

# Multiple Sensors Based Fire Extinguisher Robot Based on DTMF, Bluetooth and GSM Technology

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**Abstract:** In this paper, design and development of a multiple sensors based fire extinguisher robot is proposed and implementation is demonstrated with a brief discussion of construction and operation. The developed fire extinguisher robot can be operated in multiple modes using the DTMF and Bluetooth remote control as well as GSM and GPS technology. Basically, three different sensors of flame sensor, temperature sensor, and smoke sensor have been used to ensure proper detection of fire. The robot can be controlled using both DTMF remote control and Android smartphone and can be operated in three different modes. The first mode allows full autonomous operation of the robot which can be activated by the user or by the robot itself based on the situation. The second mode is a line following mode where robot follows a black drawn line to detect fire and the third mode is complete manual operation using remote control.

**Index Terms – Fire Extinguisher Robot; Arduino Mega; DTMF; Bluetooth**

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## 1. INTRODUCTION

Detection of fire alongside with extinguishment is a detrimental work that risks the health as well as the existence of a flame extinguisher person in the hazard but through utilizing a robot to execute fire detection and extinguishing in a fire-prone area, loss of lives and undesired incidents can be avoided in a considerable number [1]. The day by day progress of advanced technology has made it feasible to develop different types of household and industrial robot and automation. The definition of the robot states that a system with the capability of executing human tasks or behaving in a human-like manner is regarded as robot [2]. Continuous research and developments are going on for obtaining a reliable and effective method which can be enforced to develop a firefighting robot to detect and extinguish the fire to lessen the risk of injury to victims.

A Firefighting robot is an independent ground vehicle [3] which should have two main functions, ability to detect fire and the ability to extinguish the fire. A small fire extinguisher system along with various sensors are attached to a fire extinguisher robot for proper performance. The appropriate use of the robot will make sure that the fire combating as well as recovery exercises might be maintained without having place flame fighters life at danger through utilizing making use of automation technological innovation as an alternate choice of human [2].

The design approach and implementation of a fire extinguisher robot is presented in this paper where three

types of sensors of flame sensor, smoke sensor, and temperature sensor have been used for fire identification to make the detection process more reliable. Multiple control system has been implemented to make the robot more efficient to extinguish the fire. After detecting fire using three sensors, the robot is programmed to send a text message with location coordinates to its user's mobile using GSM technology or notification to its Bluetooth paired android phone to get command for a specific operation mode. The user can set any of the three modes of operation using DTMF remote control or Android Smartphone. After confirmation of mode selection, the robot will start extinguishing the fire using water from water tank utilizing a DC pump motor as well as a servo motor. The pipe of the water tank is flexible and attached to a servo motor which allows the robot to spray the water from 10o to 170o. The proposed model is divided into two major section; design and implementation as well as result analysis and discussion which have been discussed briefly.

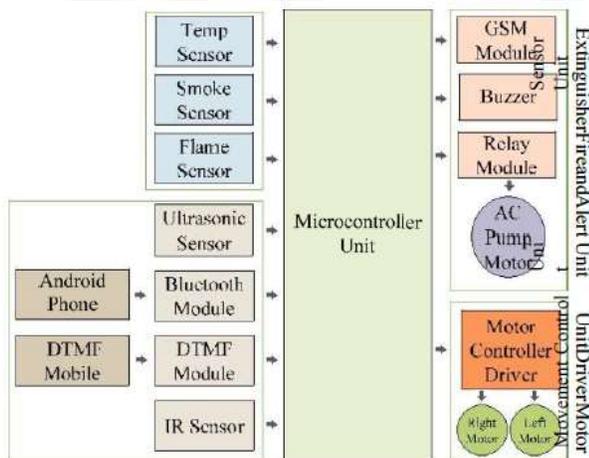
## II. LITERATURE REVIEW AND PREVIOUS WORK

