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Design and Development of a 360-degree Fire Extinguisher Robot using Microcontroller

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Abstract – *Fire hazards are a common phenomenon in developing countries like India causing loss of lives and property every year. Fire emergencies occur where either a human cannot reach on time or location of fire is hazardous and life threatening for humans to approach and douse the fire. The Design and development of a Fire Fighting Robot will provide an impactful solution for society and help save lives. The solution uses Flame sensors to detect the fire hazard, Microcontroller to analyse data from sensors and decide the right course of managing the fire hazard. After analysing it uses WIFI module as a communicating device to alert a human being in charge of the control by raising an alarm through activation of the LED. The user activates the Fire extinguisher robot using the Blynk application to spray water with the help of a pump onto the fire guided by servo motor to synchronize the direction of water output.*

***Key Words*: Fire-fighting, Extinguisher, Flame Sensor, IR, Servo, Microcontroller, Blynk**

1. INTRODUCTION

Fire hazards are a common phenomenon in developing countries like India causing loss of lives and property every year. According to the India Risk Survey (IRS) 2018, fire outbreak is the third most serious threat to business continuity and operations. Accidents from fires are alarming and devastating So, to minimize losses resulting from accidents and save lives, Fire extinguisher robots will play a vital role. Another aspect is related to the firemen involved in these accidents – they risk their lives while rescuing the victims. The location of the fire accident is important – e.g., chemical mills, garment factories, gas and petrol stations, as it affects the target area including surroundings. This type of accident results in loss to lives, and pollutes the environment. While the government and other regulatory agencies have prescribed fire safety standards and measures, execution and vigilance remain important issues.

Following are the important aspects related to the paper:

Robotics: Robots are automated devices that are capable of performing tasks in an efficient, cost-effective, and accurate manner compared to humans. It has grown in popularity as technology has advanced, minimizing human intervention.

Mechatronics: Robot development consists of hardware, electronics and programming to automate our daily tasks and to make or life easier using the concept of mechatronics.

The Firefighting robot that is presented in this paper focuses on providing remote maneuvering capability using a programmable microcontroller ESP 8266 controlled through Blynk Application, detect the fire-affected areas using a flame sensor and then letting the user manually control the robot to douse the fire using a water pump connected to a water storage tank.

1.1 Problem Statement

Fire outbreaks are known to cause significant loss of life (victims and rescuers) and property. Due to high temperature and presence of potentially hazardous material fire-fighting robots will be useful for extinguishing fire, particularly in places where fire-men cannot reach and work. It can thus reduce human injury from a burning fire.

1.2 Objectives

- To design and develop a Robotic Chassis by fabricated Sheet Metal having 2 back wheels and one front wheel.
- To design a microcontroller circuit that has Fire sensors and motor driver interfaced with the Controller. This circuit will be mounted onto the chassis.
- To code the robot such that it will do the following tasks - It will have a Rover Control i.e., Forward, Reverse, Backward, Sideways movement control through Blynk App and will detect and extinguish the fire using fire sensors and pump respectively.

1.3 Scope

- To design and develop a robotic vehicle which has rover controls. (I.e., Forward movement, Backward movement, sideways movement, etc)
- To program the flame sensors such that they detect the fire and move the robot manually towards it using the WIFI Module.

- To douse the fire using water by spraying it using a pump after detection.

2. LITERATURE REVIEW

In today's era firefighting in hazardous locations is a difficult real-life problem. Many researchers are working on Mechatronics, Internet of Things (IoT) driven techniques for firefighting robots and have developed innovative solutions.

Tawfiqur Rakib, M. A. Rashid Sarkar proposed a firefighting robot model which consists of a base platform made up of 'Kerosene wood', LM35 sensor for temperature detection, flame sensors to detect the fire and a water container of 1 litre capacity which is made up of a strong cardboard that makes it water resistant. The robot has two wheels for its movement. [1]

Saravanan P., Soni Ishawarya proposed a model which uses Atmega2560 micro-controller and in which the robot is divided into three basic units according to their functions which are as locomotive unit, fire detecting unit and extinguishing unit. Each unit performs their task in order to achieve the desired output of extinguishing fire. The locomotive unit is used for the movement of the robot and to avoid the obstacles with the help of four IR and four ultrasonic sensors. The fire detecting unit is used to detect fire using LDR and temperature sensor. The extinguishing unit is used to extinguish the fire using water container and BLDC motor. The robot also has a Bluetooth module that is connected with the smartphones in order to navigate it in the proper direction. [2]

