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AUTOMATIC FIRE DETECTING AND EXTINGUISHING ROBOT

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ROBOTICS AND AUTOMATION

UNDER THE GUIDANCE OF:
Dr. Sumit Kumar Jindal

SUBMITTED BY:
Ishu Choubey (20BEC0412)
Ashutosh Mishra (20BEC0414)
Utsav Mishra (20BEC0200)

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Abstract:

Fire is one of five major elements on earth, during this period of advancement fires and accidents are common, detecting fire and extinguishing is a hazardous job for a fire extinguisher, it often risks the life of that person. Our motive is to build a LOW-COST robot which can detect fire automatically and then put it out on its own. This is a self-acting robot able to move on its own using motors if it detects any kind of fire using flame sensor and then it automatically put out fires using a water storage tank and pump onboard, everything is controlled by a microcontroller that is ARDUINO UNO R3, using data from three different flame sensors it moves in the direction of fire spot and follows the trail of fire detected afterwards.

Introduction:

Robot is a machine that looks like a human being and performs various complex tasks. There are many types of robots such as fixed base robot, mobile robot, underwater robot, humanoid robot, space robot and medicine robot etc. Our project looks like a three wheeled car and it is focused on a firefighting robot. The firefighting robot is programmed to search and extinguish fires in affected areas. The consequences of fire cannot be prevented, and they can occur anywhere. This robot is equipped with three flame sensors used to sense environmental fire and feed the signals to the microcontroller in order to trigger the pump which sprinkles water in order to extinguish the fire. The robot chases the flame till it becomes stationary and extinguishes it. This robot implements the concepts of environmental fire sensing, proportional motor control. The motor driver is used for the bidirectional control of the motors equipped in the robot. In short, the act of sprinkling water on a fire is known as firefighting. The robotic vehicle is equipped with water tanks and a pump that is operated by wireless communication

As a result of a fire outbreak (or) fire explosion, we use human resources that are not secure to put out the fire. It is very much possible to replace human work in putting out a fire in a dangerous environment by using higher technology, specifically with help of robotics. This strategy would free firefighters from dangerous tasks, increase their efficiency, and reduce the number of fires. The programming of the robot is done using the Arduino C which is derived from C and C++ languages.

Theory:

The main controlling unit used in this project is ARDUINO UNO R3, apart from this, major components are flame sensors, stepper and servo motors and water pump are used. The list of components used are as follows:

- ARDUINO UNO R3- 1
- L293d motor driver IC board- 1
- Servo motor- 1
- Stepper motor- 2
- Wheels- 3
- Flame sensor- 3
- Car chassis- 1(plastic/wood)
- Single channel relay module- 1
- Mini breadboard
- Jumper wires and battery connectors
- 9V batteries- 3
- 5V water pump
- Small pipe piece
- Water container
- Double sided tape and cello tape
- Screwdriver and screws

In order to use this project, you need to be familiar with some major components which are explained below:

- **ARDUINO UNO R3:**
  Arduino Uno R3 is one kind of ATmega328P based microcontroller board. It includes the whole thing required to hold up the microcontroller; just attach it to a PC with the help of a USB cable, and give the supply using AC-DC adapter or a battery to get started. The R3 Arduino Uno is the 3rd as well as most recent modification of the Arduino Uno. Arduino board and IDE software are the reference versions of Arduino and currently progressed to new releases. The Uno-board is the primary in a sequence of USB-Arduino boards, & the reference model designed for the Arduino platform. As

shown in figure ‘3.a’ ARDUINO UNO R3 comprises of 14-digit I/O pins. From these pins, 6-pins can be utilized like PWM outputs. This board includes 14 digital input/output pins, Analog inputs-6, a USB connection, quartz crystal-16 MHz, a power jack, a USB connection, resonator-16Mhz, a power jack, an ICSP header an RST button.

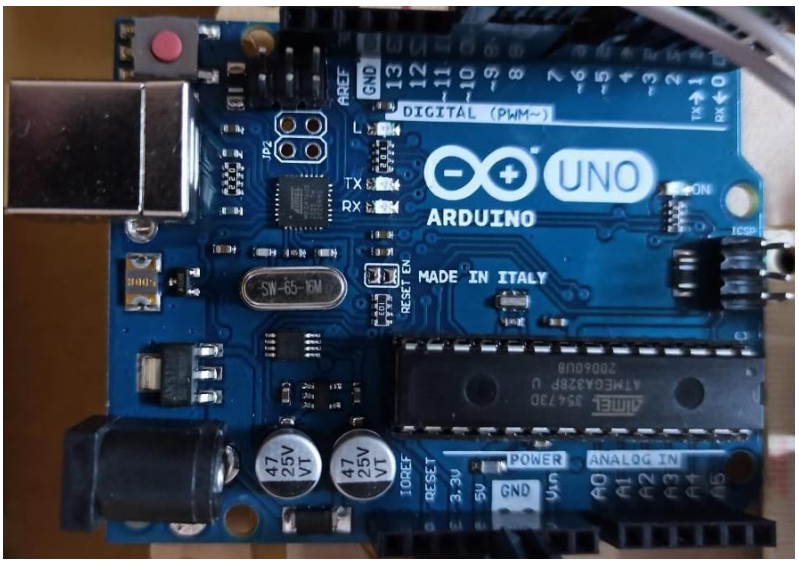


Figure 3.a (ARDUINO UNO R3)

- **L293d motor driver IC board:**

  L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293d is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. It means that you can control two DC motor with a single L293D IC.

