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## Automatic fire fighting robot with notification

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# Automatic fire fighting robot with notification

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**Abstract.** In real life, fire accidents can happen anytime and anywhere that usually hardly controllable. Fire accidents can damage the buildings, kill human and may cause unpredictable losses. In addition, death not only due to the fire but also from smoke inhalation and toxic gases. Therefore the fire security is important to human life. Note that the human is difficult to detect the fire in the location that is hard to reach or see by a human. Moreover, the human also may take a lot of time to extinguish fire due to the fact that finding a water source can be troublesome. Therefore, an automatic firefighting robot has been designed and proposed in this study. This robot used 3 flame sensors to detect the fire. It also equipped with 3 ultrasonic sensors for obstacle avoiding which protecting the robot and the internal components from any obstacles. Each sensor on the robot is controlled by the Arduino. Apart from the sensors, the robot is also equipped with the water tank that provides water once the fire is detected. The robot will move randomly in the room when the power is on. When the flame sensors detected the fire, the robot will move to the fire source and send a warning message to the user. Once the robot reached the burning area, it will stop at a certain distance and extinguish the fire by using water.

## 1. Introduction

The fire security of the home, office, and building is important to human life. A fast response to detect the small fire can avoid unpredictable damage and losses to human. However, it is difficult to detect the small fire in the location that is hard to reach or see by a human. The human also takes more time to find the water source to extinguish the fire. This will cause the fire to be spread quickly, which can increase death. Hence, to extinguish the fire within a short period of time and reduce the damage, an automatic fire fighting robot is proposed.

Robotics is one of the fastest-growing engineering fields. A lot of robots are designed to remove the human factor from labour-intensive or dangerous work. It also acts in an inaccessible environment. Today the use of robots is becoming more common than before and it is no longer exclusively used by the heavy production industries. A firefighting robot that is able to detect and extinguish the fire has been developed and used before. With the invention of such a device, people and property can be saved at a much higher rate with relatively minimal damage caused by the fire. To begin with, it is essential to design an autonomous robot and build a prototype system that could detect and extinguish fires automatically. The designed robot also able to move in a room with obstacle avoidance, detect the fire, extinguish it by using water and send a warning message to the user.

## 2. The design of the firefighting robot

Flame detectors represent one of the major types of automatic detection method and imitate the human sense of sight. They are the line of sight devices that operate on either an infrared, ultraviolet or combination principle. As radiant energy in the approximate 400 to 700 nanometers range occurs, as



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indicative of a flaming condition, the sensing equipment recognizes the fire signature and sends a signal to the fire alarm panel [1]. Kim et.al [2] had studied a fire alarm vision system based on flame detection algorithm of infrared images. From their studies, the presented flame detection algorithm measures the luminance variation of candidate flame blocks of the infrared image, then calculates the luminance variation value to determine the existence of fire. By using the test images, they performed the simulation of flame detection algorithms and tested the implemented fire alarm vision system.

The basic elements of this firefighting robot are the three flame sensors that monitor the temperature continuously. When the fire is detected, it is extinguished by water in the tank attached to the robot. But, if the temperature of the fire site is above 40°C, the alarm will be ringing so that the operator can control the firefighting robot to go back and avoid the damage of it [3]. This firefighting robot is designed to search for a fire in a small floor plan of a house, extinguish the fire and return to the front of the house at last [4]. In the target-driven obstacle avoidance model, the speed of a wheeled mobile robot is controlled by using fuzzy theory with sensor signals and allow it to move to a target location [5]. The ultrasonic sensor is the most suitable sensor for obstacle detection and avoidance because it is low cost and has a high range capability. The ultrasonic sensor is very compact and has a very high performance [6]. For the electronic circuit part, it consists Arduino Mega 2560, Adafruit motor shield V2, Ultrasonic Sensor, Flame sensor, HC-05 Bluetooth Module, 9V DC water pump, push-button, Lithium-ion Rechargeable Battery and AA Battery, 5V Single Channel Relay Module and a jumper wire. Table 1 shows the electrical components used in designing a circuit.

