IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 9, Issue 5, May 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.488

9940 572 462 6381 907 438 ijircce@gmail.com www.ijircce.com

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.488 |

|| Volume 9, Issue 5, May 2021 ||

| DOI: 10.15680/IJIRCCE.2021.0905233 |

IoT Based Virtual Reality Firefighting Robot

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ABSTRACT: The firefighting robot principle is a real-world implementation of computational robotics that involves the development of a simulated robot to accompany firefighters by putting out the fire. Our paper aims to develop a virtual reality firefighting robot that can be operated remotely using IoT technology is being planned. The desired procedure is carried out on a Raspberry Pi microcomputer, aims to provide as much extensive data about fires as possible. A fire extinguisher is mounted on the robot's body, and its operation is controlled by a signal from the Node MCU output via the Blynk App. A relay module connects the fire extinguisher pump. The robot's navigation is powered by a smartphone that has the Blynk Mobile app installed. The Node MCU ways to support is linked to a motor driver IC L293D, which allows the controller to power the DC motors used in robotic navigation. Our paper is also modified by coupling it to a pi camera so that the person in charge can monitor the robot's activity from afar.

KEYWORDS: IC L293D, IoT, pi Cam, Raspberry Pi 3 Model B+, VR headset, WiFi module.

I. INTRODUCTION

When a fire gets beside a house, it becomes the worst tragedy in history. If not addressed immediately, it can involve a wide amount of individuals and locations. It leads to a significant loss of lives and property. Due to this, several casualties have occurred. People would panic and be unable to escape in such a fire situation. Even though some fire safety training techniques exist, such as teaching people how to use a fire extinguisher to put out a fire, these procedures are not applicable in cases of widely spread fires since these training are typically conducted with small fires in enclosed areas [2]. There will be a lot of smoke, the power will be shut off, the fire will spread around the house, or there will be a lot of explosions sounds everywhere in a real fire catastrophe scenario. As a result of technological advancements, we now have Robotics, which is concerned with the design, building, function, and use of robots. Robotics ' mission is to create robots that can assist and support humans. Human intrusion has become less common as technology has advanced, and robots are now commonly used for safety purposes, including firefighting. People and property can be rescued from fire incidents with the help of firefighting robots. They can complete routine tasks faster, cheaper, and more accurately than humans. A self-contained land vehicle known as a firefighting robot (FFR) is well-known among engineering students across the globe[1].

Direct attack, indirect attack, mixture attack, fog attack, and other tactics can all be used to put out a burn. As a result of climate change, which has resulted in drier and hotter weather in many regions of the world, wildfires and forest fires have grown increasingly common in recent years. Both preventing and combating them, digital technology may play a critical role. For many years, authorities have been investigating the possibilities that technology can bring to predicting and preventing wildfires. Many risky sectors, such as mining or gas and oil, have long employed digital technology applications with remote capabilities, and the possibility of keeping humans out of harm's way when it comes to flames makes sense. Satellites and custom software are used to locate potentially dangerous fires, and drones fitted with infrared cameras are deployed to monitor the fire's progress. If the fire becomes a big threat, the device sends out a warning and sends air tankers and ground firefighters to the scene to put it out before it spreads. However, this will not put out the flames. Robots are used to detect fires and are a safer alternative to satellites since their tiny design allows them to be utilized in regions with tight entrances or limited areas. A little fire extinguisher has been mounted to a fireman robot, which is a field of applied science whose prevalent notion is based on drama fiction and cinema rather than science. Telerobots are robots having the ability to communicate with one another [5]. Telepresence robots are mobile robots that can connect via the internet. Other types of robots include autonomous robots and android robots. Telepresence robots are similar to telerobots, except they take video, audio, and other data as input [5]. As a result, telepresence robots are commonly used in many areas that include monitoring skills, such as child care and education, as well as enhancing the social and everyday activities of older adults. A mobile robot is a machine that can

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navigate and perform tasks without the assistance of humans. In contrast to android robots, which are designed to imitate humans, autonomous robots can complete the task independently and obtain power from the environment.

