Automation, Control and Intelligent Systems
2021; 9(4): 97-103
http://www.sciencepublishinggroup.com/j/acis
doi: 10.11648/j.acis.20210904.11
ISSN: 2328-5583 (Print); ISSN: 2328-5591 (Online)

Autonomous and Wireless Control Fire Fighter Robot

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To cite this article:
Mohammad Mahfujul Islam. Autonomous and Wireless Control Fire Fighter Robot. *Automation, Control and Intelligent Systems*. Vol. 9, No. 4, 2021, pp. 97-103. doi: 10.11648/j.acis.20210904.11

Received: August 31, 2021; **Accepted**: September 27, 2021; **Published**: October 12, 2021

Abstract: The aim of this paper is to explore a new model to extinguish fire without much human effort. There has been a renewed and sustained interest towards safety in both public and private sectors. During the year 2016, 3,515 people died by fire or fire related injuries in the USA alone. The total estimated economic value of fire related damages in 2017 exceeds $300 billion. Industries are the most possible places of fire accident particularly those related to chemical/hydrocarbon manufacturing and or processing. An advanced autonomous fire extinguishing system can combat fire accidents and minimize damage to both human lives and property without exposing fire fighters to additional risks. The proposed robot can autonomously detect and extinguish fire before it spreads. The robot can, without any human input, navigate through hallways or corridors of any complexity, even places unreachable by a human, to reach the origin of the fire before it is allowed to spread further. The robot can automatically recognize and avoid obstacles to reach its destination. The robot, therefore, can not only be used to effectively fight fire but can also be deployed to assist in search and rescue operations at natural disasters such as floods, hurricanes, tornadoes, volcanic eruptions, earthquakes, tsunamis, and other geologic processes. It can also be utilized to carry up to 1kg of equipment or emergency supply to hard to reach places. Its camera view can be live streamed, and if needed controlled by an authorized personal using a smartphone from a safe place through its wireless capabilities.

Keywords: Electronic, Robotic, Microcontroller

1. Introduction

Every year thousands of people die due to fire or fire related injuries while trying to extinguish fire in dangerous and hazardous places such as nuclear power plants, steam power plants, airports, fuel tanks, and forests. Despite the precautions in place and specialized protective gears, firefighting still remains a risky profession. They routinely expose themselves to dangerous situations in order to save lives. Such dangers can be minimized, however, by offloading some of the tasks to a firefighting robot. Robot is defined as a mechanical design that is capable of performing human tasks or behaving in a human like manner [1]. Considerable advancements have been made in robotics and autonomous system. This is has caused a revolution in the manufacturing industry where most of the repetitive and dangerous work has been assigned to robots. However, the potential of robots and robotic system can be realized in many other sectors. The applications of this technology is almost limitless and can have profound impact on human lives and society.

This project attempts to accomplish this through the use of three microcontrollers: Two *Atmega 16*s and an *Atmega 8*. The navigation is achieved by continuously parsing through the data received by the ultrasonic sound sensor attached to the front of the robot. To ensure stability on most surfaces including challenging terrain, a four wheel drive system is chosen for the robot.

2. Fire Deaths Numbers

267,000 peoples Death and millions of people were extremely injured by Fire in 2014 according to the WHO. Sometimes whole communities were damaged and they never recovered. Billions of Economic losses happened due to fire. Us Fire Department answered 384,000 homes fires in 2010. Children, older adults, and poor peoples are at the greatest risk. Especially those peoples are in deep risk who live in substandard or manufactured homes. [2]

The US fire administration states that 1,345,500 fires occurred in United States in 2015 which resulted in the deaths

of 3,280 people injuries of further 15,700 people. The estimated economic loss is in excess of 14 billion USD. These are just the numbers from one country. [3]

Being a developing country, Bangladesh is at particular risk of fire. Lacking critical infrastructures related to fire suppression and prevention, it is imperative for Bangladeshis to employ caution and prudence when dealing with fire hazards. There has been several large scale fires in Bangladesh with devastating costs, in both materials and human lives. Fire fighters were late to the scene in every one of the fires causing already large fires to spiral out of control even more before becoming manageable. In several of the fire incidents an autonomous robot designed to navigate and seek out fires before subduing it would have helped reduce the destruction and possible deaths. [4]

