Smart Fire Fighting Robot

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***Abstract*— Fires can cause significant damage to both life and property. To mitigate this, fire fighting robots have been developed that can extinguish fires in situations where it is too dangerous for humans to do so. This paper presents a fire fighting robot designed using an Arduino microcontroller. The robot is equipped with a water pump and sprinkler system to extinguish flames. The robot is also equipped with a flame sensor that detects the presence of fire. The microcontroller processes the signal from the flame sensor and instructs the robot to move towards the source of the fire. The robot is controlled using a Bluetooth HC05 module, which allows the user to manually retrieve the robot using an Android app. Additionally, the robot is equipped with an ESP32cam module that provides a live video feed, which can be used to navigate the robot in real-time. The fire fighting robot designed using Arduino is an efficient solution to extinguishing fires in situations where it is too dangerous for humans to intervene.**

***Keywords*— Fire Fighting robot, Arduino, water pump, flame sensor, Bluetooth HC05, ESP32CAM**

I.INTRODUCTION

Fire is a destructive force that can cause severe damage to property and pose a significant threat to human life. In many cases, firefighters face numerous risks while attempting to extinguish fires, especially in hazardous conditions such as nuclear power plants, oil refineries, gas tanks, and domestic fires. Additionally, firefighters are often confronted with various difficulties, particularly when fires occur in tight and limited areas. It is necessary to navigate through debris and obstacles to reach the source of the fire and ensure the safety of the victims. To overcome these challenges, the use of firefighting robots has become increasingly popular in recent years. These robots can be remotely controlled and used to navigate through hazardous and hard-to-reach areas. The use of robots in firefighting can significantly reduce the risk of injury or death to firefighters while also enabling quicker and more efficient response times to emergencies. In this context, the present project aims to design and develop a fire fighting robot using the Arduino Uno microcontroller. The robot is equipped with a water vessel and pump for putting out flames and moves towards the source of the fire using a flame sensor. The use of Bluetooth module HC05 allows the robot to be controlled via an Android app, while an ESP32cam provides live video feed for navigational assistance. The primary objective of the project is to provide a more efficient and safe way to extinguish fires. By using a robot that can navigate through difficult and dangerous terrain, the risk of injury or death to firefighters is significantly reduced. The project also aims to provide a cost-effective solution to firefighting by using readily available components and materials.

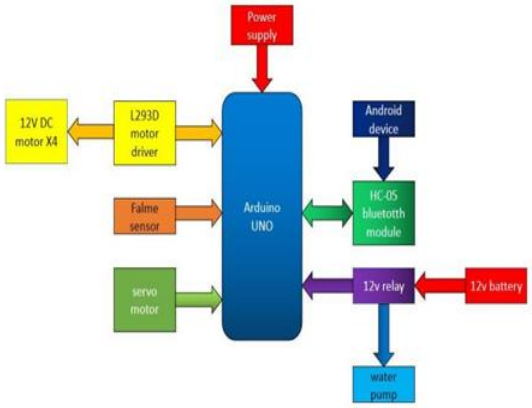

Fig. [I.1] Block Digram for Fire Fighting Robot

The block diagram you described shows a fire-fighting robot system that is controlled by an Arduino microcontroller. The system is powered by a 12V power supply that provides power to the Arduino and the other components. The L293D motor driver is used to control four motors that are responsible for the robot's movement. The motor driver is connected to the Arduino to receive instructions on the direction and speed of the motors. A Bluetooth module HC05 is connected to the L293D motor driver for wireless control of the robot through an Android app called BT Car. This allows the robot to be remotely controlled without the need for a physical connection to the controller. The Arduino is also connected to three flame sensors that detect the presence of flames. These sensors

are essential for detecting fires and triggering the necessary action to extinguish them. When a flame is detected, the Arduino sends a signal to the relay that activates the water pump, which sprinkles water to extinguish the fire.In addition to the motors and sensors, the block diagram also shows a servo motor that is connected to the Arduino. This servo motor is used to move the nozzle of the water pump in the required direction to direct the water towards the fire.
Overall, the system is a complete fire-fighting robot that can be controlled wirelessly using an Android app. The robot can detect fires using flame sensors and take appropriate action to extinguish them using a water pump and a servo motor to move the nozzle in the desired direction