  It works on the concept of H-bridge. H-bridge is a circuit which allows the voltage to be flown in either direction. As you know voltage need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge IC are ideal for driving a DC motor.

  In a single L293D chip there are two H-Bridge circuit inside the IC which can rotate two dc motor independently. Due its size it is very much used in robotic application for controlling DC motors. Given below is the pin diagram of a L293D motor controller.

  There are two Enable pins on l293d. Pin 1 and pin 9, for being able to drive the motor, the pin 1 and 9 need to be high. For driving the motor with left H-bridge you need to enable pin 1 to high. And for right H-Bridge you need to make the pin 9 to high. If anyone of the either pin1 or pin9 goes low then the motor in the corresponding section will suspend working. It’s like a switch.

  As shown in figure ‘3.b’ and ‘3.c’ here are 4 input pins for l293d, pin 2,7 on the left and pin 15 ,10 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right-hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

In simple you need to provide Logic 0 or 1 across the input pins for rotating the motor.

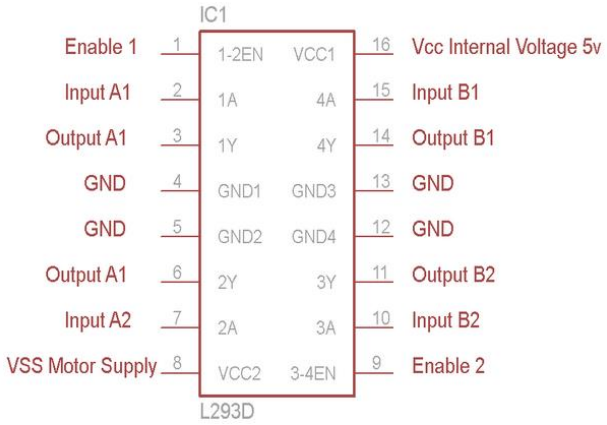


Figure 3.b (L293d pin diagram)

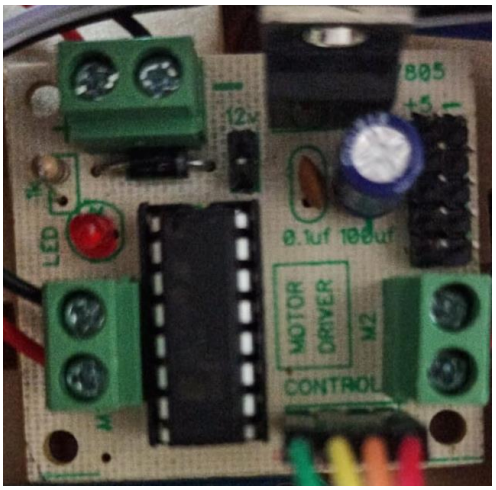


Figure 3.c (L293d IC board)

- **Flame sensor:**
  A flame-sensor is one kind of detector which is mainly designed for detecting as well as responding to the occurrence of a fire or flame. The flame detection response can depend on its fitting. It includes an alarm system, a natural gas line, propane & a fire suppression system. This sensor is used in industrial boilers. The main function of this is to give authentication whether the boiler is properly working or not. The response of these sensors is faster as well as more accurate compare with a heat/smoke detector because of its mechanism while detecting the flame. This sensor/detector can be built with an electronic circuit using a receiver like electromagnetic radiation. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice. As shown in figure '3.d' right pin is VCC centre one is ground and left pin is signal pin.

Figure 3.d (Flame sensor)

- **Single channel relay module:**

  The single-channel relay module is much more than just a plain relay, it contains components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active.

  As shown in figure '3.e' first is the screw terminal block. This is the part of the module that is in contact with mains so a reliable connection is needed. Adding screw terminals makes it easier to connect thick mains cables, which might be difficult to solder directly. The three connections on the terminal block are connected to the normally open, normally closed, and common terminals of the relay.

  The second is the relay itself, which, in this case, is a blue plastic case. Lots of information can be gleaned from the markings on the relay itself. The part number of the relay on the bottom says "05VDC", which means that the relay coil is activated at 5V minimum – any voltage lower than this will not be able to reliably close the contacts of the relay. There are also voltage and current markings, which represent the maximum voltage and current, the relay can switch. For example, the top left marking says "10A 250VAC", which means the relay can switch a maximum load of 10A when connected to a 250V mains circuit. The bottom left rating says "10A 30VDC", meaning the relay can switch a maximum current of 10A DC before the contacts get damaged.

