DESIGN OF FIRE FIGHTING ROBOTIC SYSTEM FOR FIRE DISASTER CONTROL

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Abstract- The increasing occurrences of fire-related disasters necessitate advanced technologies for efficient firefighting operations. In this context, the development of fire-fighting robots emerges as a promising solution. This abstract outline the design, functionality, and potential applications of a cutting-edge fire-fighting robot. The fire-fighting robot is equipped with a robust mechanical structure designed to withstand high temperatures and navigate through challenging terrains. It integrates state-of-the-art sensors, including thermal imaging cameras and gas detectors, enabling real-time monitoring of the fire environment. These sensors provide crucial data for decision-making algorithms implemented in the robot's control system. The control system incorporates artificial intelligence algorithms for autonomous navigation, fire detection, and suppression. Machine learning techniques enable the robot to analyze environmental data and identify the presence and spread of fire with high accuracy. Upon detection, the robot autonomously devises an optimal path towards the fire source while avoiding obstacles.
Keywords: Arduino, sensors, L298 2A Motor Driver, BO motors, Servo motors.

1. INTRODUCTION

One of the most important parameter in fire disaster is life, i.e. lives lost in saving someone else life. It is sometimes impossible for fire-fighters personnel to access the site of a fire because of explosive materials, smoke, and high temperatures. A fast response to detect the fire can avoid many disastrous things. From the given statics (Fig.1), 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 domestics people is at risk because of poor fire management system. Fire can take many lives to 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 are to provide surveillance of fire so that major fire accidents can be prevented and loss of human lives gets minimized.

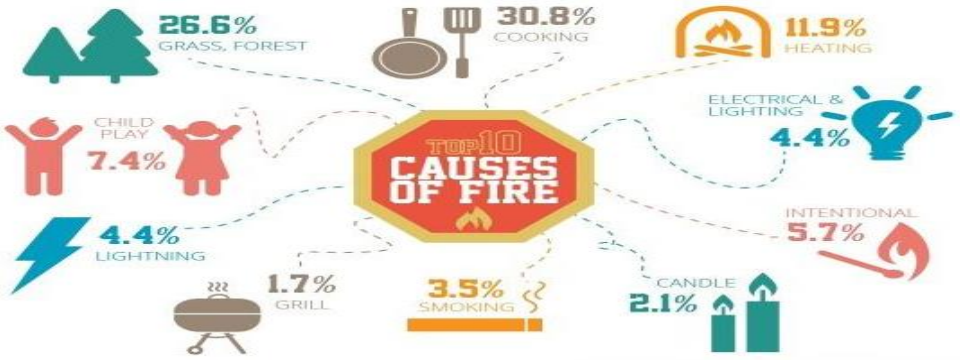

Fig. 1.1 Causes of Fire

The firefighter robot represents a significant advancement in emergency response technology, designed to assist firefighters in hazardous situations. Equipped with sensors and cameras, it can navigate through smoke-filled environments, detect heat sources, and assess the severity of fires without risking human lives. Its robust design enables it to withstand extreme temperatures and operate in challenging conditions. With remote control capabilities, firefighters can maneuver the robot to extinguish fires or locate trapped individuals, enhancing overall efficiency and safety during rescue operations. Additionally, its integration with AI algorithms allows for real-

time data analysis, providing critical information to responders for making informed decisions. Overall, the firefighter robot serves as a valuable tool in modern firefighting efforts, augmenting human capabilities and minimizing risks in dangerous environments.

2. PROBLEM FORMULATION

Fire disaster is one of the dangerous problems that can lead to heavy loss both financially and by taking lives. Sometime it becomes difficult for fighters to access the site of a fire because of explosive materials, smoke, and high temperatures. Such situations risk the lives of fire fighters too. In such environments, fire-fighting robots can be useful. This 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. Sometime delay in the arrival of fire fighters leads to numerous consequences. The Fire Extinguishing robot continuously monitors the environment and extinguishes it without delay.

3. LITERATURE SURVEY

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., Soni Ishawarya 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 4 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 has a Bluetooth module that is connected with the smartphones in order to navigate it in the proper direction. [2]

S. Jakthi Priyanka,R. Sangeetha proposed an android controlled fire fighting 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 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]

4. METHODOLOGY

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

4.1 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. Fig. 4.1 shows the basic prototype of our firefighting robot. 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.

