



## AUTOMATIC DETECTION AND EXTINGUISHING OF FIRE USING AUTONOMOUS MOBILE ROBOT

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### ABSTRACT

The traditional methods of extinguishing fire requires physical presence of fire-fighters in the fire affected area. This can be lethal for the lives of fire-fighters. This paper illustrates the benefits of an autonomous mobile robotic device that is capable of detecting and extinguishing the fire, thus minimizing human contact. The paper presents an approach to develop autonomous mobile robot capable of steering to critical fire hazard situation and simultaneously provides live feedback through images. Upon detection of the fire, initiate the extinguishing action. This paper aims to implement an eco-friendly recharging method for the batteries used in the robot. The objective of this robot is to provide fire fighters a better insight of the situation and help them prepare a better strategy while combating the fire.

**Keywords:- Robot, extinguish, detect, navigate, situation, wireless.**

### INTRODUCTION

In a fire accident, there are many circumstances where there is a danger of injury as well as casualty from fire (including the fire itself, structure shattering, insecure floors, collapsing bodies). Collapses from heights are also common.

Sudden ignition of products creates flashover, a smoke explosion which can be intensified with surplus stream of air and lead to flare up. Fire Fighters also have a high risk in combating fire specially the ones who are at front holding the water nozzle as they have a little idea about the situation. Dry hot air is usually not hazardous but in combination with smoke and chemicals from burning objects can cause burns. These burns can also occur due to prolonged exposure to high temperature, and the presence of uncertainty among firefighters can lead to traumatic events which is another cause of stress. As with most emergency services, there are long periods of quiet or routine, interrupted abruptly by periods of intense stress or activity. In addition, most fire-fighters work shifts or extended work days which can have adverse health effects. By the use of this robot the threat to human life, dangerous accidents, time consumption to extinguish fire can be prevented.

This paper proposes a methodology to develop a fire-fighting robot for automatic detection and extinguishing the fire affected area and in addition to this the robot provides live surveillance of the situation. The robot is named "Poseidon", named after the God of Sea. This automated robot is stocked with a tank filled with water and a hydraulic-type pump that is operated through wireless medium to shower water. Arduino Uno controller is utilised for this particular procedure. At the user end, commands are sent by a wireless appliance to the receiver on the robot to manage the robot's motion. Remote operation is achieved by any smartphone/Tablet etc., upon a GUI based touch screen operation. The smartphone at receiver's end functions as a remote control that

encompasses the advantage of a longer range, while the receiver has wireless control to power DC motors by the use of L293D IC and motor driver circuit to generate required effort.

## LITERATURE SURVEY

The existing techniques were aimed mostly on the autonomous nature of the firefighting robot.

Archana B.T. *et al.* [1] gives the design idea of fire-fighting robot using autonomous operation. This robot used an Arduino Uno microcontroller. A single ultrasonic module was used for obstacle recognition and dodging. Here, an IR sensor was employed for detecting the flame, i.e. when light from flame falls on the sensor, the resistance of sensor changes which in-turn will trigger the system to move in that direction. The sensors were calibrated to detect the fire at a range of 1m. LM35 sensor was used in addition to detect heat and stop at a distance.

Daniel J. Packet *et al.* [2] explains how designing a fire-fighting, autonomous robot to compete in a contest encourages students to apply knowledge gained throughout the engineering curriculum. The robot developed named Mini-Bob, an autonomous robot was created which could navigate through a square maze and also memorize its path, so that it can find its way out of the maze and in-turn was a slow process. It was first made of Lego before finally making it with an aluminium body. It could extinguish the flame at a distance of 30 cm.

Ting L. Chien *et al.* [3] aimed at developing a multiple sensor based system that contains a robot with fire extinguisher. In this Paper a robot named as Robart-III, was a cylindrical shaped robot constructed out of aluminium frame weighing over 80 kgs. For detection of fire it used 2 flame sensors and obstacle detection was using 8 IR and 8 ultrasonic sensors. Fire event information was transmitted using a GSM modem via RS232 interface. Updates on the fire event are sent to mobile. Ultrasonic sensors can detect distance from 0.25m to 10m.

Mohd Aliff *et al.* [4] developed a robot named QRob; it was compact in size as compared to the other robots. This robot could work on its own or could be manually controlled remotely. It could be controlled over a distance of 400 m. It was a diesel engine robot that powers up to 18 kW and water could be pumped up to 50 m using a high-pressure hydraulic pump.

Our paper aims on creating a power efficient, compact, semi-autonomous robot which can efficiently extinguish the fire with an added advantage of giving us the live image feedback.

