Fire Fighting Robot – “BlazeQ”

Md. Jamil Hossain Shaharia
Department of IRE,
Bangabandhu Sheikh Mujibur Rahman Digital University
1801012@iot.bdu.ac.bd

Md. Sajaratul Yakin Sagor
Department of IRE,
Bangabandhu Sheikh Mujibur Rahman Digital University
1801018@iot.bdu.ac.bd

Suraiya
Department of IRE,
Bangabandhu Sheikh Mujibur Rahman Digital University
1801021@iot.bdu.ac.bd

Adiba Jahan
Department of IRE,
Bangabandhu Sheikh Mujibur Rahman Digital University
1801044@iot.bdu.ac.bd

Mohammad Armaan
Department of IRE,
Bangabandhu Sheikh Mujibur Rahman Digital University
1801046@iot.bdu.ac.bd

***Abstract*— In this project we have created an automatic firefighting robot using Arduino Uno. What really motivated us to do this is, almost five hundred individuals die in fires in Bangladesh each year as a result of insufficient resources and appropriate preventative attempts. These folks were usually killed in fireplace accidents. Most of the time, fires develop so large that the firefighters are unable to handle the situation on their own. Many firemen are killed while putting out flames caused by extreme heat. As a result, a technology solution can aid in the prevention of life-threatening situations. To reduce these mistakes, we created a robot that can use water to fight a fire while it is being automated. The robot can maneuver on its own in certain areas. Firefighters who fought from the front lines to control the damage caused by these fires are frequently victims of these incidents. Using a firefighting robot minimizes the danger of harm to firefighters significantly. There are also certain areas where the firemen are unable to go owing to the extreme heat. However, a robot can go there and regulate the issue, maybe saving a victim's life. Again, in certain fires, a large blast of toxic gas occurs. People cannot even approach that location, however, a firefighting robot can. This concept of an automated firefighting robot is generally safe since humans may operate it from a safe distance where they will not be harmed. This robot can mitigate the fire and provide safety for both firemen and the affected people trapped in a fire.**

***Index Terms*—robot, fire, fire-fighting, accident, control, flame sensor, servo motor, gear motor.**

I. INTRODUCTION

Automatic Fire Control and Detection Robots are made to help with fire search and extinguishment tasks without requiring human interaction. For putting out forest fires and putting out fires in residential areas, there are many different firefighting technologies available. The approach we propose consists of a small robot that may be utilized to stop a fire in its early stages from spreading. These robots allow for the identification and suppression of fires without endangering the lives of fire personnel or creating hazardous situations.

They can serve as assistants in preventing harm because they work physically with people. With broader access, more sensors, and less downtime than people, they can examine assets like structures or pressure vessels more frequently, which enables early fault discovery and increases reliability.

Fire accidents are increasingly a typical occurrence. In our daily lives, we hear about huge fires and real-world harm. We lost 59 lives and several of our firefighter heroes in a recent fire in Chittagong. Our project is an automated firefighting robot based on Arduino. This robot will be able to control its movement in certain areas, which gives it an easy automated maneuvering system. A great deal of robot technology has been produced to assist human activity. The firefighting robot is the greatest of them all. Firefighting from the front lines is a perilous activity for firemen or anybody else. However, for a robot, it is not a risky job. And we've put up an automated way to control the robot from a safe distance or remotely. In this situation, the robot will move automatically and use flame sensors to locate the source of the fire. When it detects a fire, it will automatically utilize water to put it out. We hope that by doing so, we can cover up at least some of the casualties caused by fires. So, in this project, we are proposing a robot that is capable of moving on its own and can detect fire within its range. Eventually, the robot mitigates the fire by dispersing water on it effectively.

II. Literature Review

Haar Cascade Classifier was used to detect fire from CCTV footage [8]. Raspberry Pi Camera was used to capture images and Raspberry Pi 3 Model B was used to run the model and detect fires. The model was trained with a lot of positive images with the object and negative images without the object. The features were extracted from the objects to be detected such as edge features (two rectangle features), line features (three rectangle features), etc. during training. The trained model was then used to identify fires from CCTV footage. In this system, IoT was also incorporated to inform the user about the fire after detection.

