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FIRE FIGHTING ROBOTIC VECHILE

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Abstract:

Nowadays, fire accidents are very common and sometimes it becomes very hard for a fireman to protect someone's life. It is not possible to appoint a person to continuously observe weather accidental fire has started where robot can do that. Robot will detect fire remotely. These robots are mostly useful in industries. The proposed vehicle is able to detect presence of fire and extinguishing it automatically by using temperature sensor. The proposed robot has a water spray which is capable of sprinkling water in 1800 angle. The sprinkler can be move towards the required direction. At the time of moving towards the source of fire it may happen that it will come across some obstacles,then it has obstacle avoiding capability. It detects obstacles using ultrasonic sensors. Communication between the mobile phone and robot will take place through Bluetooth,which will have GUI to control the movement of robot. When mobile gets connected to Bluetooth firstly it will set module name, baud rate. It is feasible to implement Bluetooth communication between smartphones and micro-controller. Android controlled robot can be used easily in everyday life such as in homes, market,companies etc. A fire outbreak is a hazardous act that leads to numerous consequences. Detecting a fire at an early stage and extinguishing it can aid in prevention of various accidents. Till now we rely on human resource. This often leads to risking the life of that person. Therefore, fire security becomes an important aspect to save human lives. In this paper a fire extinguishing robot has been proposed and designed which detects the fire location and extinguish fire by using sprinklers on triggering the pump. This robot uses three flame sensors for accurate fire detection. This proposed model of Fire Extinguishing Robot using Arduino used to detect presence of fire and extinguishing it automatically without any human interference. It contains gear motors and motor driver to control the movement of robot when it detects any presence of fire and will automatically start the water pump to extinguish that fire breakout.This model robot has a water ejector which is capable of ejecting water at the fire breakout place. The water ejector pipe can be move towards the required direction using servo motor.The whole operation is controlled by an Arduino UNO micro-controller

Keywords: Fire detection, Temperature sensor, Ultrasonic sensor, Flame sensor, Servo motor control, Motor driver, Automatic water pump, Arduino UNO,Fire extinguishing automation, Gear motors, Bluetooth control, Obstacle avoidance, Water sprinkler (180°).

1. INTRODUCTION

Now a days mobile robots are very useful in construction sites, warehouses and manufacturing plants. Mobile robots can also be used in material handling applications which applications are growing day by day. For analyzing different items and for handling materials mobile robots can be used. Wireless navigation is also possible for movements of mobile robot, can be controlled through android. Fuzzy logic control mechanism is used to control robot.

That model does not need any mathematical model controlling. Previously Fire Fighting Robots were controlled by using different electronics devices. But this reduces the scope of control of firefighting robot.However,with the advanced techniques we can build the same robot by using android application to control the actions of the robot . With the help of such robots, fireman's work really decreased and movements of robot are so much effective.

By using an android app fireman man detect the fire and can able to extinguish it. At the same time robot can detect the obstacles and can avoid them by using ultrasonic sensors . Our project is designed to build an android application which can control operations of the fire fighting robot. Fireman can send commands to robot through Bluetooth module which is mounted on robot itself. Smart phones has facility of Bluetooth, through that Bluetooth fireman can control the movement of firefighting robot. For fire detection it is using two sensors. One is temperature sensor and second is smoke detector. Fire extinguishing system will be get activated when fire detection system detects fire. Sprinkler will start sprinkling water when it detects fire. At the transmitting end android application is used and at receiving end two motors are interface to micro-controller.

One of the most important parameter in fire disaster is life, i.e. lives lost in temperatures. A fast response to detect the fire can avoid many disastrous things. it is observed that fire can take place at domestic as well as at industrial level. A normal spark can generate a massive fire breakout. Not only lives of industrial people but also the lives of domestic's people are at risk because of poor fire management system. Fire can take many lives and can injure many people for their life time. But it can be avoided using proper fire controlling methods. For such environments, fire-fighting robot is proposed. In today's generation a lot of robots are proposed and designed to remove the human factor from dangerous and deadly work. The use of robots is becoming very common that safely completes the labour intensive or deadly work for human beings. A Fire Extinguishing Robot is based on IOT Technology. In Fire Extinguishing robot, we intend to build a system that could extinguish a small flame by sensing and moving to the location itself. It will automatically detect the fire with the help of flame sensors. Once it detects the fire breakout location, it navigates itself accordingly to reach the fire source and extinguishes the fire by using built-in fire extinguishing system. For fire detection it is using three flame sensors. First one for the left direction, second one for the forward direction and third one for the right direction. Fire extinguishing system will get activated when fire detection system detects fire. It then reaches the breakout point and water pump will start ejecting the water when it detects fire. The key features of this system is to provide surveillance of fire so that major fire accidents can be prevented and loss of human lives gets minimized.