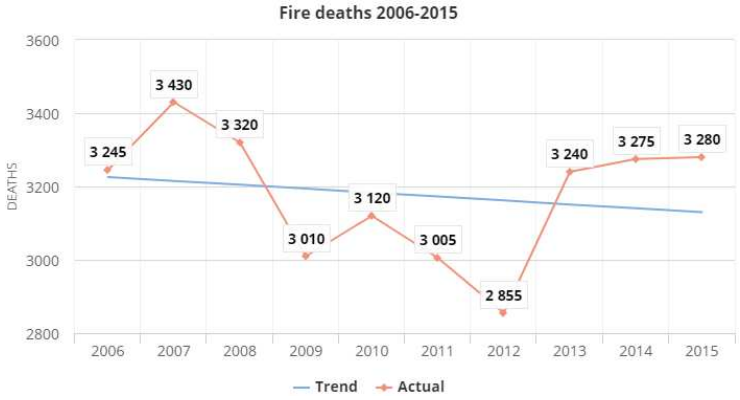

Figure 1. *Fire deaths in the US (2006-2015).*

3. Block Diagram of Fire Fighting Robot System

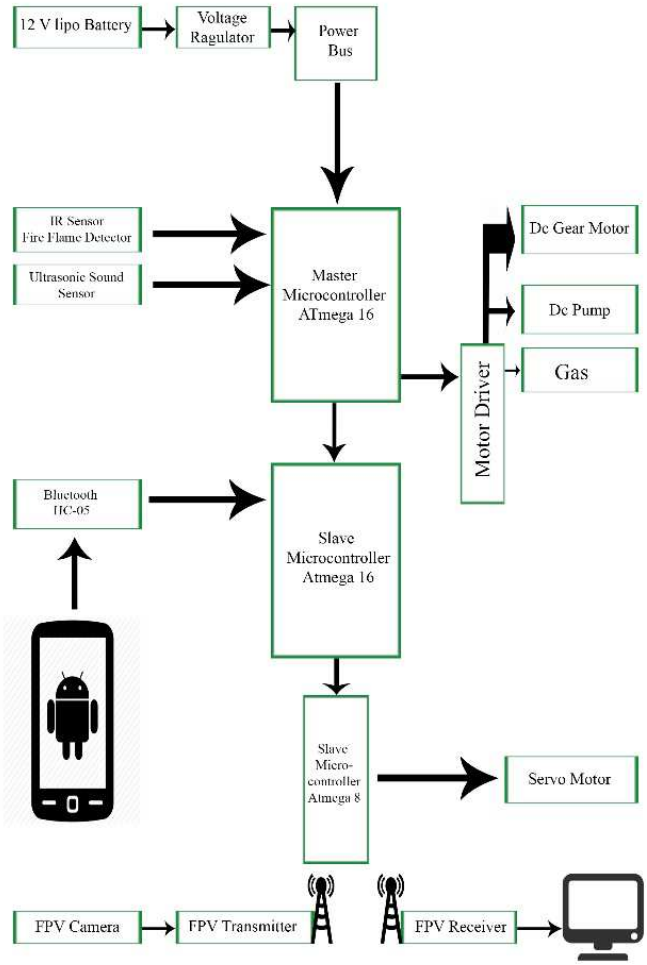

Figure 2. *Block Diagram of Fire Fighting Robot System.*

4. Similar Projects

There are multiple projects, in progress and completed, relating to fire extinguishing system.

One such project aptly named the Fire Searcher. It can work in any extreme condition such as high temperature, noxious gases by reason of its design. It Continuously monitoring the condition of a fire site and collect crucial data and sent to the operator who stays at a remote site. [5].

Jet Fighter is another sort of Autonomous Fire Fighting robot which can be operated by a remote user. On the other hand, in autonomous mode, it can extinguish flam automatically after detecting the source of the fire. It operates through a wireless communication system and it's designed with a monitoring system. The autonomous navigation system is developed by advanced obstacles avoidance system. [6].