Based on the results obtained, it was found that when the intensity of light present in the room was higher, the accuracy of detection was lower. It was concluded that the distance of the fire from the camera does not affect the level of accuracy but the brightness of the light present in the environment of fire detection affected the accuracy of measurements obtained. Shen et al [9] researched and performed deep learning for object detection. Deep learning was used rather than color-based, motion-based, or shape-based models alone as different flames may have different properties. Deep learning could be used to identify all these properties instead of a single property alone for fire detection. YOLO was used to perform flame detection. YOLO created an n by n grid where each grid was responsible for obtaining the probability and bounding box for the object that was present in it. The training procedure was divided into pre-training and formal training. Pre-training identified the grid where the center of the object was and classified the object. Formal training fixed the correct width and height for the bounding box. 172 images were used for training. For creating the dataset, 10 samples of each image were used by varying brightness and saturation. 60 epochs were used to train the model on the dataset. From the results obtained, it was found that when other bright objects were present, the accuracy of the detection was compromised. The accuracy of detection was higher when the background was simpler. Hence, it is essential to not have very bright objects during detection so that accuracy does not get compromised while following both machine learning and deep learning for fire detection.

Fire is defined as the possibility of an unwanted hazard that can cause potential loss of life and property [2]. This project is an Autonomous Fire Detecting and Extinguishing Robot without user intervention and it is designed and implemented using ATMEGA 16 Microcontroller (MCU) [10]. Under the mighty ruler of Rome Augustus, the first formal firefighting began. Since then, it has continuously evolved. The earliest recorded is the usage of the fire extinguisher pump. Then came the German invention of the first force and suction pump. Since then, we have moved a lot. Nowadays trucks and vans are used to extinguish fire along with CO2 cylinders. An automatic Firefighting system is also in place in modern-day architecture comprising smoke detectors, sprinklers, and sensors. The role of the firefighter is to control fire and safely douse the fire, obstructing further damage and rescuing victims to a safer location from the hazard. Technology has made it possible to design simple and efficient firefighting systems. Modern firefighting systems use inert gases such as Nitrogen with water mist to extinguish fire [11]. Robots were designed to locate a fire before it creates havoc. [12]. Robots have attained immense popularity due to progress in the fields of computing and nano technologies [10]. The robots have potential to prevent human loss of life. After studying the existing firefighting systems, this system is proposed to control the fire at the earliest before help arrives and the fire rages out of control.

III. Objective

The primary goal of our effort is to save the lives of our brave firefighting heroes who have lost their lives in tragic fires. Also, to save persons who have become trapped in areas of extreme heat. Our Fire-fighting robot is capable of detecting and extinguishing fires. The motor controller and Arduino programming work together to drive the robot. It is safer to utilize our firefighting robot since it is automated. It will help us limit the amount of damage caused by fire incidents each year. This project allows safe inside fire operations for major commercial fires. People suffer a great number of losses in major fires. Because of a lack of personnel, we frequently failed to control a large-scale fire mishap. In addition, it takes longer for a large-scale fire to be contained. A robot may be the greatest option in this situation. It can also provide effective protection against wildfires. And, in a wildfire situation populated by ferocious animals, human firefighting is risky. However, with a robot, this task becomes much easier because it cannot be damaged or killed by any animal and can save both the lives of animals and humans. It will be a little endeavor to lessen the number of fatalities caused by fires.

IV. Method

A fire disaster is one of the dangerous situations that can cause considerable financial and human losses. Because of volatile chemicals, smoke, and high temperatures, firefighters may have difficulty reaching the scene of a fire. In these conditions, firefighters are also at risk of death. In these circumstances, robotic firefighting devices may be beneficial. This fire extinguisher robot is powered by the Internet of Things technology. Our objective in Fire Extinguishing Robot is

to design a system that can extinguish a tiny flame by sensing it and traveling to the location. Delays in a firefighter's arrival might have serious consequences. The fire-extinguishing robot continually monitors its surroundings and extinguishes the flames as soon as possible.