As a result, we suggest a VR-based firefighting training method. We aim to create the most realistic fire incident scenarios possible. Virtual reality is a simulated environment that can be both similar and dissimilar to the real world. The term "virtual reality" is derived from the natural association of two words: virtual and physical. The former signifies "nearly" or "conceptually," implying a technologically enhanced experience that is close to reality. The software provides and serves virtual environments to consumers who wear accessories such as goggles, headphones, and other similar items. The users will view and communicate with the virtual world as if they were within it. Virtual reality tries to construct an illusory world that can be conveyed to our senses with artificial knowledge, giving the impression that it is almost real. Fire detection technology that uses video images recognizes flames in VR and then monitor's fire situations in real-time. Virtual reality offers a protected environment with 360-degree views, realistic three-dimensional landscapes of nearby buildings, and the preservation of gear and equipment for real-life emergencies. The visual display that immerses the user in the virtual environment while filtering out conflicting sensory impressions from the outside world, and a monitoring system that maintains track of the user's position are the fundamental components of a virtual World and orientation, as well as a database development and maintenance system for building and maintaining a complete and accurate representation of the virtual world [5].

II. RELATED WORK

In [1] authors discusses one method for building a Fire Fighting Robot, which has been completed in yearly robotic student contests throughout the world utilizing Trinity College rules. A firefighting robot (FFR) is a self-contained ground vehicle that is well-known among engineering students all around the world. In a virtual reality setting, the method employs computer simulation and animation. The length of time from the start of the simulation till the flame is extinguished may be validated. It is simple to assess the efficacy of algorithms and parameter values used. Rather than wasting time attempting to construct a genuine robot via trial and error. The most prevalent cause of catastrophic losses of life and property is a fire tragedy. It may happen to anybody, anywhere, at any moment. Although, certain fire safety training processes exist, such as teaching individuals how to use a fire extinguisher to put out a minor fire in a limited location, or an evacuation routine to direct people to the escape route. The basic problem with this form of training is that the scenarios are vastly different from a real-life fire. In [2] authors proposed a firefighting scenario-based virtual reality system. The main objectives are to provide as much information as possible concerning fire incidents and realistic ways to cope deal them. The equipment is controlled with a VR technology head-mounted screen and a distinctive joystick that looks like a fire extinguisher. A three-dimensional very next point of view methodology is used to portray the simulated fire conditions. Users must deal with a fire catastrophe that might occur in a variety of ways and learn from their mistakes. Firefighters are frequently exposed to greater dangers. In life-threatening circumstances, humans have been replaced by robots thanks to technological advancements. In [3] authors have created a robot that can detect and extinguish flames. By developing and deploying a firefighting robot capable of detecting and extinguishing flames, disasters can be avoided with minimal risk to human life. Also depicts the design and development of an autonomous firefighting robot that can recognize smoke and flames and automatically start pumping water over the flames. Flame and gas sensors were used to detect fire and smoke. These two sensors can detect fire and smoke automatically, allowing the robot to go to the source of the fire and begin extinguishing it using the fire extinguishing system. Major fires do occur at large-scale fire companies such as nuclear plants, oil refining, gas tanks, chemical factories, and other large-scale fire companies, and they may be disastrous. Thousands of people have perished as a consequence of such mishaps. As a result, in [4] authors have been enhanced to incorporate the employment of a robotic vehicle to fight fires. As robotics progresses, human interaction is becoming less and less prevalent, and robots are increasingly used for safety purposes. Fires occur frequently in our everyday lives, and it might be difficult for a fireman to save human lives at times. Extinguishing flames and rescuing casualties puts firefighters in dangerous circumstances, which is an unavoidable element of their job. The hazardous environment caused by combustible materials is the primary danger connected with firefighting activities; the four key concerns are smoke, poisonous atmosphere, oxygen deficit, and increased temperatures. The robot is a mechanical device capable of doing human functions or acting in a human-like manner. In [5] authors have developed the robotic vehicle that is equipped with a fire extinguisher that can be operated by wireless connection to spray chemicals in the event of a fire. A Raspberry Pi microcomputer is used to carry out the required process. At the controlling end, orders from the phone's accelerometer and gyrometer sensors are communicated to the VR Glass through an Android app using the TELNET protocol to control the robot's movement, such as forward, backward, left, or right, and so on. A wireless connection protocol is also used to send the instructions to the robotic portion. A camera is connected to a controller, and the output is sent to a WiFi module, which collects the photos for use in a Virtual Reality platform. A fire catastrophe seems to be the most prevalent cause of significant loss of life and property. People also panic and do not know what to do to avoid the fire or to escape the contingency of the fire. There will be an excess of smoke in an authentic fire