A brief study of previous works has been conducted for understanding the limitations of the previously developed robot to implement new features to the proposed model. A paper on developing of a firefighter robot has been presented in [4] where the robot would search for fire by following a navigation system of line tracker and a camera was used for getting the exact position of the target place. A custom arm was designed using servo

motors to implement the extinguishing device of the robot. Another similar automatic fire extinguisher robot has been designed in [5] using fuzzy logic along with thermostat sensor to detect fire as well as Wi-Fi enabled camera to locate fire accident. The robot was designed wirelessly in order to operate it from a remote location. Another work on firefighting robot has been presented in [6] using Arduino and flame sensor to detect the fire along with a navigator to help the robot to go to the location autonomously. This robot was designed mainly as a path guidance where it also worked as a fire extinguisher in the emergency situation. Another work is presented in [7] where the smoke detector was used to locate the source of the fire employing two PIC16F877 microcontrollers; one of which was used for delivering a message to the owner and to alert the robot about a fire as well as another one was used to navigate the robot to the fire source.

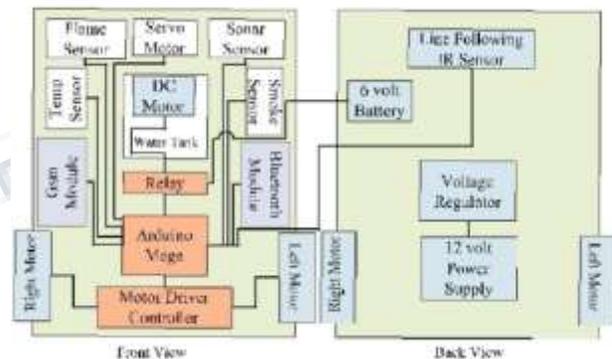
**III. OVERVIEW OF PROPOSED SYSTEM**

The functional block diagram of the proposed robot is illustrated in figure 1 and figure 2 illustrates the mechanical structure. The robot will utilize three sensors to detect temperature, smoke, and flame to implement the fire detection unit whereas one or maximum two sensors were used in the previous developed of fire extinguisher robot. When fire accidents occur, the temperature rises suddenly with smoke and flames. These three sensors will continuously monitor all-around of its range to detect any kind sudden rise of temperature, smoke or flame. If any of the sensors of gas or temperature can detect any abnormal parameters, data will be delivered instantly to the microcontroller.



**Fig. 1. Functional Block diagram of the proposed fire extinguisher robot.**

Whenever the microcontroller can detect that a fire accident is happening it will instantly contact with its user. There will be two controlling methods, the first method is using an android phone and the second method is to use a DTMF remote control which allows controlling the robot from anywhere in the world using GSM technology. If the smartphone is paired for controlling the robot, the system will notify the user by sending a notification to the paired Bluetooth android phone. An app will be developed to receive notification and control the robot. If a DTMF system is utilized, the robot will send a message to the user’s cell phone using GSM and GPS module to notify about fire accident with the coordinates of the accident’s location and wait for user’s action. The robot will also be able to send a text message to local fire service or security center with coordinates of the exact location. The system will be designed in a way that if the flame sensor can detect any kind of flame, the fire extinguishing unit will be activated instantly. But if temperature sensor and gas sensor can detect a sudden change of parameters, the user will be able to set three modes of operations to control the robot using both Android apps and DTMF mobile phone. The modes are: a) Autonomous mode b) Line following Mode c) Manual Control.



**Fig. 2. Mechanical structure of the proposed fire extinguisher robot.**

If there is no response from the user, an alert notification will be sent again to the robot from the microcontroller so that user can understand that no step is taken in the accident place. After sending the final notification the robot will automatically start its operation by selecting autonomous mode which will be set as the default mode of operation.