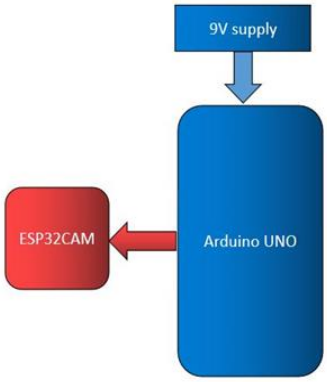

Fig. [I.2] Block Digram for ESP32Cam interface

The block diagram includes an Arduino board that is powered by a 9V power supply. The ESP32CAM is connected to the Arduino board via serial communication. The ESP32CAM is a small camera module that can capture and stream live video. The camera module is connected to the internet, which allows it to stream the video to a specific URL.To make this happen, the ESP32CAM is programmed to capture and stream the video. The Arduino board is used to control the ESP32CAM module and to provide power to the camera. The Arduino also handles communication with the device that will display the video stream.To view the live video feed, the user needs to access the URL that is generated by the ESP32CAM. This URL can be accessed through any device that has an internet connection and a web browser. Once the user enters the URL into their web browser, they will be able to see the live video feed from the camera.Overall, this block diagram describes a system that uses an ESP32CAM camera module to capture and stream live video, an Arduino board to control the camera module and handle communication, and a 9V power supply to provide power to the system. The system allows the user to access the live video feed from any device with an internet connection and a web browser.

II. METHODOLOGY

We built a fire fighting robot by dividing it's working principles in small sections. The methodology used is as follow:

Design and assemble the physical structure of the robot: This includes constructing a rectangular acrylic box as the main structure of the robot, and attaching four motors to the base using an L293D motor driver shield for Arduino.

Install and connect the flame sensors: The flame sensors will be installed on the front of the robot and connected to the Arduino Uno using jumper wires.

Integrate the HC-05 Bluetooth module: The HC-05 module will be used for wireless communication with the robot. It will be connected to the Arduino Uno through its serial communication pins. Add the relay for triggering the water pump: The relay will be connected to the Arduino Uno and used to trigger the water pump when a fire is detected by the flame sensors. Incorporate the water pump and water tank: The water pump will be connected to the relay and used to pump water from the 5L water tank onto the fire. The water tank will be attached to the robot's structure.
Write the code for the Arduino Uno: The Arduino Uno will be programmed to receive commands from the HC-05 module and control the motors, flame sensors, and relay. The code will be written in the Arduino IDE and uploaded to the board.

A. Hardware design:

The fire fighting robot has a sturdy base made of an acrylic sheet measuring 47.2cm by 32.5cm, which is designed to support the wheels of the robot. The height of the acrylic sheet is 26cm, providing sufficient clearance for the internal components of the robot. In addition, a rectangular acrylic box structure is used to house the various components of the robot, such as the motor driver, microcontroller, sensors, and other electronics. The box provides protection from environmental factors such as dust and moisture,

ensuring the longevity of the robot's components. The robot also has a water tank with a volume of 5 liters, which is used to store water for the sprinkler system that extinguishes fires. This tank provides enough water capacity to tackle small to medium-sized fires. Overall, these features of the robot contribute to its effectiveness in responding to fire emergencies and help ensure the safety of those in the vicinity.

