay(100);
    serial2.println((char)26);// ASCII code of CTRL+Z
    delay(2000);
 }
```

5.2 APPLICATIONS

- Residential Fire Safety: Detects and extinguishes fires in homes especially useful when occupants are absent.
- Industrial Facilities: Monitors and addresses fires in factories or warehouses with flammable materials.
- Defense and Security: Enhances fire fighting capabilities in high-risk defense installations.
- Healthcare Facilities: Provides autonomous fire response in hospitals, minimizing disruption to patients and staff.
- Remote or Hazardous Areas: Can operate in remote or unsafe areas where human intervention is difficult.
- Data Centers: Protects valuable data and equipment from fire damage in server rooms.
- Educational Institutions: Safeguards schools and universities, where fire risks could impact many lives.
- Museums and Art Galleries: Helps protect irreplaceable artifacts and art work from fire.
- Smart City Infrastructure: Integrates with smart city systems for enhanced urban fire safety.
- Laboratories and Research Centers: Ensures safety in facilities with sensitive or hazardous materials.

5.3 ADVANTAGES

- Rapid Response: Autonomous operation enables immediate response to fire.
- Remote Operation: Reduces the need for human intervention in hazardous situations.
- Enhanced Safety: Lowers the risk to firefighters and occupants.
- Early Detection: Sensors provide early warning of fire reducing potential damage.
- Real-time Monitoring: Live video streaming allows remote observation and control.
- Compact Design: Maneuverability in confined spaces where traditional firefighting tools may not reach.
- Efficient Resource Usage: Targeted extinguishing minimizes water or suppressant waste.
- Scalable: Suitable for various environments from homes to large facilities.
- 24/7Operation: Capable of continuous monitoring, even when no one is present.

5.4 CHALLENGES FACED DURING IMPLEMENTATION

1. Power supply stability: Issues with the battery, buck converter, or other power components.

2. Communication: Difficulties in configuring GSM or interfacing the ESP8266 with the mobile.

3. Sensor integration: Problems in detecting fire or managing the input from the fire sensor.

4. Actuator control: Issues controlling motors, the relay, or the pump.

5. Software bugs: Challenges in coding or debugging the microcontroller protocols.

5.5 SUMMARY

In this chapter gives the information about the methodology for fire fighting robot, objective of the work proposed methodology and also block diagram of fire fighting robot along with their application and advantages.

CHAPTER 6

RESULT AND DISCUSSION

6.1 OBSERVATION

Power management is achieved through a battery and a buck converter, ensuring a stable supply for all connected devices. The ESP32-CAM module allows for image or video capture, while the fire sensor provides critical safety monitoring by detecting potential hazards. Communication is facilitated through a GSM module, enabling data transmission to a mobile device for remote monitoring or control. Actuators such as motors, a relay and a pump are controlled by the microcontroller possibly for automation or response mechanisms. The inclusion of a buzzer indicates an alarm system to alert users in case of emergencies. Proper integration and synchronization of these components are crucial for ensuring system reliability and functionality.

6.2 DISCUSSION OF RESULT

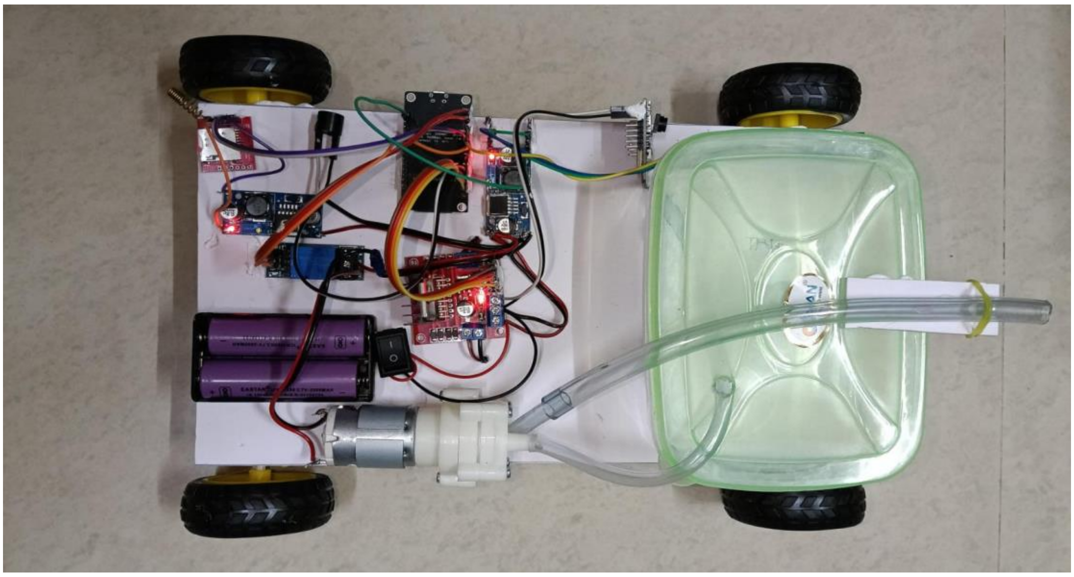

Fig 6.1 Hardware model of fire fighting robot

The system depicted in the block diagram is an integrated fire detection and response mechanism designed around the ESP8266 microcontroller. The system is powered by a battery regulated through a buck converter, ensuring stable voltage supply to all components, including the ESP32 CAM, GSM module, fire sensor, and other peripherals.

