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An Arduino Uno Controlled Fire Fighting Robot for Fires in Enclosed Spaces

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***Abstract*—A basic design of robot that can fight fires at an affordable cost could prove to be boon in fighting domestic fires, till help arrives. The robot developed consists of three elements which is the hardware, electronic interfacing circuits, and software program. The robot has four battery operated motor (BO motor). This firefighting robotic system is capable of detecting and extinguishing fire. These robots can be made to roll into places where it is not safe for humans to enter. Time is of essence when it comes to fighting fires as even a few minutes' delay can turn small fires into raging inferno. This robot is designed as a first response unit so it can suppress the fire keeps it under control till help arrives. This firefighting robotic system is controlled by an Arduino Uno development board. It is also equipped with the fire flame sensor for detecting fires. It is equipped with a water tank and a pump. So, on detecting fires it sprays water extinguishing the fire. Water spraying nozzle is mounted on servo motor to cover maximum area. Although there is a lot of scope for improvement, this could be a first step in developing a complete fire-fighting robot that could also rescue victims. The main function of this robot is to become an unmanned support vehicle, developed to search and extinguish fire. By using such robots, fire identification and rescue activities can be done with greater accuracy and securely without exposing the fire fighters to dangerous conditions. In other words, robots can reduce the need to expose fire fighters to danger.**

Keywords*— *Firefighting ROBOT, Fire Retardant, servo motor, safety, security.

I. INTRODUCTION

India recorded 1.6million fire accidents and 27,027 accidental fire deaths in the year 2021. The most common cause of house fires which also accounts for 42% of accidents is cooking [1]. Open flames from stoves can result in accidents when left unsupervised even for short duration of time. Annually 60 -70 Fire fighters die on duty, which is very high. Fighting various kinds of fire is part of every fire fighter's job which is very dangerous especially when they have to enter into buildings or tunnels filled with smoke [2]. If robots could be designed to detect and put out fires, humans will not have to put their lives at risk. The effects of fire are unpredictable, and they can occur in both young, recently constructed forests and existing natural backwoods. Fire has a direct effect on plant growth because it removes unwanted plants, allowing new species to arise [3]. Moreover, robots are not affected by poisonous fumes or carbon monoxide, hence they can enter places where it is not safe for humans to enter [4]. Although different fires require different kinds of fire retardants, here an attempt is made to detect fire before it rages out of control and becomes very difficult to extinguish [5]. A complete robot would have to detect the source of fire and also identify the type of fire and then use the right type of fire retardant. The idea being presented is around a firefighting robot. Robots are more suited to errands than humans since they are more efficient, practical, and precise [6]. As technology evolved, it filled in the gaps in domination, simplifying human labour. The firefighting robot has been upgraded to detect and extinguish fires in impacted regions [7]. Such a robot would prove to be a boon to the fire fighters and they could work with the firefighters putting out fires faster and efficiently. These robots could be used to reach the victims faster hence reducing the risk of injury to victims [8]. This paper presents a primitive Fire Fighting Robot. Robots could be made to make intelligent decision about the type of fires and the choice of retardants to use. But that would require various types of gas sensors and other key knowledge to make a decision about the type and source of fire [9]. The robot designed is similar to Fire Fox, a firefighting robot that carries its own water tank.

II. LITERATURE SURVEY

Mohd Aliff et al have developed and present a compact sized robot which can detect and put out fires without exposing the human fire fighters to danger. They being small in size can enter narrow or low entrances easily. They are equipped with an ultrasonic sensor, which allows them to detect obstacles and avoid them. These robots called QRob obtained from the phrase Rescue Robot. The Robs have a flame sensor mounted in the front [10]. These sensors detect fires by measuring the wavelength of the light from the flames of fire. Wavelengths between 760 and 1100nm indicates a fire that needs to be extinguished. The robot is also equipped with a camera which allows

the robot to constantly take pictures and sends it to a smartphone, which can control the QRob from a remote location. The QRob is so designed that it can extinguish fire from a distance of 40 meters.