One of the most important things in a fire disaster is life, or the lives lost while saving another person's life. Firefighter personnel are often unable to reach the scene of a fire due to explosive chemicals, smoke, and high temperatures. Many dangerous circumstances can be avoided by responding quickly to a fire. Fires have been observed in both residential and business settings. A little spark may ignite a massive fire. A poor fire management system endangers not just the lives of industrial workers, but also those of domestic workers. A fire can claim many lives and injure many individuals for the rest of their lives. It may, however, be avoided by using appropriate fire suppression procedures.

For these conditions, firefighting robots are recommended. Many robots are being developed and built by today's age to replace humans in dangerous and fatal tasks. Robotics are increasingly being employed to safely perform risky or labor-intensive jobs that would otherwise need the utilization of human personnel. A fire extinguisher robot is constructed using IOT technologies. We want to build a system for the Fire Extinguishing Robot that can detect and extinguish a small flame.

V. Circuit Diagram

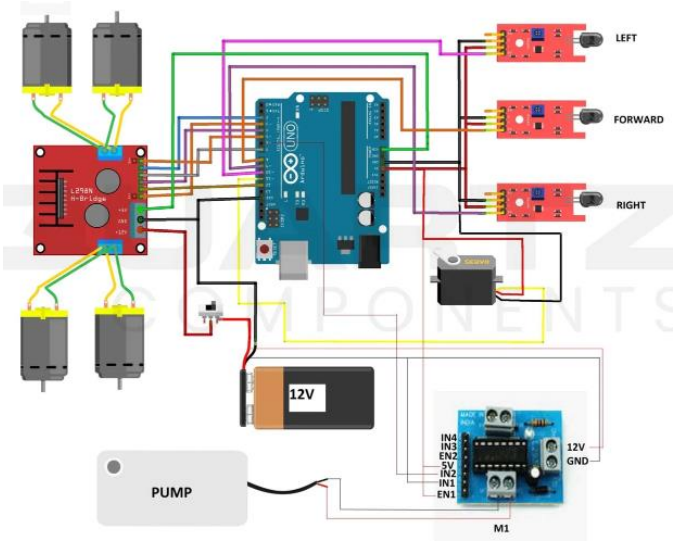

Fig. 1. Circuit Diagram.

VI. Flow Chart

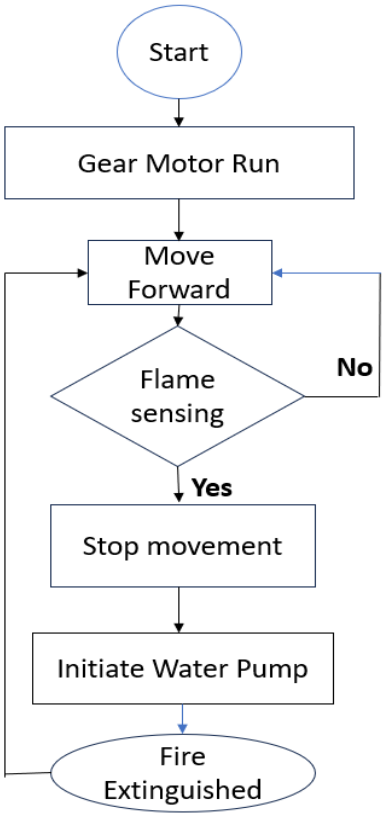

Fig. 2. Flow Chart.

VII. Experimental Setup

To finally give a physical formation to our project" Fire Fighting Robot" we used some electronic and electric components. The components we are using for this project are Arduino Uno, USB cable, Car chassis, L293 Motor Driver IC, Flame sensor, Servo motor, L293D Motor Driver Shield, DC submersible pump, 12V battery, switch, Connecting wires, Glue gun, etc. Here is a detailed explanation of the materials:

A. Arduino Uno

The Arduino Uno is an open-source microcontroller board created by Arduino. It is based on the Microchip ATmega328P microprocessor. A variety of expansion boards (shields) and other circuits can be interfaced with the board's sets of digital and analog input/output (I/O) pins. The board features 6 analog I/O pins, 6 digital I/O pins, and 14 digital I/O pins, six of which can be used for PWM output.