Boo Siew Khoo demonstrates the Fire Droid, an automated fire extinguisher robot that can detect and extinguish flames. When a fire breaks out in a home, the fire-fighting robot will be able to detect the flame and proceed to the source of the fire. Water is pumped out of the water tank after the fire position is secured and the flame distance is calculated, hence dousing the fire. [3]

H.P. Singh developed the control system for a mobile autonomous industrial firefighting robot. The paper demonstrates the creation and design of firefighting robots with a wide range of capabilities. Two optically separated D.C. engines are housed within the structure. The robot transforms data from infrared sensors in a variety of ways, from simple to complex. There are five infrared sensors in use. Two sensors control the robots' movement, while the other three are used to detect fire. A D.C water syphon and a water compartment are included in the douser. The primary goal of the paper is to identify and suffocate fire flare-ups. This infrared sensor serves as an information sensor, detecting infrared beams emitted by the fire. The extinguishing mechanism is controlled by the microcontroller. [4]

3. DESIGN AND ARCHITECTURE

The Robot Hardware (Chassis) should be designed such that:

- It should have low weight for a single person to carry during emergencies.
- It should move fast and manoeuvre the entire fire area, at the same time being stable without losing balance.
- The robot chassis and its structure must accommodate for all the sensors and microcontroller and should have it suitably covered for protection against fire or water.

We fabricated the chassis using Mild Steel.

We decided to use Mild Steel because of the following reasons:

- Ductile – Mild steel is particularly ductile due to the minimal quantity of carbon utilised in its production and the lack of any alloying components. Low carbon steel can be deformed and shaped without losing its hardness, making it an extremely malleable steel that may be utilised for a variety of applications.
- Machinable and Weldable – Mild steel's ductility makes it particularly well suited to a variety of steel fabrication techniques, including welding. The smaller the proportion of carbon in the steel, the more bendable the steel becomes.
- Affordable – Mild steel is a cost-effective type of steel that many steel fabrication customers utilise to finish their industrial projects because it takes minimal resources and ingredients.

The system components are as follows:

1. ESP 8266 WIFI Module

The ESP8266 Microcontroller (Also a WIFI Module) is a self-contained SOC with an integrated TCP/IP protocol stack that can provide access to your WIFI network to any microcontroller. The ESP8266 may either host an application or offload all Wi-Fi networking functionality to a separate application processor.

2. Flame Sensor

The flame sensor is used to detect a fire by using infrared technology. Photo Transistor is placed at the front of a flame sensor to detect the flame.

The three pins for connections of the Flame Sensor are as follows:

1. Ground – The common ground pin for the flame sensor.

2. VCC – The positive 5V voltage that powers the flame sensor.

3. Digital Out – Flame Detection Pin.

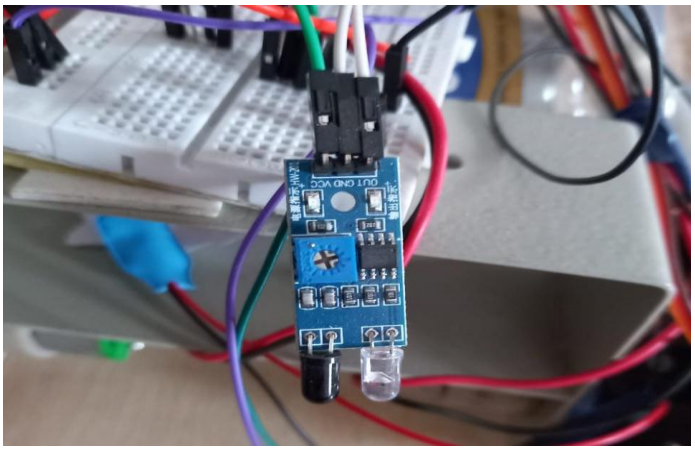

Fig -1: Flame Sensor

3. L298N Motor Driver Module

The Motor Driver is a motor control module that lets you control the speed and direction of two motors at the same time. The L298N IC was used to create and build this Motor Driver. Its output is high voltage and high current, which is utilized to drive the motors that are employed in the project to move the robot in the four directions.