Changzhong Wu et al have designed and developed a firefighting robot which moves on crawlers driven by a pair of DC motors. A fire arm that carries a sprinkler is located on top of the body of the robot shaped like a battle tank [11]. The fire arm can replicate the movement of a human upper arm, but can turn 360º. Cameras are located in the center of the body of the robot. The camera is mounted behind the fire arm and can rotate through 360º and can transmit pictures of the current situation back to the control station [12]. The fire arm is equipped with a water gun which can spray water at a very high pressure killing of fire. The various parts of the robot are controlled by STM32 controller. The entire robot is covered by a strong cover, which protects the various parts from heat damage.

SaravananP et al. has designed and developed an Integrated Semi-Autonomous Fire Fighting Mo- bile robot. The System controls four D.C. motors powered by Atmega2560 which can be controlled au- tonomously by a navigation system. Navigation system comprises of integrated ultrasonic sensors and in- frared sensors [13]. The robot has a wireless camera mounted on it which captures the video and transmits it to the base station. The fire detection system comprises of LDR and temperature sensor. In case of a fire, thefire sensor detects it and through appropriate control signals the robot can be moved to the source of fire which can be then extinguished. The extinguishing system consists of a BLDC motor coupled to a pump and a water reservoir [14]. The SABOT can be operated manually for extreme conditions. It comprises of a GUI support through which robot can be controlled from the base station.

Ipin Prasojo et all have design of a robot that moves like an insect. The robot has three parts – i. A fire sensor UV-Tron that senses presence of a fire ii. A DC motor coupled to a pump that is turned ON and OFF by a relay iii. Sixteen ultrasonic sensors mounted all around the robot to sense any obstacles and avoid them [15]. Fire detection is done by a combination of sensors controlled by a PIC microcontroller. Fire detection is done taking inputs from flame sensors, temperature sensors and smoke sensors. Based on the input to the PIC microcontroller from these three sensors the Microcontroller detects presence of a fire and sends appropriate signals to the AT89S52 microcontroller which activates the relay that turns ON the motor. The motor either sprays water or foam to put extinguish the fire.

III. Overall Functional Design of the Fire Fighting Robot

The design of this firefighting robot involves:

- Design of the body of the robot is designed like a car with the water tank mounted on it.
- Choice of motor that can drive the robot with a full tank of water and which can be controlled by a simple microcontroller.
- Designing and interfacing circuits for various sensors for detecting fires and avoiding obstacles, with the Arduino UNO based microcontroller.

Writing a program to make the robot semi-autonomous, so it can act on its own in the event of a fire breaking out in the vicinity of the robot and still be controllable by a human operator.

The overall assembly of the firefighting robot system is as shown in Figure 1. Two servo motors are used for driving the wheels of the robot and another servomotor is used with the water spraying system. Arduino libraries make programming easier by providing a wider range of libraries and addition of extra libraries are also possible. Four fire sensors are used to detect fires on all the sides of the robot. 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 flam

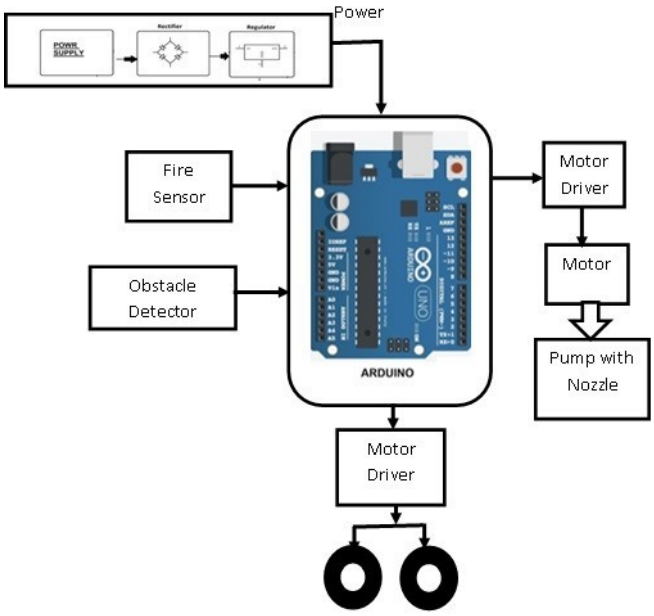

Fig. 1. Fire fighting Robot System

Flame sensor detects flame whose wavelength is within the range of 760 nm – 1100 nm. Flame detection can be done from a distance of 100cm and the detection angle will be 360º.This sensor can easily be damaged due to high temperatures and hence the sensor cannot be taken too close to the flame. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust and even water vapor. The flame sensor is mounted in front of the robots and can sense flame or fire from a distance of 1 meter and send signal to the Arduino UNO. Four sensor are mounted such that complete 360º are covered.

