PIR Sensor based Blaze Barricade using Raspberry Pi

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Abstract. Right from small fire accidents to the recent explosion cause by fire in Beirut, and many forest fires not only damages lots and lots of vegetation and kills animals but also gives high risk to human lives and properties. Everyone is well aware that fire Extinguishing is extended dangerous and it damages environment in all nations around the world. Fire accidents causes lot of loss, causing hundreds of death and widespread damage to the property. A risk survey in India 2019 reports that a total of 1,13,961 people lost their lives due to fire accidents from 2010 to 2014, which is an average of 62 deaths a day. In this paper we develop a priority enabled robot which could control the fire extinguishers process as soon as possible. The design consists of various sensors like ultrasonic sensor which is used to detect object, PIR sensor which is used to detect human motion and Raspberry pi camera module is used to detect the fire. Raspberry pi is used to control the movement of the robot to reduce the fire extinguish.

1. Introduction

In India from 2010-2014 more than 1.2 lakhs deaths caused by the fire accident according to (NCRB) National Crime Records even though there are a lot of precautions taken against blaze accidents, these natural or man-made disasters do occur now and then. India Risk Survey 2017 states that the fire has been ranked fifth in the risk factors which up by three positions form previous year’s survey ranking. It also concluded that 42.1% of deaths were caused by fire accidents in residential buildings. Another major factor in fire accident damages is the fire fighters and other resources could not access to the fire more that some point. They can spray water or fire extinguisher from far away. Thus, we used robots to resolve this problem. A fire fighter robot has a capability to controls a fire quickly, preventing damage and rescue victim. And also, the robots are easy to be equipped with many sensors as possible to collect information and control the situation. The robot is lightweight and automatically moves to the fire place. It collects information from the sites and send the information to the authorised person through GSM module. The robot is even attached with a small water tanker and water pump. This will make the robot to control the fire as early as possible in case of small fire accidents.

2. Existing Method

In the existing method Shang Gao et al. proposed a fire fighting robot [1] which uses ATmega128 processor and sensors to detect the fire and also the method has a water spraying unit along with the water tank. In this method the test was done 5 times and at the end of 5th test the robot was unable to put off the fire due to lack of water. In such cases the fire will damage the building and nobody knows until they saw the fire outside the building.

Mukul Diwanji et al. proposed a robot design [2] to find the fire location. The development of this method consists of a hardware and software. The hardware part used Arduino Uno board and its
Arduino IDE programming. But the proposed method used Raspberry Pi module which is the advanced version of hardware. The performance is better when compared to Arduino module.

A.Q.M. Sazzad Sayyed et al. proposed a method [3] which consist of image processing technology. The usage of so many image processing methods required many computation cycles and require much time. Within the processing time, the fire will get increased and it means that the image is not effective for current time applications. All these methods [4] – [10] do not specify any solution for the case of detecting fire in more than one place.

In the proposed method use Raspberry Pi module for processing. The performance is higher when compared with the Arduino UNO module. It also used Raspberry Pi camera module to take pictures and GSM module to send alert to concern persons. It not only depends on image data but also used PIR and ultrasonic sensors for detecting fire. It is also attached with a water tank to take the first step in controlling the fire. The proposed method also follows the priority-based robot, which will take decision depends upon the given priority while encountering fire in more than one place

3. Proposed Method

The proposed Blaze Barricade firefighter robot consist of sensors, camera modules as inputs to the robot. A DC motor to control the wheels for the movement of the robot and a relay module. It also consists of a monitor and a storage unit. The complete unit is controlled by the Raspberry Pi processor. The proposed method uses wheeled locomotion for the robot with improved load capacity. It consists of four wheels which is controlled by the DC motor and derived by the Raspberry Pi processor.

3.1 Sensors

The proposed method mainly consists of two sensors, PIR and ultrasonic sensor. The PIR sensor is a passive infrared sensor which is used to detect motion which is given in Figure 2.

It consists of two slots, made up of special material which is sensitive to infrared radiation. These two slots detect same amount of infrared radiated from the environment at idle conditions. If a warm body intercepts the sensor, it will disturb one half of the PIR sensor and causes a positive differential
change between two slots. Once the warm body moves from the sensor, a negative differential change happens. These changes are detected as pulses by the PIR sensor.