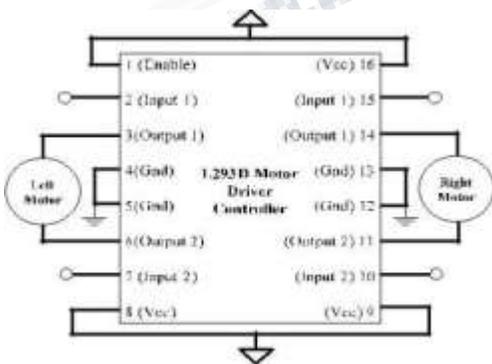
If the user gives instruction to activate any specific mode, the robot will follow the command by executing user’s instruction. For line following mode, it will follow a black line to search the flame. The manual mode will be

operated by a user and the robot will move according to user's instruction. The manual mode can be controlled both using DTMF mobile phone and android app. In all three modes, the fire extinguishing system will be automatically activate after the flame detection. The robot will stop its movement and start the DC motor pump with a flexible water pipe attached to a servo with the ability to rotate 10o to 170o to spray water to the target place efficiently. A water tank will be attached to the extinguishing unit to store water and after the competition of extinguishing operation, the robot will stop DC motor and go back to its previous position.

**IV. DESIGN AND IMPLEMENTATION**

**A. Microcontroller Unit and Motor Driver Controller**

The project is implemented using Atmega microcontroller platform known as Arduino Mega. It consists of 54 digital as well as 16 analog input/output pins with 4 UARTs and 16 MHz crystal oscillator [10]. The Mega 2560 board is specially chosen because of its compatibility with most sensors and modules. The employed motor driver module circuit for firefighting robot is known as L293D motor driver controller consists of 4 inputs and 4 outputs to control two DC motors. One of the main facility of L293D is to provide up to 600mA current at voltages variation from 4.5 V to 36V [9]. The direction of rotation of DC motor in forward and reverse can be controlled through combining different input logics. Another strong reason to choose this specific IC for movement control is the ability to control the speed of two motors using PWM from microcontroller which is required to control the robot for different modes. The basic circuit arrangement of L293D is shown in figure 3. The circuit diagram in figure 5 shows that the four inputs are connected to the digital pin of D9, D10, D11 and D12.



**Fig. 3. Circuit diagram of L293D based motor driver controller module.**

**B. Sensors**

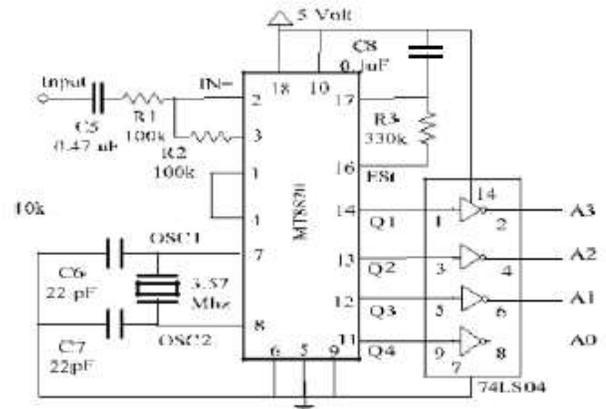
1) Temperature Detection: LM35 is a highly accurate inherent calibrated temperature sensor to detect the abrupt rise of temperature with attributes of low linear output impedance as well as less heating issue and capable of operating from a voltage range of 4 volt to 30 Volt with the drain current lower than 60 μA [11]. It is comprised of three pins of Vcc, Out & Ground. Out has been linked with the analog pin A0 of Arduino Mega as shown in the circuit diagram of figure 5.

2) Smoke Detection: A smoke sensor made of a micro aluminum oxide ceramic tube known as MQ9 is utilized to detect smoke. The sensor combined with a sensitive layer of Tin Dioxide with high sensitiveness to carbon monoxide for detecting smoke or gas in presence of carbon monoxide (CO) [12]. MQ9 includes of measuring electrode and necessary work conditions of sensitive components are provided by a heater [12]. Four pins have been used to get signals and other two pins have been utilized to provide heating current. The analog output pin of the gas sensor has been connected to the analog pin A1 of Arduino Mega.