The controller on receiving signal from the flame sensor, starts moving towards the flame. As the robot moves towards the flame any obstacle in the path of the robot is detected by the obstacle detector and the robot moves either towards the left or right and goes around the obstacle till it is 1 meter away from the source of flame and sprays water on the flame. The complete interfacing circuit is as shown in Figure 2

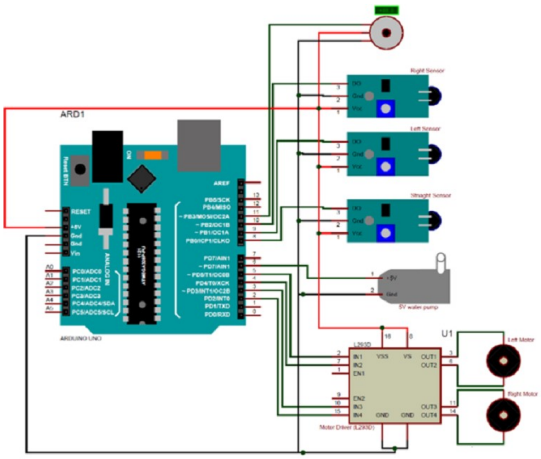

FIG. 2. Complete Interfacing Circuit.

The robot is driven by a DC servo motor which comes with a closed loop control system. Therefore, interfacing and controlling the motor with a microcontroller is easy. The motor that drives the pump is also a DC servo motor for the same reason mentioned above.

IV. Results and Discussion

The flow of the way the robot works is explained in the flow chart which is shown in the Figure 3a and 3b. The robot constantly keeps taking inputs from the flame sensor every few minutes to detect presence of fires. Once the fire is detected the robot follows the steps as programmed and puts out the fire by turning on the water sprinkling system. The robot used for our project is as shown in Figure 4.

