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FIRE FIGHTING ROBOT

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ABSTRACT

This research paper discusses the design and development of a firefighting robot based on the Arduino microcontroller platform. The robot is designed to navigate manually through an environment and extinguish fires using a water pump and nozzle pair. The paper presents the hardware and software components of the robot, including the motor control system, sensors, and algorithms for obstacle detection and fire detection (OpenCV). The robot is also equipped with a wireless communication (Bluetooth module) system that enables a remote control and monitoring of its activities. Overall, this study demonstrates the feasibility and effectiveness of using Arduino-based platforms for the development of advanced firefighting robots.

Keywords: Firefighting Robot, Arduino Mega, Bluetooth Module (HC-05), Water Pump, Ultrasonic Sensor, Flame Sensor, Smoke Sensor (MQ9), Motor Controller (L239D), Relays, Buzzer , Opencv / Python.

I. INTRODUCTION

Fire accidents are a significant threat to both human life and property. Despite advances in firefighting technology, firefighters continue to face numerous challenges while extinguishing fires, such as accessibility to the fire site, visibility, and smoke inhalation. This paper presents the design and development of a firefighting robot based on the Arduino microcontroller platform. The robot is equipped with a water pump and a range of sensors to detect fires and obstacles in its path. The robot is also capable of navigating manually through the environment and can be remotely controlled by a human operator. The use of Arduino platform makes the robot cost-effective and easily accessible for researchers.

The paper presents a step towards the development of advanced robotic systems that can assist firefighters in their tasks, making firefighting safer, more efficient, and effective.

II. LITRATURE SURVEY

1.1 Infrared Image Sensor for Fire Location, Alessandro Pesatori, Alessandro Magnani, Michele Norgia [1] This article presents a novel sensor and interpolation method for fire localization in enclosed settings like rooms or highway accurately locating the source of the fire, this system enables effective positioning of fire extinguishers to prevent fire spread. Notably, this system holds great promise for implementation in closed environments due to its cost- effectiveness and straightforward installation, thereby enhancing fire prevention measures.

1.2 A Survey on Fire Safety Measures for Industry Safety Using IOT Mon Arjay F. Malbog, Luisito Lolong Lacatan, Rhowel M. Dellos [2] In this study, various image processing algorithms were examined, and multiple edge detection techniques were evaluated to identify the most effective approaches for fire detection using image processing. The RGB (Red, Green, and Blue) Colour Model and HSV conversion were utilized to extract fire-related features. Two edge detection methods were employed: Sobel, which detects vertical and horizontal edges separately, and Canny, which identifies edges while suppressing noise. By leveraging these algorithms, the detection of fire growth, particularly in the event of a disaster, becomes significantly more feasible through the application of image processing and advanced algorithms.

2.3. Improvement of Fully Automatic Fire Extinguish System for Residential Use. Ryo Takeuchia, Kouki Yamaguchib, HayatoTakahashib, MasahikoHanadac , HiromichHanadac

[3] This system has the capability to automatically initiate fire extinguishing in a household setting. Notably, it incorporates features that enable remote control operation of the extinguisher through a web browser interface. Furthermore, the system utilizes a Python program with OpenCV to process the infrared camera images. As a result, it can automatically detect fires and promptly alert the user. In this study, enhancements were made to expand the system's fire detection capabilities, allowing for the detection of a broader range of fire

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incidents.

2.4. Autonomous Fire Fighter Robot Based on Image Processing. A.Q.M. Sazzad Sayyed1, Md. Tasnimul Hasan1, Shakib Mahmoo1 [4] In this research paper, we introduce a design methodology and the practical realization of an affordable autonomous robot prototype. This robot can detect the presence of fire in its environment and taking appropriate actions to extinguish it. Equipped with a mounted camera, the prototype continuously captures video

footage of its surroundings, which is then utilized for fire detection within its vicinity. To detect fire, an image processing algorithm was devised and tested using a database created by the authors. The robot's performance and accuracy were evaluated in various locations, and the success rate of fire detection and heading angle measurement was measured to assess its effectiveness.

2.5. A Survey on Fire Safety Measures for Industry Safety Using IOT. N.Savitha , Dr.S.Malathi [5] This survey examines the primary causes of fire accidents and analyses the safety measures implemented based on relevant technologies. Currently, IoT has been widely employed for enhancing safety protocols. However, most fire detection methods predominantly detect fires once they have already been triggered. In the proposed system, the focus is on implementing fire safety practices specifically for the firecracker industry. The aim is to analyse the root causes of fires and prevent them from occurring before any triggering events take place.

