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# An Iot Based Forest Fire Detection using Raspberry Pi

**Pamarthi Kanakaraja, Kotapati Vaishnavi, Konathala Pradeep, Pathan Imran Khan**

***Abstract:*** ***As we all know forests are the main source of oxygen and its protection is essential to sustain the human and animal race. Since we all learnt about the necessity of air, yet we lack at taking measures to protect our mother forest. Forest Fires are the main reason for the deforestation and destruction of trees and wildlife. Forest Fires are due to these two ways either by man-made or naturally caused. In either way we have to pay for the loss occurred because we have left with only certain area for the forest. So, we have to take measures to prevent forest fire at its early stage. The main aim of our project is to design and implement an IoT based hardware module that could detect the fire and prevent it by alerting the monitoring stations with an alert message and also provides location to the nearest base station. An automatic message will be sent to the nearest base station in addition to these, it has a 360 degrees rotation camera which helps to provide continuous surveillance. We can rotate the camera in any direction from the base station itself. A buzzer that alarms when the incident is happening and a water motor, this water motor will be on automatically. We can also find location where the incident is taking place with the help of Wi-Fi module. This device helps in identifying the fire at its early stage and helps in the prevention of spread all over the forest.***

***Keywords: Fire Detection, Camera, Buzzer, Water Motor, Notification, Authentication, Wi-Fi module.***

## I. INTRODUCTION

A forest is basically a place for various types of trees and wildlife. The first thing that comes to our mind when we think about forest is trees. Forest is a home for varieties of plants and animals. The main source of oxygen is plants; it inhales carbon dioxide and other greenhouse gases and exhales oxygen. Since all are aware of the types of pollutions, air pollution has become more and more due to industries and wide use of vehicles these days. Only way to purify toxic air is growing trees and protecting forest. Forest fire causes huge damage to the world. Forest fires are can't be noticed easily and it spreads quickly damaging many plants and killing wild animals. Forest covers approximately 30 percentage of world's land [1].

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* Correspondence Author
**Pamarthi Kanakaraja*,** Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P, India.
**Kotapati Vaishnavi,** Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P, India.
**Konathala Pradeep,** Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P, India.
**Pathan Imran Khan,** Department of ECE, Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P, India



Now a day's forest fires are increasing. This may be due to natural or man-made disasters [1]. In recent studies it was shown that damage caused due to forest fire is huge. The survey conducted by Nation Interagency Center says that more than 65,577 wildlife's and trees are affected due to forest fire, in 2017 the damage has increased to 71,499 and more acres of forest land was burned [1] . IoT (Internet of Things) has become common. IoT is nothing but sharing data through internet without human to human, machine to machine and human to machine interventions. In short words IoT is a network that helps to connect to all the physical devices to internet and to communicate with each other and analyze, share data [2]. Using IoT a large range of applications have been developed [3]. IoT applications have become popular these days.

We have many incidents on forest fire which have taken place in all over the world. The major cause of the forest fire is mainly due to natural or man-made faults. Forest fire spreads quickly so the model should be designed in such a way that detects while the incident is happening and to notify within seconds. The forest fire spreads quickly and if it is not identified and measures are not taken properly it spreads so fast causing damage to the ecosystem.

Forest is a home for all the wild animals and trees. There are many incidents which prove the damage caused by forest fires one such example is Bandipur. Bandipur incident took place in February 2019, it burnt down about 10,920 acres of forest land [4]. Bandipur forest is a home for several animals and about 250 species of birds and huge range of vegetation [4]. In many monitoring stations the authorities do not have any pre warning system or a device which sends message while the incident is taking place [5]. So, the life of the forest guards would be in danger.

In this project we have designed and developed a hardware model which helps in detecting forest fire at its earlier stage itself. This device helps to detect the fire and prevent loss to the government by indicating about the incident and also takes necessary actions to prevent the forest fire. The hardware model consists of sensor's like gas/smoke sensor and temperature sensor. A buzzer is also provided which helps to alert while the incident is taking place. A buzzer alerts nearby animals, birds and in the worst case it alerts humans with its alarm or buzzing sound. A camera is interfaced to the Raspberry Pi. It can be rotated in any direction. If it detects any trace of fire it sends message to the monitoring station. From the monitoring station if anyone wants to see the state of fire it could be done with the help of help of camera and this camera has 360 degrees rotation feature.