  The 'relay status LED' turns on whenever the relay is active and provides an indication of current flowing through the relay coil.

  The input jumper is used to supply power to the relay coil and LEDs. The jumper also has the input pin, which when pulled high activates the relay.

  The switching transistor takes an input that cannot supply enough current to directly drive the relay coil and amplifies it using the supply voltage to drive the relay coil. This way, the input can be driven from a microcontroller or sensor output. The freewheeling diode prevents voltage spikes when the relay is switched off.

  The power LED is connected to VCC and turns on whenever the module is powered.

Figure 3.e (Single channel 5V relay)

Working:

Fig '4.a' shows the Block Diagram of this robot used in project. The main focus of this project is to sense or search the surrounding for any possible fire and extinguish it with the help of a water pump. The Arduino UNO Microcontroller board based on the ATmega328P. The ATmega328P is good platform for robotics application. Thus, the real time fire extinguishing can be performed.

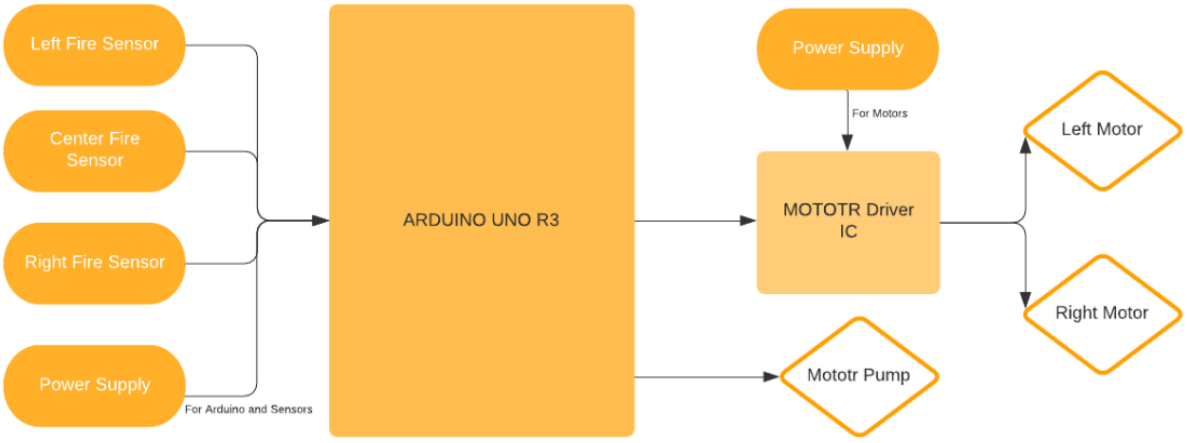


Figure 4.a (Block diagram)

The main aim of this project is to develop a fully automated fire extinguishing robot which detects the fire location and extinguish fire by using sprinklers on triggering the pump. The direction of movement of the robot are described by the motor driver board. It is used to give high voltage and high current is given as an output to run the motors which are used in the project for the movement of the robot. In this project a simple DC motor is used for the rotation of the wheel which are responsible for the movement of the robot. DC motors usually convert electrical energy into mechanical energy. To extinguish the fire a pump is used to pump the water on to the flame. A simple single channel relay module is used to pump the water and a servo motor is mounted on pipe's head so that it can sprinkle water over more area. The pumping motor in extinguishing system controls the flow of water coming out of pumping.

Software Implementation:

The connections are shown in figure ‘4.b’, as we can see that the motor driver control is connected through pin 2,3,4 and 5 pin 2 and 3 for controlling left wheel and pin 4 and5 for controlling right wheel. In sext step we connected three flame sensors via pin 8,9 and 10, pin 8 is connected to left flame sensor, pin 9 is connected to centre flame sensor and the right flame sensor is connected via pin 10. A servo motor is connected to pin number 11, the use of the servo motor is that it will help in scattering more water over a large area as the head of pipe is connected to the stepper motor, a 5V water pump is also attached to pin 6. A 9V battery is used to power up whole system.

The whole software simulation is done on proteus 8 professional (version 8.13), and code was written on ARDUINO IDE to generate a .HEX file.