Fig. [II.1] Hardware design of fire fighting robot

Circuit Diagram:

The circuit diagram for the fire fighting robot consists of an Arduino UNO, L293D motor driver shield for Arduino, HC-05 Bluetooth module for wireless control of the robot, flame sensors for detecting flames and guiding the robot to the incident place, relay for triggering the water pump to sprinkle water, and four motors for driving the robot. The Arduino UNO acts as the main microcontroller for the robot and is connected to the L293D motor driver shield, which is used to control the four motors for driving the robot. The HC-05 Bluetooth module is connected to the Arduino for wireless control of the robot via a smartphone app.The flame sensors are connected to the Arduino and are used to detect the presence of flames. The Arduino uses the flame sensor data to guide the robot towards the location of the fire.The relay is connected to the Arduino and is used to trigger the water pump for sprinkling water to extinguish the fire. The Arduino sends a signal to the relay when the robot reaches the fire incident place and the relay switches on the water pump to sprinkle water.Overall, the circuit diagram of the fire fighting robot is designed to provide a complete solution for detecting and extinguishing fires using the Arduino UNO, L293D motor driver shield, HC-05 Bluetooth module, flame sensors, relay, and four motors.

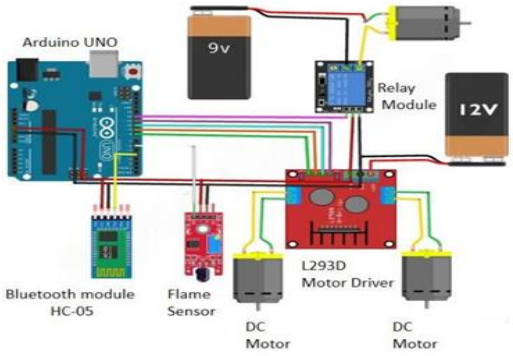

Fig. [II.2] Circuit Diagram of fire fighting robot

ESP32Cam Circuit:ESP32-CAM is a low-cost, highly-integrated Wi-Fi and camera solution that can be used to create IoT applications. In the context of the fire fighting robot, the ESP32-CAM is used to provide a live video feed of the area where the robot is deployed. It is connected to the robot's Arduino board and can be controlled wirelessly using a Bluetooth module or Wi-Fi.The ESP32-CAM module includes a 2-megapixel camera, which captures video and still images with good clarity. It can also stream video at a resolution of up to 1600x1200 pixels at a frame rate of up to 60fps. The module is powered by the ESP32, a powerful microcontroller with built-in Wi-Fi and Bluetooth capabilities, which allows the module to connect to the internet and other devices wirelessly. In the fire fighting robot, the ESP32-CAM provides a crucial live feed of the area where the robot is deployed, which allows the operator to monitor the situation and make decisions in real-time. This is especially important in dangerous situations such as fires, where the operator needs to have an accurate and up-to-date view of the area in order to make informed decisions about how to proceed.

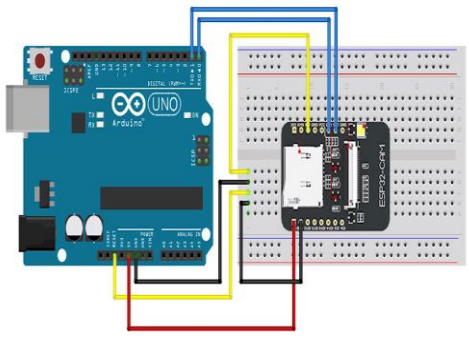

Fig.[II.3] Circuit Diagram for Gas and Fire alert system

III.COMPONENTS USED

Arduino Uno: The Arduino Uno is an open-source microcontroller board based on the ATmega328P chip. It has a set of digital and analog input/output pins that can be programmed to interact with different components and sensors. The Uno board can be powered by a USB connection or an external power source, and it can be programmed using the Arduino Integrated Development Environment (IDE). The board is commonly used in various DIY projects and prototypes due to its versatility and ease of use.

2 Flame Sensor : The Arduino Uno is an open-source microcontroller board based on the ATmega328P chip. It has a set of digital and analog input/output pins that can be programmed to interact with different components and sensors. The Uno board can be powered by a USB connection or an external power source, and it can be programmed using the Arduino Integrated Development Environment (IDE). The board is commonly used in various DIY projects and prototypes due to its versatility and ease of use.