## METHODOLOGY AND MATERIALS

The operation of the proposed methodology is demonstrated in the block diagram as shown in Fig. 1.

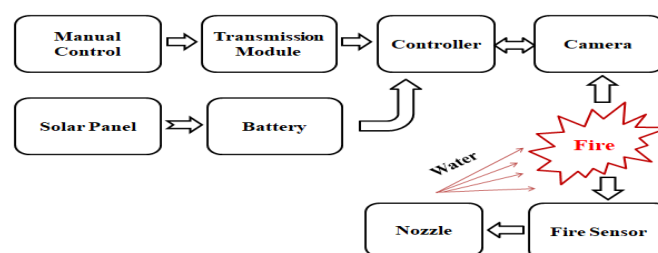


Figure 1: General Block Diagram of Fire Fighting Robot

The operator controls the robotic device via wireless medium (Bluetooth/ Wi-fi), by viewing the live pictures transmitted by the camera affixed at the robot. The robot is navigated to the location of fire affected area from a

safe distance and hence acquiring the update of the fire affected facility. This controller is powered by rechargeable battery which is recharged in an eco-friendly method by using solar panel.

Once the fire is detected by the operator via camera or detected through flame sensor the robot will halt at a safe distance and will start extinguishing action through water spray nozzle.

The proposed methodology for this paper is categorized as below:

1. Navigate the Robot to the fire location.
2. Automatic detection of the fire, and extinguishing the fire by spraying water using nozzle.
3. Robot will be charged using Solar panel.

The project methodology is explained as follows:

### 3.1 Navigate the Robot to the location of the fire

The operation for navigation of the robot is demonstrated in figure 2.

A camera module is fixed at the front of the robot that will continuously capture images. This OV7670 is linked to Arduino Uno which acts as the central processing unit of the robot. A wireless transmission module is connected to Arduino which communicates with remote wireless device. The wireless transmission module receives commands from the remote wireless device.

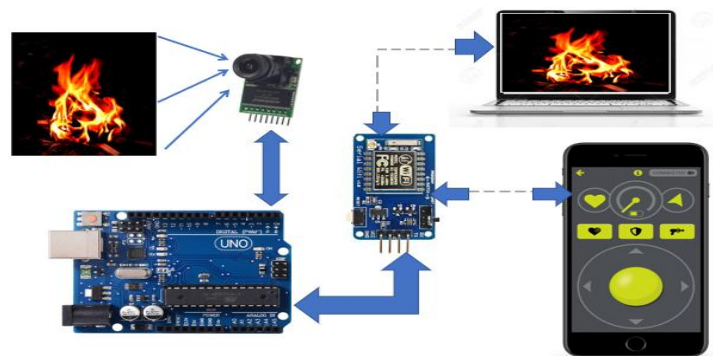


Figure 2: Navigation of robot

#### a) Arduino Uno:

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits. Arduino Uno is used as a Central Processing Unit in this robot.

#### b) Wireless Transmission module (Bluetooth/Wi-fi):

The HC-05 is a module which can add two-way (full-duplex) wireless functionality to communicate between two microcontrollers like Arduino or communicate with any device with Bluetooth functionality like a Phone or Laptop.

#### c) Remote wireless device (Mobile/Laptop):

This device is used for controlling the vehicle in a wireless manner. This can be a smartphone, laptop or computer.

d) Camera Module (OV7670):

The camera used is a camera module by the name of OV7670. It is a 0.3 MP(mega-pixel) C-Mos colour module, it can output 640x480 VGA resolution image at 30 frames per second

In situation of fire accident it can be fatal entering the place without having the knowledge of the situation, that's when fire fighting robot can help it can enter the place and can provide surveillance of the situation, and can help extinguish the fire, the first step is to steer the robot to the region affected by fire.

Navigation of the robot is to be done through a wireless transmission module (Wi-Fi/Bluetooth). The camera affixed at the front of the robot continuously transmits the live images from the situation to the operator in a safe location. Operator can monitor the situation and can give directions to the robot through a wireless medium. According to the images provided by the camera module the user can control the robot and navigate it to the location of fire. The flamesensors detect the flames as it gets at a specific distance from the fire. Once the robot gets at safe distance from fire, the process of extinguishing fire is initiated.

### 3.2 Automatic detection of the fire, and extinguishing fire by spraying water using nozzle.

A flame sensor which is connected to the arduino is used to detect the fire. A soon as it detects the fire it sends a signal to arduino and in turn arduino triggers the pump. A submersible pump is placed inside a water tank which is situated on the robot. A servo motor is used to regulatethe courseof water spraying nozzle.