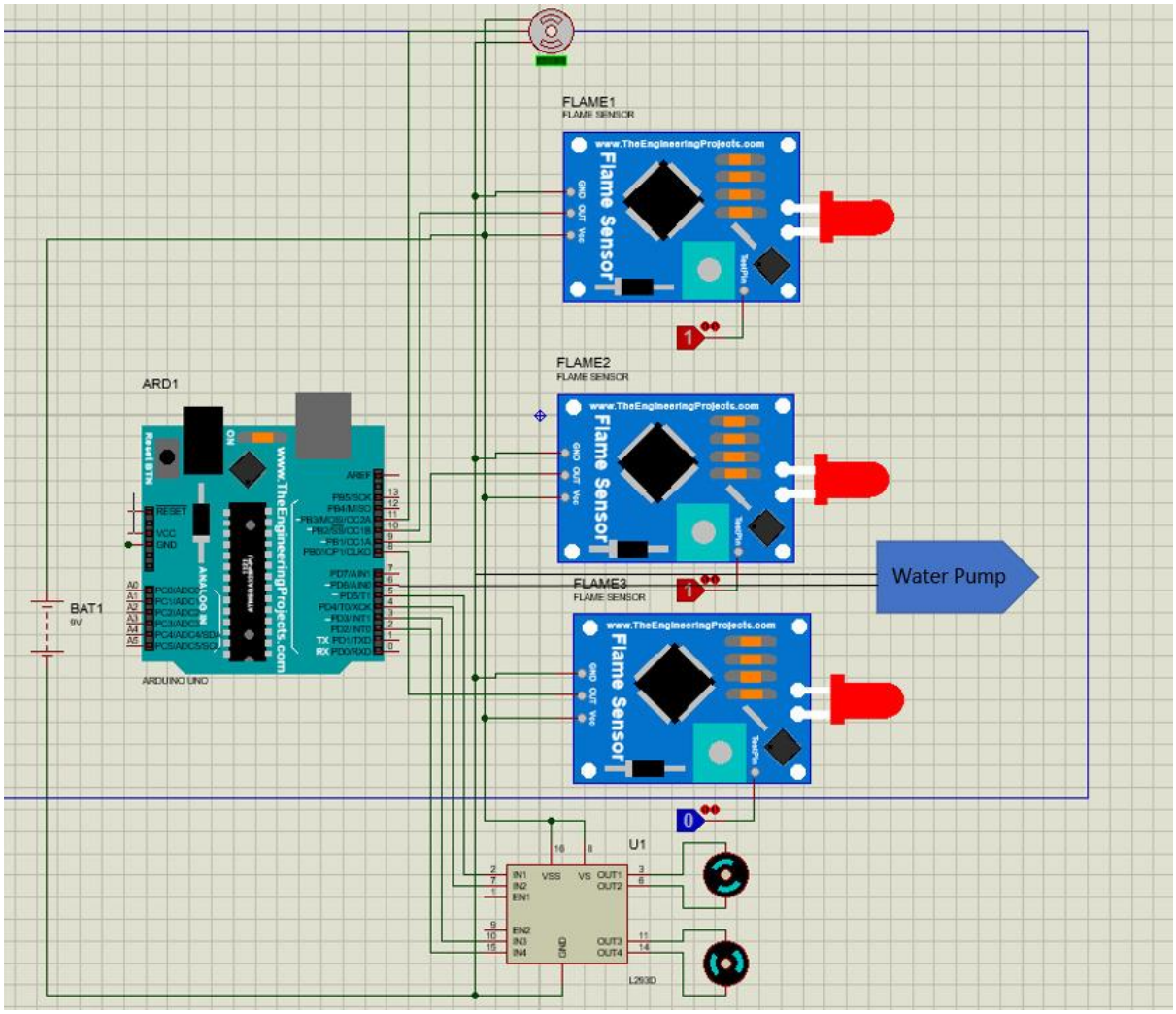


Figure 4.b (circuit diagram)

Hardware Implementation:

All the connections are made according to figure ‘4.b’, two wheels are attached to the two stepper motors respectively, a non-powered support wheel is also attached in front of chassis, all connections are done on a small breadboard mounted on the back of the vehicle. The flame sensors are mounted on front of the car chassis, one extra thing is added to hardware is a 5V single channel relay module to power up the pump we are using, the reason behind using this relay is that the Arduino pins aren’t providing sufficient power to water pump.

As shown in figure ‘4.c’ the servo motor is mounted on top front side of the setup and a water container is also placed on top of the vehicle for water supply. Water pump is submerged inside the water container, a pipe is used to deliver water out of the container. The head of pipe is attached to head pf servo motor as shown.

In total three 9V batteries are used to power up full system, one battery is used to power up ARDUINO and flame sensors, servo motor and relay module also draw their power from ARDUINO, the other battery is used to power up motors and it is directly connected to motor driver module the last and third battery is connected to the replay module and is used to power up our water pump, as shown in figure ’4.c, 4.d, 4.e, 4.f, 4.g, 4.h’.

