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Arduino Based Fire Fighting Robot

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Abstract: *In recent years, fire accidents have become increasingly common, leading to significant loss of life and property. To address this issue, we propose an Arduino-based Fire Fighting Robot designed to detect and extinguish fire in its vicinity. This robot is a prototype of an autonomous system capable of identifying fire hazards and responding without human intervention, making it ideal for use in environments that are unsafe for humans.*

The robot is equipped with flame sensors to detect the presence and intensity of fire. Upon detection, the robot navigates toward the fire source using DC motors and a motor driver module, controlled by an Arduino microcontroller. Once in proximity, the robot activates a water pump or fan mechanism to extinguish the fire. Additional components such as ultrasonic sensors are used for obstacle avoidance, ensuring safe and accurate movement.

This project demonstrates a cost-effective and efficient solution to early-stage fire fighting, especially useful in industries, homes, and laboratories. With further enhancements, such robots can be integrated into fire safety systems to improve emergency response and reduce risks to human life..

Keywords: Arduino; Fire Fighting robot

I. INTRODUCTION

Cultural property management is entrusted with the responsibility of protecting and preserving an institution's buildings, collections, operations and occupants. Constant attention is required to minimize adverse impact due to climate, pollution, theft, vandalism, insects, mold and fire. Because of the speed and totality of the destructive forces of fire, it constitutes one of the more serious threats. Vandalized or environmentally damaged structures can be repaired and stolen objects recovered. Items destroyed by fire, however, are gone forever. An uncontrolled fire can obliterate an entire room's contents within a few minutes and completely burn out a building in a couple of hours. Hence it has become very necessary to control and cease the fire to protect the Life and costlier things. For that we purposed to design and fabricate the fire-fighting robot.

Autonomous robots can act on their own, independent of any controller. The basic idea is to program the robot to respond in a certain way to outside stimuli. The very simple bump-and-go robot is a good illustration of how this works. This sort of robot has a sensor to detect obstacles. When you turn the robot on, it zips along in a straight line. When it finally hits an obstacle, the impact is on sensors, i.e, sansors may get damaged. Using Ultrasonic sensor and programming logic, the robot is guided to turn right and move forward again, when the robot finds an obstacle in its way. In this way, the robot changes direction any time it encounters an obstacle. Advanced robots use more elaborate versions of this same idea. Roboticists create new programs and sensor systems, to make robots smarter and more perceptive. Today, robots can effectively navigate in a variety of environments.

II. LITERATURE REVIEW

Fire accidents are among the most devastating threats to life and property, often occurring in environments that are hazardous or inaccessible to human responders. To address these challenges, researchers and developers have turned toward automation and robotics. The “Arduino Based Fire Fighting Robot” is one such initiative that leverages embedded systems and sensors to detect and extinguish fire in its early stages.

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1. Fire Detection Systems

Numerous studies have focused on fire detection using a combination of flame sensors, temperature sensors, and infrared (IR) sensors. According to [Kumar et al., 2018], integrating flame sensors with temperature feedback improves the accuracy of fire detection. These sensors can be calibrated to detect fire within a specific range and trigger actions accordingly.

Arduino as a Microcontroller Platform

Arduino boards (e.g., Arduino Uno or Nano) are widely used in robotics due to their ease of programming, affordability, and a vast support community. As per [Patel & Shah, 2017], Arduino's GPIO pins allow seamless interfacing with various modules such as flame sensors, servo motors, and water pumps, making it ideal for rapid prototyping in fire-fighting robots.

2. Mobility and Navigation

To ensure mobility in hazardous environments, many prototypes use DC motors with motor drivers (e.g., L298N) for movement. Research by [Singh et al., 2019] introduced obstacle-avoiding features using ultrasonic sensors to prevent collisions while navigating towards the fire source. Pathfinding algorithms and remote control mechanisms (via Bluetooth or RF modules) are often integrated to improve mobility.

3. Fire Extinguishing Mechanisms

Several projects have implemented miniature fire extinguishing systems. For instance, [Joshi et al., 2020] describe a robot equipped with a water pump and a small tank that activates upon fire detection. Others have explored alternatives like CO_2 sprays or fire-retardant chemical release systems.

III. PROJECT OVERVIEW

The project is designed to develop a firefighting robot using Arduino uno. The robotic vehicle is loaded with water pump which is controlled by servos. An ATMega 328 microcontroller is used for the desired operation. At the receiving end tow motors are interfaced to the microcontroller where two of them are used for the movement of the vehicle and the one to position the robot. The ultrasonic sensor adequate range with obstacle detection, while the receiver driver module used to drive DC motors via motor driver IC for necessary work. A water tank along with water pump is mounted on the robot body and its operation is carried out from the microcontroller output through appropriate command from the transmitting end. The whole operation is controlled by an ATmega 328 microcontroller. A motor driver IC is interfaced to the microcontroller through which the controller drives the motors, three ir flame sensors are fixed on robot chassis to sense the fire and to reach the destination to put off the fire.