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2. LITERATURESURVEY

Tawfiqur Rakib, M. A. Rashid Sarkar 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. [1]

Saravanan P.SoniIshawarya 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 have a Bluetooth module that is connected with the smartphones in order to navigate it in the proper direction. [2]

S. JakthiPriyanka,R. Sangeetha proposed an android controlled firefighting 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 an open source software which is Arduino IDE is required to code and to implement that code in Arduino UNO. [3]

Nagesh MS, Deepika T V, Stafford Michahial, Dr M Shivakumar proposed a fire extinguishing robot which employs DTMF (Dual Tone Multi Frequency Tones) technology for the navigation of the robot and uses a flame sensor for fire detection that is capable of sensing flame of the wavelength range 760 to 1100 nm and sensitivity varies from 10cm to 1.5feet. [4]

Sushrut Khajuria, Rakesh Johar, Varenyam Sharma, Abhideep Bhatti proposed an Arduino based fire fighter robot which consists of RF based remote operation to operate the robot and water pump.The robot is controlled by the user within a range of 7 meters.It also consists of a wireless camera which helps user to move the robot in the required direction.[5]

Khaled Sailan, Prof. Dr.-Ing. Klaus-Dieter Kuhnert, Simon Hardt proposed an obstacle avoidance robot named as Amphibious Autonomous Vehicle. In this robot, a fuzzy controller is used to avoid static obstacle in real time. It aims to guide the robot or vehicle along its path avoiding all the obstacle that comes along the path.[6]

J Jalani1, D Misman1, A S Sadun1 and L C Hong1 proposed a automatic fire fighting robot with notification.This robot consists of three flame sensors for fire detection in left, right and center direction.It also consists of three ultrasonic sensors for obstacle detection and avoidance.When the robot detects fire it also sends a warning notification to the user using Bluetooth module.[7]

Shivam Agrawal,Nidhi Agrawal proposed that the human can control the robot by using the Bluetooth module. The Bluetooth module is work with the android application. In this the Bluetooth model communicate android application by using driving motor, Arduino mega, voltage divider, tires , Bluetooth, motor driver.[3] Saravanan P. ,Soni Ishawarya stated that there are three different types of system unit is use.[8]

Alessandro Pesatori, Alessandro Magnani, Michele Norgia" Infrared Image Sensor for Fire Location."[9]

Sreesruthi Ramasubramanian, Senthil Arumugam Muthukumaraswamy, A.Sasikala, "Edge Detection Comparison of Hybrid Feature Extraction for Combustible Fire Segmentation: A Canny vs Sobel Performance Analysis." [10]

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3. PROPOSED SYSTEM

It's a movable prototype of our chosen system, which includes flame sensors, gear motors and motor drivers for robot mobility, and a pump control relay that detects and extinguishes the flames. Typically, prototype movement is done at at a slow and uniform rate. When sensor detects the flame of fire in the vicinity, some signals verifying a fire is then input to Microcontroller, who subsequently extinguishes the fire. When a positive fire detection is acquired, the prototype will stop at the fire area, the pump will start, and water will be sprayed via a sprinkling nozzle by the time smoke has been extinguished. The total controls are done with an Arduino that is attached to an infrared sensor, allowing for autonomous control of the robot. The theme of this paper is to automatically sense the environmental fire and extinguish it without human intervention. The methodology is divided into three parts. The first part is on the design structure, followed by hardware description and the finally on the programming design. All these three parts were assembled together and experiments were then performed to build a system that can extinguish the fire that was carried out.

