FOREST FIRE PREDICTION SYSTEM USING NODE MCU

Abstract

The work aims to predict and detect forest fires using an IoT-based system with Node MCU. Forest fires, uncontrolled and non-prescribed combustion of vegetation, are a significant concern due to their unpredictability and the widespread damage they can cause. The project is motivated by the need for advanced fire fighting systems, especially in environments where human intervention is not effective. The system uses a temperature sensor and a DHT 11humidity sensor interfaced with Node MCU to detect temperature and humidity changes indicative of a fire. The sensor data is uploaded and an analysis is conducted based on threshold values to detect a potential fire. These models, which are based on the forest structure GIS (geographical information system), are used to predict wildfire potential under various climate futures. Maps are created to identify areas more susceptible to wildfires, enabling targeted management to reduce wildfire chances.

Keywords: Forest fire prediction, IoT based system,, forest structure GIS, climate futures, SPIN protocol, Tiny OS, remote sensing.

Authors

Suparna Biswas
Electronics and Communication Engineering Department,
Guru Nanak Institute of Technology, Sodepur.
suparna.biswas@gnit.ac.in

Moumita Pal
Electronics and Communication Engineering Department,
JIS College of Engineering, Kalyani.

Ranjana Ray
Electronics and Communication Engineering Department,
JIS College of Engineering, Kalyani.

Saptarshi Pramanik
Electronics and Communication Engineering Department,
Guru Nanak Institute of Technology, Sodepur.

Sambit Chanda
Electronics and Communication Engineering Department,
Guru Nanak Institute of Technology, Sodepur.

Sourav Paul
Electronics and Communication Engineering Department,
Guru Nanak Institute of Technology, Sodepur.

I. INTRODUCTION

The Forest Fire bush, can be explained as any uninhibited and sudden combustion or burning of plants in a natural setting such as a forest, grassland, brush land or tundra, which eat up the natural fuels and spreads depending on the conditions of environment. The wildfire, bushfire, wild land fire or rural fire is an unexpected, unrestrained and uncertain fire in an area of combustible vegetation starting in rural and urban areas. Farmers sometimes use the slash-and-burn technique of clearing fields at the time of the dry season. When most of the farmers apply this technique at the same time, much of a continent can appear from orbit to be a huge blaze.

If the fire happens in different places, fire fighting is impeded by the mazes of crowded buildings, high temperatures, smoke, and the risk of explosions However, in environments where humans can't work effectively, it is desirable to extinguish a fire rapidly applying fire-fighting robots. Different research work is going in different countries [1] to solve the problem of catastrophic fire related accidents.

This comprehensive survey explores machine learning method for forest fire prediction and detection. It covers different techniques and systems, including those based on neural networks, logistic regression, decision trees, and their ensembles. The study also discusses factors influencing fire occurrence and risk assessment [2].

In this work, the authors presented an integrated system that combines IoT (Internet of Things) technology with Node-MCU for forest fire prediction and detection. The paper provides insights into the design and testing of this system. Focusing on core design criteria and peer-to-peer networking, this study introduces a cheap IoT based prototype for permanent on- site forest fire monitoring. The system leverages Node-MCU and aims to enhance forest fire detection capabilities [3].

The rest of the paper is organized as: in section 2 we have presented the contributions of present work and Section 3 presents the description of component used, and proposed technique are discussed in Section 4. Section 5 presented the experimental results, and atlast conclusions and future scope are discussed in Section 6.

II. CONTRIBUTIONS

In this present work, a temperature sensor, DHT 11 humidity sensor is interfaced to Node MCU to detect the temperature and humidity produced from the fire. The values are collected from the Sensor and then it is uploaded to the cloud i.e., in Thing speak. After the detection, an email sent with an warning message utilizing computed sensor values and the fire is predicted [4][5].

The System is designed by using Node MCU, Soil Moisture Sensor, Temperature Sensor and DHT 11 Humidity Sensor. We can predict and detect fire in the Forest. We can also travel with it. With the sensors we can measure the humidity of the air and the moisture level in the soil. When humidity will fall down then the chance of forest fire will rise. Similarly, when light will rise then the resistance of the LDR will drop and the current will flow and we will get to know about the fire. In the project of Forest Fire Prediction, we are willing to alert the people who are surrounded by the forest that they should leave the place as soon as possible.