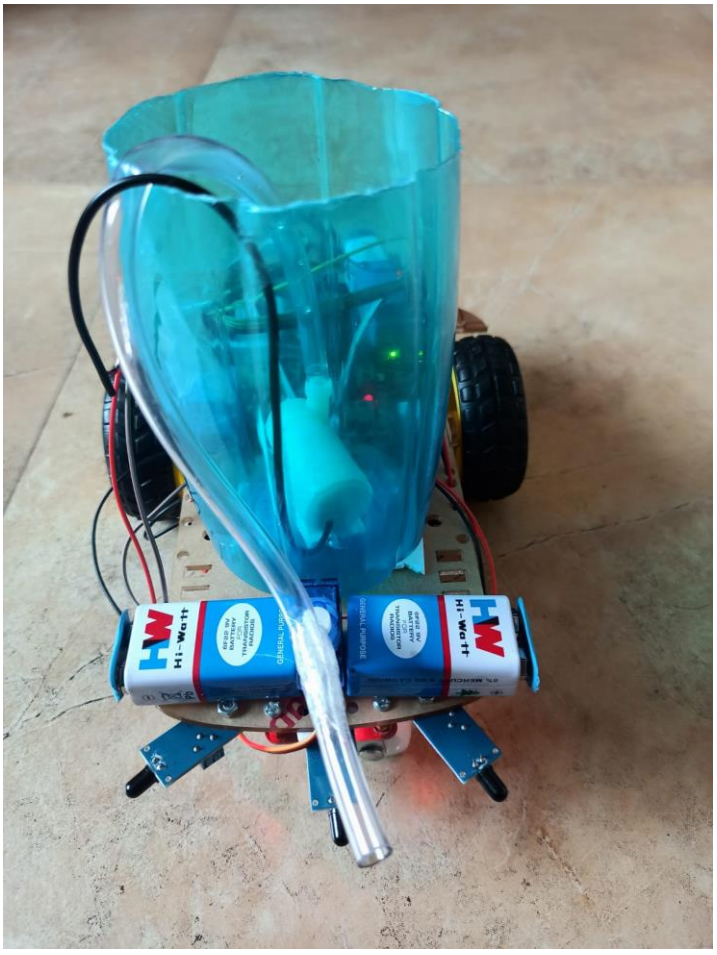


Figure 4.c (Front view/servo motor and pipe connections)

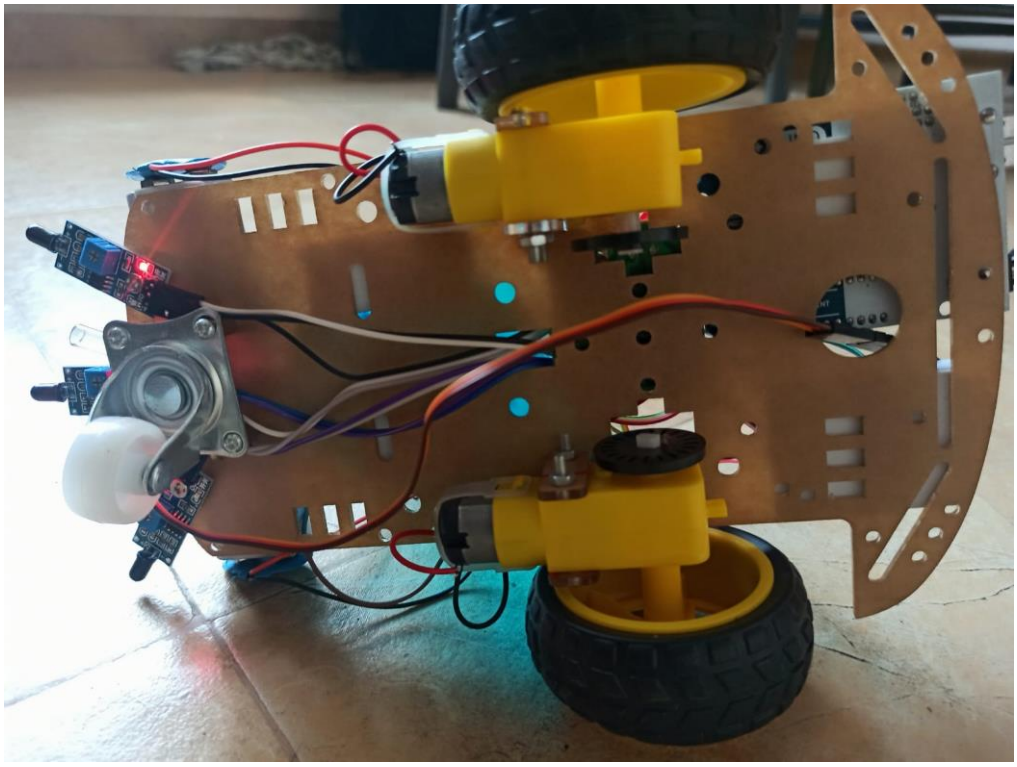


Figure 4.e (Bottom view/flame sensor connections and wheel orientations)