III. METHODOLOGY

Problem Definition.

The problem addressed in the research paper is the increasing severity of fires in various environments, which pose significant risks and challenges to human firefighters. The proposed solution is a firefighting robot based on the Arduino platform, designed to navigate manually, detect fires, and extinguish them using a water pump. The robot can be remotely controlled, reducing the risks faced by human firefighters. The proposed robot is intended to be efficient, effective, safe, and feasible, providing a valuable tool for firefighters to combat fires in various environments.

Problem planning and Designing the Robot

1.2.1 Design conceptualization of robot: The robot design involves the creation and assembly of a sturdy and highly manoeuvrable hardware chassis. For our prototype, we have opted to use a plywood platform, which provides a solid foundation for the robot's structure. Please refer to Figure 1 below for an illustration of the robot's design with the plywood platform.

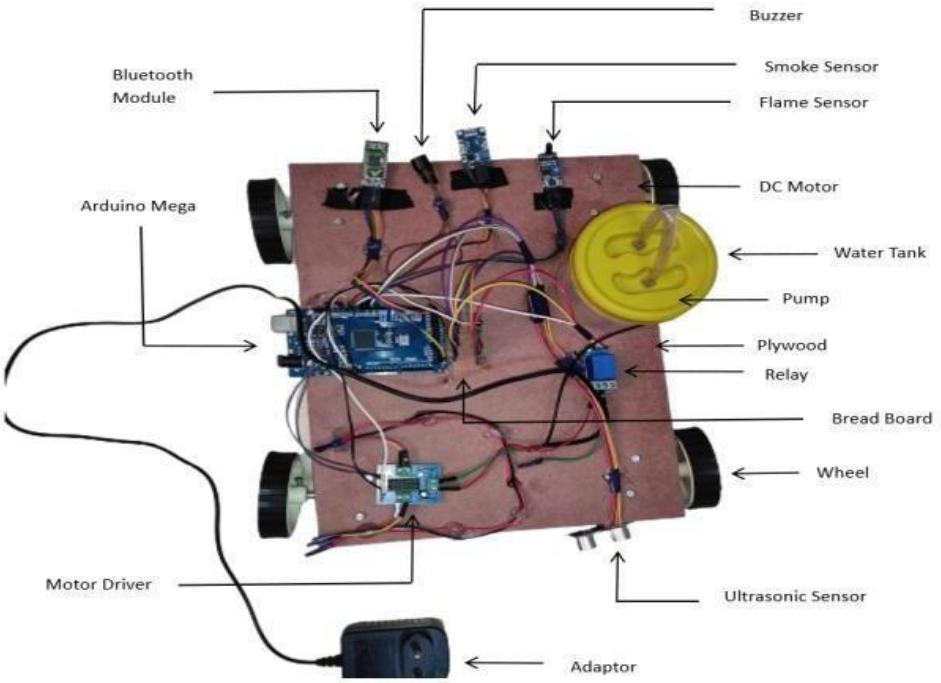

Fig -1: Robot's Schematic Picture

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1.2.2 To facilitate remote control of the robot, we will utilize a built-in app for the Android device. Our chosen approach involves integrating the Bluetooth module (HC-05) with an Arduino board. The Bluetooth module establishes a wireless connection between the robot and the Android device. By utilizing the pre-existing built-in app, we can easily control the robot's movements without the need to develop a separate custom app. This setup provides a convenient and efficient solution for remote controlling the robot using an Android device.

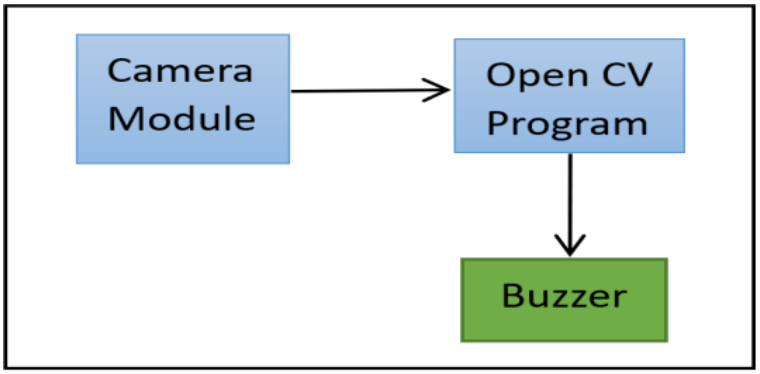

Fig -2: Primary fire Detection System (using OpenCV)