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disaster situation, the power will be cut off the fire will spread across the building, or explosion noise will be abundant everywhere. But it doesn't fixate on the user kineticism feedback in the subsisting method. We, therefore, suggest firefighting scenarios predicated on the virtual authenticity network training framework. The key goals of our work are to provide as authentic information as possible about fire accidents and how to cope with this crucial situation. Via denotes of virtual authenticity head-mounted display and our customs control that mimic the fire extinguisher, the players communicate with our device. A user utilizing virtual reality equipment may typically gaze about the simulated environment, walk around in it, and interact with the elements or objects displayed. Virtual worlds generate sense perceptions artificially, which can include visual perception, touch, atrial perception, and, less typically, smell. Many virtual realities from the 2016 period can be viewed on a computer screen, a projection screen, or with the use of virtual reality equipment. Our project is planned to build a Virtual Authenticity Fire Fighting Robot for remote operation using IoT technology.

III. EXISTING SYSTEM

Fire brigades, portable fire extinguishers (handheld), and sprinklers are all typical traditional firefighting tactics [4]. The emergency services must be dispatched from the fire department and must navigate through traffic to reach the fire-stricken region. The transportable extinguisher seems to be no gift because it is usually placed from one of the building's corners, which might be hard to access, and it requires regular inspections. Sprayer and smoky detector systems, on either hand, are a very unreliable way since sprinkler pipes with any flaw may not produce enough force, and they are designed to cover broad regions [4]. The issue with the current strategy is that, rather than the fire alone, even the most prevalent cause of fire injuries and fatalities is exposed to the hazardous and chaotic fire atmosphere. The ability to acquire precise real-time information on the situation directly at the center of the fire is crucial for leading rescue efforts and any counter-measures [4]. However, firefighting areas are typically difficult to access, with obstructions, crumbling infrastructures, and sight limited by smoke, toxic chemicals, or dusty. The fire site is an information-poor condition as a result of the absence of knowledge on the fire alarm control panel, firemen, and survivors, as well as factual information for focused strategic thinking. Furthermore, present firefighting tactics are ineffective and inefficient, relying mainly on people who, no matter how educated, are likely to make mistakes.

IV. PROPOSED SYSTEM

A. *Description of the Proposed System:*

The technique we propose is to build a firefighting robot out of two major components: the Node-MCU and the Raspberry Pi 3 Model B+ modules. The Node-MCU is a low-cost IoT Enabled platform that comes with firmware that works with the ESP866 WiFi module at first. Node-MCU aids with robot navigation, temperature monitoring, and fire extinguishment by pumping water to fire-affected regions. The Raspberry Pi 3 Model B+ is a hardware module we're using for this project. At the controlling end, mobile phone orders are delivered to the Node MCU to control the robot's movement, such as moving forward, backward, left, or right, and so on. A wireless connection protocol is used to send the instructions to the robotic portion. The Pi camera is connected to the Raspberry Pi, and the output is delivered through WiFi. Using the Pi camera, the images are captured and the actions are performed as realistically as possible. Tilt and pan are operated by servo motors. L293D is a motor driver that serves as the robot's motor. Two direct current motors are employed in this application. The robotic vehicle is fitted with a wirelessly operated extinguisher.

B. *Advantages of the Proposed System:*

- The robot will be employed in situations where people are not permitted.
- Reduce the amount of work required by humans.
- Reliable and cost-effective.
- It minimizes the time it takes to get to a fire-affected region.
- Sensors have a long lifespan and are less expensive.
- It lowers the mistakes and limits that human firefighters are subjected to.
- Accurate sensing capability with enhanced versatility.

C. *Mechanical Design Structure :*

AutoCAD is a program that allows you to create 3D and 2D schematic designs. To achieve the desired mobility, robots have two wheels on the backside and two wheels on the front side of the mainframe. The robot's wheels, which can spin 360 degrees, may be used to stabilize it. A variety of elements and technology were used to build the robot.

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This IoT-based firefighting robot is made up of sensors, a servo engine, a Raspberry Pi, a dc motor, and a motor driver. Fig 1 demonstrates the basic platform frame comprises an acrylic profile that is lighter for its size, durable, easy to process, and protects the electronic circuit useful in a range of applications. The acrylic profile installed in the platform is 250mm*250mm. The profile is easy to assemble and different frames can be developed with minimum processing. The body of the acrylic chassis contains holes that make it easier to mounting of various types of sensors and other mechanical components. The most fundamental feature of the system is Virtual reality. In addition, a pi camera was installed on the front side of the robot to monitor the way and condition of the location and is linked to the smartphone. The system has two driving DC motors with a power of 12 volts each. The DHT11 temperature and humidity sensor were installed in front of them to detect the fire respectively. An extinguisher water tank is also installed.