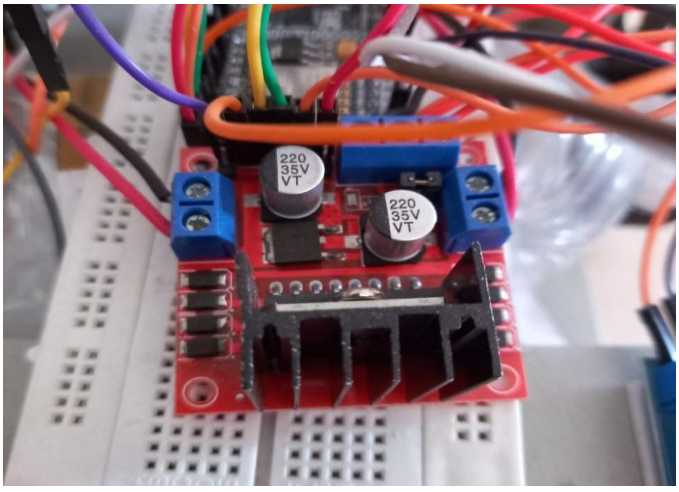

Fig -2: L298N Motor Driver Module

4. Servo Motor (SG 90)

A servo motor is a miniature motor with an output shaft. By delivering a coded signal to the servo, this shaft can be moved to specific angular positions. The servo will retain the shaft's angular position as long as the coded signal is present on the input line.

The three pins for connections of the Servo Motor are as follows:

1. Ground – The common ground pin for the servo motor

2. Power – The positive 5V voltage that powers the servo

3. Control – The input digital pin for sending the commands to the servo

Fig -3: Servo Motor (SG 90)

5. Relay

The water pump is connected to the Arduino through a relay. A relay is a device that allows a low-current device, such as NodeMCU, to control a device that requires a lot of current, such as a water pump. The relay functions similarly to an electrically operated switch.

The relay has three terminals on the low current side- VCC, GND, and IN. The IN pin is how the NodeMCU controls the relay.

The relay also has three terminals on the high current side – NO, C, and NC – which stand for Normally Open, Common, and Normally Closed, respectively.

If the pump circuit is connected between NO and C, then the pump is initially OFF. Giving a LOW signal to the IN pin will cause the relay to close the circuit, and the pump will run.

If the pump circuit is connected between NC and C, then the pump is initially running. Giving a LOW signal to the IN pin will cause the relay to open the circuit, and the pump will switch OFF.

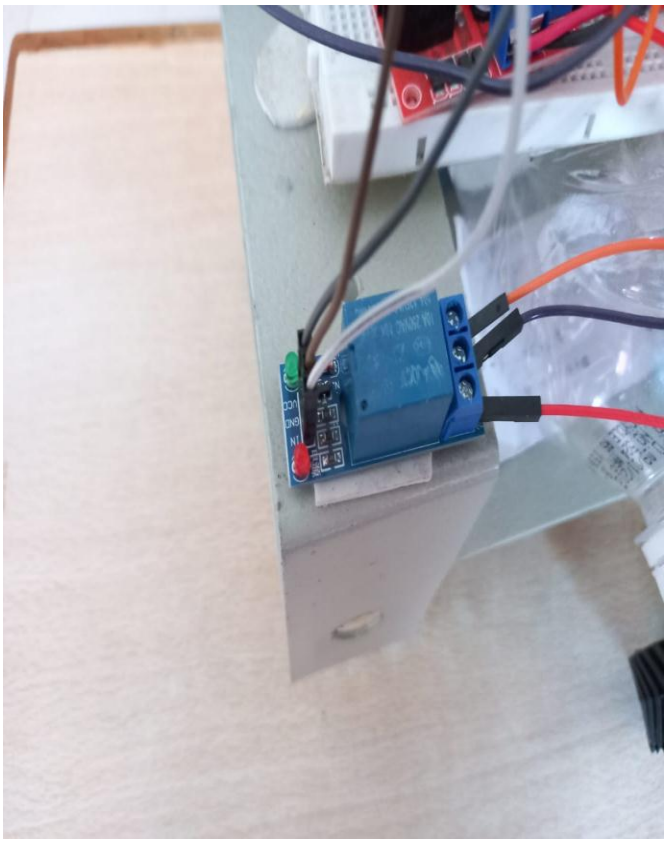

Fig -4: Relay

4. 3D MODELLING USING CATIA V5R21

Following is the 3D CAD model made using DS Catia V5R21 designing software. We designed the individual components first, followed by the assembly of the chassis.

First, we designed the chassis of our project using the dimensions according to our calculations.

For designing the main body, we used the various tools like sketcher tool, pad tool, pocket tool, multipad tool and mirror tool. Using the sketcher tool, we designed a 2D structure of our chassis. Thereafter, by using the pad and multipad tools to extrude, pocket tool for removing material and mirror tool for mirroring the necessary components on the chassis, we completed the design of the chassis.