3) Flame Detection: The chosen flame sensor has properties of sensitiveness to radiation and flame spectrum along with the capability of detection of origin of the ordinary light source. The flame sensor has been attached to the analog pin of A2 of Arduino Mega.

**C. Development of DTMF , Bluetooth ,GSM and GPS**

1) DTMF Remote Control: MT8870 is the best choice for developing DTMF remote control. A mobile has been attached to the system to receives a signal via DTMF receiver. Figure 4 is showing the circuit diagram of the MT8870 DTMF module.



**Fig. 4. Circuit diagram of MT8870 based DTMF Module.**

After making a phone call to the DTMF receiver connected phone, symbol pulse is provided to the system

when any button is pressed. The outputs of DTMF module are Q1, Q2, Q3 and Q4 which has been interfaced with the digital pin of Arduino Mega D2, D3, D4, and D5. 2) Bluetooth Remote Control: The Bluetooth module HC05 has been employed with the system with digital pin D0 and D1 of Arduino Mega using main function pins of RX and TX for receiving and transmitting data. Radio waves are utilized by Bluetooth technology to interconnect with other peripheral devices for data exchanging.

3) GSM and GPS Module: The 808 GSM GPS module has been connected with D14 and D15 of Arduino Mega and provides location coordinates using GPS. The microcontroller is able to send SMS using GSM to user and fire extinguisher unit. The sim808 module incorporates Quad-Band network as well as brings together GPS technology for satellite routing [14]. It has ultra-low power absorption as well as 22 tracking and 66 receiver channels [14]. Indoor localization by A-GPS as well as control capability through AT instruction by using UART is additionally obtainable.

can be detected by microcontroller due to voltage variation. A Comparator known as LM358 is used for comparing the output voltage with a reference voltage for ensuring proper operation and adjusting the sensitivity.

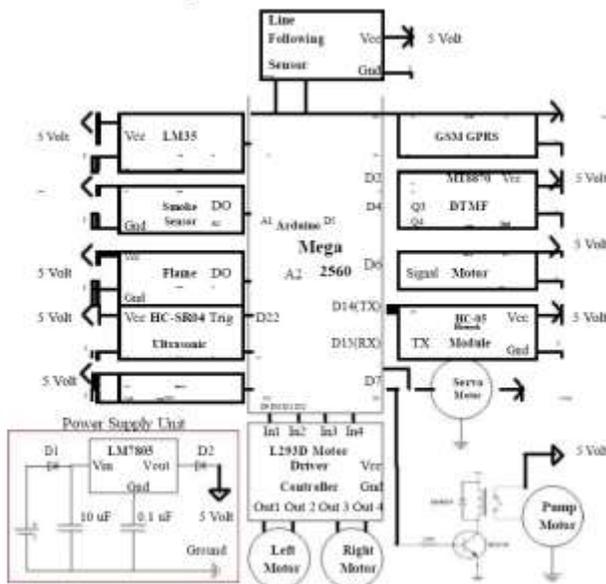
2) Development of Autonomous Control: An ultrasonic sensor has been interfaced with Arduino Mega for autonomous

controlling of the robot. The ultrasonic sensor is noted as HC-SR04 which comprises of 4 pins of Vcc, ground, Trig as well as Echo and 2cm to 400cm non-contact distance can be measured to locate obstacle in front of the robot using the sensor [13]. Trig and echo have been attached to the digital pin of D22 and D24 of Arduino mega. Signal is sent by Trig pin and the detection of the signal is determined by Echo.

3) Development of Manual Control: Manual control requires no extra hardware interfacing with the microcontroller. It can be fully controlled using the DTMF phone or Android app after activating the manual mode by user.

