# Fire Fighting and Rescue Bot with Bangla Voice Recognition Technology

Nowshin Lubaba
*Dept. of Electrical and Electronics Engineering*
*Bangladesh University of Engineering and Technology*
*1906038@eee.buet.ac.bd*

Hasib Ur Rashid Ifti
*Dept. of Electrical and Electronics Engineering*
*Bangladesh University of Engineering and Technology*
*1906059@eee.buet.ac.bd*

Mohammad Ismail Chowdhury
*Dept. of Electrical and Electronics Engineering*
*Bangladesh University of Engineering and Technology*
*1906058@eee.buet.ac.bd*

Abrar Mahir
*Dept. of Electrical and Electronics Engineering*
*Bangladesh University of Engineering and Technology*
*1906039@eee.buet.ac.bd*

Al Mahmud Sajid
*Dept. of Electrical and Electronics Engineering*
*Bangladesh University of Engineering and Technology*
*1906050@eee.buet.ac.bd*

***Abstract*—Fire hazard is one of the most crucial problems in Bangladesh right now. Especially at high rise buildings, the fire spreads faster than emergency services can respond. If an autonomous fire fighting robot can be stationed at every room or other potentially hazardous locations, the robot can act as the first line of defence before the emergency services can respond. Moreover, if the bots can also notify the authority of a victim stuck somewhere, it can help the rescue team to respond accordingly. This project intends to recognise both of these solutions and provides a scalable solution.**

***Index Terms*—IR (Infrared) sensors, SDG (Sustainable Development Goals), OTA (Over The Air) Firmware Update, GSM(Global System for Mobile Communication)**

## I. Introduction

A total of 24,102 fire incidents were reported across Bangladesh in 2022. During these incidents, at least 98 people were killed and 407 wounded. Unfortunately, response time from the fire stations isn't good enough to nip the hazard at its bud. An autonomous fire fighting and rescue bot has been designed in this project that detects the fire using IR and gas sensors, moves towards the source of the fire and mitigates the fire by using a pump and its own tank. But most fire fighting robots available does not have any feature to rescue the victims stuck at the accident spot. An extra Bangla voice recognition feature has been added in this project that identifies the call for help by any victim and notifies the emergency service by using a SIM module installed in the bot. The emergency service will get notified with a message that will contain the location or room number where the victim is stuck and so that they can respond accordingly. A microphone is attached to the robot that will identify the voice of the victim using Elechouse Voice Recognition Module V3. A trigger word was selected which the module has been trained to identify and respond accordingly. Although the project is in its primary prototype stage due to the limited budget and time, it can be scaled up and implemented in industrial level.

## II. Literature Review

### A. Overview

An overview of the overall project has been provided below

### B. Choosing the fire detection method

We had two major options of fire detection- Image processing and IR sensor. Image processing requires the fire to be in the visible range of the robot whereas IR sensors can detect fire using IR radiation. Fire sources emit IR rays with a wavelength ranging from 0.7 to 1000 micrometers. An IR sensor is a device that detects IR radiation from the environment and outputs an electric signal. This sensor includes an IR LED and an IR Photodiode and combining these two provides a photo-coupler or opto-coupler. An infrared transmitteer is used to detect the radiation by infrared receivers. These infrared receivers are available in photodiode form. When used as an IR transmitter and receiver, the wavelength of the receiver must match that of the transmitter. The infrared photodiode is activated by the IR light produced by IR LED. The photodiode's resistance and change in output voltage are proportional to the amount of IR radiation obtained.

Moreover, image processing requires raspberry pi to be implemented which would raise the costing. Since we wanted to implement the fire fighting robot within a budget, using IR sensors was chosen as our fire detection method. However, using image processing would have increased the range of fire detection since locally available IR sensors have very close detection range and problems with sensitivity.