By our work we can also predict the fire in the forest. Thus, we can save the human's life as well as the animal's life who lives in the forest. By automating the process, becomes more accurate, cost effective and predictable. The use of this project will help us to make sure that the people around the forest are safe.

III. COMPONENTS USED

The following components are used to implement the system.

1. Breadboard

The breadboard is a platform used for building prototypes of electronic circuits as shown in Fig.1. The term originally referred to a wooden board used for cutting bread. However, in the 1970s, the solder less breadboard was introduced, and it has since become the standard for reusable prototyping platforms. Unlike traditional methods that require soldering, solderless breadboard sallow for the easy assembly of temporary prototypes and circuit experiments, making them a popular choice in educational settings.

Earlier versions of breadboards were not reusable. In contrast, stripboards and other prototyping printed circuit boards, which are used for semi-permanent soldered prototypes, are not easily reusable.

Despite their advantages, modern breadboards have some limitations compared to permanent circuit connections. They have very high parasitic capacitance, very high resistance, and less reliable connections which are susceptible to physical degradation and movement. Their signalling capabilities are limited to around 10MHz, and even at frequencies below that, not all functions operate optimally [6].

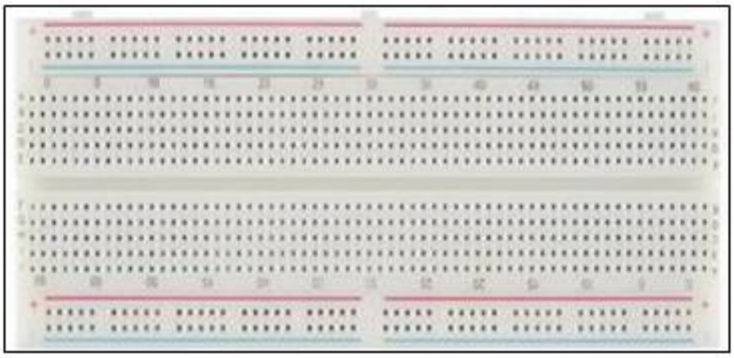

Figure 1: Bread Board

2. Node MCU

The Node MCU is an freely accessible firmware and prototyping board design as shown in Fig.2. The name "Node MCU" is consist of "node" and "MCU", and it specifically refers to the firmware, not the development kits.

The firmware is built on the Eula project using the Expressive Non-OS SDK for ESP8266, and it uses the Lua scripting language. For prototyping, a circuit board in a dual in-line package (DIP) format is typically used. This board combines a USB controller with a smaller surface-mounted board that houses the MCU and antenna. The DIP format makes prototyping on breadboards easy. The design, is based on the ESP-12 module of the ESP8266, features a Wi-Fi System-on-Chip (SoC) combined with a Ten silica Extensa LX106 core, which is commonly used in various applications of IoT [6].

Figure 2: Node MCU

3. IC (74 HC CD4052)

The CD4052 is a versatile IC used for electronic circuit design as shown in Fig.3. It can function as a 4:1 multiplexer (MUX), taking inputs from four channels and converting them to a single output, or as a 1:4 demultiplexer (DEMUX), taking one input and providing it to one of four output channels. The selection of output depends on the settings of pins A and B. This IC can handle both analog and digital voltages, making it suitable for various applications [6].

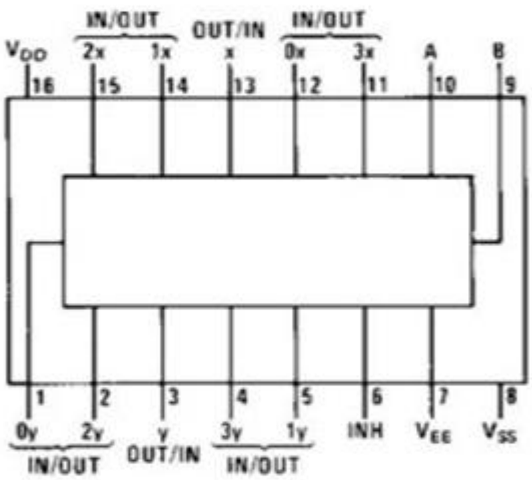

Figure 3: IC (74 HC CD4052)

4. Soil Moisture Sensor

Soil moisture as shown in Fig. 4 plays a crucial role in both irrigation and garden settings. Nutrients in the soil nourish plant growth, and supplying water is essential for regulating plant temperature. Transpiration, where water affects plant temperature, is a key process.