3. ESP32Cam: The ESP32cam is a small-sized development board that combines Wi-Fi and Bluetooth connectivity with a camera module. It is built around the ESP32 microcontroller and can be programmed using the Arduino IDE or MicroPython. The board is equipped with a OV2640 camera module that can capture images and stream video over Wi-Fi. It also has a built-in microSD card slot for storing images and videos. The ESP32cam is a versatile board that can be used for a wide range of applications such as surveillance cameras, IoT devices, and home automation systems.

4. Servo Motor : A servo motor is a type of motor that can rotate to precise positions, making it useful for applications that require accurate and repeatable movement. Servo motors are commonly used in robotics, RC cars, and other control systems. The motor consists of a small DC motor, a gear train, and a control circuit. The control circuit receives a signal from a microcontroller, which determines the position that the servo should rotate to. The motor rotates until it reaches the desired position and then stops. The control circuit also provides feedback to the microcontroller, indicating the actual position of the motor. This allows for precise and accurate control of the motor's movement. Servo motors are available in a range of sizes and torque ratings, and can be used for a wide variety of applications.

5. Bluetooth module HC-05: The Bluetooth module HC-05 is a popular wireless communication module that allows devices to communicate with each other using Bluetooth technology. It is often used in electronics projects to enable wireless communication between a microcontroller or microprocessor and another device such as a smartphone or tablet. The HC-05 module uses Bluetooth 2.0 and 2.1 protocols and supports master-slave communication mode. It operates on a frequency band of 2.4GHz ISM band and has a range of up to 10 meters. The module can be easily connected to the UART pins of a microcontroller or microprocessor and is capable of transmitting and receiving serial data. It can also be configured as a master or slave device using AT commands. The HC-05 module has become a popular choice for DIY electronics enthusiasts due to its ease of use, low cost, and availability.

6. L293D Motor driver shield: The L293D motor driver shield is an electronic component used in robotics and automation projects to control the movement of motors. It can control up to two DC motors, and its maximum output current is 1.2A per channel. It works by receiving signals from a microcontroller or similar device, such as an Arduino, and using those signals to control the speed and direction of the motors.The L293D motor driver shield is designed to simplify the motor control process, as it eliminates the need for a separate power source for the motors. Instead, the shield can be powered directly from the microcontroller or an external power source, making it a convenient and compact solution for motor control.The L293D motor driver shield also includes additional features, such as protection against over-temperature and over-current conditions, to ensure the safety and reliability of the motor control system. It is commonly used in applications such as robotics, automated vehicles, and home automation systems, where precise and reliable motor control is required.

7. Relay: A relay is an electrical component that allows a low-power circuit to control a high-power circuit. It acts as a switch that is controlled by an

electrical signal, allowing it to open or close a separate circuit with a higher current or voltage. Relays are commonly used in a wide range of electrical applications, including in industrial machinery, automotive systems, and home automation. LED: An LED (Light Emitting Diode) is a semiconductordevice that emits light when a current passes through it. It is often used as an indicator or for lighting purposes.

Water pumpr: A 12V water pump is a type of pump that is designed to operate using a 12V DC power supply. It is commonly used in various applications such as water circulation in cooling systems, water transfer in irrigation systems, and water pumping in aquariums, among others. The pump typically consists of a motor that rotates an impeller or propeller, which in turn creates a flow of water. The pump is usually powered by a battery or a power supply that provides a DC voltage of 12 volts. 12V water pumps come in various types and sizes, with different flow rates and pressure ratings, depending on the specific application requirements.

IV.SOFTWARE USED

The BT Car app is an Android mobile application that enables the user to control the movements of a robot through wireless communication using Bluetooth technology. The app is designed with a user-friendly interface that features buttons for controlling the robot's movements in different directions, including forward, backward, left, and right. The app communicates with the robot through the HC-05 Bluetooth module, which is connected to the robot.