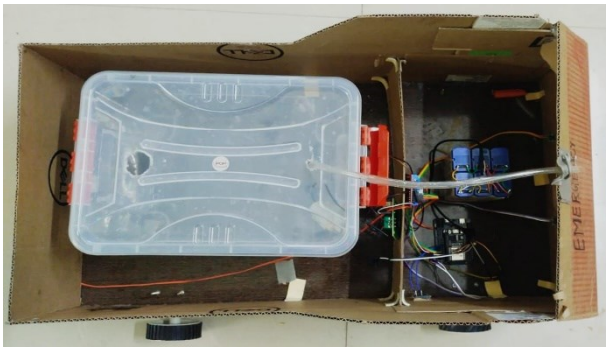

Figure1: *Proposedsystem.*

3.1 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.

3.2 Problem planning and Designing the Robot

3.2.1 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.

3.2.2 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.

3.2.3 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.

3.2.4 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.

3.2.5 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.

Figure 2: *Prototype of fire fighting robotic vehicle*

3.2.6 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.

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

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

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

4.EXPERIMENTALANALYSIS

The experimental analysis of the fire-fighting robotic vehicle focuses on evaluating its performance in detecting and extinguishing fires under various conditions. The robot is tested for accuracy, efficiency, and reliability in real-time fire scenarios.

Fire Detection Accuracy:
The robot is placed in different environments with controlled fire sources.Flame sensors and temperature sensors are tested for responsiveness to fire at varying distances.Detection range, sensitivity, and false alarm rates are recorded.

Water Sprinkler Performance:
The sprinkler mechanism is tested for its ability to rotate 180° and target fire precisely.Water flow rate and effectiveness in extinguishing flames are analyzed.
Time taken to suppress different fire intensities is measured.

Obstacle Avoidance Efficiency:
The ultrasonic sensors are evaluated for detecting and avoiding obstacles.The robot’s response time and navigation accuracy in cluttered environments are tested.Success rate in maneuveringaround obstacles to reach fire sources is recorded.

Bluetooth Communication & Control:
The GUI-based mobile control is tested for responsiveness and ease of operation.Bluetooth connectivity range and stability are analyzed.
Delay in command execution is recorded to ensure real-time control.

Autonomous Movement & Fire Suppression:
The robot's ability to autonomously navigate toward fire is evaluated.
Speed, path accuracy, and decision-making efficiency are

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tested.The effectiveness of automatic fire extinguishing without human intervention is observed.

Power Consumption & Battery Life:
The energy consumption of motors, sensors, and pumps is monitored.
Battery efficiency is tested under continuous operation.Optimal power management strategies are analysed.

Environmental Adaptability:
The robot is tested in different environments, including indoor and outdoor conditions.Performance under varying temperatures, smoke levels, and wind conditions is recorded.

Applications:
Fire-fighting robotic vehicles are designed to operate in hazardous environments where traditional firefighting methods may be ineffective or pose a significant risk to human life. These robots have a wide range of applications across different sectors:

IndustrialSafety:
Fire outbreaks in industries such as power plants, chemical factories, and manufacturing units can lead to catastrophic losses. Fire-fighting robots help in detecting and extinguishing fires in these high-risk areas, ensuring minimal damage and reducing the need for human firefighters.

Residential Fire Protection:
These robots can be integrated into smart home security systems to detect fire at an early stage and take preventive actions. This is especially useful in high-rise buildings and apartments where fire can spread rapidly.

CommercialBuildings:
Shopping malls, hotels, and office buildings require advanced fire safety measures. Fire-fighting robots can patrol such areas, detect fire hazards, and respond immediately before the situation worsens.

Warehouses & Storage Units:
Large warehouses and storage facilities often contain flammable materials. A fire-fighting robotic vehicle can monitor these spaces, detect fire at an early stage, and quickly extinguish flames to prevent major losses.

Hospitals & Laboratories:
Medical facilities house life-saving equipment, sensitive electronics, and hazardous chemicals. Fire-fighting robots provide an added layer of security by monitoring these areas and ensuring fires are controlled before they cause harm to patients and medical personnel.