For designing the wheels, sketcher tool, pad, pocket and pattern tools were used. First, we designed the 2D structure of our wheel using the sketcher tool, thereafter using the pad tool, pocket tools and pattern tool, our wheels were designed.

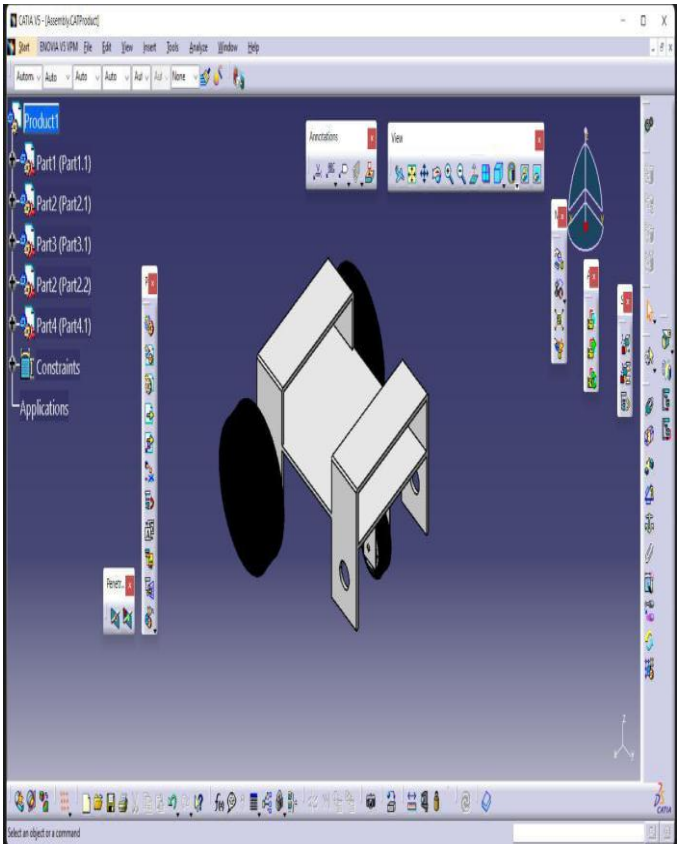

Fig -5: Robot Chassis Assembly using Catia

5. WORKING

The robot works by the following method.

The robot will detect the fire, with the help of IR Flame sensors. It will give an alarm to the user on the Blynk application by activating a LED on the screen. Once the user sees this, he will take manual action by using the four controls of front, back and sideways to maneuver the robot to the fire area. Once robot reaches there it will spray water with the help of pump onto the fire and using servo pump output can be sprayed over the fire area easily. All these actions of the robot are controlled by the user through the Blynk application interface.

The Blynk Application Interface is given in the picture below

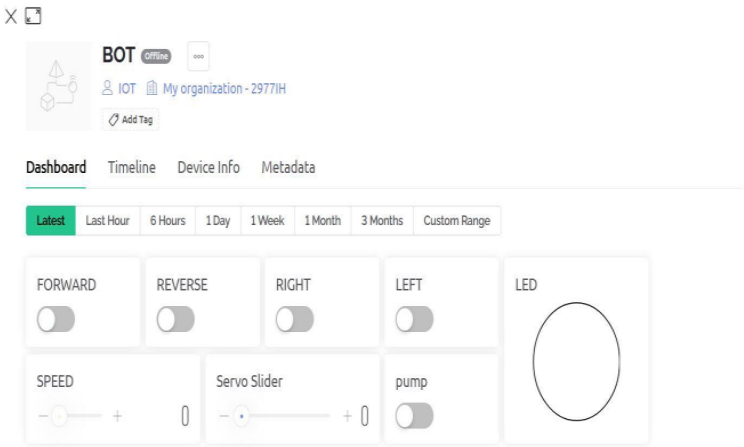

Fig -6: The Blynk Application Interface

6. CONCLUSIONS

Because this robot is a prototype, it has a number of limitations. To improve the current robot, more research is needed. It can only extinguish fire in the room where it is now installed, however this can be remedied by adding sensors in different rooms that would inform the robot when it senses fire. The robot will next proceed to the location to put out the fire. A more efficient fire extinguisher can alternatively be used in place of the water carrier.

We can also attach a Gas Sensor to the robot in the future, which can detect toxic gases for example smoke, iso-butane, propane, and other related compounds that are harmful to humans. We may also utilise the Raspberry Pi with a camera installed on it for monitoring and to determine the line of motion.

Another advancement could be to use substances other than water such as carbon-di-oxide or fire extinguishing powders by mounting a spray system like a fire extinguisher on top of the robot.

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