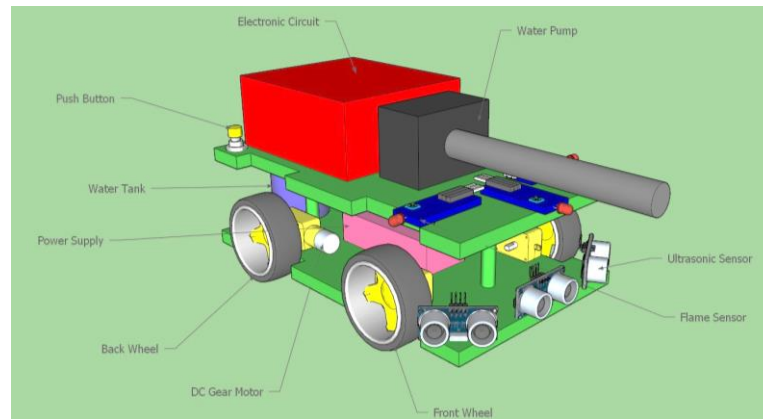
**Table 1.** Electric components for designing a circuit

Component	Features
Arduino Mega 2560	A microcontroller board based on the ATmega2560.
Adafruit motor shield V2	The motor shield is a driver module for motors that allows using Arduino to control the working speed and direction of the motor.
Ultrasonic Sensor	The ultrasonic ranging module HC-SR04 provides 2cm-400cm non-contact measurement function.
Flame sensor	The flame sensor is used to detect flame or infrared.
HC-05 Bluetooth Module	HC-05 Bluetooth module provides switching mode between master and slave mode which means it able to use neither receiving nor transmitting data.

The group in [7] had explored the implementation of Bluetooth technology in mobile robots. The mobile robot had the capability to move around autonomously by using a complicated and powerful algorithm. A PC stored the algorithms and act as a master cum server. The mobile robot will transmit all sensor readings to the master and processed. Subsequently, the server will transmit command or instruction for further action to the mobile robot in a bi-directional full-duplex communication mode. It focuses on the interfacing between Bluetooth transceiver and microcontroller of the mobile robot.

### 3. The architecture of the robot

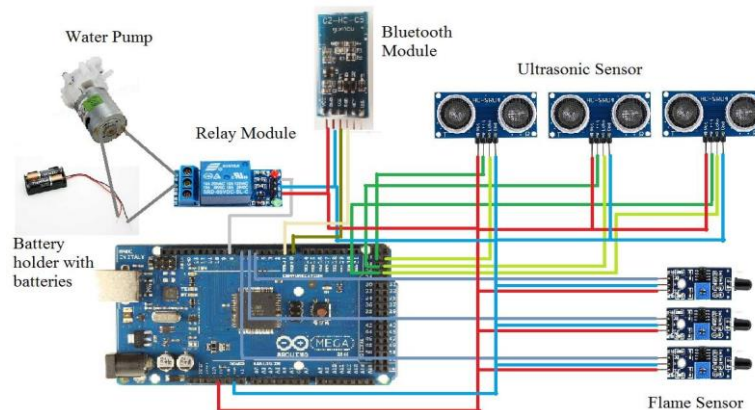
There are two parts to be considered in the firefighting robot design. The first part is a mechanical design as shown in Figure 1. Meanwhile, the second part is the software design where the SketchUp software is used. The software is a 3D modeling, computer program for a wide range of drawing applications such as architectural, interior design, civil and mechanical engineering.



**Figure 1.** Design of the prototype.

#### 3.1. Connection between Components

There are a lot of connections between components and Arduino by using jumper wires. The 4 DC gear motors were connected to the motor driver shield. All the components excluded DC gear motors are connected to an Arduino board as shown in Figure 2.



**Figure 2.** The connection between components and Arduino.

### 4. Arduino Software

In order to control the firefighting robot, Arduino Software was employed. Arduino programs may be written in any programming language with a compiler that produces binary machine code. The Arduino project provides the Arduino integrated development environment (IDE), which is a cross-platform application written in the programming language Java. The Arduino IDE supports the languages C and C++ using special rules to organize code. When the firefighting robot detecting the fire, it will send a warning notification to the user via phone by using Bluetooth module. Therefore, Arduino Wireless Vibration Apps was used to receive the signal from the Bluetooth module. If the flame sensor is triggered, it will send data “1” to android smartphone and giving a notification with sound and vibration on the Android smartphone by using this application. Vibrate interval and alarm sounds are adjustable in this application.