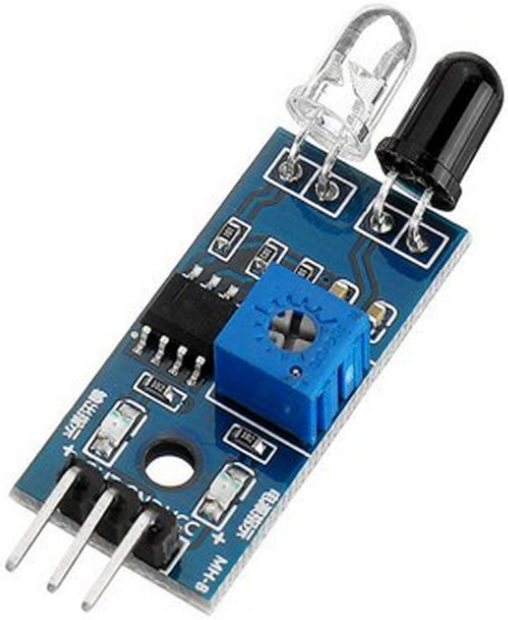

Fig. 1. IR sensor

### C. Voice Detection

For voice detection, we chose an ELECHOUSE Voice recognition module was used. The module was trained to identify a trigger word. Upon detection of the trigger word, the module can perform any operation with the Arduino. The Arduino was programmed to send a text using SIM 900a to the emergency services.

### D. Sending text using SIM module

Initially, a SIM 800L was chosen. However, SIM 800L does not have the country unlock feature and does not work with SIMs in Bangladesh. Therefore, a SIM 900a module was used with country unlock feature activated. The SIM module requires a 5V DC supply to be turned on and is very voltage sensitive. Anything less than 5V does not turn the module on. The 5V output pin of the Arduino was used to supply power to the SIM 900a Module.

### E. Motor Driver

L298N module is a high voltage, high current dual full-bridge motor driver module for controlling DC motor and stepper motor. It can control both the speed and rotation direction of two DC motors. This module consists of an L298 dual-channel H-Bridge motor driver IC. This module uses two techniques for the control speed and rotation direction of the DC motors. These are PWM – For controlling the speed and H-Bridge – For controlling rotation direction. These modules can control two DC motor or one stepper motor at the same time.

An H-Bridge circuit contains four switching elements, like transistors (BJT or MOSFET), with the motor at the center forming an H-like configuration. Input IN1, IN2, IN3, and IN4 pins actually control the switches of the H-Bridge circuit inside L298N IC.

We can change the direction of the current flow by activating two particular switches at the same time, this way we can change the rotation direction of the motor.

L298n motor driver module uses the PWM technique to control the speed of rotation of a DC motor. In this technique, the speed of a DC motor can be controlled by changing its input voltage.

Pulse Width Modulation is a technique where the average value of the input voltage is adjusted by sending a series of ON-OFF pulses. The average voltage is proportional to the width of the pulses, these pulses known as Duty Cycle.

If the duty cycle higher, then the average voltage is applied to the DC motor (High Speed), and the lower the duty cycle, the less the average voltage being applied to the dc motor(Low Speed).

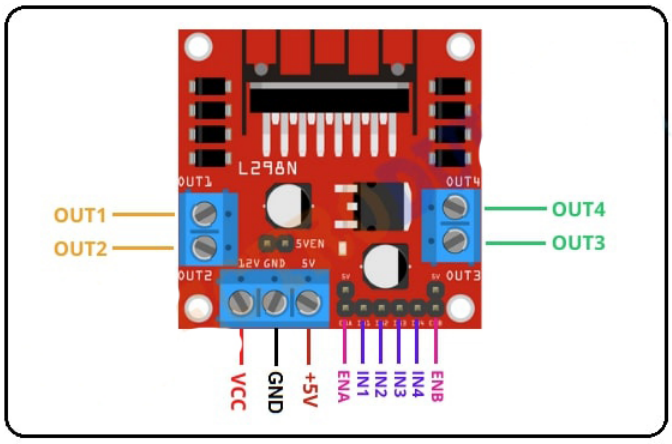


Fig. 2. L298N Motor Driver

## III. Methodolgy

We followed several procedures to achieve the objective of this project.