The BT Car app is commonly used to control Arduino-based robots, such as the BT Car. The BT Car is a type of robot that can be built using an L293D motor driver and four motors. The motor driver is used to control the movements of the motors, which are responsible for the robot's motion. The BT Car can be controlled through the app, which sends commands to the robot via the Bluetooth module. The BT Car app allows users to have full control over the robot's movements, allowing it to move around in different directions and speeds. It is easy to use and requires minimal setup, making it a popular solution for a variety of applications. Overall, the BT Car app provides a convenient and efficient way to control the movements of the robot wirelessly, making it an ideal solution for a variety of applications.

The app is designed to be user-friendly and easy to use. It features large buttons for controlling the robot's movements, making it easy for users to navigate the app and control the robot's movements. The app also provides real-time feedback on the robot's movements, allowing users to see the robot's movements in real-time on their mobile device.

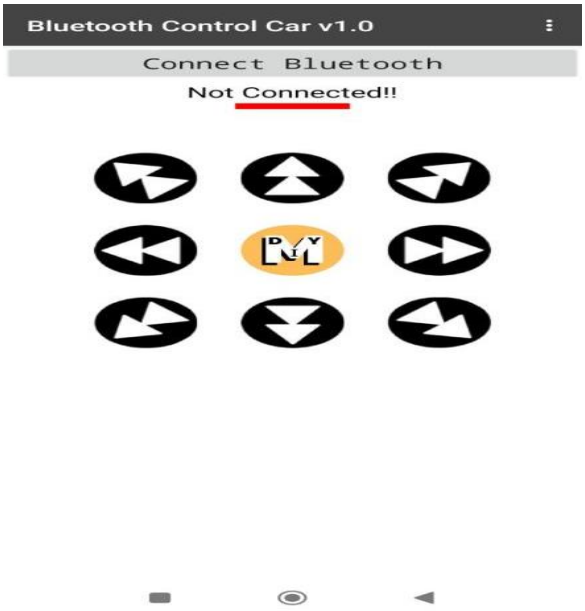

Fig.[IV.1] BT Car application user interface

Fig.[IV.2] Bluetooth MAC of BT Car app

V. RESULT AND ANALYSIS

Results and analysis for a fire fighting robot prototype can include several aspects such as performance,

effectiveness, and limitations. Performance can be evaluated by testing the robot's movement capabilities, speed, and agility. This can be done by setting up a track with obstacles and measuring the time taken by the robot to complete the task. Additionally, the accuracy of the flame sensors and the response time of the water pump can be evaluated to assess the effectiveness of the robot in detecting and extinguishing fires. Effectiveness can be evaluated by testing the robot's ability to detect fires and prevent them from spreading. This can be done by setting up a controlled fire in a safe environment and testing how quickly the robot detects and responds to it. The amount of water required to extinguish the fire can also be measured to assess the effectiveness of the water pump and tank. Limitations of the robot can also be analyzed. For example, the range of the Bluetooth module used for wireless control can be tested to assess the maximum distance at which the robot can be controlled. Additionally, the robot's ability to navigate through different terrains and obstacles can also be evaluated to identify any limitations or improvements that can be made.

