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INDUSTRIAL APPLICATION MULTITASK FIRE FIGHTING ROBOT DESIGN AND ANALYSIS

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Abstract
Fire accidents have been occurring frequently these days, with or without the intervention of humans. A fire incident is a disaster that can potentially cause the loss of life, property damage, and permanent disability to the affected victims. Fire fighters are primarily tasked to handle fire incidents, but they are often exposed to higher risks when extinguishing the fire, especially in hazardous environments such as nuclear power plants, petroleum refineries, gas tanks, etc. They also face other problems, especially if a fire breaks out in a small, cramped area, as they need to explore the ruins of buildings and obstacles to extinguish the fire and save the victim. In the case of high barriers and risks in fire fighting activities, innovation can be used to assist the fire brigade. With the use of current technology, we have developed a fire-fighting robot. This fire fighting robot uses Different sensors fire sensors, smoke sensors, temperature sensors, PIR sensors etc. When the Robot detects a fire, it gives a message to the Controller. Then controller sends the signal to the motor driver and thus water is sprayed in the direction of the fire. The Camera module is used for live operating of module. The PIR sensor detects the human being and starts the buzzer and give information about victim. It assists fire fighters in extinguishing the fire. And it will perform its operation where fire fighters can't reach. This will save the risk of fire fighters' life and avoid any further damage.

Keywords: NODEMCU, Servomotors, Flame sensor, PIR Sensor, ESP32 Wi-Fi Module, Relay, BO motor, Motor driver, Water Pump, 4-Wheel Robot Chassis Kit

Introduction

Cultural property management is entrusted with the responsibility of protecting andpreserving 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, itconstitutes 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 fewminutes 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 basicidea is to program the robot to respond in a certain way to outside stimuli. The very simplebump-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., sensors 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. Robot cists create new programs and sensor systems, to make robots smarter and more perceptive. Today, robots can effectively navigate in a variety of environments.

Literature

The previous research paper and their research on the Design and Working of Multitasking Robot. The information obtained from these papers is very helpful for designing, finalizing and specializing the Multitasking Robot. The source of the review is collected or studied from journals, websites, and books.

Mohd Aliff [1**]** explain robot is an automated device which performs functions usually attributed to humans or machines tasked with repetitive or flexible set of actions. Numerous studies have shown that robot can be beneficial in medicine, rehabilitation, rescue operation and industry. Over the years, robotics has been introduced in various industries. The industrial robots are multi-function manipulators designed for more specialized materials, divisions, gadgets, or devices through various programmatic movements to perform various tasks.

Kazi Shahadat [2] this paper demonstrates the simulation and implementation of an autonomous firefighting robot which can automatically sense the smoke, fire and start to pump water over the flames. Flame and gas sensors were used to detect the fire and smoke. These two sensors can automatically detect fire and smoke & the robot navigates itself to the source of the fire & start extinguishing it by using the fire extinguishing system. This robot also consists with a container on top of the servo motor in order to control the path where water is being sprayed on. Two DC motors were used to control the motor movement while the robot is on operation mode to extinguish the fire.

Rasika Sohani [3]explains Robot is a machine that seems as though a person and performs different complex assignments. There are numerous kinds of robot. Here a FIRE Quenching ROBOT is proposed. This robot is furnished with a solitary fire sensor used to detect ecological fire and feed the signs to the microcontroller so as to trigger the siphon which sprinkles water so as to stifle the fire. This robot is made to be worked by utilizing Arduino Uno microcontroller. This robot actualizes the ideas of natural fire detecting, corresponding engine control. The engine driver is utilized for the bidirectional control of the engines prepared in the robot. Each guidance for movement control is given to the robot with the assistance of microcontroller.

Manoj Vinay [4] **t**he main objective of this paper is to build a Semi-Autonomous Robot which fights fire. The objective is to develop robot that navigates with the help of Android application through Wi-Fi, search certain area, find and extinguish the flame for different flame positions. It detects fire with the help of flame sensors and extinguishes fire by sprinkling the water. Robot will also be capable of live video streaming of a disaster-prone area through Wi-Fi. This Robot reduces the risk of human lives at the disaster-prone area.