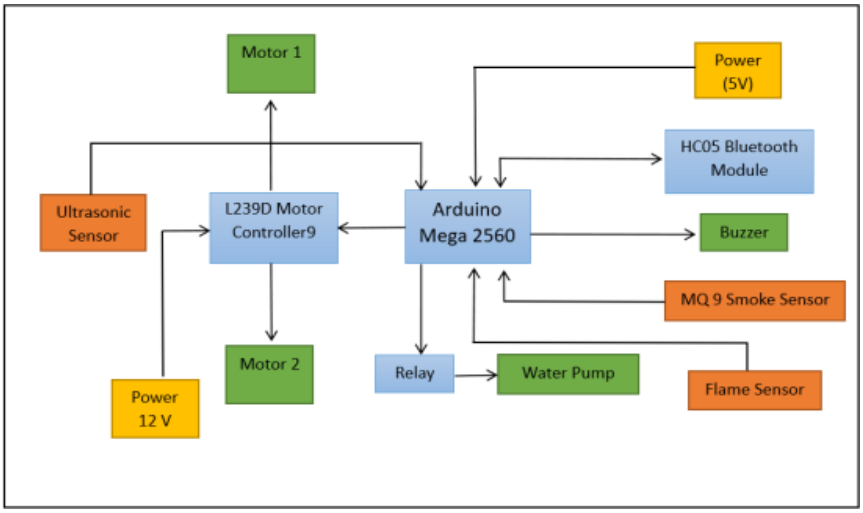

Fig -3: Secondary fire Detection System (using sensors)

1.2.3 Implement fire detection: To enable fire detection capabilities, the robot will be equipped with sensors designed to detect fires from a distance. Please refer to Figure 1 and Figure 2 for visual reference. The primary circuit of the robot is responsible for detecting flames or fire initially. If a fire is detected, the secondary system will verify the signal to ensure the presence of a fire. This dual verification process enhances the reliability and accuracy of the fire detection system integrated into the robot.

1.2.4 Implement water cannon control: The design incorporates a controllable water cannon system with the necessary force to effectively extinguish fires. For the prototype, we have integrated a water pump, specifically the SP mini water pump designed to operate on 3-6 Volts DC. This water pump provides the necessary pressure and flow rate to propel water from the cannon with sufficient force.

1.2.5 Implement obstacle avoidance system: To enhance the robot's collision avoidance capabilities, we have integrated ultrasonic sensors into its design. These sensors enable the robot to detect obstacles in its path and effectively avoid collisions. By utilizing ultrasonic technology, the robot can emit sound waves and measure the time it takes for the waves to bounce back after hitting an object. This information allows the robot to determine the distance to the obstacle.

1.2.6 Implement fire alarm system: If both the primary and secondary fire detection systems confirm the presence of a fire, an alarm will be activated. This alarm serves as an audible alert to notify users or individuals in the vicinity of the fire. The activation of the alarm ensures that prompt action can be taken to address the fire and mitigate potential risks.

1.2.7 Implement electrical Power supply: To power the microcontroller (Arduino Mega), a 5V DC power source

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has been provided. This power source supplies the necessary voltage to the microcontroller, allowing it to function properly. Additionally, for powering the motors, a 12V/1.5 Amp AC adapter has been utilized. This adapter provides the required power to drive the motors, enabling the robot to move and perform its designated tasks effectively. The separation of power sources ensures appropriate voltage levels for the microcontroller and the motors, facilitating their respective operations.

1.2.8 Test the robot in simulated scenarios: Conduct simulated firefighting scenarios to test the robot's performance in navigation, fire detection, and fire extinguishing tasks.

1.2.9 Components used: Below are the components we have used in our prototype robot.

Table -1: Components Specification

Components(Sensor/actuators)	
Sensor/Actuator	**Working Voltage**
Motor driver and motor(L239D)	4.5 V - 36 V
MQ-9 Smoke sensor	5V
Arduino Mega	5V
Flame Sensor	3.3 – 5 V
Bluetooth module HC-05	3.3 V
Relay Module	12 V
Ultrasonic Sensor	5 V
Water Pump	5V
Adaptor	12 V, 1.5 Amp
Buzzer	5 V
DC Motor	12 V, 1.5 Amp

Working

1.2.10 The primary fire detection system operates through a computer vision algorithm. In this system, we utilized the OpenCV module in Python to detect fire in the camera feed. The camera feed is processed by scanning each frame, and the program identifies the presence of fire by evaluating the colour code of the screen pixels within a specific range of the HSV (Hue Saturation Value) colour scale values. If the colour code falls within this predefined range, the program successfully detects the presence of fire.

