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Fire Fighting Robot

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Abstract: As per the recent technology, Robots take the place of humans in almost all the fields. Our aim is to design the robot capable of detecting fire and suppressing it. We hereby are trying to design and implement an autonomous robot capable of detecting and extinguishing flames, disasters can be avoided within minimal risk of human life. It also involves the obstacle avoidance, GPS and GSM modules in cooperated within this robot.

Keywords: CO₂, IDE, Autonomous, Microcontroller, Extinguisher

I. INTRODUCTION

Chemical process that releases heat, light and other various other products is known as fire. At some point of the reaction, flames are produced, flames generally consist of CO₂, water vapor, nitrogen and oxygen. Fire is a process which is important in affecting ecological system. Thus fire has both positive and negative impacts. Positive impacts may include simultaneously growth and maintenance of various ecological systems. Similarly negative effects may include hazard to life and property, pollution, removal of vegetation, loss of nitrogen in the soil etc. There are different classes of fire such as Class A, Class B, Class C, Class D, Class E. Here, we are mainly concentrating on Class A, Class E, Class B forms of fire. The robot provides protection from any kind of fire accidents, it avoids electrical hazards since it makes use of CO₂ for extinguisher. The robot has a range of about 2-3kms. Since it makes use of GPS and GSM technology, the robot can be used during massive fire accidents to send a message to the near by service station. The robot is compatible with all the classes of fire and is human friendly

II. LITERATURE SURVEY

The motion control in robotics system is divided into two categories, sensor based systems and vision based system. The sensor based system is controlled by the feedback from different kinds of sensors i.e., obstacle sensors, IR sensors, Flame sensors etc. Whereas vision based system uses image processing technique. The fire-fighting robot is an unnamed ground vehicle, designed to find and extinguish fire [1]. There are fire detecting systems which are generally fixed on the wall and ceiling. This method is not flexible to detect fires. The design of fire-fighting robot to detect fire and extinguish it was designed [2]. In order to fight the fire a robot was designed which was able to transmit fire event to the supervised computer using RF interface and the internet, and transmit the fire information to cell phone using GPS [3]. Since there are different classes of fire, the same kind of extinguisher cannot be used to extinguish them, a robot which makes use of extinguisher with gas such as CO₂, N₂, found more advantages compared to robot using water. For example, these robots can provide electrical insulation, they avoid water damages to electrical equipment's, paper materials, etc. They are also useful in spaces hidden from extinguisher [4]. [5] PID controller based on the back propagation neural network was introduced to reduce the error rate and adjust concurrently in Realtime. The 'size and weight' and 'cost and performance' are major drawbacks of such kind of robots. Fire accidents in industry involve combustible materials for example, petroleum and other chemicals. When fire fighting units engage in such situation there is a high risk of life of fire personnel's. In our day to day life it is not feasible to always rely on human patrol during fire accidents. If an automated system is made to patrol the perimeters of fire accidents and which also has a warning system is more effective to avoid fire accidents in industrial areas [6]. An autonomous robot was designed with a security system which was able to detect the abnormal and dangerous situation and notify the user [7]. A fire fighting robot which works on sensor based method was designed which was made up of aluminum frame with the diameter of 50 cm and height of about 130 cm. There are six systems, including structure, obstacle avoidance, driver system, software development system, fire detection, remote supervisor system and others. The robot made use of two flames sensors [8]. Another work on fire fighting robot has been presented in [9] which uses fuzzy logic, WIFI enabled camera to detect and locate the fire accident. This robot was mainly designed for path guidance during emergency situations. The design of multi sensor-based fire extinguisher robot is presented in [10]. The robot is able to operate in multiple modes. It has DTMF, Bluetooth remote control as well as GPS technology. It uses three different kinds of sensors, flame sensor, temperature sensor, and smoke sensor.

III.METHODOLOGY

The fire-fighting robot designed in this paper is compatible with class A ,B ,C ,D and E .It makes use of CO2 cartridge to extinguish the flame, the cartridge is mounted on the robot which discharges when fire is detected. It is done by attaching a servo motor to the leveler to discharge the cartridge. The robot has a field view of 180 degree to detect flames with obstacle avoidance and maneuver in the surroundings. It makes use of different kinds of sensors .The flame sensors are placed 60 degree apart in order to achieve 18 degree field view. The robot also consist of GPS systems which on receiving proper signals, sends a message with a near by fire station as well as to the person in concern to it.