Raspberry Pi 4 model is used in the development of the hardware model. Raspberry Pi is just like a mini computer, it has many features and it is more advantageous over Arduino.

Raspberry Pi is fast and its clock speed is high compared with Arduino. We can detect the exact location where the forest fire is detected with the help of Raspberry Pi 4, it has inbuilt Wi-Fi module. It has water motor, which is interfaced with the Raspberry Pi module. Water motor helps in case of emergency if we want to eliminate the starting level fire. One of the major concern about any hardware device is power. So have come up with an idea of solar panel, it has solar battery to store the power. Here we used solar module for the power consumption. During the day time it takes the power from the solar module and during night times it takes power from the battery to charge the system.

## II. METHODOLOGY

In this paper we have used different types of devices which are explained below.

### A) Raspberry Pi

Raspberry Pi 4 is a cost efficient, high performance computational device. It is small and can be carried to anywhere easily. Pi is the modern world smallest CPU. The Pi primarily runs a version of Linux operating system called Raspbian to host software applications that you write. Pi is apt to implement embedded applications [1]. Raspberry pi 4 is capable to handle 64 bit data and with 1.5GHz clock speed. It has Bluetooth 5.0 technology make IOT solution better with 2x speed, 4x range, 8x data transfer speed, having such a faster and long distance connectivity. It also have type-C USB port from which Pi can take up to 3A current to operate, so Pi 4 can provide more power to on board chips and peripherals are interfaced. In this project Raspberry Pi 4 is used as gateway. Hardware upgrade Pi 4 is used as gateway. Hardware upgrade on Pi 4 developed for more faster performance not only the loading time with all new 4GB LPDDR4 SDRAM variants but also in connectivity with dual-band 2.4GHz and 5GHz, 802.11 b/g/n/ac wireless LAN and PoE capability via a separate HAT[6].

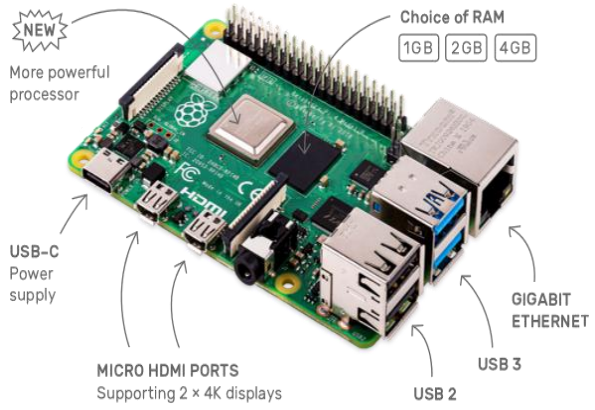


**Figure: 1 Structure of Raspberry Pi 4**

**Source**:https://www.google.com/search?q=raspberry+pi+4+structure&safe=strict&sxsrf=ACYBGNTvF8EeuzUOpKn3rxlwnxUIH-Y8Ug:1572850385277&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjH_v6j_M_lAhU1huYKHeplAUoQ_AUIEygC&biw=639&bih=591#imgrc=UZkJh9k1mgsaIM:

### B) Node MCU

The ESP8266 has in engineered Wi-Fi networking, give a bridge between the node MCU and in addition perform self-contained applications. It includes each code that runs on the ESP8266 SoC, and hardware that relies on the ESP-12. On setup ESP8266 with these equipment and do wonderful stuff like dominant monitoring, analysis and far additional tasks. Node MCU itself acts as an individual node during this project and senses the info and send the info to the cloud using Wi-Fi communication [7].