FTDI USB-to-serial driver chip, even though it communicates using the original STK500 protocol. In its place, a USB-to-serial converter built using the Atmega16U2 (or Atmega8U2 up to version R2) is used.

Fig. 3. Arduino Uno.

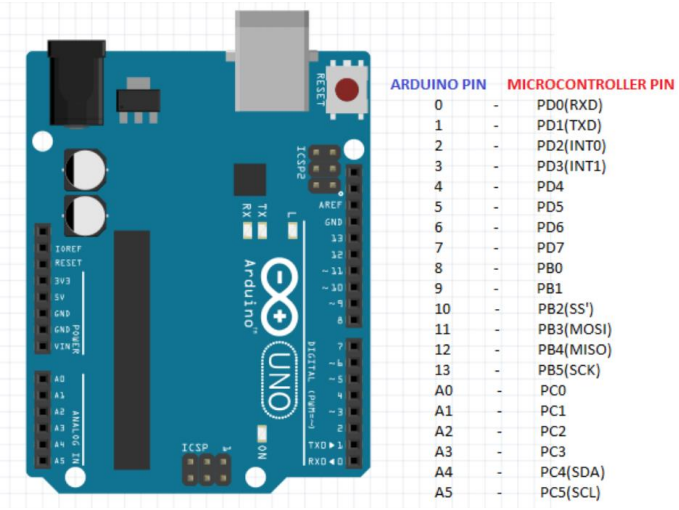

Fig. 4. Arduino Uno Pin Diagram.

B. L293D Motor Driver Shield

We can simply control motor direction and speed with an Arduino thanks to the Arduino Motor Shield. It makes it very easy to include a motor in our project because it allows us to easily address Arduino pins. Additionally, it enables us to run a motor using a separate power source with a maximum voltage of 12 volts. Best of all, finding the shield is a breeze. The Arduino Motor Shield is a fantastic tool to have in our toolbox for quick prototyping and general exploring for all of these reasons. The L293D Motor driver shield is one of the best ways for controlling the DC motor, Servo motor, and Stepper motors in a single board. It can control the rotation direction and speed of four DC motors, two Servo motors, and two Stepper motors. It is easy to connect with an Arduino UNO or MEGA. This shield especially uses Arduino projects like robotics and CNC. This module consists of two L293d dual-channel H-Bridge motor driver IC and a 74HC595 shift register IC.

C. L293d motor driver IC

The L293D is a dual-channel H-Bridge motor driver. A single IC is able to control two DC motors or one stepper motor. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. and a Peak Output Current of 1.2 A Per Channel. This IC has two enable inputs, these are provided to enable or disable the device independently of the input signals. The motor driver shield has two L293D motor driver IC. So, the L293d shield is able to control four DC motors or one stepper motor.

D. External Power Supply

The shield has a 2-pin terminal block for External Power Supply. It is used for DC power supply for motors. It also can be used for the power supply to the Arduino board, possibly by the “Power Supply Selection Jumper”.

- Single DC power supply for both Arduino and motors
  If we want to provide a single DC power supply for both Arduino and motors. So, we have to place the power jumper on the motor shield. Now we can simply connect the power supply to the DC jack on the Arduino or the 2pin External Power Supply terminal block on the shield. But, this method is only used when the motor supply voltage is less than 12V.
- Arduino powered through USB and motors through an External Power Supply pin If we want to power the Arduino board through the USB and the motors powered through the DC power supply. First, plug in the USB cable, then connect the motor supply to the external Power. Now we can turn on the power supply one by one (first the Arduino power supply then the motor power supply). In this condition, we should not place the jumper on the shield.
- Two separate DC power supplies for the Arduino and motors If we want to use two separate power supplies for the Arduino boards and motors. At first, we need to connect the power supply to the DC jack on the Arduino, Then connect the motor power supply to the 2pin External Power Supply terminal block on the shield.