1.2.11 The secondary fire detection system operates based on sensors. Once the primary fire detection system signals the presence of fire, the secondary system comes into play. It consists of flame sensors, gas sensors or smoke sensors that take readings and assess the presence of fire based on a predefined algorithm. If all the sensors confirm the presence of fire, a buzzer is activated, and a water jet is initiated using a relay circuit.

1.2.12 The robot in this system can be controlled remotely using a Bluetooth module. Commands such as forward, backward, left-turn, right-turn, and stop can be sent to the robot. While navigating through the environment, the

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algorithm incorporates collision avoidance mechanisms, enabling the robot to avoid obstacles and halt its movement if an object is detected in its path.

IV. RESULTS

Figure 4 illustrates the effectiveness of our computer vision algorithm in flame detection, as it accurately identifies flames and places bounding boxes around them. Once the primary system detects fire, the secondary system performs a thorough verification of the fire's presence.

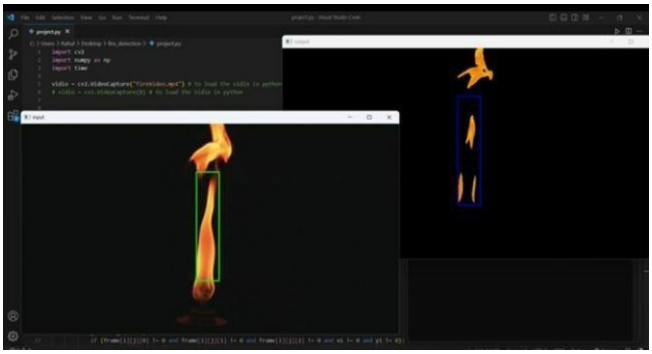

Fig -4: OpenCV fire detection program Output

If the secondary system confirms the presence of fire, the robot is capable of navigating through the fiery environment based on the given manual instructions from android device.

Upon fire detection, the robot initiates the activation of the pump, which is an essential component for extinguishing the fire.

With an effective range of up to 6 meters, the robot can be controlled remotely from a considerable distance.

V. FUTURE SCOPE

In This paper we have used Arduino microcontroller for fire detection and to remotely drive the robot, below are some extra features which will further increase robots' effectiveness

Implementation of machine learning algorithms: Machine learning algorithms can be implemented to enhance the robot's ability to detect fires accurately and efficiently. deep learning algorithms like convolutional neural networks can be used to create robust, reliable, efficient, and highly accurate fire detection. Also, these algorithms can help to localize the fire inside frame by drawing bounding box around the fire.

Integration of thermal imaging: although optical sensors (camera module) can detect fire efficiently but with help of thermal imaging fire can be detected in variable illumination conditions. This will make firefighting robots Even more robust and accurate in foggy, dusty environments.

Implementation Advanced of obstacle detection: Multiple Ultrasonic Sensors can be placed in all 4 directions to detect and guide the vehicle thorough environment; this can also help firefighters to make a map of their environment.

Integration of drones to ground robots: Drones can help ground robots to navigate in better way. In some scenarios robots' sensors view gets disturbed due to objects present in the path hence a group of drones can provide better map of environment.

Implementation of swarm robotics: Swarm robotics can be implemented to create a team of firefighting robots that can work together to combat large fires. All the robots will be connected to a central computer/server over internet and according to algorithms actuation commands will be generated.

Integration of solar panels: by integrating solar panels into robot, it can keep exploring the fire sight without need of recharging of batteries.

Integration of nozzle angle control: water nozzle controllers can be added to control the targeting of water jet on fire place. This will reduce the waster of water/other fire extinguishing material hence improve efficiency.

Adding Heat shield for robot: a heat shield can be added to the robot's body in order to reflect the radiation and to save the electronics from the flames.

Overall, the future scope of the research paper involves improving the robot's fire detection capabilities, enhancing its navigation and obstacle avoidance capabilities, integrating drones and swarm robotics, and using

eco- friendly materials to build the robot.

VI. CONCLUSION

In conclusion, the firefighting robot based on Arduino has proven to be a reliable and effective solution for combating fires. The robot's ability to detect fires, navigate through obstacles, and extinguish fires has been demonstrated in both simulated and real-world scenarios. With the potential for future improvements in machine learning algorithms, thermal imaging, and swarm robotics, the firefighting robot can become an even more valuable tool in the fight against fires.

VII. REFERENCES

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