**Figure: 2 Structure of Node MCU**

**Source:**https://www.google.com/search?q=raspberry+pi+structure&source=lnms&tbm=isch&sa=X&ved=0ahUKEwin6r_w4LHhAhXNbn0KHZFMAVYQ_AUIDigB&biw=1350&bih=64 8#imgrc=4uvb4TRL_Kzw7M:

### C) Camera

Camera is used for surveillance purpose which is situated at main station. This is accessed when there is an alert, then we can see what is happening over there and control the situation. This can also monitor the human activities like smuggling wood and sandal wood. The camera used in this is Logitech C270. It is a 5MP camera with 720P resolution and also having night mode enabled in it. In this project camera is withstand on 360o rotating motor. So that monitoring can be done in all direction. The camera visuals are directly posted to the user interface through cloud[8].


**Figure: 3 Structure of camera**

**Source:**https://www.google.com/search?q=logitech+c270+webcam+description&safe=strict&sxsrf=ACYBGNRrNiISNutAqC9jcNe1_1CIaK5esw:1572800318300&source=lnms&tbm=isch&sa=X&ved=0ahUKEwidkpniwc7lAhUE7HMBHdqkBs4Q_AUIEygC&biw=1280&bih=599#imgrc=cHlbuF0Ed3sAvM:

**D) Smoke sensor**

MQ2 is the smoke sensor used in this project. MQ2 is an electronic sensor used for sensing the concentration of gases in the air like carbon-di-oxide and some other gases. Mostly trees release flammable methane gas when they get fire. To detect this, smoke sensor is used. The sensor is located at main station and also at each and every node so sensing is easy. The data is sent to cloud using Node MCU. MQ2 be a metal chemical compound semiconductor type of gas detector. Concentrations of gas within the gas are measured employing a potential divider network gift within the detector. This detector works on 5V DC voltage [8]. It will discover within the concentrations of 10000ppm.

**Figure: 4 Structure of MQ2 gas sensor**

**Source:**https://www.google.com/search?q=mq2+gas+sensor&safe=active&sxsrf=ACYBGNQBTwx9E_2huzVaZeCcBehMRdzs3A:1572850588465&source=lnms&tbm=isch&sa=X&ved=0ahUKEwievfCE_c_lAhXC7HMBHUXbAdAQ_AUIEigB&biw=1280&bih=599&dpr=1.5#imgrc=qPzxXw1YIAN1-M:

**E) Temperature sensor**

Temperature sensor is used to detect the temperature variation. In forest the normal temperature somewhat low when compared to the outside of forest. The temperature sensor used to sense, is LM35 which is capable to detect temperature variations from -50oC to 150oC, temperature sensors are situated at each and every node along with gas sensors. Before detection of smoke, the rise in temperature can help to alert[9].

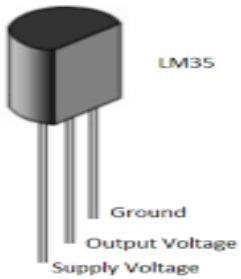


**Figure: 5 Structure of LM35**

**Source:**https://www.google.com/search?q=lm35+temperature+sensor+working&safe=strict&sxsrf=ACYBGNTlm1uOGmqYMr7oJsMmKd5qmeQhTA:1572804856596&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjB5ZzW0s7lAhWw6XMBHXZxBE4Q_AUIEigB&biw=639&bih=591#imgrc=FogFoJnAZEvvoM:

**F) Solar module**

Solar module helps to provide power supply to the nodes. Because the whole nodes are placed in the forest it is difficult for power supply lines. It is the best alternate to provide supply. The solar panel will charge the battery through the day under sunlight. It converts solar energy into electricity.