E. Flame Sensor

A flame sensor is a type of sensor that responds most strongly to ambient light. This sensor module is utilized in flame alarms as a result. When the light source’s wavelength is between 760 and 1100 nanometers, this sensor can detect flames. High temperatures have the potential to easily harm this sensor. So, a specific distance from the flame can be chosen for this sensor’s placement. With a detection angle of 600 degrees, the flame can be detected from a distance of 100 cm. This sensor outputs either an analog signal or a digital signal. These sensors serve as a flame alert in firefighting robots.

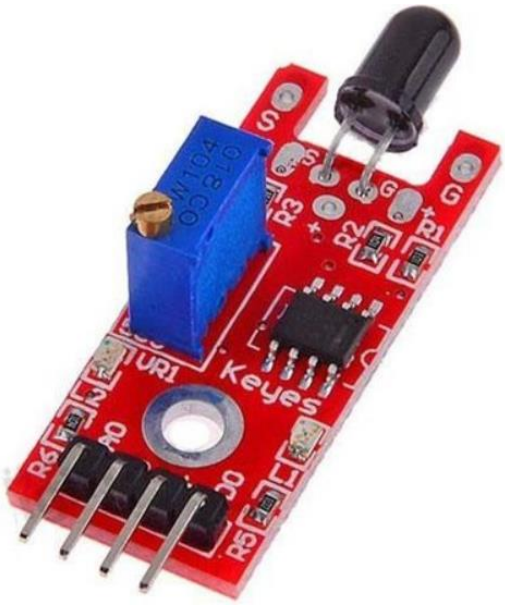

Fig. 5. Flame Sensor.

F. Water Pump

This DC 3-6 V Mini Micro Submersible Water Pump is a low-cost, small-size Submersible Pump Motor that can be operated from a 2.5 ~ 6V power supply. It can take up to 120 liters per hour with a very low current consumption of 220mA. Just connect the tube pipe to the motor outlet, submerge it in water, and power it.

Fig. 6. Water Pump

G. Breadboard

The contemporary breadboard is a plug-and-play method of connecting electronic parts. Its name comes from the long-ago tradition of prototyping circuits on a wooden board, or a breadboard if one was available. To prototype a circuit, hobbyists would drive tiny nails or thumbtacks into the board and thread wires around them.

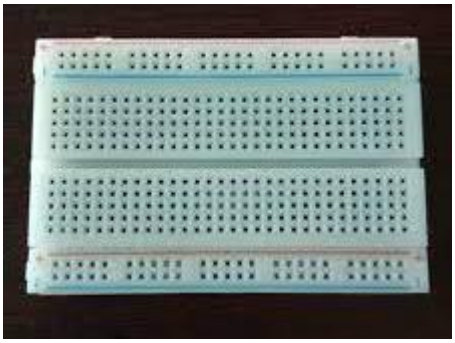

Fig. 7. Breadboard.

H. Servo Motor

A servomotor (or servo motor) is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analog or digital) representing the position commanded for the output shaft.

Fig. 8. Servo motor.

I. Battery

A lithium-ion battery or Li-ion battery is a type of rechargeable battery composed of cells in which lithium ions move from the negative electrode through an electrolyte to the positive electrode during discharge and back when charging. Li-ion cells use an intercalated lithium compound as the material at the positive electrode and typically graphite at the negative electrode. Li-ion batteries have a high energy density, no memory effect (other than LFP cells), and low self-discharge.

J. Connecting Wire

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply ”tinned”), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their ”end connectors” into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

Fig. 9. Jumper Wires.

VI. ROBOT'S STRUCTURE

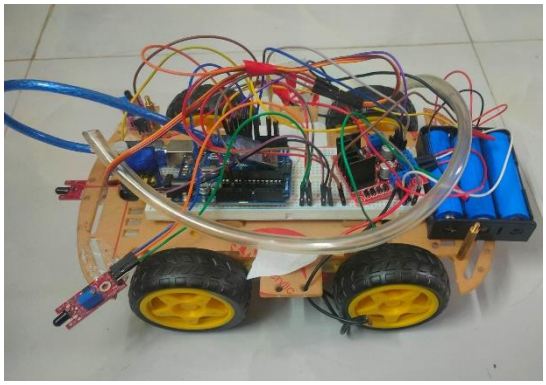

Fig. 10. Image of Robot's side view.