Another type called the Portable Fire Evacuation Guide Robot System is precisely designed to gather data and information by thrown it into the fire area. This robot is use for search victims and rescue them from the fire site. By the combination of microphone and speaker system victims can able to communicate with operator. In addition, it has camera for live broadcasting, different sensors used for temperature, CO_2 and O_2 concentration measurement. The robot is specially designed with waterproofed and temperature resistance technology therefor it can survive over 15000°C and any weather. [7].

For robot communication, a mobile platform can be built around a wireless sensor network, for instance by using ZigBee wireless communication modules. For remote control centers, it gives you opportunities to send huge data transfer facilities, which you can use for video and audio live broadcasting. In addition, checked the signal strength of the wireless sensor for robot position identification [8].

A rescuing robot called BEAR (Battlefield Extraction-Assist Robot) is one sort of robot that can lift and carry victims from fire accident places. Sometimes its also use for food and medicine supply. However, its manufacturing cost is so high. [9].

The Fire Fighting Robot fire detection system was designed according to four flame sensors and the internal program based on sensors output. The temperature was monitor by four thermistors or flame sensors. If the current temperature value crossed the set value then the buzzer run for extinguished. On the other hand, it also sends warning messages to the authorities and nearby fire stations by the GSM module. [10]

In 2015 Saravanan P discussed a semi-Autonomous mobile robot (SA-BOT) in the same architecture and implementation. This robot has four DC geared motors for movement. The navigation system was designed by the integrated ultrasonic sound sensor and infra-red sensors. Atmega2560 microcontroller use for processing all data and generate outputs. Wireless camera outfitted with the robot for video transmitting to the base station. The fire detection system here used LDR (Light Depends Resistor) and temperature sensor. If sensors detect any fire then the robot moved to the fire source and starts the extinguishing process. The Extinguishing system is designed by a water container and water pump. In extreme conditions, the SABOT also operated manually. In addition by GUI (Graphic User Interfacing) implemented, the robot can be controlled from the remote base station. [11].

5. Working Principal

A robot is a machine designed to perform one or more tasks automatically with speed and precision. Most robot in existence are industrial in nature, built for a very specific set of tasks. Most of them are remotely controlled, or at the minimum monitored, by a human operator, sometimes from a great distance. Robots that truly autonomous in performing its tasks are rarer, mainly due to the challenges in designing and implementing the system required for its autonomy. The Autonomous & Wireless Fire-Fighter Robot is capable of extinguishing fires in the absence of humans operators. The flexibility of its control system enables it expand its repertoire of tasks besides its name sake such as providing emergency breathable air, food and water trapped victims. The Autonomous & Wireless Fire-Fighter Robot is designed with AVR Microcontrollers. Operation of this robot is divided into two parts:

5.1. Autonomous Mode

In this mode, the Autonomous & Wireless Fire-Fighter Robot is able to tackle fires independently of human operator input. When the robot first boots up, the two servo motors attached to the fire and obstacle detection sensors respectively, will reset their position to face in front of the robot. Fire detection is achieved through the use of IR (Infra-Red) Sensor which detects IR (Infra-Red) light wavelength between 760 nm – 1100 nm (Nano meter) that is emitted from fire flame [13].

The IR sensor used is of the passive infrared sensor type. It is an electronic appliance that measures the infrared radiation from objects. The reading varies upon the outside characteristics and temperature of the objects in front of detector. Fires will naturally emit intense infra-red radiation constantly making it easy to detect and pinpoint through the passive IR sensor. [14].

The robot will attempt to detect the presence of a fire within 1 meter from the front of the IR sensor. If a fire is found then the robot will move forwards towards its location and stop at a safe distance and activate the pump to spray water and solenoid valve to dispense CO_2 gas. After the fire is deemed to have been stopped, the ultrasonic sensor will determine whether the path is clear or blocked. If the path is obstacle free then the robot will again move forward.