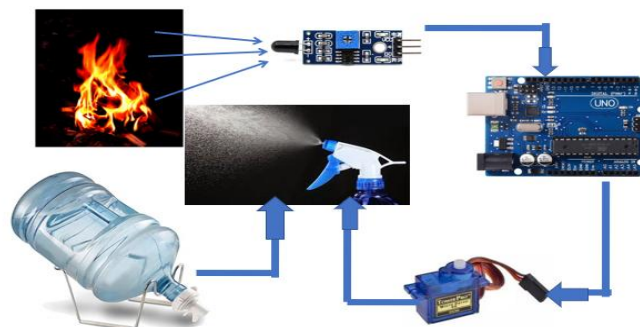


Figure 3: Extinguishing action.

a) Flame Sensor:

Flame can be sensed by wavelength of the light waves emitted by the flame, that's why module which is very sensitive towards light waves is employed in Flame sensor. These sensors detect fire if wavelength within limits of 760 nanometres to 1100 nanometres from a source of light. The detection of fire flames can be achieved from a distance of one hundred centimetre and the angle of its perception is 60. An analogue signal is obtained as the output of this sensor which is converted to digital signal. These sensors actsimilar toa flame alarm.

• b) Submersible Pump:

It is a hydraulic pump. This pump contains a motor, propeller inside a hermetically sealed body. The whole assembly is submerged in the liquid to be pumped. The motor is performs the rotary action to thrust the

liquid to the surface. This whole mechanism is done by converting rotary energy into kinetic energy into pressure energy.

- c) Servo Motor:

A servo motor is an electrical device which can drive or turn an entity with utter accuracy. It is merely constructed of simple DC motor which is executed over servo mechanism.

- d) Water tank:

The water to be pumped intended for in quench the fire is stored in water tank placed on the robot.

On navigating robot to the fire affected area, flame sensor spots the fire and notifies the operator and triggers the water nozzle. Direction of water nozzle can be controlled by the operator through the laptop, as a servo motor is installed in the robot.

The water nozzle gets the water supply from the water tank which is placed on the robot. The nozzle is flexible and its direction can be adjusted according to fire. According to the images sent by the camera, the user can locate the fire and extinguishes the fire by spraying water on the fire by using the nozzle.

### 3.3 Charging of Robot using Solar panel

The robot is completely battery operated. In order to not rely on the electricity sources and make the vehicle more independent, solar panels are used for charging the robot.

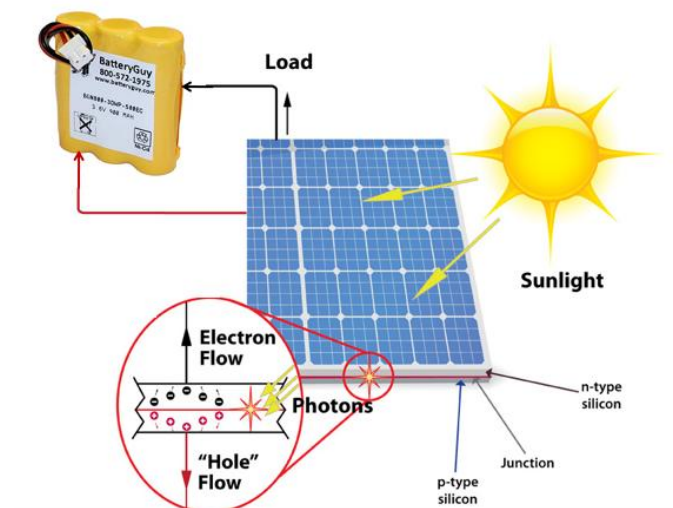


Figure 4: Charging of batteries using solar panel.

- a) Rechargeable Batteries:

As opposed to a disposable or primary battery, rechargeable batteries are a type of electrical batteries that can be charged and discharged into a particular utilisation. Those can be recharged multiple times. Primary batteries are used and discarded after its said use.

- b) Solar Panel:

Solar panels are fabrication of silicon cells arranged in a frame work. A group of photovoltaic cells is called a Photovoltaic Panel. These Silicon cells convert energy from sun into current flow DC. Arrays of a photovoltaic system deliver electricity to industrial usage

Robot may face a situation where there is inadequate power supply. In such a situation the robot can be charged using solar energy through solar panels.

Robot can be charged through solar panel, the solar panel charging station will be external and portable.

Solar panels sometimes referred to as Solar Modules have cells of silicon in form of layers, a frame of metal, a casing of glass and wires for the current to flow. The non-metal Silicon has 14 atomic on the periodic table that makes it possible to output electricity from charged photons from sun rays. When sun rays make contact with silicon, it gives rise to flow of electron particles in the silicon, which is electric current. It is the "Photovoltaic effect". This demonstrates the principle behind use of solar panels. The energy generated from the solar panel will be used to charge the lithium ion battery, which further will be used to provide power to the robot.