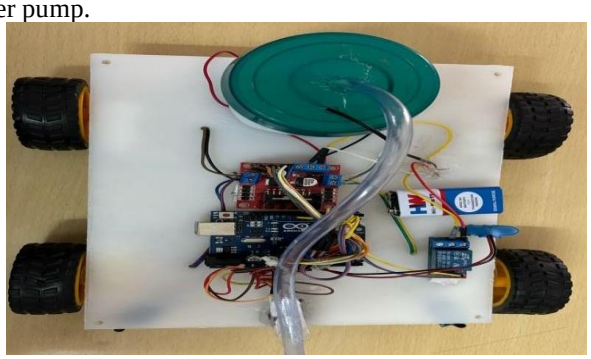

Fig. 4.1 Fire Fighting Robot

4.2 Hardware Implementation

The hardware part is one of the crucial parts in the development of firefighting robot. It includes Arduino UNO, IR flame sensors, servo motors, submersible water pump, motor driver, mini breadboard, BO motors, and rubber wheels. Fig. 4.2 shows the block diagram of firefighting robot which consists of three IR flame sensors as the input of the system. Arduino UNO is used as a micro-controller that connects other components. L293D Motor driver is used to drive motors and is capable of running two DC motors (Left DC motor and Right DC motor) at the same time.

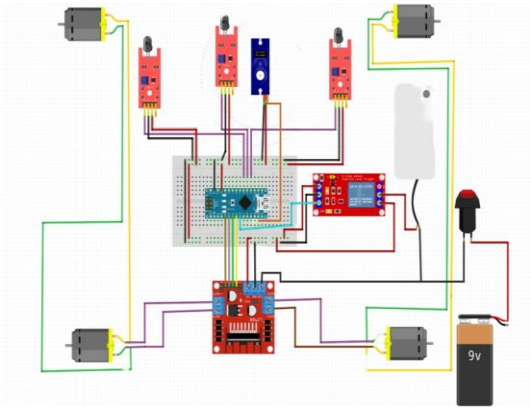

Fig. 4.2 Block diagram of Fire Fighting Robot

4.3 Hardware Used

4.3.1 ATmega328P IC (Arduino UNO)

Fig. 4.3 shows the Arduino UNO board. It is basically a micro-controller kit that is used to get data from peripheral devices (sensors, motors, etc.). The Arduino UNO Micro-controller board is based on the ATmega328P IC. The ATmega328P is good platform for robotics application which makes robot to extinguish fire in real time. Arduino UNO board consist the sets of digital and analog pins that may act as an interface to various expansion boards and other circuits. It contains everything needed to support the microcontroller.

Fig. 4.3 Arduino UNO

4.3.2 IR Flame Sensor

Fig. 4.4 shows the IR Flame Sensor. The IR flame sensor senses the environment and detects the presence of fire or flame. The module is based on the IR receiver and basically detects the presence of flammable and harmful gases like nitrogen, hydeogen, carbon mono oxide. The signal detection capacity is adjustable. The robot contains three flame sensors.

Fig. 4.4 IR Flame Sensor

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4.3.3 L298 2A Motor Driver

Fig. shows the L298 2A Motor Driver. L298 2A is a motor driver or motor driver IC which is responsible for the movement of DC motor on either direction L298 2A is a IC through which we are able to run four DC motors simultaneously in any direction.

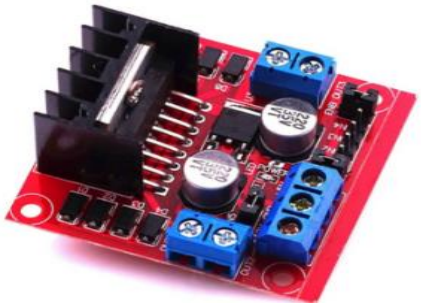

Fig. 4.5 L298 2A Motor Driver

4.3.4 Servo Motors

Fig. Shows the Servo Motors. Servo Motors are electronic devices that are mainly used for providing specific velocity and acceleration.