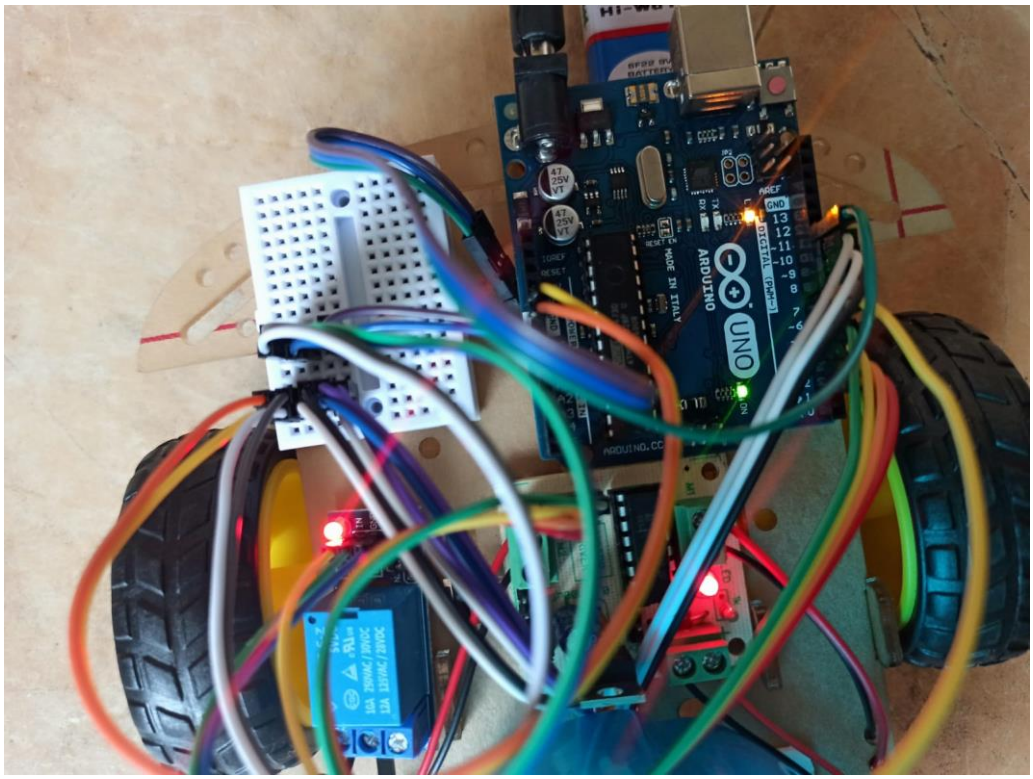


Figure 4.f (Rear view/breadboard connections)

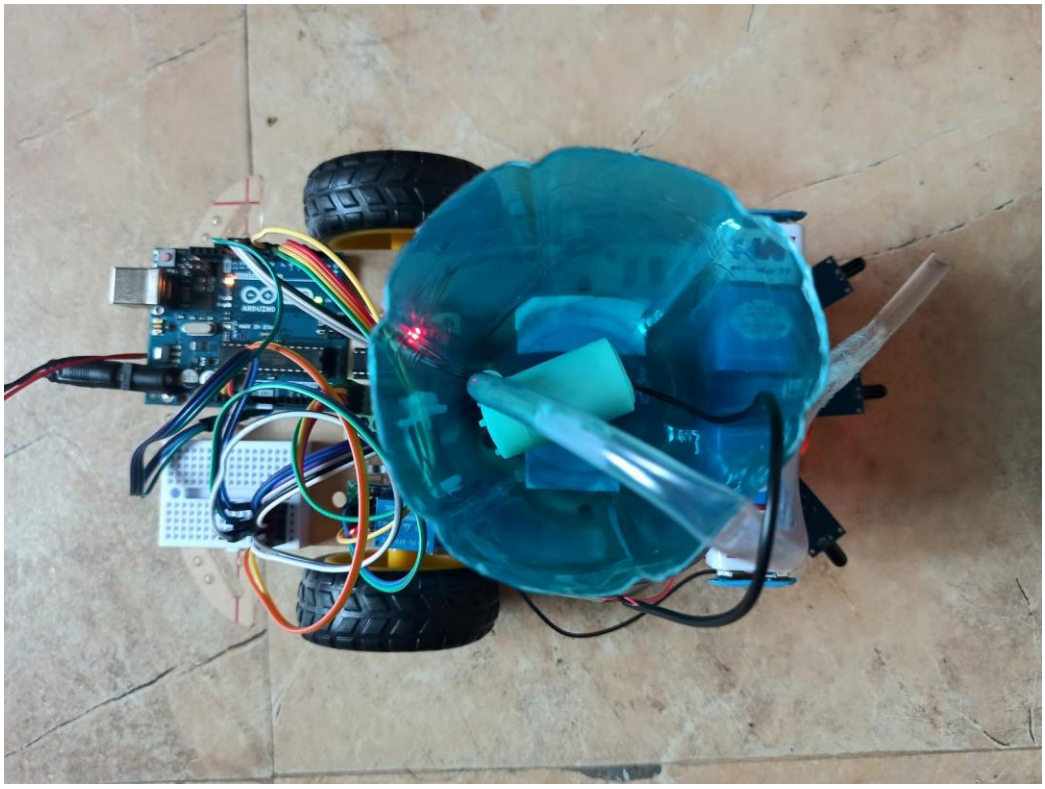


Figure 4.g (Top view)