IV. METHODOLOGY OF THE PROJECT

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

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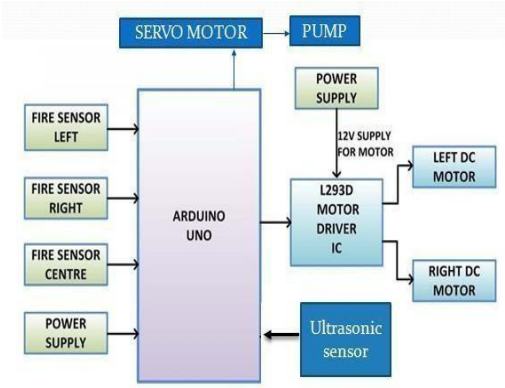

Fig. 2.1 Block Diagram

Components & Details:

Arduino Mega Board Model:

Arduino is an open-source computer hardware, open-source software and microcontroller-based device building kit and interactive objects that can sense and control physical devices. arduino designs and manufactures software, software and software.

The project is focused on the design of the microcontrollers. The board contains a combination of digital and analog input / output (I / O) pins, which can connect to specific expansion boards (termed shields).

L293D Driver Module

The Motor Driver is a module for motors that allows you to control the working speed and direction of two motors simultaneously. This Motor Driver is designed and developed based on L293D IC. L293D is a 16 Pin Motor Driver IC. This is designed to provide bidirectional drive currents at voltages from 5 V to 36 V.

LM393 Comparator

For sensors, there are normally two ways as output, the analog value or digital value output.

Analog value: Most sensors only provide the analog value, so it outputs a voltage value to indicate the sensing parameters. Arduino read this value on A0 to A9, and from 0 till 1023. In AVR, the analog voltage varies from 0V till 5V. We sign AO (Analog Output) as a pin name on many sensors' boards.

Digital Value: Sometimes we only want the sensors only give feedback when the sensing value read a threshold that we want, so when it reached the feedback is 1, and 0 vice versa. Here the LM393 IC do the voltage comparing here, a reference voltage (UR) is set by the adjustable potentiometer, when the analog output value over this value, the LM393 will output a digital value to indicate this sensor is triggered by reaching this setup threshold.

DC Motor

Motors convert electrical energy into mechanical energy. A DC motor is an electric motor that runs on direct current (DC) electricity.

V. ADVANTAGES

1. Early Fire Detection

• Equipped with flame, smoke, or temperature sensors to detect fires early.
• Can react faster than humans, potentially preventing major damage.

2. Low Cost & DIY Friendly

• Arduino boards and basic components are inexpensive and widely available.
• Suitable for hobbyists, students, and small-scale deployments.

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3. Human Safety
• Operates in dangerous or hard-to-reach areas, reducing the risk to firefighters and civilians.
• Can work in environments with toxic smoke or high temperatures.
4. Customizability and Flexibility
• Easily programmable to suit different needs (patrolling, fixed monitoring, IoT integration).
• Add-on modules (e.g., camera, GSM, Bluetooth) enhance functionality.
5. Autonomous Operation
• Can navigate autonomously using line-following or obstacle-avoiding logic.
• Finds and extinguishes the fire without human intervention.

VI. APPLICATIONS

1. Fire Hazard Safety in Homes and Offices
• Can patrol or stay stationed in rooms to detect early signs of fire (e.g., flame or smoke).
• Automatically activate alarms or suppression systems.
• Reduce risk to human life by acting in the early moments of a fire.

2. Warehouses and Storage Facilities
• Detect and suppress fires in large storage areas, especially where flammable materials are kept.
• Useful in places with limited human monitoring or dangerous conditions.

3. Industrial Applications
• Operate in environments with high fire risks (chemical plants, manufacturing units).
• Monitor and manage fires in confined or hazardous zones where it may be unsafe for workers.

VII. CONCLUSION

The prototype of the fire fighter robot was efficiently designed. This prototype has facilities to be integrated with many sensors making it moves forward. The toolkit detects the infrared light emitted by the fire with photo diode and sends signal to controller. We intend to extend this work to provide a keypad programmed to allow manipulation of robot to move desired direction with help of motor driver module and extinguish the flames using water tank which is rotated at 180 degrees with help of servo in order for faster result. This future work will also explore to the use of a long- distance sensor with suitable hardware to get more better and faster results addition to the characters.

VIII. FUTURE SCOPE

The project has been motivated by the desire to design a system that can detect fires and take appropriate action, without any human intervention. The development of sensor networks and the maturity of robotics suggests that we can use mobile agents for tasks that involve perception of an external stimulus and reacting to the stimulus, even when the reaction involves a significant number of mechanical actions. This provides us the opportunity to pass on to robot's tasks that traditionally humans had to do but were inherently life- threatening. Fire-fighting is an obvious candidate for such automation. Given the number of lives lost regularly in fire- fighting, the system we envision is crying for adoption. Our experience suggests that designing a fire-fighting system with sensors and robots is within the reach of the current sensor network and mobile agent technologies. Furthermore, we believe that the techniques developed in this work will carry over to other areas involving sensing and reacting to stimulus, where we desire to replace the human with an automated mobile agent.

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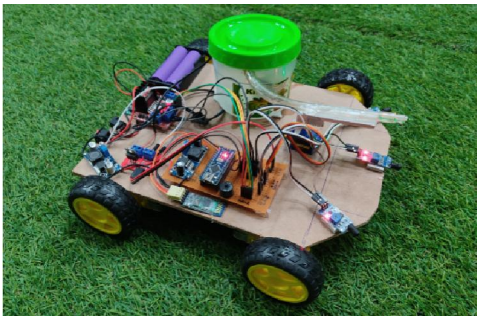
Result



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