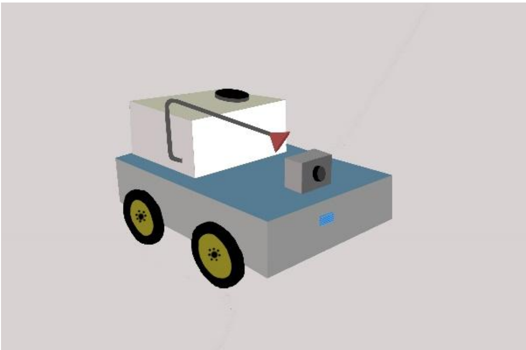

Fig.1. Side View of the design structure

V. METHODOLOGY

Initially, we must ensure that all of the components are linked and that power is provided via an external source. The robot first remains still but eventually begins to rotate 360 degrees to identify the existence of fire in the event area. Whereas if the fire is not located, it goes to the next step and checks for the occurrence of fire once more. It goes to a certain region after locating the fire. It, therefore, triggers an extinguisher or a pumps to shower water upon fire once it approaches it. The design diagram of the proposed system is described in Fig 4. Our proposed method is divided into two sections, each with its circuit schematic shown in Fig 2 and Fig 3. The first portion of the robotics component is the operational Node-MCU. The temperature and humidity sensor DHT11 and the motor driver L293D are all linked to the Node-MCU. U1 relates to the Wheels or Navigating function in the Involves planning, whereas U2 actively illustrates the pumping operation. The orders for navigation are received by Node MCU through IoT via the Blynk App. The Node MCU is coupled to the motor driver L293D, which controls the DC motors for movement. The Water Pump may be switched on using the push button on the Blynk Application installed. The application Interface also has a temperature gauge meter to assist us in determining the current temperature. The robot navigation is operated by a joystick with positioning coordinates indicating the direction parameters. The monitor phase of the project, in which Raspberry Pi assumes a significant job, is the second phase of the project. The Raspberry Pi module is attached with a Pi camera, and the desired output is transmitted via the WiFi module. The Pi camera's action is aided with Servo motors for pan and tilting adjustments, and it is integrated into a mobile phone through VR glass, which offers control for the camera's motion coupled to the robot. The objective of a WiFi camera is to elicit many feelings in a real environment and mimic a user's presence in that area to interact with it. The robot's operation, however, is fully dependent on the cellular network as well as its strength. Our proposed robot substitute's human work, hence making firefighters' lifelessness hazardous.

A. *Software Implementation :*

To begin working on the project, we created a new project in the Proteus Professional program. Following that, we assembled all of the necessary components, including the Raspberry Pi, Node MCU, Pi camera, DC Motors, Servo Motor, L293D motor driver, DHT 11 Sensor, and Pump. Second, we used the Arduino IDE software to write a C program that will regulate the Node MCU's operation. When the program is complete, we return to the Proteus environment and complete all of the connections as instructed in the code. The sensors are powered by a 5V supply voltage, whereas the L293D is powered by a 12V supply voltage. The output must then be monitored in the serial monitor. Finally, we used the Python IDE software to create a python program code that will command the Raspberry Pi 3 Model B+ module's operation. When the programming is complete, we return to the Proteus environment and

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complete all of the connections as instructed in the code. The Raspberry Pi 3 Model B+ is connected to the power supply. The output must then be monitored on a desktop screen. After looking at all of the outputs, it's safe to state that they all match the predicted result. As a result, the software implementation was completed effectively. Fig.2 describes the circuit architecture for the monitoring part. Fig.3 shows the circuit architecture for the robot portion. All of the connections were made according to the code's instructions. Fig 5 describes the flowchart working of the firefighting robot.