**Figure: 6 structure of solar module**

**Source:**https://www.google.com/search?safe=strict&biw=1266&bih=591&tbm=isch&sxsrf=ACYBGNRXLBxfyNlHm-RWX-lhJaeuf5vSIg%3A1572859464750&sa=1&ei=SO6_XYbCLYvjvgTejYX4Aw&q=mini+solar+module&oq=mini+solar+module&gs_l=img.3..0i24.8221.9122..9285...0.0..0.106.464.4j1.....0....1..gws-wiz-img.....0i7i30j0i8i7i30.m5t-EN18b_s&ved=0ahUKEwiGhraNntDlAhWLsY8KHd5GAT8Q4dUDCAc&uact=5#imgrc=YFnZOxv8Nu2VcM:

## III. BLOCK DIAGRAM

The functionality of the hardware module is explained clearly with the help of block diagram. The main block is Raspberry Pi 4 module. To the Raspberry Pi module a temperature, gas sensor is connected through ADC (Analog to Digital Convertor) that is MCP 3008 device. From the main block a buzzer driver is connected to the buzzer. A Logitech camera is connected to the Raspberry Pi module. From Raspberry Pi a motor driver is interfaced through this a 360 degree motor is connected. Another relay driver is interfaced to the main module through which it has given connection to the water motor. A cloud acts as an analyzer and also a storing element which stores the data and sends it to the monitoring station. We place n number of mini nodes at different places these all nodes are connected to main module through virtual internet. Each node MCU has a gas sensor, temperature sensor, solar panel for power supply. The data from all these nodes are monitored and analyzed through cloud. Through cloud we can predict the data. The data will be updated continuously to the monitoring stations.

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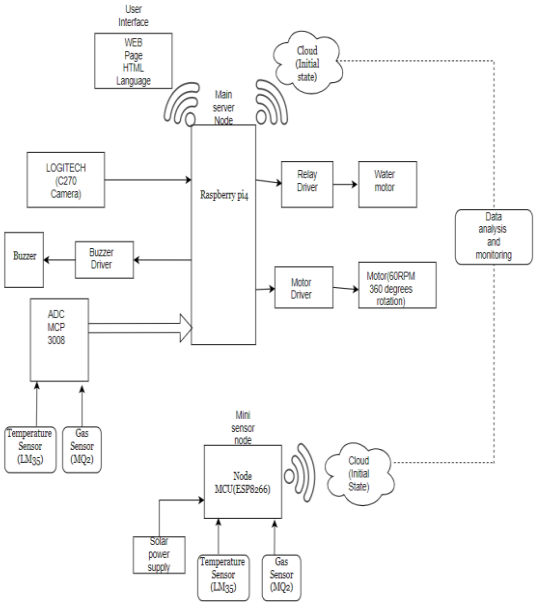


**Figure7: Functional block diagram**

## IV. FLOW CHART

After initializing the system, it takes analog data from the sensors and passes the data through ADC which converts analog data to digital. The system then initializes the camera and upstream the video footage continuously to the base station. The Raspberry Pi board starts transmitting to cloud and the computing or data analysis is at the cloud. When the readings exceed the threshold value it automatically turns on the water motor to put out the fire and turns on the buzzer to alert the officials.