The HC-SR04 Ultrasonic sensor is a 4-pin module. The pins are named as Ground, Echo, Trigger and Vcc. The sensor is used to measure distance of the objects. One of the two projections in the front panel transmits ultrasonic wave and the other receives the reflected ultrasonic waves. The distance of the object is measured by a simple formula, distance equals speed x time. The overall function of the ultrasonic sensor is, the ultrasonic waves are transmitted from the transmitter, which is reflected by the object and received by the receiver. The distance is calculated by speed of the ultrasonic waves and the time taken for the wave to reflected back to the sensor. Here, the universal speed of the ultrasonic waves is 330m/s and the non-contact range detection is from 2cm to 400cm and the operation voltage is 5V.

3.2 Camera Module
The Pi camera module given in figure.5 supports Raspberry Pi processor. It is mainly used for image processing, surveillance and machine learning applications. Because of its light weight, it is mainly used in surveillance drones. The Pi camera module can connect with computers as normal USB module other than the Raspberry Pi module.

The Pi camera module communicate with serial interface protocol. It also can be connected with ribbon cable with camera serial interface. Apart from these it can also be connected as USB also. The pin diagram for the camera module is given in figure 6.

3.3 Relay module
Relay is an electromagnetic switch used to control a high voltage supply by using a small control signal like microcontroller. The 4-channel relay module given in Figure.7 works with 5V and 15 to 20mA current and can control 250V and 10A AC supply or 30V and 10A DC supply. The interface present in the relay module can be used to connect the circuit directly with a microcontroller. When the signal port is low the signal light will glow and optocoupler 817c will conduct.
This will make the transistor to conduct and the relay coil to be electrified. Thus, open contact of the relay will be we closed. When signal port is high then the closed contact of the relay will be closed. Thus, the load can be connected or disconnected by controlling the level of signal port.

![Figure 7. Relay module](image)

![Figure 8. DC Motor driver circuit](image)

3.4 DC Motor and motor driver
The normal DC motor is used to rotate the wheels. To derive the DC motor the driver circuit is required. L293D driver circuit given in figure 8 is used in this proposed work. Each circuit is capable of driving two motor and the directions can be controlled independent to each other. So, for to drive four wheels of the robot two driver ICs are used.

3.5 Water pump
In the proposed work the R385 6-12V DC Diaphragm Based Mini Aquarium Water Pump. The proposed work is capable of using a bigger water tank and water pump. But, for the cost efficiency the smaller version was used. This pump is very effective in variety of liquids and can able to produce enough pressure for nozzles to spray water.

3.6 Display and SD card
The Raspberry Pi is connected with a 16×2 LCD display and also a memory unit for displaying and storing the image information for further investigation and analysis.

3.7 Raspberry Pi controller
The third generation Raspberry Pi 3 processor is credit card sized board which can able to done simple functions like a general computer. The quad-core Raspberry Pi 3 is faster and 50 to 60% better in performance. The Raspberry Pi 3 processor and its pin diagram is given in figure 9.
4. Implementation
The connections are given for all the sensors, modules and components as per the guidelines given in the manual of the devices. The robot can be enabled by two inputs. The flame sensors and the camera input. The flame sensors can detect the flames when the robot is nearby the fire place. The camera module is interfaced with the raspberry pi using the cable. The camera is capable of detecting 60° angle and the sensors are used to get 180° angle detection. The images taken by the camera modules are processed to find the flames. And also, when a fire is detected by the sensors, the camera will take images of the fire spot. Once the flames are detected the PIR sensor is used to find the human activity and the ultrasonic sensor is used to find the obstacles.

The robot is designed to give high priority to the place where PIR sensor detects movements. Then the processor enables the driver circuit to move the robot towards the fire spot. The wheels of the robot were driven by the DC motor via motor driver IC. As the robot is used inside the buildings the total map of the building with all the immovable are already loaded along with possible paths. The pump will be enabled to spray the water in the fire spot at the same time an alert is also sent to the authorized person by the processor. The still images are stored in the memory device and the display will show the location of the fire spot. Coding according to the process of the robot is done in the Raspbian software. The flow of the software is given in figure 10.

5. Conclusion
In this work we designed a blaze barricade robot that takes image of the environment and send a enabled signal to the processor. The robot also has a flame detector sensor to detect the flame. Once the flame is detected the raspberry pi enables the dc motor driver circuit through relay circuit. A wheel is attached to the dc motor. The robot moves to the location by controlling the direction of the wheel by using the map of the building. Once it reaches a safe distance it enables the water pump to spray the water. It sends an alert message to the authorized person and take images for further investigation. The robot is also programmed to give high priority to human and living creatures.
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