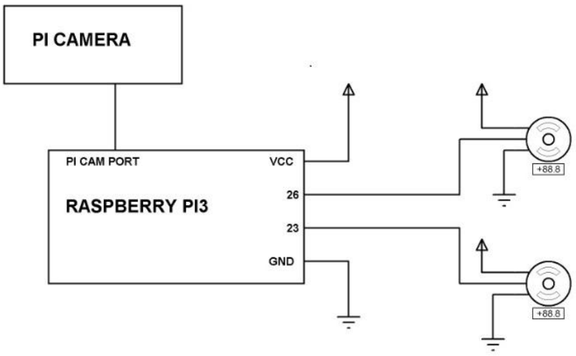

Fig.2. Circuit Diagram of Monitoring section

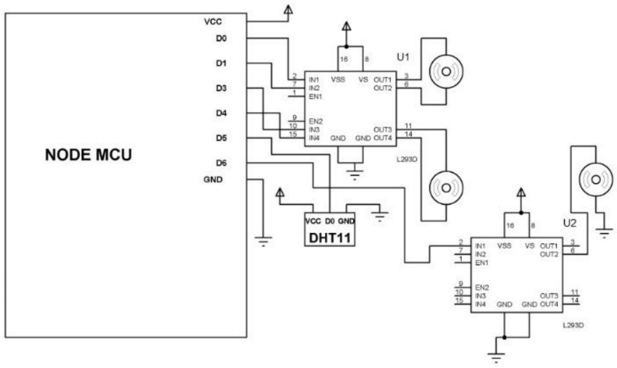

Fig.3. Circuit Diagram of Robot section

B. *Design Diagram :*

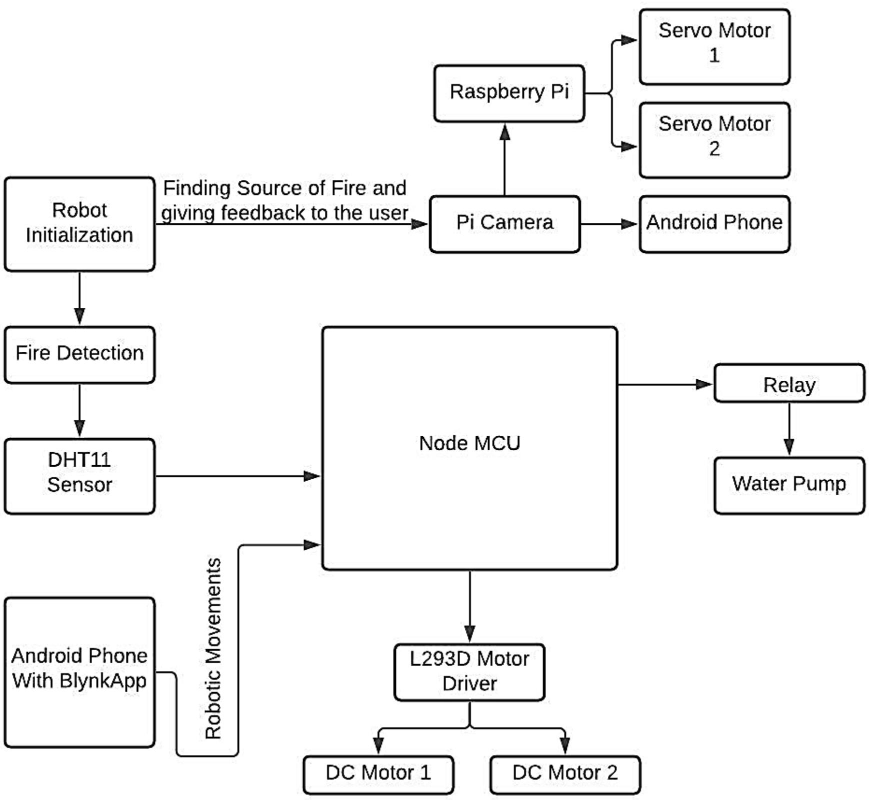

Fig.4. Block Diagram

C. *Hardware Implementation:*

This robot has a variety of sensors, and the Raspberry Pi 3 Model B+ and Node MCU, which control all of the other components, are the most important parts of the robot. The Raspberry Pi is utilized as a minicomputer in Fig 4, and

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Node MCU is utilized as the open-source firmware that connects to other components. For capturing the incident area, a Raspberry Pi with a Pi camera is attached. The Motor Driver is a device that controls the movement of a DC motor. The system also features a DHT 11 temperature sensor as information. The robot is equipped with a fire extinguisher to stop the fire. Table 1 reveals the list of components used in our design.