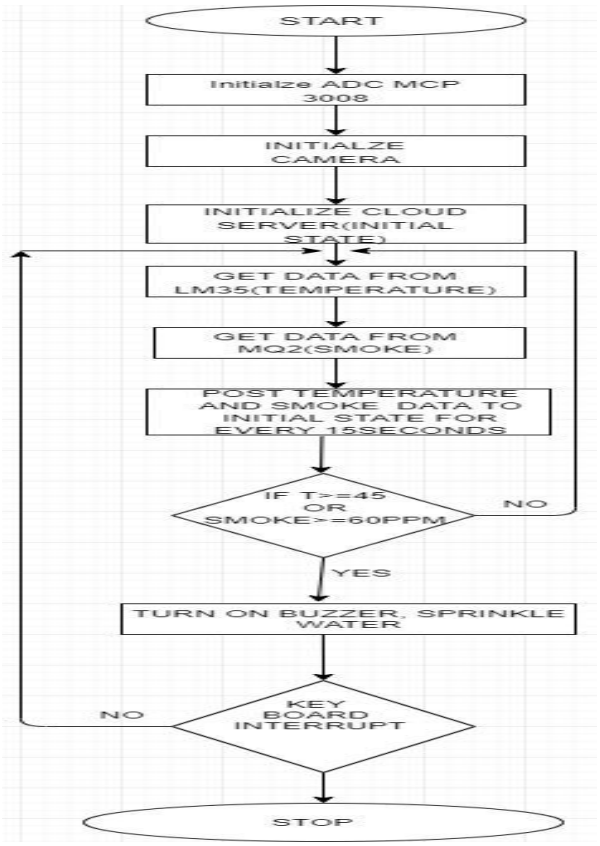


**Figure 8: Flowchart of forest fire detection system**

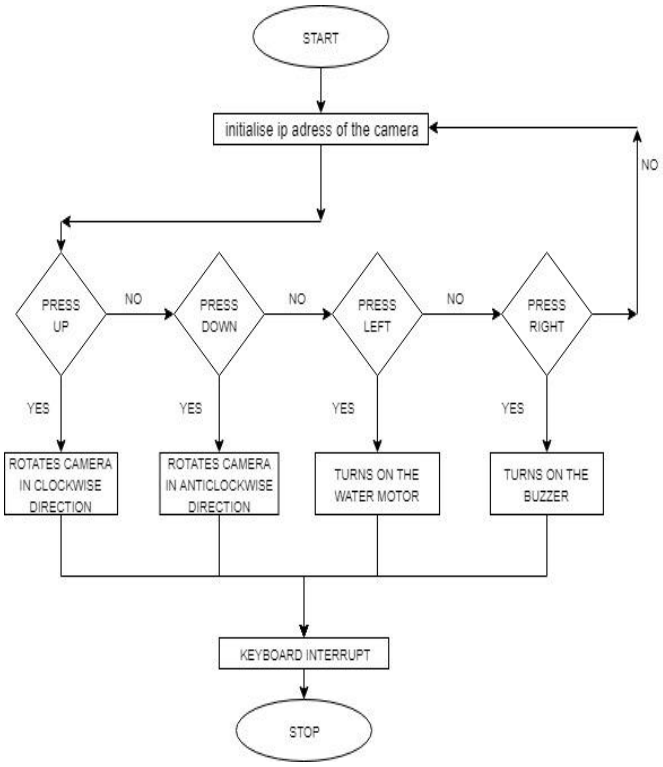


**Figure 9: Flowchart of User Interface for remote access and control using HTML**

Upon initializing the ip address of the camera the Raspberry Pi board up streams the video data to the HTML webpage for monitoring. In this webpage we have also included buttons to remotely turn on the buzzer, water motor and also to rotate the camera in 360 degrees. When the 'up' button is pressed it rotates the camera in clockwise direction and like-wise it performs all the remaining functions that are predefined when the remaining keys are pressed.

## V. CIRCUIT DIAGRAM

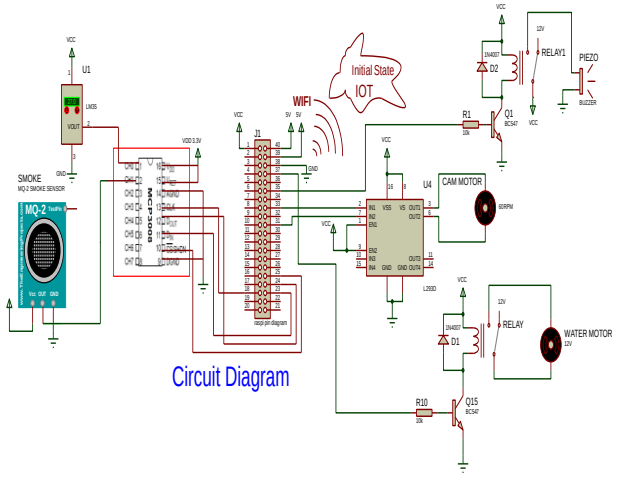


**Figure 10: circuit diagram of raspberry pi board which is sending signals to cloud**

The signal which we sent from the cloud is sent to Raspberry Pi board, instead of using initial state we can use VNC viewer to remotely access the system.