The robot will stop after a set amount of time and scan the surrounding area for fire and obstacles by following these logic steps: When the robot first stops, it scans the area

directly ahead of it for fire and obstacles. It then does the same for the area 90 degrees to its right. It then turns 180 degrees to scan the left side. If a fire is detected, the robot will immediately cease following any prior instructions to try and extinguish the fire. After the fire is deemed to have been dealt with, the robot will resume its prior activities. If no fire or obstacles is detected the Robot will keep turning and checking every 90 degrees until it makes a full revolution and starts moving forward along its prior path. If an obstacle I detected, the robot will turn 90 degrees and check if the path is obstacle free. Once it detects that patch is clear, it will move forward.

While the robot's basic locomotion structure is built similar to a car, there is no steering, as in the front wheels cannot turn. Turning is achieved by turning the front and rear wheels on one side in one directions while turning the front and rear wheels on the other side on the opposite direction.

Table 1. *Movement and turning breakdown.*

Movement Direction	Motor 1	Motor 2	Motor 3	Motor 4
Forward	Clockwise	Clockwise	Clock-wise	Clock-wise
Right	Clock-wise	Anticlockwise	Clock-wise	Anticlockwise
Left	Anticlockwise	Clockwise	Anticlockwise	Clockwise
Reverse	Anticlockwise	Anticlockwise	Anticlockwise	Anticlockwise

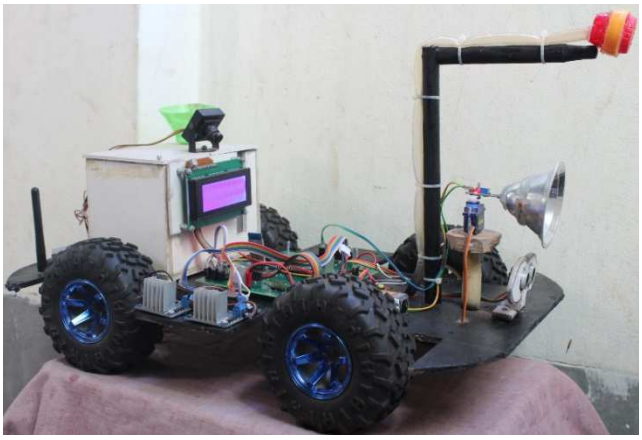

Figure 3. *Fire Fighter robot hardware implementation.*

5.2. Remote Control Mode

While the Robot is autonomous and designed to run without human input, it can, however, be remotely controlled by a human operator if the need arises. This is achieved by sending instructions using an app on a smartphone to a receiver on the Robot through Bluetooth radio waves. The Robot has been successfully tested using and ordinary Android smartphone with Bluetooth capability as the transmitter and a Bluetooth Serial Module Card HC-05 has been used as the receiver. The HC-05 Bluetooth-Serial Module Card is designed for use with Bluetooth SPS (Serial Port Standard) and wireless serial communication applications [15].

The app required to effectively communicate with and control the robot is Bluetooth spp pro. It can be found and installed from Google Play Store or linked directly: [*https://play.google.com/store/apps/details?id=mobi.dzs.android.BLE_SPP_PRO&hl=nl*]. The Bluetooth HC-05 module can be paired directly through the app, Bluetooth spp pro. After pairing, the Robot can be easily directed through the use of the D-Pad as shown in the screenshot below. The effective range of communication between the Robot and the user is 30 meters.

In both Autonomous and Remote Control Mode the robot will transmit live video in the form of FPV (First-person view) to the user with the receiver. The current wireless technology and standards enables the range of the transmission of the camera feed to the user up to 500 m.