### A. Fire detection

Fire has been detected using IR sensors. Fire sources emit IR rays with a wavelength ranging from 0.7 to 1000 micrometers. An IR sensor is a device that detects IR radiation from the environment and outputs an electric signal. This sensor includes an IR LED and an IR Photodiode and combining these two provides a photo-coupler or opto-coupler. An infrared transmitteer is used to detect the radiation by infrared receivers. These infrared receivers are available in photodiode form. When used as an IR transmitter and receiver, the wavelength of the receiver must match that of the transmitter. The infrared photodiode is activated by the IR light produced by IR LED. The photodiode's resistance and change in output voltage are proportional to the amount of IR radiation obtained. The IR sensors used in this project gives an output of HIGH (Around 2-3V) when it does not detect

any IR. When it receives IR radiation, it provides an output of digital LOW (A few mV). Therefore, the logic is inverted. This output LOW was input into the microprocessor (Arduino UNO in this case) and output signals from the Arduino UNO was used to run the motor driver.

An MQ2 gas sensor was also used which works in a similar inverted digital logic as the IR sensors. The MQ2 gas sensor was used to detect smoke from the place of fire and act accordingly. In case of small fire, IR sensors might not always be able to detect the infrared. In that case, smoke detection was used to move the robot towards the fire.

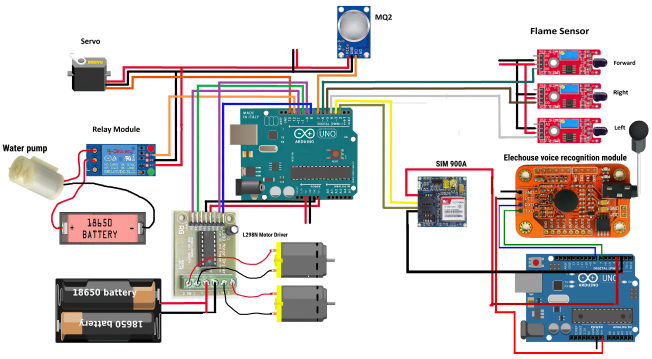


Fig. 3. Circuit Diagram

### B. Fire Mitigation

Upon detection of fire, fire was mitigated by using water from a tank contained within the robot structure. Upon receiving data from IR and gas sensor, the robot moves towards the fire. Thereafter, the Arduino sends signal to the relay module which turns on the 5V DC pump. The pump outlet pumps out water from the tank through the pipe. The pipe is connected to a servo motor attached in front of the robot that sprays water to the fire and mitigates it.

### C. Bangla Voice Detection

An ELECHOUSE voice recognition module V3 was used to identify the victim. The module comes with a built in microphone. It supports up to 80 voice commands in all. Max 7 voice commands could work at the same time. The module is trained with the trigger word which is the word ”help” in Bangla. Upon recognition of voice, the module sends signal to the Arduino which is connected to the SIM 900a module.

### D. Sending text via SIM 900a

The SIM 900a module is used to send a SMS to emergency services. SIM900A GSM Module is the smallest and cheapest module for GPRS/GSM communication. It is common with Arduino and microcontroller in most of embedded application. The module offers GPRS/GSM technology for communication with the uses of a mobile sim. It uses a 900 and 1800MHz frequency band and allows users to receive/send mobile calls and SMS. The keypad and display interface allows the developers to make the customize application with it. Furthermore,