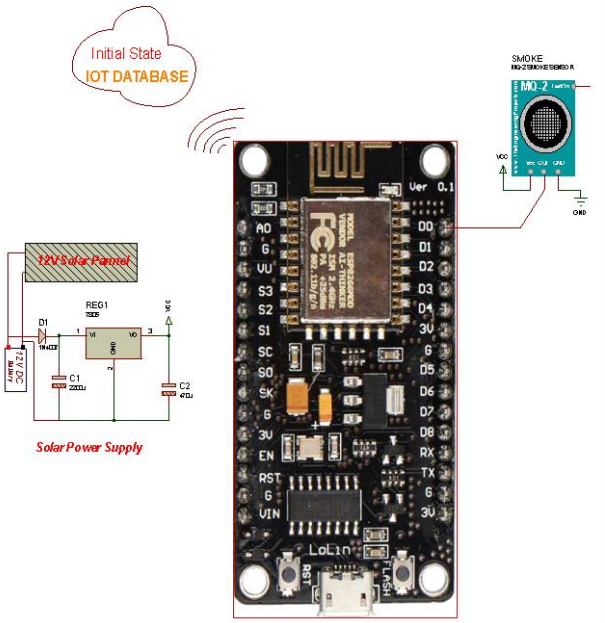


**Figure 11: circuit diagram of NODE MCU**

The data gets automatically updated to the cloud from time to time from various nodes placed at different parts of the forest.

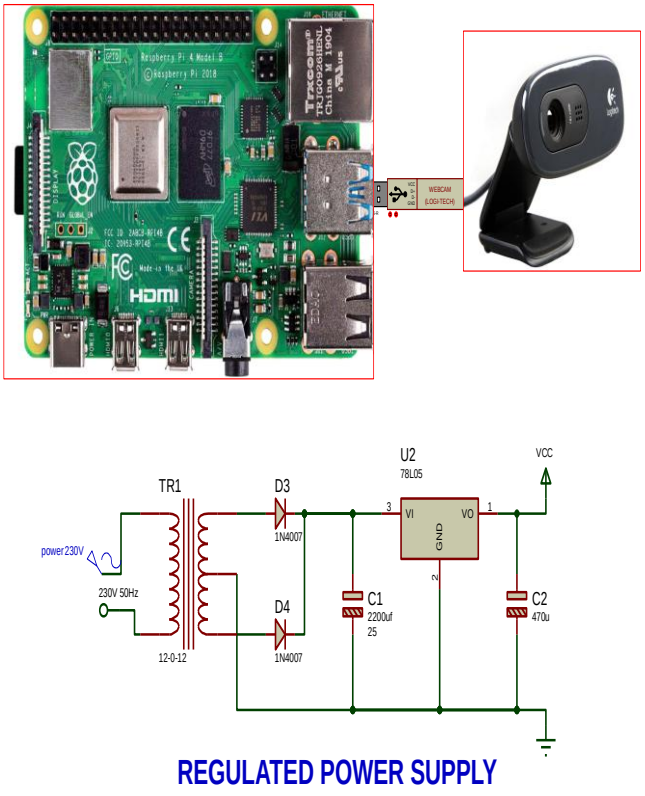


**Figure 12: circuit diagram of raspberry pi which is connected to the camera**

The Raspberry Pi board which is interfaced to the camera continuously uploads the video data to the HTML page we created for monitoring the system.

## VI. RESULTS AND DISCUSION

In this paper we discuss how the circuit is designed and implemented. We have conducted this experiment in various stages in order to check the working of various sensors and to make the system fault tolerant. We have also performed this experiment at places where the speed of the internet / Wi-Fi is significantly low to make sure that the data is being transmitted even at low data rates. the experimented results and values for all the sensors, the data transmitted to cloud and also the image or video which was displayed in the webpage we created for monitoring are listed below.Figure 13 explains the live streaming of video footage to webpage and how we can remotely control the devices connected to the system.