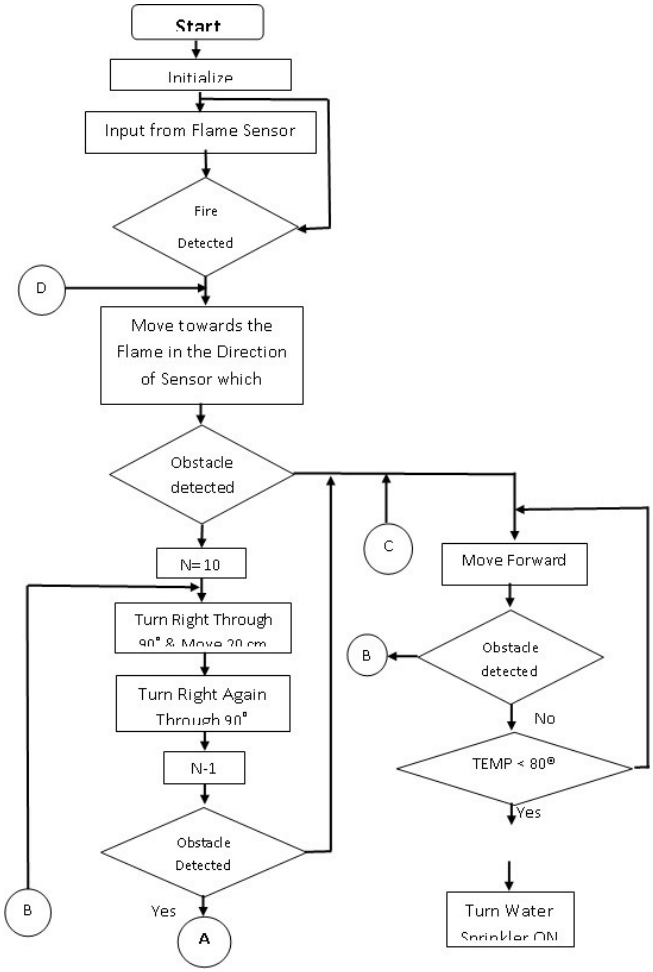

FIG. 3A. Flow Chart

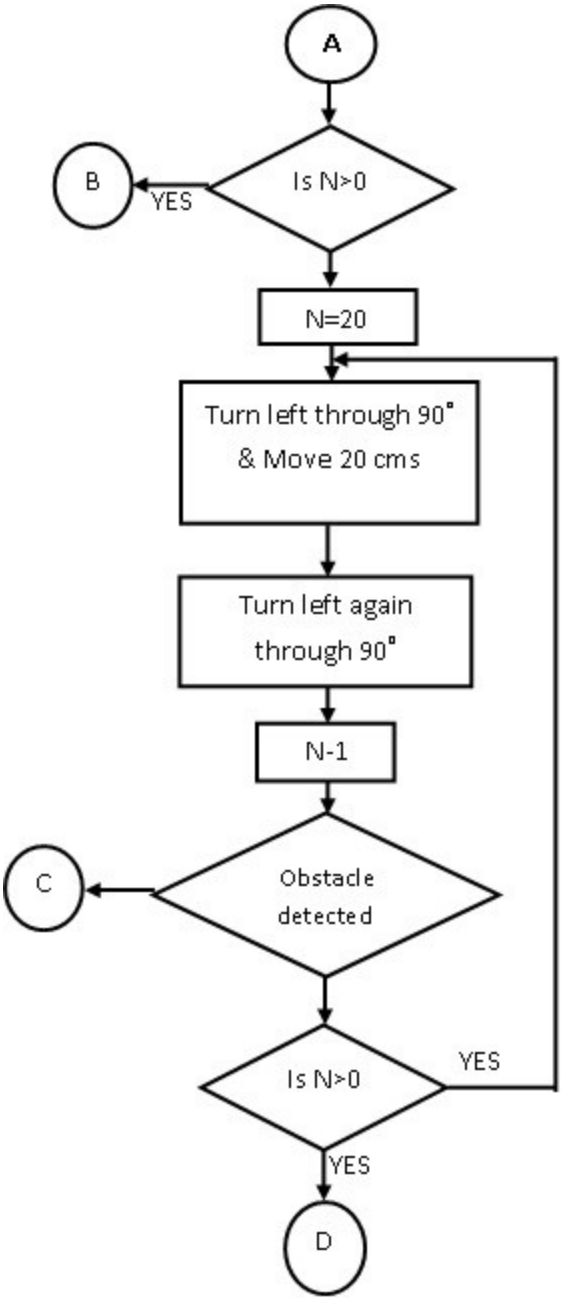

FIG. 3B. Flow Chart.

Ideally, we would have liked to use caterpillar tread instead of wheels and make the entire body out of fire proof material.

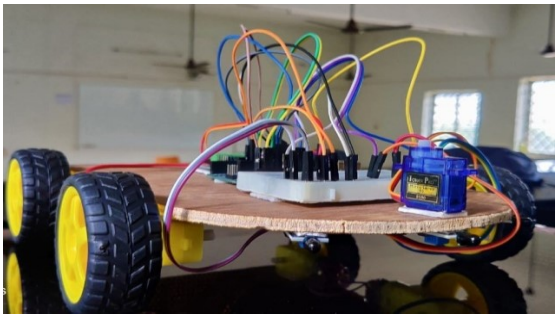

FIG. 4. The robot with all the control circuitry and sensors mounted

V. CONCLUSION

Firefighting robot is ideally suited for conditions where the passage is narrow and reaching the source is difficult for humans due to smoke. This robot can still be improved by adding certain element of intelligence by which the robot can identify the source and type of fire and select the fire retardant to be used on these fires instead of using water all the time which might not work always. The robot presented here moves on wheels which can prove difficult when the terrain it moves on is uneven. Therefore, caterpillar tread can work better as they can move fine on all kinds of terrains. We created a system that detects and extinguishes flames before they start while also lighting up the electronic environment. The goals here are microcontroller and engine control using a reductive engine, as well as fire detection with a fire sensor. The robot created for this study interacts via the sequential port and cycles the basic and computerized data collected from the sensors in the microcontroller control to identify whether the fire is in an open or closed environment. The fire sensor being sensitive to temperature need to be shielded by enclosing it in a thermal proof material. This system could be effective for house hold fires that could happen when there is no one around. The robot could be upgraded by adding a signal transmitter and receiver so it can send messages to a smartphone and receive commands from the phone.

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