S. Kavitha [5] the Fire Fighting Robots are most popularly searched to prevent the fire injuries and to improve the effectiveness of the robot. In order to determine the lead of the fire to the robot, smoke and fire (thermal) reflections can be clued. The paper aims to design a robotic fire extinguishing vehicle that can be operated both wirelessly and manually.

Teh Nam Khoon [6] Fire detection and extinguishment are the hazardous job that invariably put the life of a fire fighter in danger. By putting a mobile robot to perform this task in a fire-prone area, it can aid to avoid untoward incidents or the loss of lives. This paper describes the development of an Autonomous Fire Fighting Mobile Platform (AFFMP) that is equipped with the basic fighting equipment that can patrol through the hazardous site via a guiding track with the aim of early detection for fire. When the fire source is being identified, the flame will be promptly extinguished using the fire extinguishing system that is mounted on its platform.

Rahul Ray [7] the research paper is describes the design of a small autonomous Fire Fighting Robot. The Fire Fighting Robot is designed to search for a fire in a small floor plan of a house of the specific dimensions, extinguish the fire with the help of a toy hovercraft, and then return to the front of the house. This mission is divided into smaller tasks, and each task is implemented in the most efficient manner such as self-autonomous start of the robot, navigation of the robot in every room step by step, finds the fire in a specific room, approaches the fire at a very fixed distance, and extinguishes it and

finally returning to the front of the house. Finding the target or fire is achieved by the remote control. The very important and crucial concept of this Fire Fighting Robot is that it navigates and extinguishes the candle by colliding with the wall of the floor plan to at least extent

K. Shamili Devi [8] this paper presents the development of a fire fighting robot dubbed QRob that can extinguish fire without the need for fire fighters to be exposed to unnecessary danger. QRob is designed to be compact in size than other conventional fire-fighting robot in order to ease small location entry for deeper reach of extinguishing fire in narrow space. QRob is also equipped with an ultrasonic sensor to avoid it from hitting any obstacle and surrounding objects, while a flame sensor is attached for fire detection. This resulted in QRob demonstrating capabilities of identifying fire locations automatically and ability to extinguish fire remotely at particular distance. QRob is programmed to find the fire location and stop at maximum distance of 40 cm from the fire. A human operator can monitor the robot by using camera which connects to a smart phone or remote devices

M. S. M. Hasimi [9] this paper presents the development of a fire fighting robot having three DC motor, two for driving system and another single DC motor for ball suction subsystem and the fire blowing subsystem. Various sensors are also interfaced with PIC16F877A as feedback to the robot such as photoelectric sensors, fiber optic sensor and RGB color sensors. LCD display also gives the graphical information of the robot status to the user. For the programming part

, C language is used to determine the robot action gain from the sensors input

Amol. A. Bhosle [10] the prototype robot has four 100 rpm Battery Operated motors for driving system. Additionally, ATmega328P microprocessor also interfaces with various sensors namely MQ2 gas sensor, Flame sensor as feedback to the robot. With the assistance of a microcontroller, each guidance for controlling movement is given to the robot, with this assistance the robot can douse the fire.

Problem Definition

The Fire fighting Robot project intends to create a robotic device that can independently locate and put out flames in a variety of conditions. The robot will include cutting-edge sensors, AI algorithms, and fire fighting gear so that it can respond to fire emergencies effectively while posing the fewest hazards to human fire fighters.

The Robot is designed to develop a firefighting robot using NODEMCU. The robotic vehicle is loaded with water pump which is controlled by servos. An ESP32 CAMmicrocontroller is used for the desired operation. At the transmitting end using commandsare sent to the receiver to control the movement of the robot either to move forward, and left or right etc. At the receiving end tow motors are interfaced to the microcontroller wheretwo of them are used for the movement of the vehicle and the one to position the robot. The PIR sensor human 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 fromthe microcontroller output through appropriate command from the transmitting end. The whole operation is controlled by an NODEMCU microcontroller. A motor driver IC is interfaced to the microcontroller through which the controller drives the motors, 5 ir flame sensors are fixed on robot chassis to sense the fire and to reach the destination to put-off the fire.The key objective of robot is to Fire Detection, Navigation and mapping, Autonomous Operation, Communication and Coordination, Safety measures and Human Interaction:

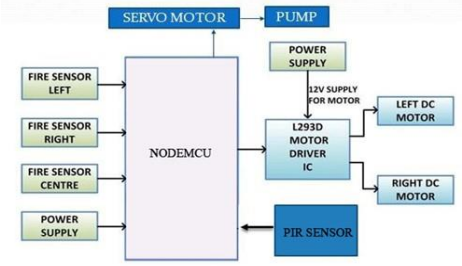

Figure 1: Overview design of Fire fighting Robot

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Figure 1 show the overview design of fire fighting robot.
There are at least five interfacing circuits, L293d driver module, Arduino-Uno with Microcontroller, flame sensors, ultrasonic sensors, servo motor and 5v pump. Here Arduino Uno acts a heart of paper, in the fig. 1 block diagram you can see that there are three flame sensors and ultrasonic sensor which acts as input interface to themicrocontroller and servomotor, pump ,driver module acts a output interface to the microcontroller, here the input and output interface can be indicated with the arrow lines with the respective the microcontroller performs with the respective commands and delaywhich is programmed on Arduino software.
These sensors have a FLEM SENSOR which is used to detectthe fire. How is this possible? When fire burns it emits a small amount of Infra-red light,this light will be received by the receiver on the sensor module. Then we use an Op-Amp to check for change in voltage across the Receiver, so that if a fire is detected the output pin will give 0V(LOW) and if the is no fire the output pin will be 5V(HIGH). So, we place three such sensors in three directions of the robot to sense on which direction the fire is burning. We detect the direction of the fire we can use the motors to move near the fire by driving our motors through the L293D module. When near a fire we have to put it out using water. Using a small container we can carry water, a 5V pump is also placed in the container and the whole container is placed on top ofa servo motor so that we can control the direction in which the water has to be sprayed.

Methodology
The objectives of the Fire Fighting Robot are -
1. Design and development of low-cost multifunctional robot.
2. Run automatically robot/human detection.
3. Extinguish fire & supply medical facilities.
4. To detect fire in the disaster-prone areas.
5. Also provide audio and visual indication.

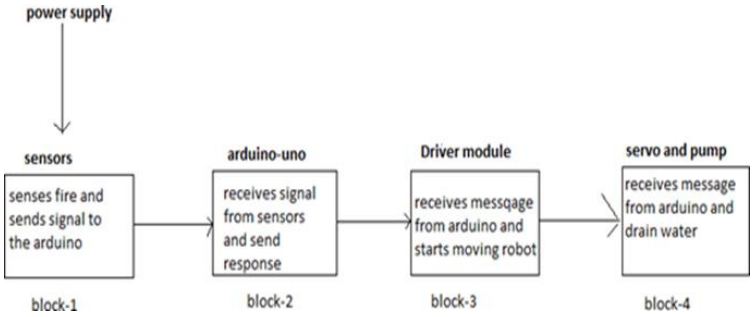

Figure 2: Functional working of Robot

The constituent parts involved in the process are sensors, Arduino with Atmel Atmega328 microcontroller, L293 driver module & Servo with pump
Fig.2 shows the functional working of robot in which First block portrays to be sensors which receives, verifies and forwards the messageto the Microcontroller. Micro is the second block. Micro processes the message and sendsto the driver module. Driver module behaving as the third constituent part and servo pumpacts as fourth part which extinguishes the fire.