Oil Refineries & Gas Stations:
These locations deal with highly flammable substances, making them one of the most dangerous places for a fire outbreak. Fire-fighting robots are designed to handle extreme conditions and safely extinguish fires in such environments without risking human lives.

Military &Defense Applications:
Fire-fighting robots are used in ammunition depots, military bases, and explosive storage facilities where fire outbreaks can be extremely dangerous. They help in minimizing potential explosions and protecting personnel and equipment.

Public Spaces & Transportation Hubs:
Airports, railway stations, and metro stations experience high foot traffic and require efficient fire safety systems. Fire-fighting robots can detect fire in such places and take immediate action before evacuations become necessary.

Remote and Hazardous Locations:
In areas like forests, tunnels, and mines, where human firefighters may struggle to reach, fire-fighting robots can navigate autonomously to control fire outbreaks. They play a vital role in reducing the spread of wildfires and ensuring underground safety.

Educational Institutions:
Schools, colleges, and universities are at risk of fire incidents due to laboratories, electrical faults, and cooking facilities. Fire-fighting robots can be deployed to enhance fire safety protocols and provide rapid response in case of an emergency.

Advantages:

The fire-fighting robotic vehicle is an advanced technology designed to improve firefighting efficiency, safety, and reliability. Some of its major advantages include:

Early Fire Detection:
The robot is equipped with flame and temperature sensors that detect fire at an early stage. This helps in preventing small fires from escalating into uncontrollable disasters.

Figure 3: *Represents the fire extinguish*

Reduces Human Risk:
Firefighting is a dangerous task that often puts firefighters' lives at risk. By using fire-fighting robots, human intervention in hazardous areas is minimized, ensuring safety for personnel.

Remote & Autonomous Operation:
These robots can be controlled remotely via a smartphone application using Bluetooth or Wi-Fi. Additionally, they can autonomously detect and move towards the fire, making real-time firefighting more efficient.

Efficient Fire Suppression:
The fire-fighting robot is equipped with a water sprinkler or ejector, capable of targeting the fire accurately. The 180° rotational water spray ensures a wide coverage area, effectively extinguishing the fire.

Obstacle Avoidance Capability:
Ultrasonic sensors enable the robot to detect obstacles in its path and navigate safely. This feature ensures that the robot reaches the fire source without getting stuck or blocked by

obstacles.

Works in Hazardous Environments:
The robot can operate in places where human firefighters cannot, such as areas with toxic fumes, high temperatures, or risk of explosion. This makes it ideal for chemical plants, nuclear facilities, and oil refineries.

Continuous Monitoring & Fire Prevention:
Fire-fighting robots can be used for constant surveillance in high-risk areas. By continuously monitoring temperature and air quality, they help prevent potential fire hazards.

Cost-Effective Solution:
Although fire-fighting robots require an initial investment, they reduce long-term firefighting costs by preventing extensive fire damage and reducing the reliance on human firefighters. This makes them a cost-effective solution for industries and public safety.

Adaptability & Versatility:
These robots can be deployed in different environments, including homes, offices, factories, and public spaces. Their adaptability allows them to handle various types of fire emergencies effectively.

Energy Efficient & Sustainable:
Fire-fighting robots are designed to operate with minimal power consumption. Many models incorporate battery management systems to ensure extended operation times, making them energy-efficient and environmentally friendly.

Quick Response Time:
Since the robot is always active and ready for deployment, it can reach the fire source much faster than traditional firefighting teams. This rapid response time helps in controlling fires before they cause significant damage.

Reliable and Safe Operation:
Unlike human firefighters, fire-fighting robots do not experience fatigue or panic. They operate consistently with high efficiency, ensuring reliable fire detection and suppression.

CONCLUSION:

Accidents caused by fire can result in significant injury and property loss. This paper presents fire detection and extinguishment using autonomous robot, as well as a complete assessment of several fire-fighting robots. This will undoubtedly result in a better system for monitoring water quality, and the water resources can be rendered safe by fast action. Despite the fact that there has been numerous good fire-fighting devices, the research topic remains tough. This paper provides an overview of current research efforts by researchers to make fire-fighting robots smarter, less expensive and more efficient. The use of cutting-edge sensors for measuring various quality criteria as well as the usage of wireless communication standards for improved efficiency.

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