Table.1. List of Components

REQUIREMENTS	QUATITY
Raspberry Pi 3 Model B+	1
Node MCU	1
Pi Cam V2	1
VR Headset	1
Motor Driver L293D	2
Servo Motor	1
DC Motor	2
DHT 11 Sensor	1
Pump	1

D. *Flowchart Working:*

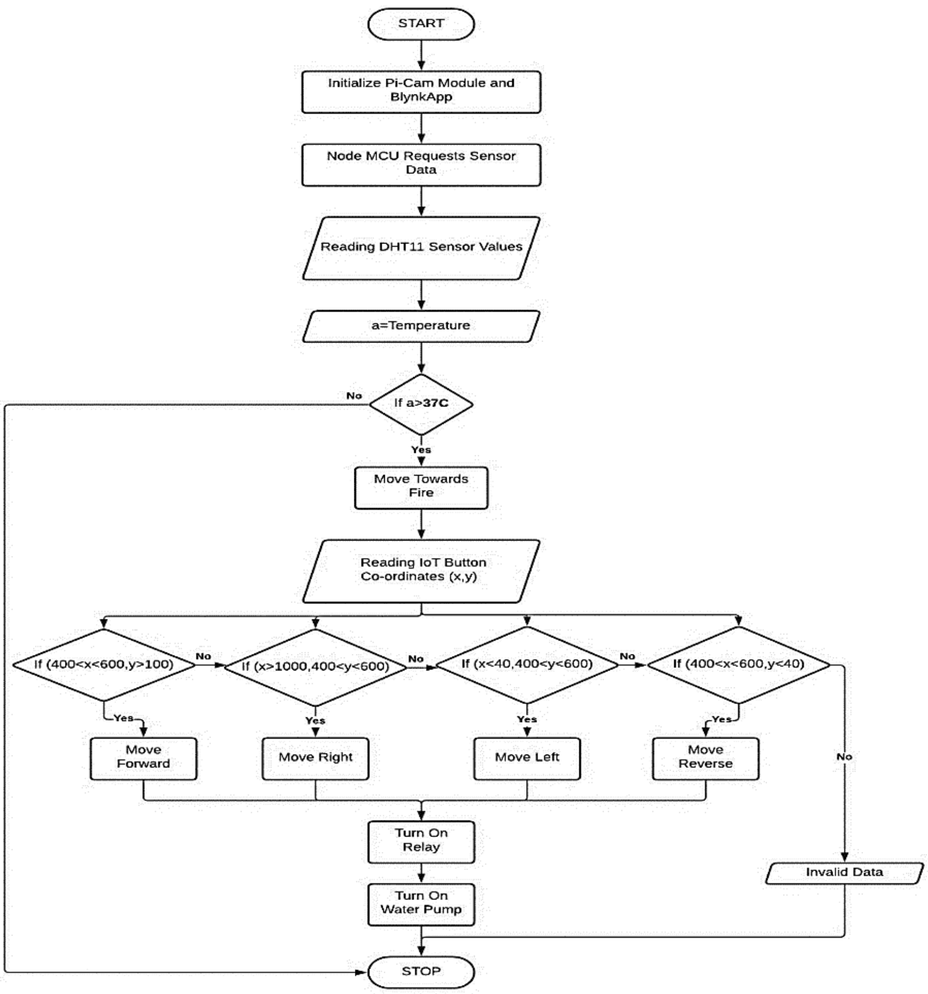

Fig.5. Flowchart

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 7.488 |

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VI. EXPERIMENTAL RESULTS

In the experiment, the robot was initialized at first and it can continue in motion by receiving the readings from the Blynk App. Fire sources were set up in the fire scene to use the wireless remote control to control the robot to enter the fire scene, and then the robot was able to detect the fire using the temperature and humidity sensor. Node MCU controls the navigation of the Robot using DC motors and the Pi camera's panning and tilting operation is controlled through Raspberry Pi. After the robot finds obstacles in the process of moving, the experimenter can see the scene through the returned video and can use the Blynk App controller to control the robot to get close to the obstacles, and accurately avoid the obstacles, and continue to walk. The Pi Camera successfully feedbacks the real-time processing video back to the android phone which is placed inside a VR controller. This design can find the fire source, stop near the fire source, and immediately aim the water pump at the flame to extinguish the fire.