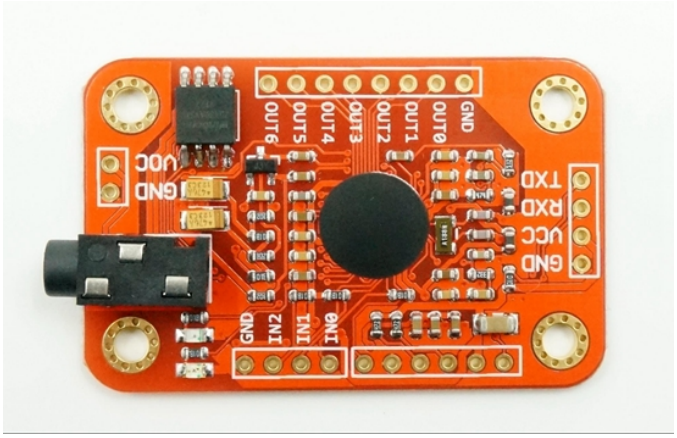


Fig. 4. Elechouse voice recognition module V3

it also has modes, command mode and data mode. In every country the GPRS/GSM and different protocols/frequencies to operate. Command mode helps the developers to change the default setting according to their requirements.

### E. Limitations

- IR sensors often detect sunlight as well and their sensitivity needs to be adjusted using the potentiometer included in them accordingly
- The 5V DC pump cannot pump out much water as compared to its successors like a 12V DC pump
- The SIM900a module supports 3G sim only, which might not always be available. A SIM module supporting 4G sim would have been more suitable.
- In case of environment noise, the voice detection might be a challenge.

## IV. Result and Discussion

The fire fighting robot was tested multiple times and it could successfully move towards the area of the fire, throw water using the pump and mitigate the fire. It could also successfully recognise the voice of the victim in Bangla and send a text to the emergency services. Since its area of operation includes a particular room in any high rise buildings such as high-end laboratories, it could send a text message indicating that the person is stuck in that particular room number. The prototype also included a cover to contain the entire circuitry and give the entire prototype a more compact and motile advantage.

## V. Comparative Analysis with Existing Model

| Changes | Our Model | Previous Model |
|---|---|---|
| Voice recognition | Available | Not available |
| Gas sensor | Available | None |
| Notification feature | Sends text | Not available |
| Environment friendly | Solar battery charging | None |

## VI. Implementation

### A. Cost analysis

| Component | Quantity | Price |
|---|---|---|
| Arduino | 2 | 1300 |
| Elechouse module | 1 | 2900 |
| Breadboard | 2 | 140 |
| GSM 900a | 1 | 700 |
| Motor Driver L298D | 1 | 450 |
| MQ2 sensor | 1 | 150 |
| Relay | 1 | 70 |
| Servo | 1 | 450 |
| Batteries | 6 | 1550 |
| Others | - | 150 |
| Total | | 9965 |

### B. Impact on environment

Most robotics based projects end up harming the environment considering the materials used. In this project, rechargeable Lithium ion batteries were used which could be recharged using solar panel based charging. This allows the reuse of batteries without discarding harmful Lithium into the earth.

### C. Correspondence with SDG goals

• SDG goal 7 aims to ensure access to affordable, reliable and sustainable energy for all and using solar powered charging for batteries is a step in that direction. • SDG goal 9 aims to provide safe, resilient and sustainable infrastructure and industrialisation. A fire fighting robot installed in industries, garments and high rise buildings can act as the first line of defence and ensure a safe working environment along with protection from hazardous infrastructures.

### D. Future modifications

Our fire fighting and rescue bot can be modified to a larger scale in future for better performance and broader features. Further improvements could include: • Image processing can be employed for detecting fire for more accurate result.

• High-end IR and gas sensors should be used for enhancing its working range.

• We can use Raspberry Pi instead of Arduino UNO for enhanced features.

• Eco-friendly materials may be used for building the robot.

• The material used for building the robot must also be heat and fire resistant so that it can withstand the fire to be mitigated.

• Data acquisition and monitoring system from user end like gas or temperature parameters can be integrated for forecasting potential fire accident. It can upload the data from temperature and gas sensors to a database and create a trend of the data. Once the trend is broken, it can indicate a potential gas leak somewhere, notify the central authority and stop any potential fire hazard.

• OTA (Over The Air) firmware update can be provided for updating features on regular basis as proposed by the CEO of Inovace Technologies .

• Aluminum based batteries can be used as these are recyclable.

• Higher quality microphone and voice recognition module like VRBot module could be added for better detection of victim.

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