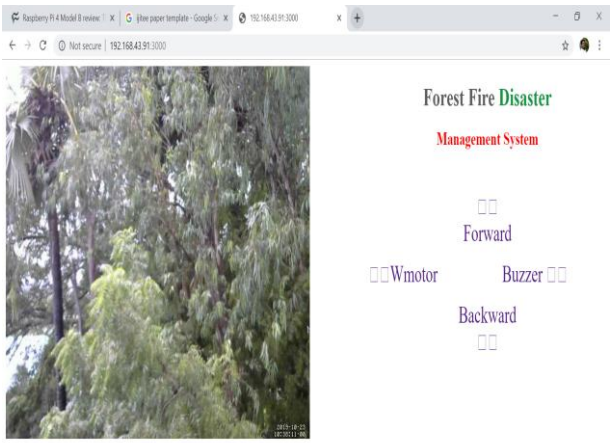


**Figure 13: remote control of the system through webpage**

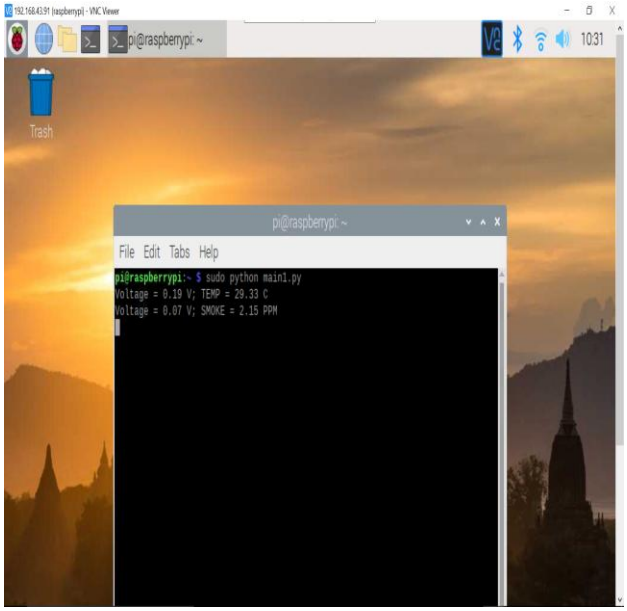


**Figure 14(a)**

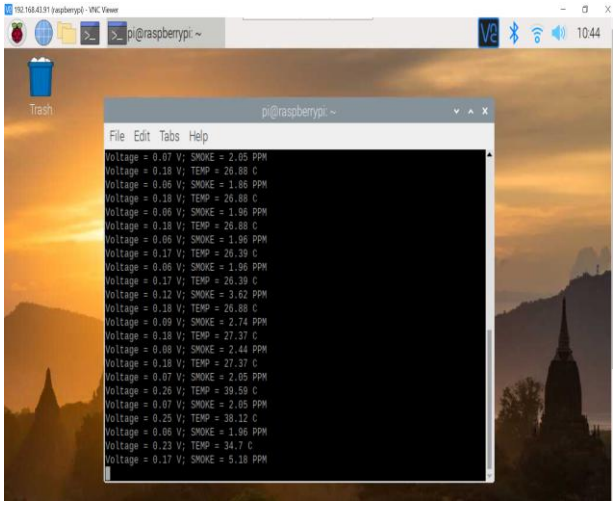


**Figure 14(b)**

**Figure 14(a), 14(b): remote access of Raspberry Pi through VNC**

Figure 14 explains the remote access of raspberry pi through VNC. We can even see all the values and results of the sensors attached to board by entering a simple command in the terminal.