A. Hardware Implementation

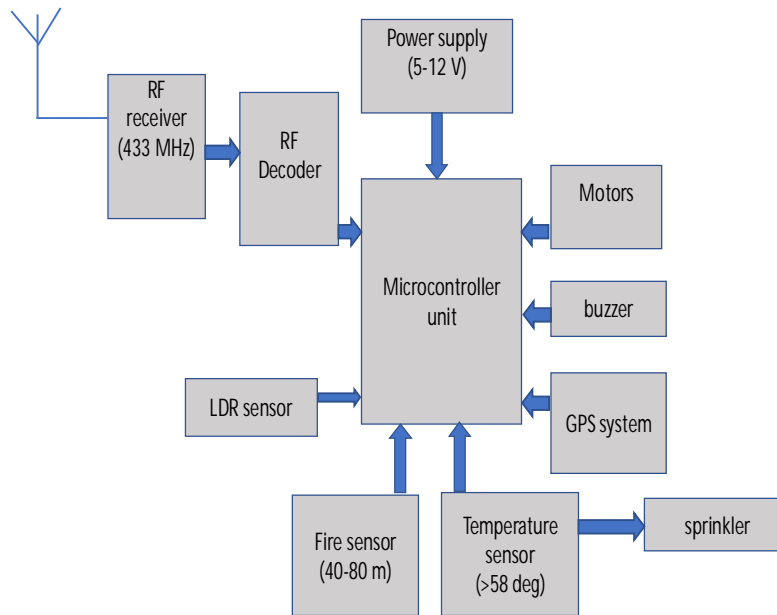


Fig A: Hardware block diagram

The four wheeled differential drive robot with desired mobility and speed is used for this application. The microcontroller is used to read analog and digital values sensed from the sensor and also to send control signals to the motor controller board. In order to generate a PWM signal, to control a servo motor attached to the robot tire inflator to discharge CO2. Thus it can be achieved by mounting a suitable servo motors arm to control the inflator. This can be mounted on existing differential drive robot. By turning the servo motor on, the CO2 can be discharged from the cartridge. It is noted that a high torque servo motor such as HS5685 should be used to discharge CO2. The flame sensor produces an output i.e., digital and analog signal, in order to obtain higher accuracy we use the ADC to read analog signals instead of digital values.

There are three flame sensors used with the detection angle of total 180 degree with each sensor having detection angle of 60 degree. The flame sensor operates from 5V-3.3V. its detection range varies from 20-100cm. the distance increases with increase in this flame intensity. The output from the ultrasonic sensor is used to find distance between the robot and the obstacle along with interfacing microcontroller.

As shown in the fig A, the block diagram is modified from Bluetooth to GPS & GSM communication. This also provides us with sufficient data, not only avoid the obstacles but also to maintain a safe distance between fire source and extinguish the fire. The GPS receiver gets the signal from GPS satellite. It transmits an exact time when the signals are sent. The GPS receiver can determine the position in three dimensions, east, north, altitude. Here GPS itself does not require an internet connection but it makes use of MAPS app. Other than flame sensor there is an ultrasonic sensor which is mounted on the servo motor to pan the surroundings in order to choose a optimum path when it encounters an obstacle or fire.

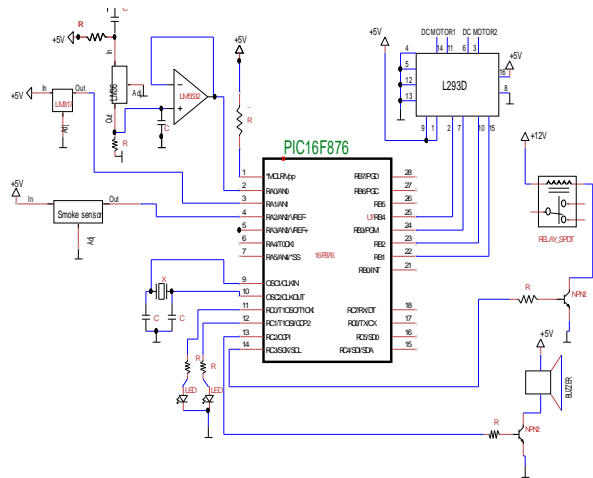


Fig B: Hardware circuit diagram

As shown in fig B, the robot consist of PIC16F876 microcontroller, flame sensors, ultrasonic sensors, infrared sensors, smoke sensor, smoke cartridge, motor drivers, buzzer.

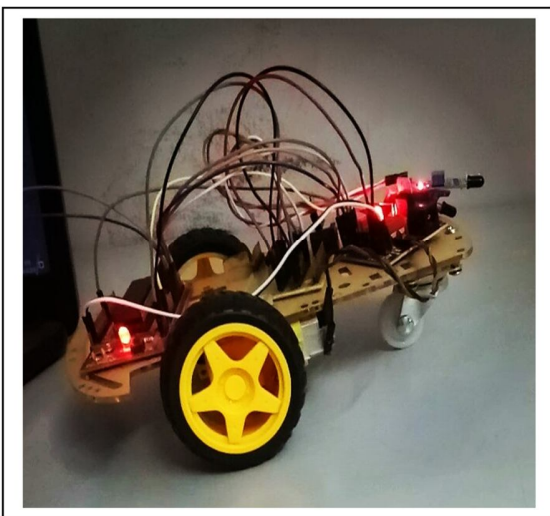


Fig C: Prototype

B. Software Implementation

The microcontroller is programmed using Micro Pro C. Once the robot is powered on, it will initialise a digital I/O pin as an output in order to send control signals to ultrasonic distance sensor. The ultrasonic sensor returns a pulse whose duration is equal to time taken for the ultrasonic pulse to travel from sensor to the object and reflect it back. This pulse is sent back to the I/O pin of the sensor. Hence the digital I/O pin should be made as input in order to read this input pulse. The pulse duration is received for the wave to propagate from sensor to the object and back again. Here we divide pulse duration by 2.