**E. Fire Extinguisher System with Servo Motor and pump**

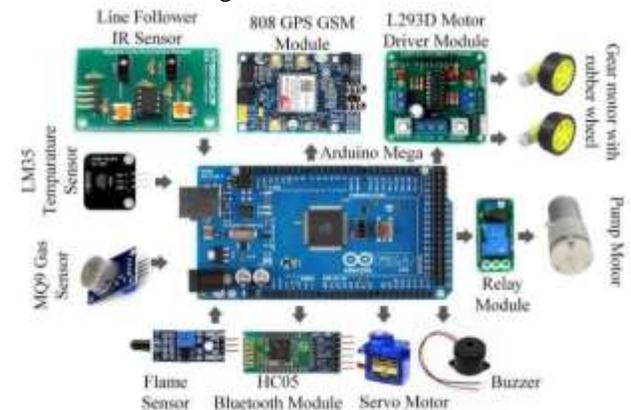
The fire extinguisher system has been designed using a relay module along with a water tank, DC pump motor and a servo motor. Relay module has been used with a transistor BC 547 which has been linked to the digital pin of D8 of the microcontroller to run DC pump motor. When fire extinguisher system will be activated the relay will switch on the DC pump motor to pump the water out of the tank and spray on the fire through a pipe which will be rotating from 10o -170o and in reverse direction continuously to ensure proper fire extinguishing. The overall hardware arrangement of the fire extinguisher robot is shown in figure 6.



**Fig. 5. Circuit diagram of proposed fire extinguisher robot.**

**D. Modes of operations**

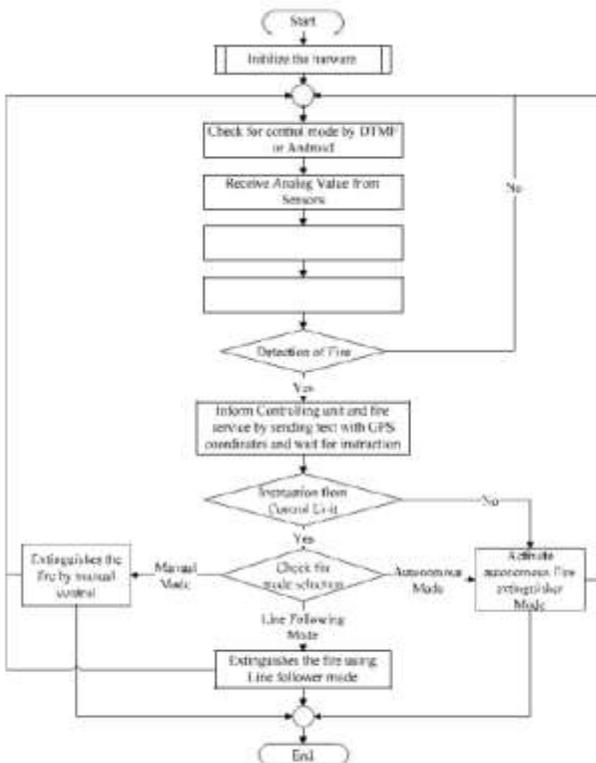
1) Development of Line Following method: Three modes of control system have been developed using line following, autonomous and manual control. The line following sensor has been implemented using two sets of IR LED with photodiode arrangement for each motor. To identify a black line from a white surface, the reflected IR light from the white surface falls on the photodiode that



**Fig. 6. Hardware arrangement of the fire extinguisher robot.**

**F. Programming**

The programming for the microcontroller of the robot is presented through a flowchart in figure 7. After installing the robot the sensor will initiate hardware at first and check for the selected control mode of either DTMF or Android. An android app will be developed for controlling the robot which will utilize Bluetooth to pair with the robot. Figure 8 is showing the proposed user interface of the android app. If a fire incident happens in any place, the sensors will detect and provide notification to the microcontroller. The sensors will provide analog values to the microcontroller, so after getting the value microcontroller will convert the values into digital format using A/D converter. Then converted value will be compared to the predetermined values of the sensors to detect fire. Once fire detection is confirmed, the microcontroller will inform the control unit instantly by sending a text about a fire incident.