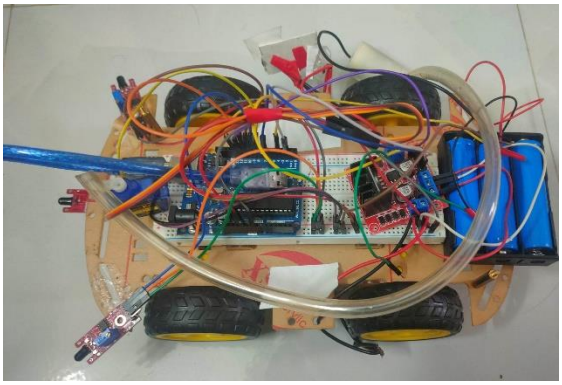

Fig. 11. Image of Robot's top view.

The Robot has 3 flame sensors as the fire detection system. It also has 4 gear motors working as wheels. These help the robot to move accordingly. It also contains a servo motor as an arm that actually helps to direct the water flows direction by moving automatically after sensing the flame. Lastly, as the water dispersing method we used a mini submersible pump which gets activated when the fire is detected and fires water through a nozzle in the direction or spot of the fire. We connected all of the above using Arduino Uno and the robot is powered by the batteries.

We can say that the robot is automated with the help of pre-uploaded code in Arduino Uno. That eventually helps the robot to act accordingly in certain situations. The robot is built on a chassis of an RC car. Which is giving the robot proper structure.

VII. RESULT AND DISCUSSION

Fire Fighting Robot has developed a gadget that can detect and extinguish flames in order to save lives. It recognizes the fireplace using IR flame sensors and an Arduino UNO to control the movement of a motor drive, allowing the robot to reach the fireplace and extinguish it using pumping mechanisms. If a fire erupts in the industry, someone must constantly monitor and repair it. If this procedure is even slightly delayed, the industry will suffer irreversible damage. The fire-fighting robot continually monitors the area and aids in the extinguishment of the flames. Our robot can move forward, left, and right with ease. The Arduino code, in conjunction with the motors, controls the robot's movement. When the motor detects a risky environment using flame sensors, it will begin to spin and convey the robot to that place, where it will begin to pump water via a servo motor. The procedure will be used until the fire is completely extinguished. The secure environment will then be displayed. Once the project had been completed successfully, the simulation was conducted, and the predicted outcome was obtained.

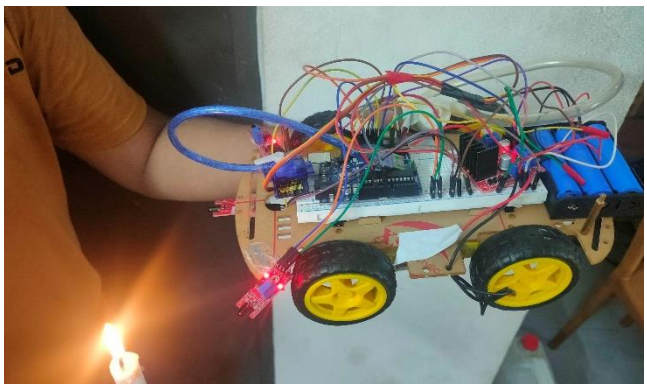

Fig. 12. Fire Detection.

Trail No.	Latency (water pump activation)	Accuracy
1	2 sec	Good
2	3 sec	Good
3	2 sec	Average
4	1.5 sec	Good
5	1.8 sec	Good
6	3 sec	Missed
7	2 sec	Good
8	2.5 sec	Good
9	3 sec	Average
10	2 sec	Good
11	1 sec	Average

Looking at the stats we can say that this robot is really good for confined spaces fire detection and mitigation. It has almost top-level accuracy for certain situations and it has less latency. I think the robot can serve its purpose of extinguishing fire in confined places and has the great future potential of working in public.

While testing the robot's capabilities we came to find that if we can provide it power on a regular course it will work properly in every destined situation.