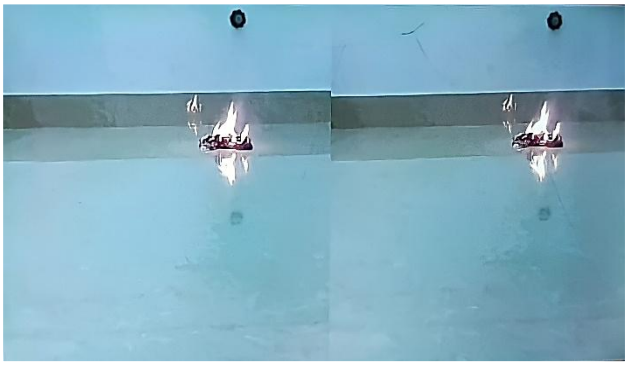

Fig.6. VR Screen

Fig.7. Fire Fighting Robot near the Fire

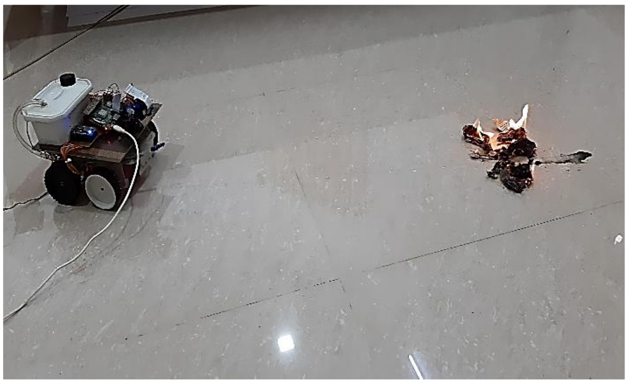

Fig.8. Robot Extinguishing the Fire

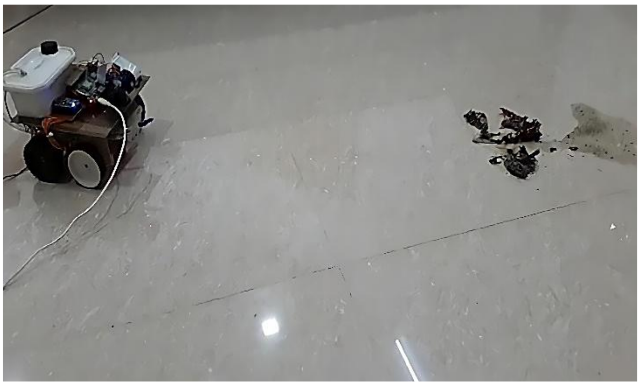

Fig. 9. After Extinguishing the Fire

VII. CONCLUSION AND FUTURE WORK

As a result, the robot has been trained to put out fires in fire-prone areas. We offer a firefighting robot system in this study that can detect, extinguish, and raise awareness of fires in the field. The firefighting robot is capable of putting out a fire in a limited area. In darker environments, fire sensors operate better. It can detect fire quickly and put it out before it spreads. This robot will reduce the danger of injuries to firefighters and possible victims while also lowering the financial costs, which will rise as the fire burns longer. Operators may also use the smartphone's camera to check the area throughout the firefighting procedure. This modular design technique was a smart choice for deploying the firefighting robot since it allowed individuals to work independently on their jobs. This device is capable of traveling to the fire and then utilizing the pump to extinguish it. New and inventive concepts were incorporated into the project as a result of the analysis to make it more efficient. Our main objectives are to give as much accurate information regarding fire incidents as possible, as well as how to deal with this critical scenario. In the future, the suggested concept might be expanded to incorporate the usage of various sprinklers to automatically extinguish fires based on the type of fire that occurred. It could also be enhanced by utilizing gas detectors to provide information to the user or owner of the location about the cause of the fire disaster. The system becomes fully automated when the above-mentioned principles are implemented, and the user is additionally notified about the fireplace by the robot.

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| DOI: 10.15680/IJIRCCE.2021.0905233 |

ACKNOWLEDGMENT

We would like to convey our deep gratitude to our mentor, Asst. Prof. **Shyam Krishna K** for providing us with the opportunity to work on this fantastic project and for assisting us in doing it. We'd also like to express our gratitude to our principal, **Dr. Nixon Kuruvila**, for supplying us with all of the requisite facilities. This project's final concept has been implemented successfully. The kindness and wisdom of every one of you have changed this report in many respects and rescued us from many mistakes; those that eventually remain are solely our fault.

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