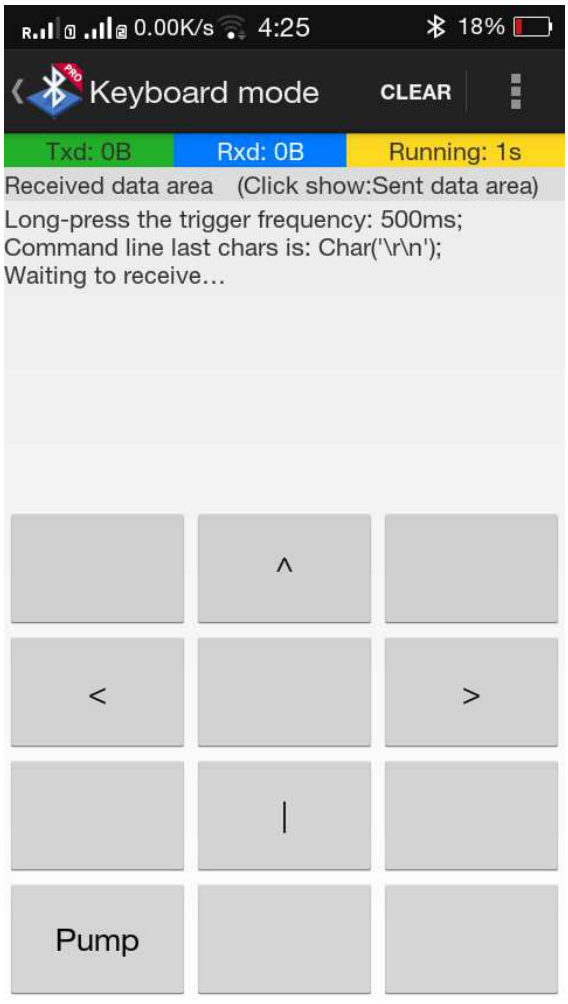

Figure 4. *Bluetooth Spp Pro software setting.*

6. Algorithm

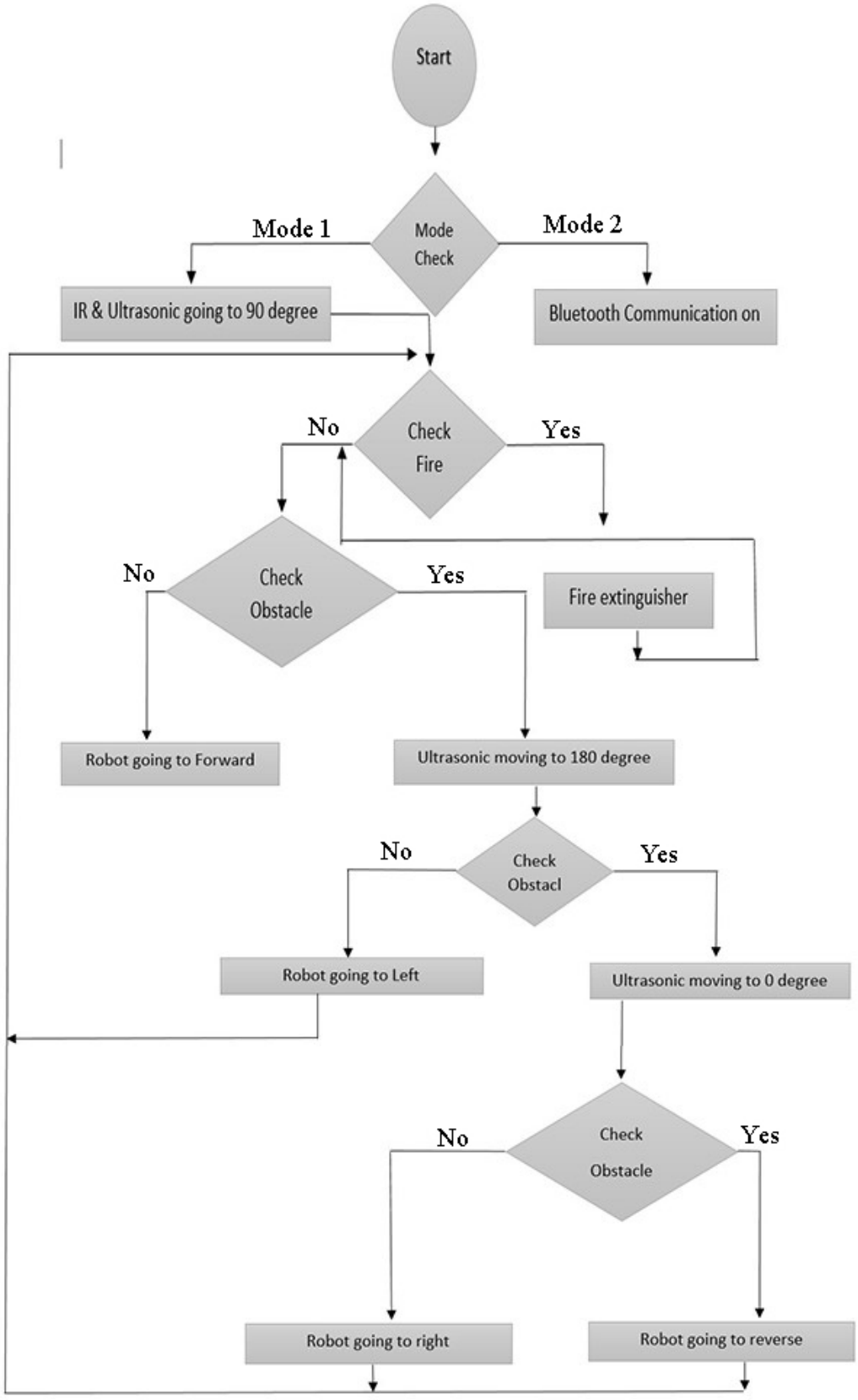

Figure 5. *Algorithm of the robot working system.*

7. Instruments Used

Table 2. *Instruments and parts used to build robot.*

Sl	Instrument list	Quantity	Purpose
1	DC gear motor (12 v)	4	Robot locomotion.
2	DC pump (12 v)	1	Water pumping.
3	LCD Display (20*4)	1	Operation display.
4	Servo motor	2	Ultrasonic and Flame sensor rotation.
5	Ultrasonic sound sensor	1	Obstacle and distance measurement.
6	Bluetooth module (HC-05)	1	Bluetooth Communication.
7	Fire Flame Detector	1	For fire detection.
8	ATmega 16	2	Single processing and output controlling.
9	ATmega 8	1	Single processing and output controlling.
10	Motor Driver	2	Motor controlling.
11	FPV camera	1	Live view.
12	FPV transmitter	1	FPV camera signal transmit.
13	FPV reciver	1	FPV camera signal receive.
14	Lipo Battery (11 v)	1	Total power supply.
15	Voltage ragulator (7805)	1	12v DC to 5v DC conversion.