## RESULTS AND DISCUSSIONS

The software requirements for the implementation of the methodology is as listed below:

a) Arduino IDE:

IDE: The integrated development environment (IDE) is an app that comprises of a text editor for source code editing, debugger, compiler and a run time environment for compiling and executing a program which supplies wide-ranging solutions to professional coders for development of software. IDEs such as Arduino IDE, codeblocks etc. include the essential compiler and interpreter.

The Arduino Integrated Development Environment (IDE) is a cross-platform application available for Windows, macOS, Linux that supports the programming languages like C and C++. The Arduino IDE is used for programming the Arduino microcontroller. The Arduino IDE supplies a software library which also contains many API (Application Programming Interface) required for interfacing various devices. Arduino IDE was used for scripting the source code and uploading it in the Arduino microcontroller.

b) EAGLE:

EAGLE stands for Easily Applicable Graphical Layout Editor. EAGLE is a scriptable electronic design automation (EDA) application in cooperation with schematic capture, printed circuit board (PCB) layout, auto-router and computer-aided manufacturing (CAM) features. This software is used for making the supplementary circuits of flame sensors as well as the solar charge-control circuit.

• c) Proteus:

The Proteus Design Suite is an exclusive software tool that is predominantly used for performing the simulations on the electronic circuits and testing the source. This software is used for testing the program used in the system.

• d) Arduino Bluetooth Control app:

Arduino Bluetooth Control is an android application that allows user to send commands to Arduino board through the Bluetooth. This tool offers multiple buttons which can be fully customized, that allow to send specific signal when clicked.

The fire-fighting robot implemented using the proposed methodology is displayed in the figure no. 5.

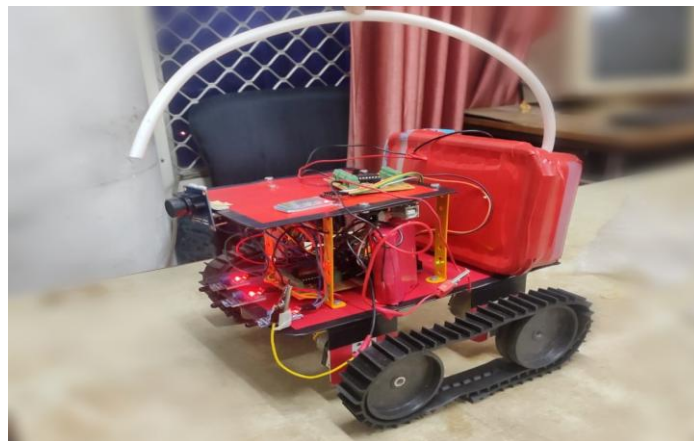


Figure 5: Result

The methodology is successfully executed and the resultant robotic device is capable of detecting fire by the use of flame sensors and simultaneously extinguishes it by spraying water using a water nozzle.

The steering of the robot is done comfortably using a wireless device.

The robot is capable of transmitting live feedback using the camera.

The batteries used in the robot are efficiently charged using solar energy by employing a solar charging station.

## APPLICATIONS

This paper aims at developing a robot that is capable of extinguishing fire and surveillance of the fire affected area, and also implementing an eco-friendly method for charging the robot.

### 1. Fire Fighting

The robot extinguishes fire by sensing flame coming off from a fire using flame sensors and extinguishing it by using water nozzle. This application is useful where the probability of explosion is high. It can also be useful in the situation of chemical hazards.

### 2. Surveillance

The camera present on the robot will give us live image feedback for better understanding of the fire affected area. This can also be used as a mode of surveillance for any situation that requires live feedback. It can be employed for disaster area monitoring, as well as server room monitoring. It can enter a room where it can be fatal for humans, like places filled with poisonous fumes and can monitor the situation by transmitting the images which provides a better understanding of the situation to the people involved in the operation.

### 3. Eco-friendly Charging

A solar charging station is installed for charging of the robot. This assures an ecofriendly and cost effective way of powering this robot. It is not possible that the place of accident will have a power supply, so robot can be charged using solar energy through solar power.

## CONCLUSIONS

In order to handle catastrophic fire associated incidents, the concept of fire fighting robots is put forward. Firefighting robots are function ed in situations where fire fighters are unable to perform. The proposed Robot is an efficient and safe method to extinguish fire from a safe distance and be able to be successfully deployed in emergency situations. Robot is capable be broadcasting live images of the affected area. The proposed robot will reduce the risk of possible casualties of human and animal life.

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