Fig. 4.6 Servo Motors

4.3.5 Submersible Water Pump

Fig. shows the submersible water pump. Submersible Water Pump is ideal for making automatic watering system using Arduino. The water pump is an important part of the robot as it will pump water to extinguish the fire.

Fig. 4.7 Submersible Water Pump

4.3.6 BO Motors

Fig. shows the BO motor. BO Motor is a dual shaft motor having 300 rpm. It converts electrical energy into mechanical energy. It is the replacement to our metal gear DC motors. Our robot uses four single shaft motors.

Fig. 4.8 BO Motors

4.3.7 Programming

For programming, the Arduino software provides an integrated development environment (Arduino IDE) and core libraries. The Arduino IDE program is a software program written in Java language and based on the Processing. The Arduino IDE is basically a framework built on top of C and C++ and compiled using avr-gcc and AVR Libc. The open-source Arduino IDE makes it easy to write code and upload it to the Arduino Uno for execution. It is available for all major desktop platform i.e., Windows, Mac OS X, and Linux.

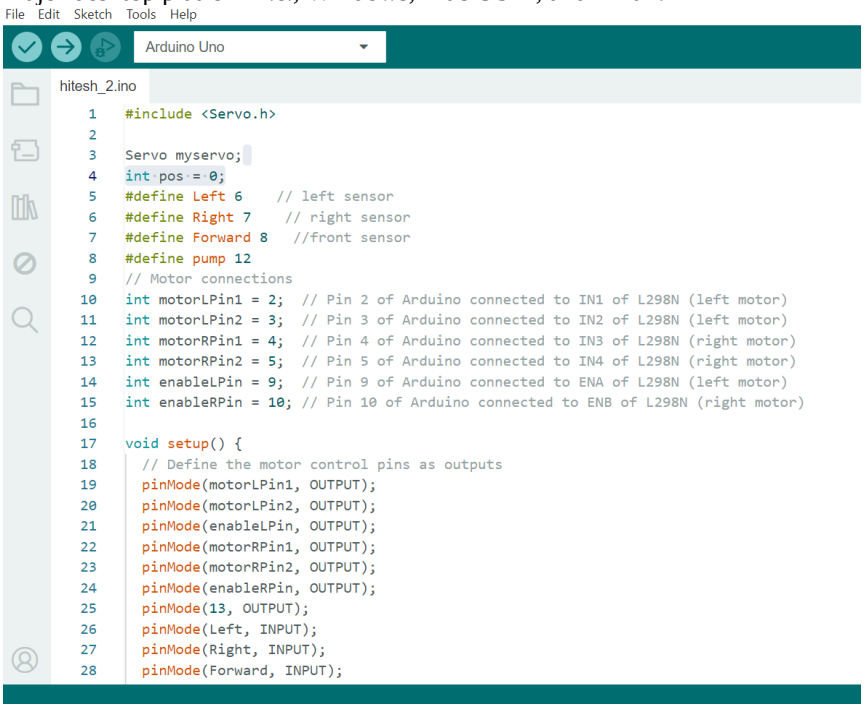

Fig. 4.9 The Arduino IDE Program

RESULT DISCUSSION

Fire Fighting Robot has developed to reduce human life lost and to develop such a device that automatically sense fire and extinguish it without human intervention. In this the fireplace is detected using IR flame sensors and are connected to Arduino UNO, which control the movement of Motor drive that helps the robot to reach the fireplace and extinguishes it with the pumping mechanisms In the industry if any fire accident occurs, there is a need of person to monitor continuously and rectify it. In this process if any time delay takes place irreparable loss occurs in industry. The firefighting robot continuously monitors the surrounding and helps in extinguishing the fire.Fig.11 shows the overall prototype of fire fighting robot.

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CONCLUSION

This model of Fire Extinguishing Robot aids to share out the burden of fire fighters in firefighting task. Our project aims to build a real time firefighting robot which moves in a constant speed, identify the fire and then extinguish it with the help of pumping mechanism. The detection and extinguishing was done with the help basic hardware components attached with the robot. Firstly, IR Flame sensors are used for the detection of fire. Secondly, BO Motors and Rubber wheels are used to navigate the robot to reach the fireplace. Finally, the robot extinguishes the fire with the help of submersible water pump and servo motors.

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