8. Circuit Design (by Proteus)

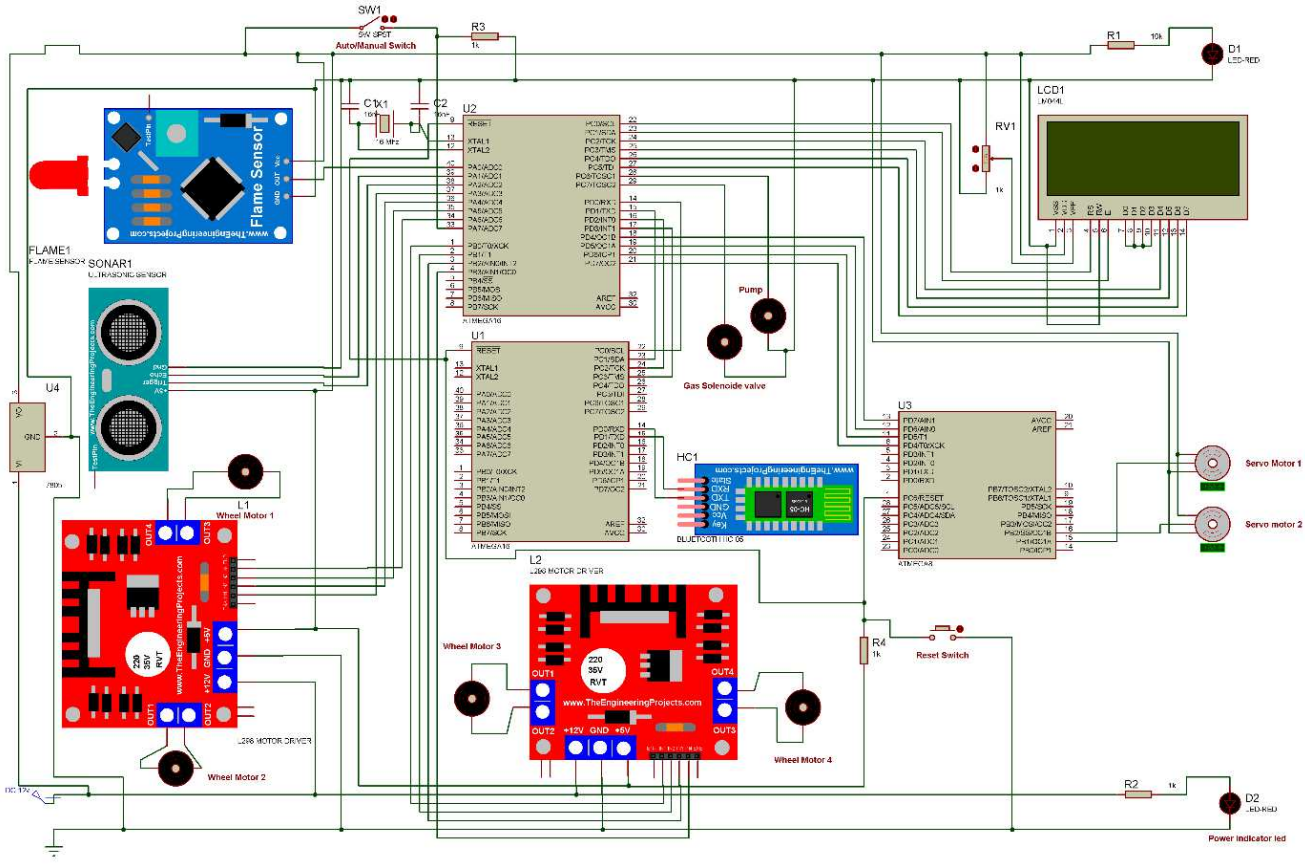

Figure 6. *Proteus Circuit Design.*

9. Application

1) The robot can detect and extinguish fires in dangerous place or hard to reach places.
2) This robot is ideal for use in industrial and urban areas for fire extinguishing.
3) Fires in nuclear power plants and combustion power plant can be dealt by the robot if its body and internals are adequately shielded from heat and radiation.

4) Can reduce risk to human lives if utilized in conjunction with fire fighters.
5) Rapid decisions can be made through the observation of the live video broadcast from the robot.
6) Provide crucial data to aid in search and rescue operations during natural disasters, especially during the aftermath of earthquakes and hurricanes.

10. Conclusion

One of the strongest driving force for the advancement of science and technology has been the need to achieve more while using less manpower. Humans have become proficient in utilizing technology to aid them in every facet of their life. This is also even more true for professions and work that that has a possibility of posing a threat to the wellbeing of the user. Our project aims to drastically reduce, even eliminate any danger a human might face while combating fires and participating in search and rescue operations. The parts and equipment used in the creation of the robot are readily available and easily assembled. The software and the circuit design can be provided free of charge upon contacting the author. The author would feel honored if his work contributed to any advancement in technology that would beneficial to mankind.

Future Scope

1) Expanding and fortifying the robot's chassis to enable it to carry even more water and possible a CO_2 cannister.
2) Upgrading the batter pack to increase its operating time.
3) Upgrading the water pump and to combat fires from farther away.
4) Adding more capable and sensitive sensors to detect fire and survivors from farther and through obstacles.
5) Adding GSM e-sims module to enable full control while still relaying to operators from much further away.
6) Including multiple GPS modules to relay highly accurate positioning data.
7) Integrating more advanced Image Processing System (IPS) and System on Chip (SoC) to increase its processing power to enable faster decision making.

Acknowledgements

First of all, the author would like to thanks Almighty Allah for everything in our life. The author acknowledges the funding of Dhaka International University, Dhaka, Bangladesh towards this project which instrumental for its completion. The author also expresses his deepest gratitude to his mentor, Mohammed Tareq, Assistant Professor, Department of Electrical & Electronic Engineering, who inspired him to push himself, selfless guidance, and valuable suggestions which was essential in bringing this research work to its conclusion.

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