Software requirements for robot-
Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensionsfor different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations.

```
include <Servo.h>
Servo Myservo;
int pos = 0;
int Status = D1;
int sensor = D8;
#define Left D5     // left sensor
#define Right D6    // right sensor
#define Forward D7  //front sensor
#define pump D2

void setup() {
  //pinMode(D2,INPUT);
  Myservo.attach(16);
  pinMode(pump, OUTPUT);
  pinMode(sensor, INPUT); // declare sensor as input
  pinMode(Status, OUTPUT);  // declare LED as output
}

void loop()
{

  if (digitalRead(Left) == 1) {
    digitalWrite(pump, HIGH);
    Myservo.write(180);
    delay(1000);
    Myservo.write(0);
    delay(1000);
  } else {
    Myservo.write(0);
    digitalWrite(pump, LOW);
  }
  long state = digitalRead(sensor);
  delay(1000);
    if(state == HIGH){
      digitalWrite (Status, HIGH);
      Serial.println("Motion detected!");
    }
    else {
      digitalWrite (Status, LOW);
      Serial.println("Motion absent!");
      }
```

Figure 3: Uploaded Program to the Arduino

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Data Flow Diagram

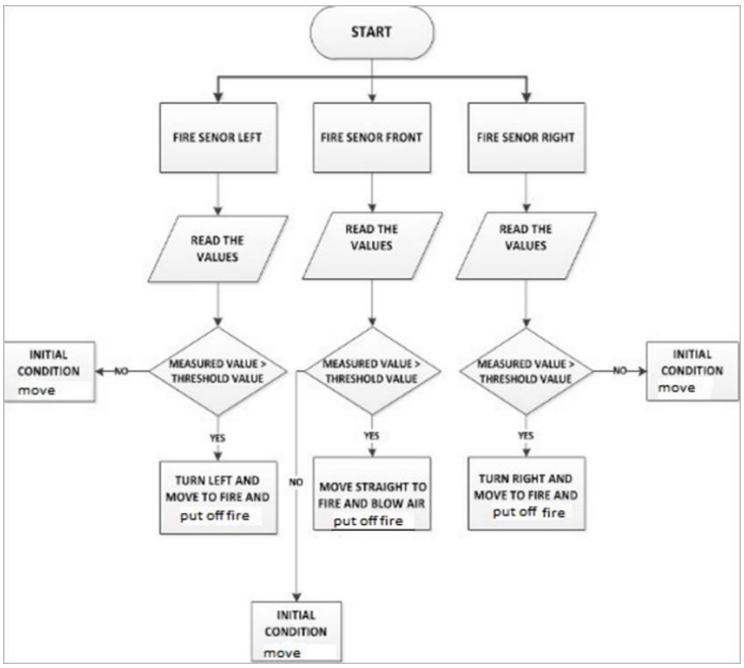

Figure 4: Flow Chart of Robot

Fig. 4 explains the data flow of robot design. The flow starts by initializing the ports of components. First the power supply should be on to the circuit and three sensors are there one on middle and remains two on right and left side of chassis whenever the fire is occurred the respective value is read by the sensors when fire is occurred the voltage becomes zero and chassis is moved to the respective and put off fire whenever there is no fire then there is no input is occurred occurred voltage is more than 0 volts and the initial condition is move to other direction

Implementation and Testing

Make the necessary connections and upload the code to Arduino UNO. To test the functionality of the flame sensor, place a fired lighter or a match stick in front of the sensor. Under normal conditions, the output from the Flame Sensor is high. When the sensor detects any fire, its output becomes LOW. Arduino detects this LOW signal on its input pin and activates the Buzzer. For example, if the object is 10 cm away from the sensor, and the speed of the sound is 340 m/s or 0.034 cm/µs the sound wave will need to travel about 294 u seconds.But what you will get from the Echo pin will be double that number because the sound wave needs to travel forward and bounce backward. So in order to get the distance in cm we need to multiply the received travel time value from the echo pin by 0.034 and divide it by 2.Fig.5 show the microcontroller flame sensor interfacing of robot.