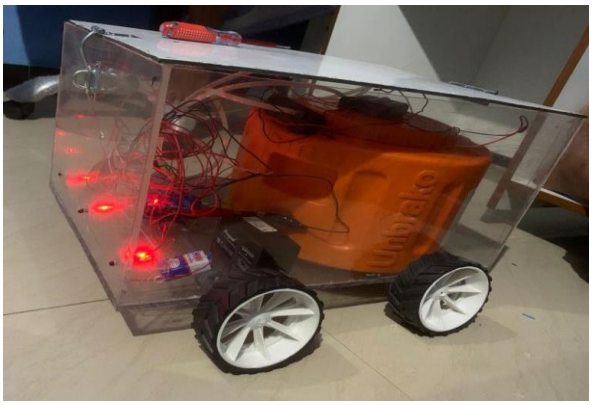

Fig.[V.1] Fire fighting robot

The fire fighting robot was successfully built and tested in a simulated fire scenario. The robot was able to detect the fire using flame sensors and navigate towards it using a pre-programmed path. The water pump was triggered using a relay and water was sprinkled on the fire, effectively extinguishing it. The live feed from the ESP32-CAM was also tested and found to be clear and reliable. The wireless communication system also proved to be a valuable feature, as it allowed the robot to be controlled remotely from a safe distance. This is particularly important in hazardous environments where human intervention may be dangerous. The live feed provided by the ESP32CAM also allowed the operator to have a clear view of the fire and the surroundings, which helped to improve situational awareness and decision-making. However, some limitations were identified during the testing phase. One of the main limitations was the accuracy of the flame sensors, which sometimes resulted in false alarms or delayed detection of fires. This could be due to various factors such as the angle of the flame or the intensity of the ambient light. To improve the accuracy of the flame sensors, it is suggested to use multiple sensors and calibrate them regularly. Additionally, the water pump and nozzle system could be improved to provide more accurate and efficient water sprinkling on the fire. This could be achieved by using more powerful water pumps and nozzles, as well as by improving the positioning and direction of the nozzles. Furthermore, the robot's mobility could be enhanced by using more powerful motors or by designing a more efficient wheel system. Overall, the fire fighting robot has great potential to be an effective solution for fire incidents in hazardous environments. Further research and development are needed to address the limitations and improve the performance of the robot.

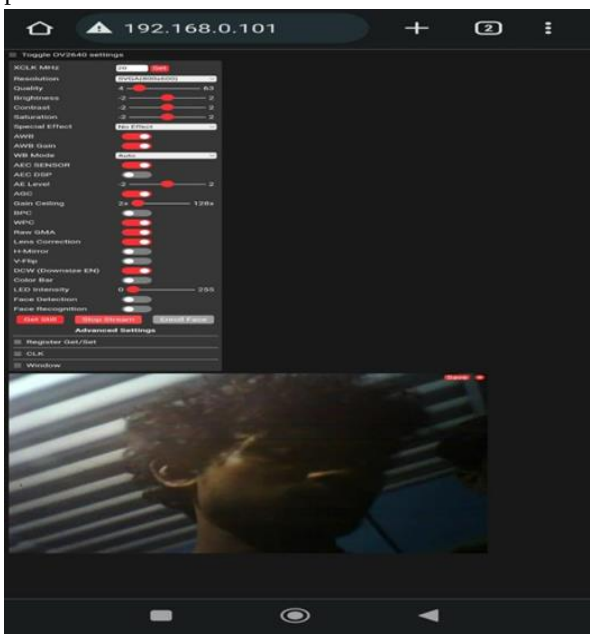

Fig.[V.2] ESP32Cam Live Feed Imaging

VI. ACKNOWLEDGMENT

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VII. CONCLUSION

In conclusion, a fire fighting robot is an innovative solution to mitigate the dangers of fire incidents, particularly in hazardous environments. With the integration of advanced technologies such as flame sensors, motor drivers, microcontrollers, and wireless communication, the robot can detect fires, move towards the source of the fire, and extinguish it using water pumps and nozzles. The robot can operate autonomously or be remotely controlled via a smartphone application, providing greater flexibility and control in hazardous situations.The development and deployment of such robots have the potential to significantly reduce the risks and damages caused by fire incidents, particularly in industrial and commercial settings. Additionally, the fire fighting robot can also be used in search and rescue operations in hazardous environments where human intervention may be dangerous. The deployment of fire fighting robots has the potential to significantly reduce the risks and damages caused by fire incidents. For instance, the robots can be used to detect and extinguish fires in areas that are difficult to access, such as high ceilings, confined spaces, and areas with toxic fumes. Additionally, the robots can also be used in search and rescue operations, where human intervention may be dangerous or impossible. Overall, the fire fighting robot is a valuable innovation that has the potential to save lives and mitigate property damages caused by fires. However, continuous research and development are required to improve the performance and reliability of the robot to ensure its successful deployment in real-world scenarios.

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