VIII. Conclusion

The Fire Fighting Robot is capable of putting out small-scale flames. It is particularly sensitive to fire flame in darker surroundings. It was designed as a firefighting robot since it can identify and extinguish fires rapidly. This multisensory-based robot might provide comprehensive fire protection. This robot has several sensors, including flame and smoke sensors. If a fire is detected, a water spraying system is triggered to extinguish it. This sort of fire extinguisher robot aids in the distribution of firefighter workload. The purpose of our project is to develop a real-time firefighting robot that runs at a constant speed, locates flames, and then extinguishes them using a pumping mechanism. The detection and extinguishing were carried out with the aid of the robot's basic hardware components. The architecture of this robot allows it to fight large fires with greater reserve capacity, money, and scope, and an improved sensor unit can even give early fire detection in all conditions. As a consequence, the "Fire Fighting Robot" project has successfully completed its mission

IX. Future Works

The experimental robot prototype can be developed into a functional robot in the future, although this will necessitate overall performance improvements. Face detection technology for firefighting robots is being developed in order to help individuals stuck in fires. Face detection technology informs of the presence of persons caught in the fire to aid in their rescue. The ultrasonic sensor may also be attached to the robot to identify surrounding objects and avoid collisions. A wireless remote-control idea might be implemented in this system to allow humans to regulate the robot's mechanism according to their own needs. and its performance may be increased by attaching it to a higher-resolution wireless zooming camera so that the person operating it can view the robot's movement on a screen remotely.

Acknowledgment

We convey our heartfelt appreciation and gratitude to Allah for His Almighty Blessing, which enabled us to successfully accomplish this project.

We are grateful for each individual who has been directly or indirectly engaged with this project and has helped us accomplish it effectively. First and foremost, we are grateful to our renowned teachers, Lecturer Nurjahan Nipa mam and Lecturer Suman Saha sir, who have helped us through the project. Their support and direction enabled us to take on this type of job and accomplish it on time. Our project effort also includes other classmates who encouraged us and our friends who provided us with helpful recommendations.

References

[1] Aswinth Raj, "Arduino Based Fire Fighting Robot" , Circuit Digest Kirti Kadam, Ayush Bidkar, Vaishnavi Pimpale, Dhanashri Doke, Rachana Patil, "Fire Fighting Robot", International Journal of Engineering and Computer Science , 6 January 2018.

[2] G. V. Hadjisophocleous and Z. Fu, "Literature Review of Fire Risk Assessment Technologies."

[3] V. Mangayarkarasi, "Remote Controlled Fire Fighting Robot.", International Journal of Trend in Scientific Research and Development.

[4] "Arduino UNO for beginners - Projects, Programming and Parts". makerspaces.com. 7 February 2017. Retrieved 4 February 2018.

[5] Chattunyakit S.Kondo T.and Nilkhamhangl.(2013),"Development of Robotic Platform for swarm Robots in Fire Detection Application",Kasetsart Jour- nal Natural Science,47,pp.967-976

[6] "Introduction to Arduino" (PDF). princeton.edu. Archived from the original (PDF) on 3 April 2018. Retrieved 4 February 2018.

[7] H. Pranamurti, A. Murti, and C. Setianingsih, "Fire Detection Use CCTV with Image Processing Based Raspberry Pi.",Journal of Physics: Conference Series, 2019

[8] Shen, D. et al., "Flame detection using deep learning", 2018 4th International Conference on Control, Automation and Robotics (ICCAR), pp.416–420.

[9] V. Mangayarkarasi, "Remote Controlled Fire Fighting Robot.", International Journal of Trend in Scientific Research and Development

[10] Michael John Gollner, "Literature Riview on Hybrid FireSuspensionSystems"

[11] Kuo L. Su ,"Automatic Fire Detection system using Adaptive Fusion Algorithm for Fire Fighting Robot", – IEEE

[12] "HJ Round was a pioneer in the development of the LED". www.myledpassion.com. Archived from the original on October 28, 2020. Retrieved April 11, 2017.

[13] Ratnesh Malik,S.S.Kumbalkar,"Fire Fighting Robot:An Approach",Indian Streams Research Journal,Vol.2,Issue.II/March;12pp.1-4

[14] Archana B , K Suma, "Fighting Robot with Obstacle detection And Fire Detection Using Arduino "