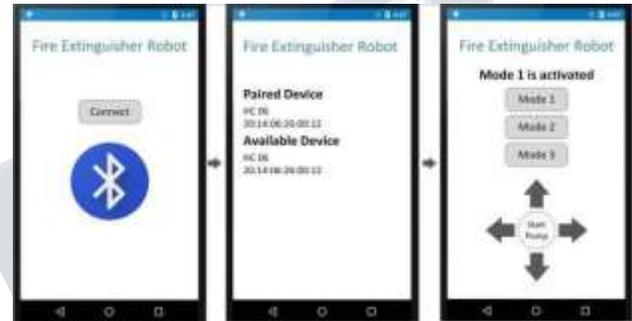


**Fig. 7. Flow chart of Programming for fire extinguisher robot.**

An instruction will be delivered with the location coordinates to fire service to take immediate action from the control unit. The control unit will check mode selection by the user. There are three modes which can be selected by the user. The modes are manual control by

DTMF, extinguish the fire by following the line tracker or fully autonomous mode.

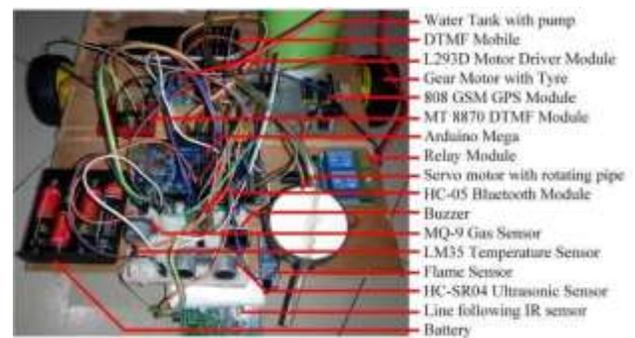
If no action is taken from the user within a certain time period, the control unit will select the autonomous mode. Then the robot will be controlled fully automatically and will go for extinguishing the fire according to the information provided by the control unit. Automatic control mode can also be selected by the user. If manual mode is selected the user will have the ability to control the robot manually using DTMF remote or Android phone. This process will be continued and the sensors will be ready for scanning of fire source continuously for all the time.



**Fig. 8. Proposed User Interface of android app to control the robot.**

**V. RESULT ANALYSIS AND DISCUSSION**

The developed robot has been tested to evaluate performance analysis as well as to demonstrate the ability to extinguish the fire. The robot has shown quite good performance to detect and extinguish the fire using different sensors and developed fire extinguishing unit. Figure 9 and figure 10 illustrate the front view and the top view of the robot.



**Fig. 9. Front view of the developed fire extinguisher robot.**



Fig. 10. Top view of the developed fire extinguisher robot.

#### A. Fire Detection using Multiple Sensor

Temperature sensor LM35 is capable of sensing temperature between +2 °C and +150°C [11]. The programming of microcontroller has determined a range of parameters for normal room temperature and abnormal room temperature during fire accident. The temperature has been raised using a lighter for testing purpose and it has been noticed that the sensor was able to detect the sudden rise of the temperature. Since the output voltage is the function of the temperature, it was able to get Celsius degree unit by analysis the output voltage of the sensor.

The smoke sensor has the ability of detection smoke using the method of making temperature cycle high and low. Smoke generally contains carbon and during the testing, smoke has

been detected by measurement of output signal within one or two complete heating period. SnO<sub>2</sub> is the sensitive substance of smoke sensor with characteristics of lower conductivity in clean air and sensor's conductivity was more significant along with the rising of gas concentration [12].

Flame sensor has shown the ability to detect the source of fire flame within the range of a wavelength 760nm-1100 nm. It has been observed that the detection distance of flame has shown better performance within the range of to 25cm to 90 cm whereas standard range is defined as 20 cm to 100 cm.