A fire sensor connected to the ESP8266 continuously monitors for fire incidents. Upon detecting fire, the ESP8266 activates a buzzer for an audible alert, triggers a relay to operate a pump for extinguishing the fire, and uses a motor driver to control two motors, enabling mobility or directed action if the system is designed for deployment in mobile platforms.

Simultaneously, the ESP8266 communicates with a GSM module to send alerts to a predefined mobile number, providing critical information about the incident. The ESP32 CAM further enhances the system by capturing real-time visuals, which can be stored or transmitted for remote monitoring.

The design ensures efficient operation through systematic power distribution and real-time decision-making controlled by the ESP8266. This methodology integrates sensing, alerting, and action to provide a comprehensive solution for fire emergencies, with the added capability of mobile communication and visual monitoring for enhanced safety and response.

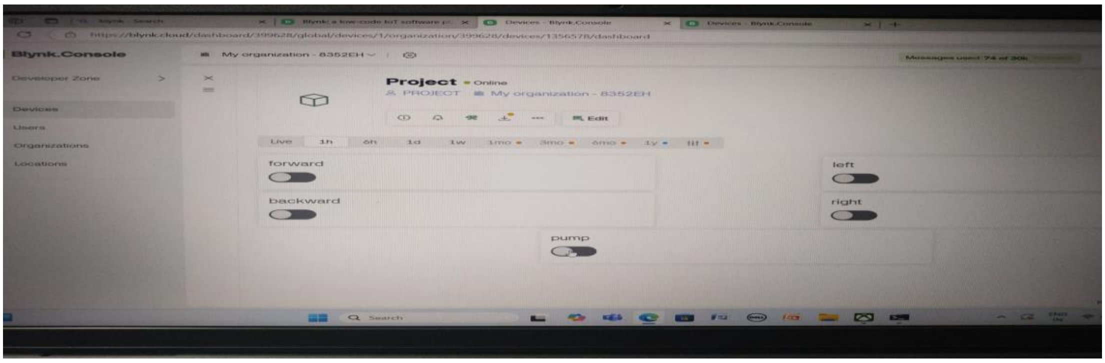

Fig 6.2 The robot controlled using blynk application

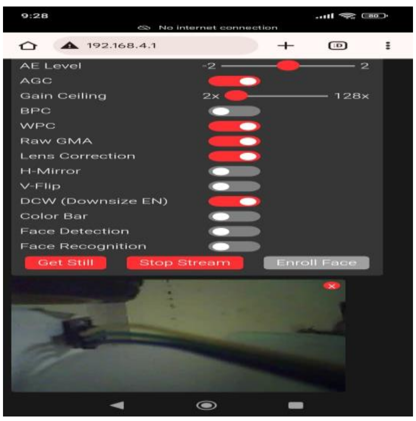

Fig 6.3 Real time monitoring through ESP32CAM Fig 6.4 Fire detected message send by GSM

CHAPTER 7

CONCLUSION AND FUTURE WORK

7.1 CONCLUSION

Conclusions From the experimental results, a smart fire-fighting robot has achieved its aim and objective successfully. The robot developed to help firefighters in their duty. It has advantageous features such as the ability to detect the source of fire, extinguish it and increase the knowledge about fire behavior from the incident area. This robot will reduce the risk of injury for firefighters and possible victims and decrease the monetary losses which increase considerably as fire duration increases. The robot can be used in a place that has a small entrance or in small spaces because it has a compact structure.

The development of a smart fire fighter robot represents a significant advancement in fire safety technology. By detecting and extinguishing fires autonomously and providing real-time video monitoring with night vision, the robot enhances firefighting capabilities while minimizing risk to human life and property. The use of RF and Wi-Fi modules for remote control and communication ensures that the robot can be operated from a safe distance, further reducing the hazards associated with firefighting. This innovative solution has the potential to significantly improve fire response times and effectiveness, ultimately saving lives and reducing property damage.

7.2 LIMITATIONS

- Limited Extinguishing Capacity: Smaller robots may have limited capacity.
- Power Dependency: Requires a reliable power source for continuous operation.
- Sensor Limitations: Sensors may not detect all fire types with complete accuracy.
- Environmental Sensitivity: Extreme temperatures may affect functionality.
- Maintenance Requirements: Requires regular maintenance to ensure reliability.
- Control Range: WiFi range is limited, potentially restricting remote operation.
- Potential for Malfunction: Mechanical or sensor failures could impair response inemergencies.

7.3 FUTURE WORK

In upcoming years, we can incorporate image processing techniques to efficient images of fire, using hybrid techniques for the classification of data and lossless image techniques. The robot can be programmed to work on priority basis wherein more importance will be given to the area that contains more human lives according to the priority parameters. We can make the made robot adaptable to move over staircases. Incorporation of fire extinguishers are to be made. The robot can be programmed to work on priority basis wherein more importance will be given to the area that contains more human lives according to the priority parameters.

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