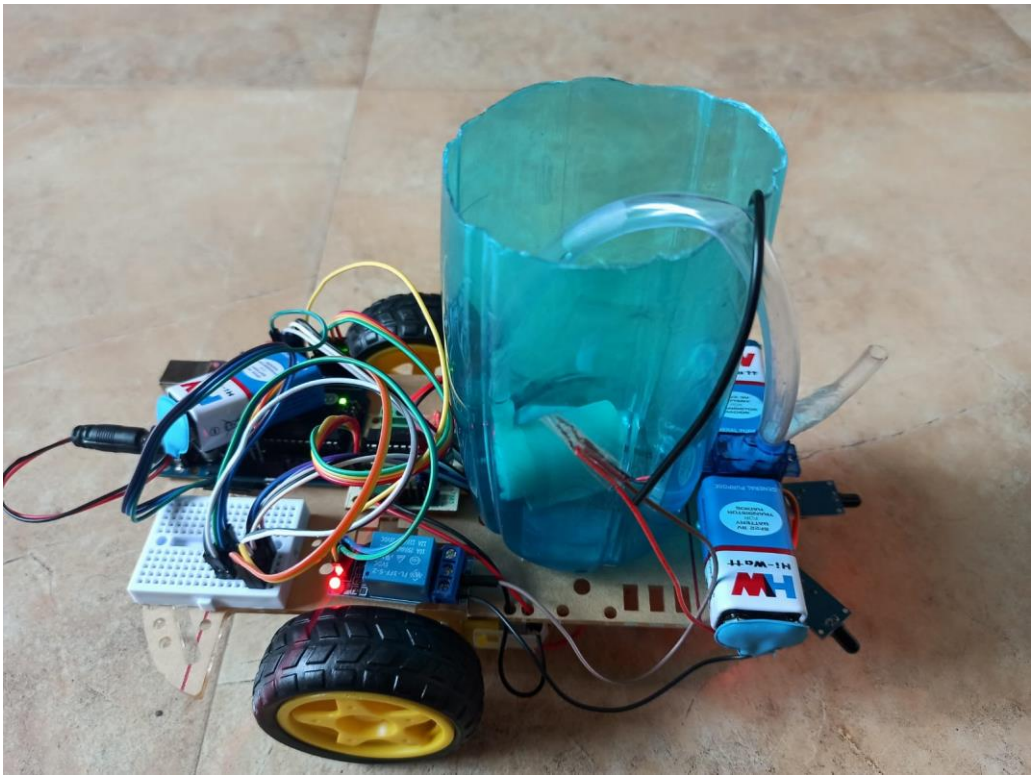


Figure 4.h (Side view)

Video link of working hardware: https://drive.google.com/file/d/1DvYI7w-taS5JYH84RZLqDp6nTD8JBcJt/view?usp=sharing