#### B. Modes of operation

The program of microcontroller has been developed in such a way if any two sensors could sense abnormal parameters, the robot would send an SMS to its user or a

notification to the paired android phone. The user can activate the whole system by using DTMF or android app. Band pass filter along with a digital decoder function for DTMF are capable of to decode DTMF tone [15]. When the control keys of the mobile phone has been pushed, a DTMF signal was transmitted to the microcontroller. The keypad buttons of mobile phone generated two high and low tones of different frequencies. Applying the decoder from the DTMF signal equivalent binary code has been attained during testing.

The robot can be activated by pressing number 1 key of the mobile. The user has the ability to select three modes of operation by pressing 2, 3 and 4. Number 2 key has been assigned to select the line the following mode. Number 3 has been used to set autonomous mode and number 4 has been able to select manual control mode using the DTMF phone.

1) Mode A (Line the following method): In the case of the line the following method, the robot has followed the predetermined path defined by a black line for detection of flame. The robot has searched to detect flame and whenever any flame has been detected by the robot, it has stopped the movement to activate the fire extinguisher unit. The fire extinguisher unit has sprayed the water using a DC motor from the water tank and servo motor has made ensured that the water could reach every possible spot of fire by rotating the water flowing pipe 100 to 170°. Table I shows the different position of the robot during line the following mode.

TABLE I.  
POSITION OF ROBOT DURING LINE  
FOLLOWING MODE

Sensor 1	Sensor 2	Position of Robot
0	0	Robot is out of track
0	1	Robot's left is out of track
1	0	Robot's right is out of track
1	1	The robot is on completely on track.

The robot is on completely on track.

2) Mode B (Autonomous Mode): When the autonomous mode has been selected, all the operation of the robot has been performed by the robot autonomously. The robot has employed ultrasonic sensor for obstacle detection during autonomous mode.

3) Mode C (Manual Mode): The user has been able to control the robot by selecting manual mode by using DTMF remote or android app. 5, 6, 7 and 8 buttons of the DTMF mobile have been used to move the robot manually

respectively right, left, forward and backward position in any place. Once the incident place has been detected, the DC motor pump has started as soon as the detection of fire. The robot has stopped spraying water as well as the pump when the sensors have stopped sending abnormal parameters of fire detection. Table II represents the different DTMF buttons, output decoder, and action.

**TABLE II.**  
**DTMF BUTTONS, OUTPUT DECODER, AND ACTION**

Button	Output of Decoder	Action
1	0x01 (00000001)	Turn On the robot
2	0x02 (00000010)	Set mode A (Autonomous mode)
3	0x03 (00000011)	Set mode B (Line Following Mode)
4	0x04 (00000100)	Set Mode C (Manual Mode)
5	0x05 (00000101)	Forward
6	0x06 (00000110)	Backward
7	0x07 (00000111)	Left
8	0x08 (00001000)	Right
9	0x09 (00001001)	Spray Water

### V. CONCLUSION

Autonomous fire extinguisher robot is just not an idea now, rather it is demand in this era of automation engineering. An autonomous robot can work for extinguishing fire simultaneously with the human without requiring any kind of command and also can work individually where there is life risk of a human. Even a robot can be more efficient and quick than human. Besides it takes some time to inform fire service team and then their arrival to the spot. But if there is an autonomous fire extinguisher robot in every factory or shop or house, the loss of life and assets can be reduced significantly as the robot will go for action as soon as it detects any kind of symbol of fire.

The robot has been designed with three types of sensors such as a flame sensor, smoke sensor, and temperature sensor whereas one or maximum two types of sensors was used to implement such kind of robot in the previous development[4]-[7]. As a consequence, the detecting of fire will be more precise and quick. Moreover due to the use of three kind of sensors, the robot will not stop spraying water until all three sensors respond negatively so that the fire cannot break out again some time later as it is a common nature of fire that it can turn on anytime if a flammable source is available in the incident spot. Additionally, use of multiple control ability will make the robot more reliable. However, the robot can be modified while implementing the manufacturing process in future.

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