$$\text{Distance} = \text{pulse duration} / 2 / 29$$

Once the distance is computed compare it to a pre-set threshold value. Here pre-set threshold value is a safe distance the robot maintains from an object. This value can be obtained trail and error method. In case if the measure distance is more than threshold, the robot continues to move. forward. If the distance measured is less the servo motor to which UV sensor is mounted is controlled by sending PWM signals. The sensor is moved left to right to measure the least obstacle path.

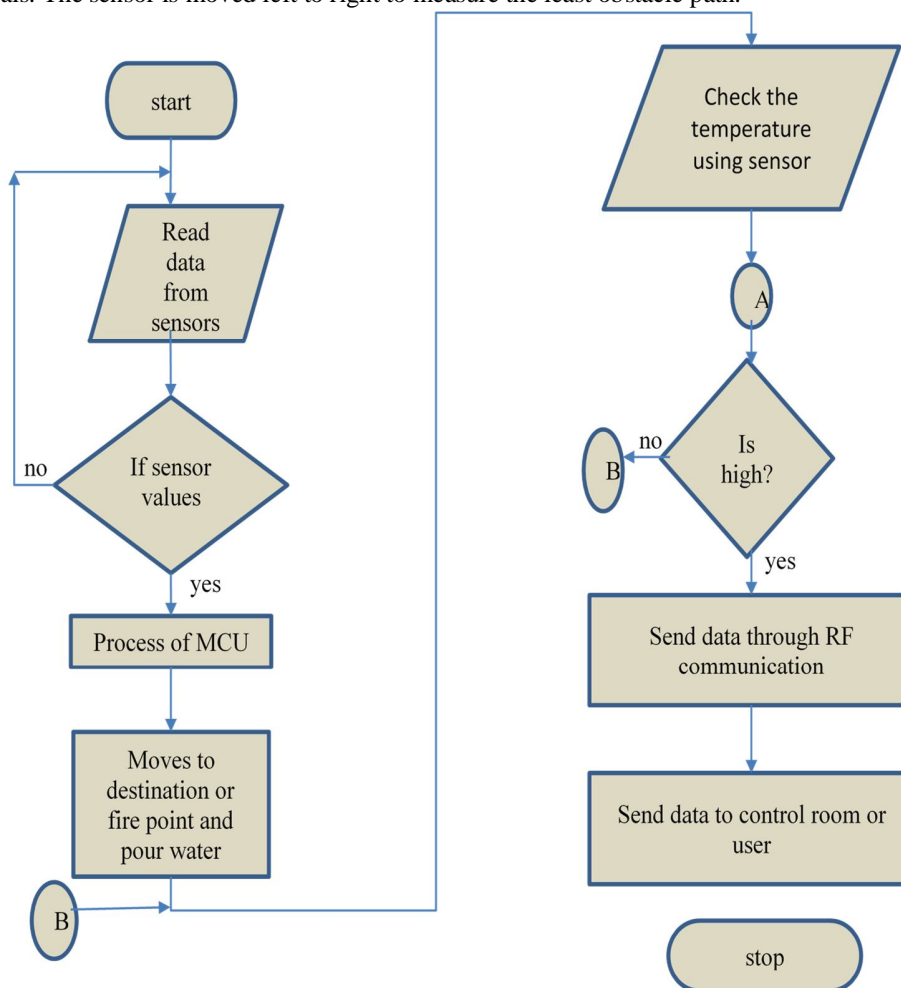


Fig D: Software flow chart

From the fig D, initially after initialising the variables the sensor reads the data and if the value is satisfied then the command is sent to the MCU unit or else the process is repeated. The output from the MCU is given to the motor driver in order to determine the direction. The temperature sensor senses the value, if condition is satisfied it sends the data to RF communication. Once the output of RF communication is processed, the output reaches the user or the control room. Hence after completing these process, the program control is terminated.

IV. CONCLUSION

Earlier, the device used to just sense the fire and send the message to the person in concern to it using Bluetooth. Bluetooth has got a small range, low speed and not much efficient when compared to other modes of communication. Presently, the fire fighting robot is capable of detecting flames and extinguishing them successfully. The motor and the microcontroller work together to control the movement of the robot with the obstacle avoidance. It can detect the flame more effectively in a building and fixed lighting condition. Here the robot is designed for only indoor application. Since the amount of daylight throughout the day, a dynamic threshold value is necessary to compensate for the change in ambient light. The use of high torque servo motor was necessary to discharge a CO2 cartridge. The use of GPS and GSM system that provides message to the nearby fire station in case of massive fire accidents is indirectly helpful in outdoor application.



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