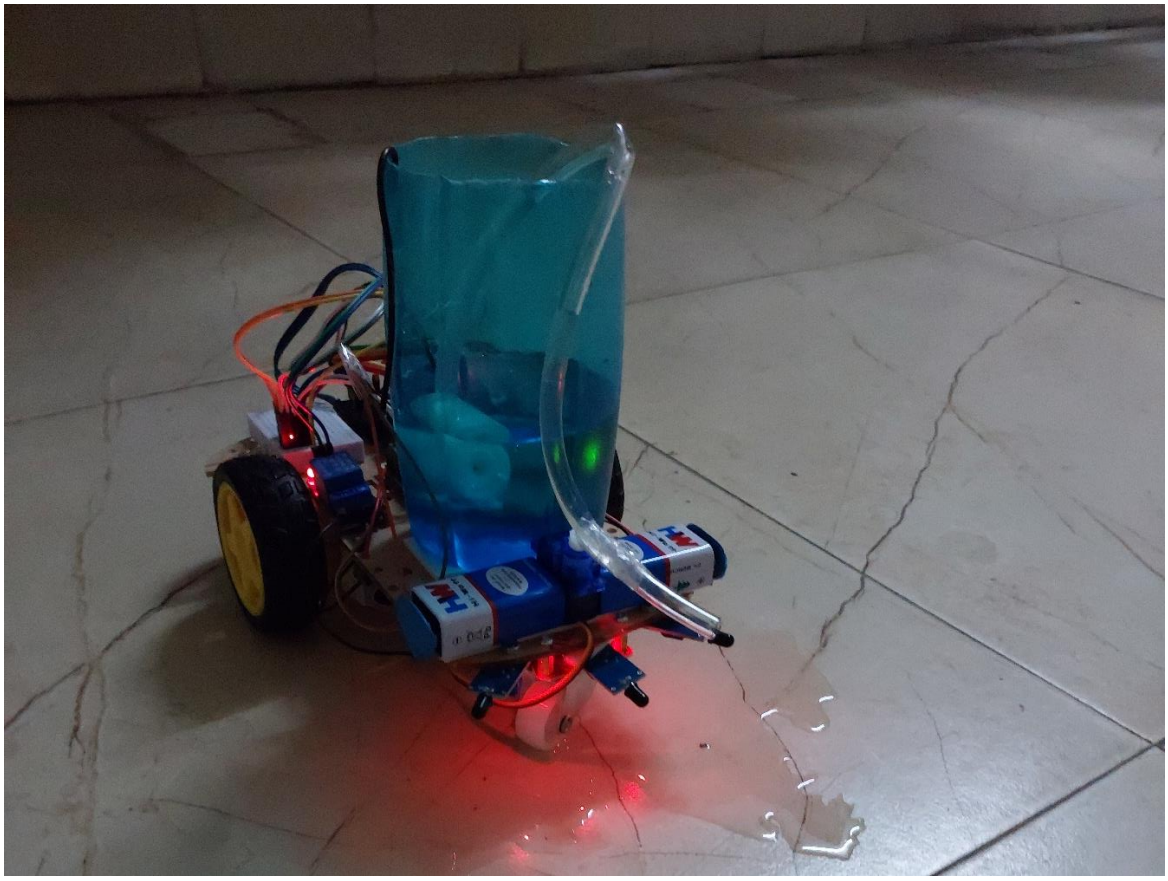
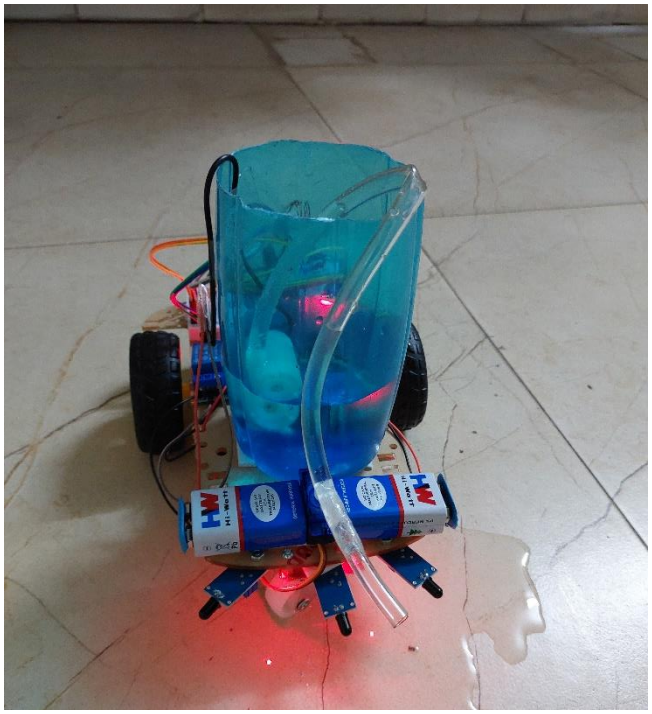


Figure 4.i (Pic taken while simulating)



Results and Discussion:

The robot works exactly as expected in both software as well as in hardware, in case of software, due to heavy load on local machine's processor (laptop in this case), the simulation is not real time, but the circuit responds to signals accordingly.

This local lag in software can be overcome by using a machine with better specifications.

In case of hardware simulation, the robot detects a flame around 1meter from it and move accordingly, for example is left sensor detects a flame then right side motor gets activated and robot just shifts itself in direction of fire, similarly if right sensor detects a flame then left side motor gets activated and robot just shifts itself in direction of fire. Once the robot is automatically aligned with the fire source it checks for fire again and this time when front flame senor detects fire, the robot moves forward in the direction of fire, then it stops automatically at a safe distance from fire and after stopping the water pump and servo motor gets activated and fire gets extinguished.

The responsiveness of this whole system depends on the amount of input voltage supply we are providing, in this case we are using three 9V batteries, but they drain very fast, so alternatively we can use any DC source to power this system.

Conclusions:

The robot is best suited for operating in an environment where humans cannot go, for example forest fire. Also, with the help of this idea we can save many human lives, using this robot properly we can put out fire in very short time, the robot efficiently detects fire then align itself in direction of fire then moves towards it, and after stopping at a very safe distance from fire the robot stops and then sprinkle water on fire source till it extinguishes.

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