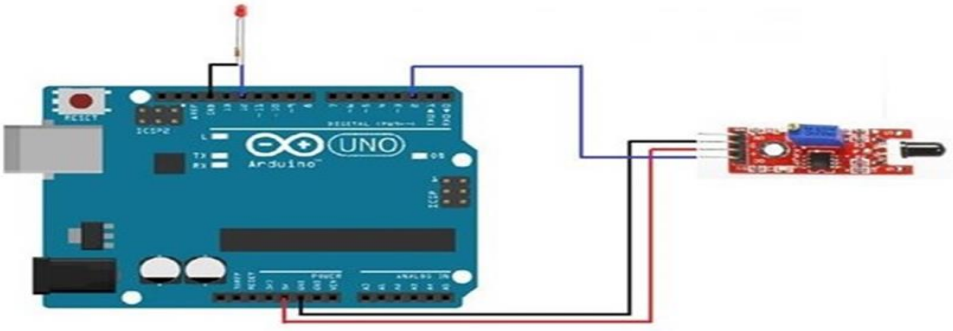

Figure 5: Microcontroller-Flame Sensor Interfacing

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Programming Overview

About Arduino Uno R3 Programming To programming Arduino Uno, you need the open-source Arduino IDE software that the card manufacturer company wrote. The Arduino IDE Program is a software program written in Java language, used to program Arduino cards and to download Arduino cards to Arduino cards. download the program that I downloaded from the firm's site (https://www.arduino.cc/) with this program. It has an editor that uses the Processing / Wiring language, the commands that resemble the C language in some places, and the supporting utilities for the projects (Library - library). Along with this, another company's editor (IDE) has been developed since Arduino includes open-source software. A boot loader (boot loader) has already been installed on ATmega328 on Arduino Uno. With this boot loader we can develop software without theneed for an external programmer to program Arduino. The programming work can easilybe performed by making the necessary settings and definitions in the IDE program.

Working Model

The initial stage of the paper is the part of Finding fire, fire sensor LM393 The fire sensordetects fire at a certain distance. It does not receive data from areas outside of the determinedarea. It was decided to use two Reducing motors in order to realize the motion system. Bothof these Reducing engines can move forward and backward. According to the obstacle state,if the motor is to be turned, one of the motors is given a reverse current by the processor andthe axial rotation is provided and the obstacle less driving is provided. Thus, every obstaclewas easily overcome in the environment where the system is located. Figure 6 show the working model of Multitask Fire Fighting robot

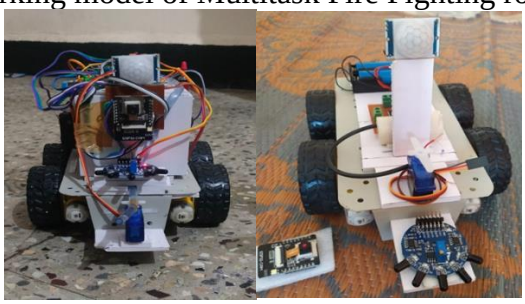

Figure 6: Working Model of Fire Fighting Robot

Conclusion

Results

In this paper, an autonomous Fire fighting Robot has been implemented which is capable of detecting flames & smokes and extinguishing them successfully. This robot can move forward, move left & right flawlessly. Due to the camera, we can see the live footage of process. The Flame sensor detects the fire and the motor will start to rotate & pump the water with the help of servo motor. The workings of robot are done by using mobile as well as remote also. The PIR sensor is detecting the human being and start the buzzer and notify to operator. This process will be continued until the fire or smoke has been extinguished completely. Then it will display about the safe environment. After successfully building the project, the simulation was run and the desired output was obtained. Proper snapshots of the results were attached. Thus, an autonomous firefighting robot has been built to achieve the objectives of this project successfully.

Conclusion

Prototype of the fire fighter robot was efficiently designed. This prototype hasfacilities 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 robotto move desired direction with help of the motor driver module and extinguish the flames usingwater tank which is rotated at 180 degrees with help of servo in

order for faster result. Thisfuture work will also explore to the use of a long-distance sensor with suitable hardware toget better and faster results addition to the characters.

Future scope

The paper has been motivated by the desire to design a system that can detectfires and take appropriate action, without any human intervention. The development of sensor networks and the maturity of robotics suggest 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 amount of mechanical actions. This provides us the opportunity to pass on to robots' 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 cryingfor 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 otherareas involving sensing and reacting to stimulus, where we desire to replace the human with an automated mobile agent.

However, there has been research on many of these pieces in different contexts,

e.g., coordination among mobile agents, techniques for detecting and avoiding obstacles, on-the fly communication between humans and mobile agents, etc. It will be both interesting and challenging to put all this together into a practical, autonomous fire-fightingservice.

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