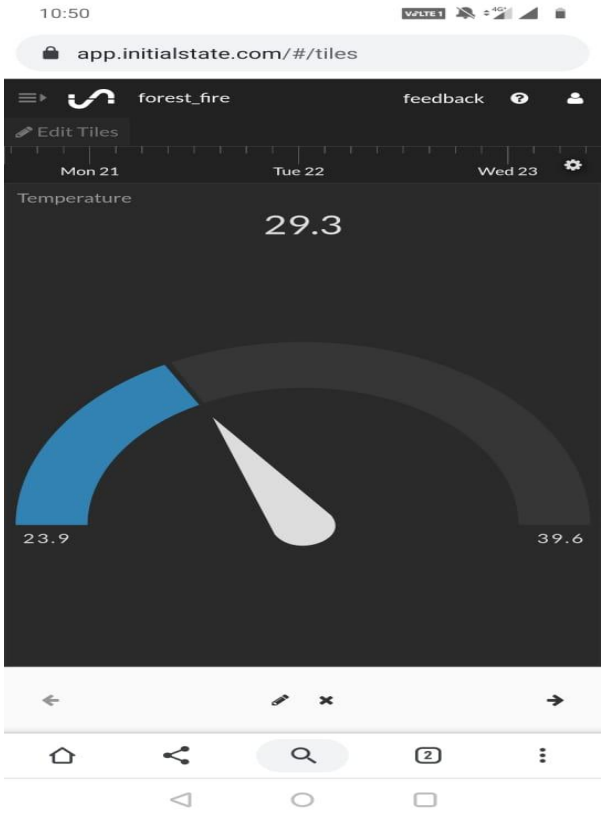


**Figure 15: display of the result through widgets in cloud**

Figure 15 explains how the data collected from different sensors through cloud is displayed with the help of widgets in initial state. Here we can see the widgets for the temperature and smoke sensors.

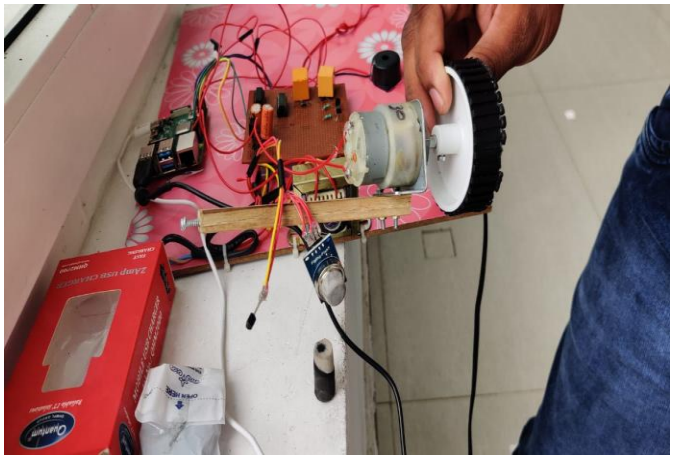

**Figure 16: sensors, buzzer and water motor interfaced with Raspberry Pi**

## VII. CONCLUSION AND FUTURESCOPE

In this work, the system is designed and tested for its reliability and scalability due to improved sensor technology. The new technology can help to mitigate serious accidents caused by fire [10]. We can also add more sensors and train this system to detect animal movements, loggers and hunters in restricted areas of forest.

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## AUTHORS PROFILE

**Pamarthi Kanakaraja** currently working as Assistant Professor in KLEF (Deemed to be University). He has 8 Years working experience On Embedded Designing & Programming Concepts. He is Technical EMBEDDED DESIGNING concepts Adviser for many Engineering and Polytechnic (DIPLOMA) Students. He also published papers in various international journals. He is a Regular Contributor in EFY (Electronic for You) International Technical magazine. His area of research is Embedded Designing, Internet of Things (IoT) & Artificial Intelligence (AI).

**Kotapati Vaishnavi**, pursuing Bachelor of technology in Electronics and Communication Engineering at Koneru Lakshmaiah Education Foundation, A.P, India. She has developed a Smart Home Automation system using Verilog programming. She is a Certified UiPath RPA Developer.

**Konathala Pradeep**, pursuing Bachelor of technology in Electronics and Communication Engineering at Koneru Lakshmaiah Education Foundation, Vaddeswaram, A.P, India. He did a project on cancer cells detection using image processing.

**Pathan Imran khan**, pursing graduation Electronics and Communication Engineering at KL University, Vaddeswaram, A.P, India. Certified LabView associate developer and immense interest in electronics. I have done women security module using LabView as my academic project. A part from electronics I am good at review writing and proofing.