## 5. Results

Figure 3 shows the final configuration of an Automatic Fire Fighting Robot with notification. The control circuit is located at the top of the robot body. The size of the robot is (26 x 16 x 18) cm. The robot will operate in the auto mode after switch on, it will move randomly in house, office or any place that required early fire extinguisher. During the auto mode, if there is no fire detected, it will keep on moving and scanning. Meanwhile, if fire detected, it will move toward the fire source and activate the water pump to pump the water to extinguish the fire. If the left flame sensor detecting fire, the left sensor will send the data to Arduino telling that the fire is at the left-hand side, the Arduino will send the command to the motor driver to turn the robot to left direction. The robot will remain turning to left direction until the front flame sensor detecting fire. When the front sensor detecting fire, the sensor will send the data to Arduino to tell the Arduino that there is a fire in front of it. Then the Arduino will send data to the motor driver shield and motor driver will activate the motors to move the robot backward the fire if the fire is too close to the robot. Otherwise, if the fire is too far from the robot, the motor driver will activate the motors to move the robot forward to the fire. This process will be the same if the right flame sensor detecting fire.



**Figure 3.** Automatic Fire Fighting Robot with Notification

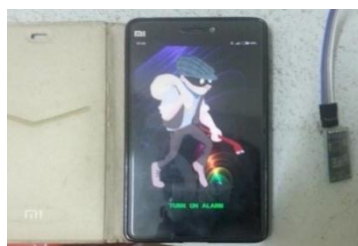
## 6. Analysis

### 6.1. Fire Detection and Extinguishing

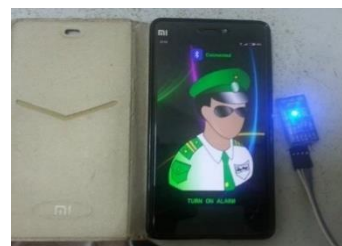
The flame sensors will only activate to detect fire when the robot is powered on. The operating voltage for the flame sensor is 5V. Voltage supply for these sensors is from Arduino that supplied by using 7.4V Li-ion rechargeable battery. The voltage will decrease when the sensors detect fire. The voltage will decrease from 4.8V to 0.1V, if the voltage continues to decrease until reached 0.1V, the sensor will recognize the input as “fire” and send digital data to Arduino. The Arduino will determine which sensors are sending the data and send commands to the motor driver for activated the DC motor, Hence the DC motor triggered according to which sensor detecting fire first. The robot will move toward the fire until it reached extinguished range set in the program. When the robot reached the extinguished range, it will start to pump the water from the water tank.

### 6.2. Sending Notification by Bluetooth Module

“Automatic Fire Fighting Robot with Notification” able to send a warning notification to the user when the robot detecting the fire. This can alert the user which action can be immediately taken to stop the fire by calling the firefighter. Of course, when action is taken by the user, the firefighting robot has performed its function.



**Figure 4.** Bluetooth module and inactive alarm



**Figure 5.** Bluetooth module and active alarm

This operation was carried out by using a Bluetooth module. Bluetooth module inside the robot able to send the notification to the user via smartphone after the robot detecting fire. When the user's smartphone received the signal from the Bluetooth module, it will vibrate and sound. Therefore, the user knows that there is a fire accident and able to immediately take action to control the fire. Figure 4 and figure 5 show the Bluetooth module and the alarm when the flame sensor detecting fire.

## 7. Conclusion

The automatic fire fighting robot with notification was able to detect and extinguish the fire. Besides, it is also able to move randomly in a room with obstacle avoidance function. The robot was successfully fabricated and functioned as expected. The hardware was developed according to the initial design and modified based on current conditions and improvements. In addition, the input voltage port and ground port of the sensors, Bluetooth module and relay was connected and soldering on the PCB in series. This is because there is only one port of 5V voltage supply from Arduino, but there are 8 components were required for the voltage supply for operation. Next, the coding was designed and developed using Arduino software. The completeness of the software library smoothens the project's process with the help of real-time simulation. However, it was observed that the accuracy of the fire extinguisher can be further improved despite the firefighting robot designed and presented here provides the significance assistance to human. This firefighting robot concept can be widely applied in various applications.

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