Additionally, plant root systems thrive in moist soil. However, extreme soil moisture levels can lead to anaerobic conditions, impacting plant growth and soil health. Now, let's delve into the soil moisture sensor, which gauges the volumetric water content within the soil. Unlike direct gravimetric measurements these sensors infer water content using properties like dielectric constant, electrical resistance, and interaction with neutrons.. These sensors find applications in agriculture and remote sensing within hydrology. It helps to monitor soil moisture [6].

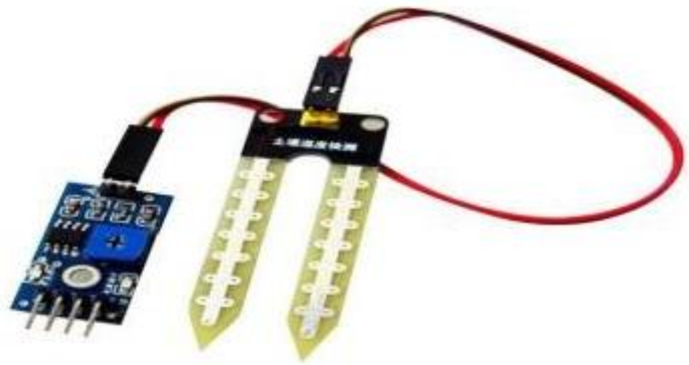

Figure 4: Soil Moisture Sensor

5. Temperature and Humidity Sensor (DHT 11)

The DHT-11 Digital Temperature and Humidity Sensor is an affordable and straightforward device as shown in Fig. 5. It combines a capacitive humidity sensor and thermistor to compute air conditions. The sensor gives a digital output on its data pin, eliminating the need for analog input pins. However, it’s essential to time data retrieval carefully since new data is available only every 2 seconds. Compared to the DHT22, the DHT-11 is less precise, less accurate, and has a narrower temperature/humidity range. Despite these drawbacks, it is a cost-effective device for temperature and humidity measurements [6].

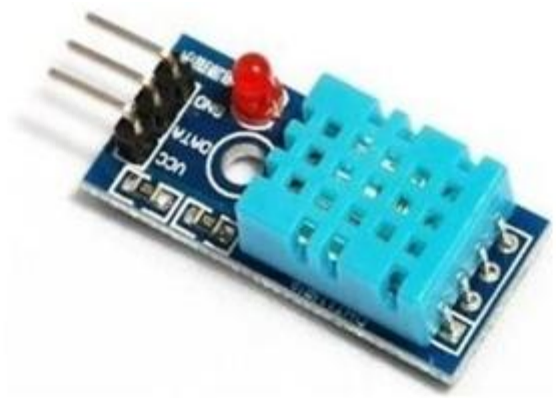

Figure 5: DHT 11

6. LDR

An LDR (Light Dependent Resistor) as shown in Fig.6, is an electronic component whose resistance changes based on the intensity of light falling on its surface. It is generally applied in light-sensing circuits. The typical LDR exhibits a resistance that decreases as light intensity increases, as depicted in the image above. Specifically, in daylight, the LDR's resistance is around 5000 ohms. In dark conditions, the resistance increases significantly to approximately 20,000,000 ohms [6].

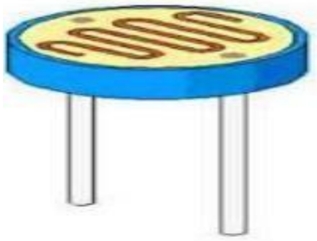

Figure 6: LDR

7. Jumper Wires

A jumper wire, also known as a DuPont wire, is an electrical cable or group of wires with connectors or pins at each end as shown in Fig.7. These wires are commonly used to interconnect components on a breadboard or other prototype circuits without soldering. By bundling the wires into a non-flexing arrangement, space is optimized, and the risk of short circuits is minimized. In computers, a jumper consists of a pair of prongs set into the motherboard or an adapter card. When you set a jumper, you complete an electrical contact by placing a plug on the prongs. Essentially, jumpers act as switches, either closing or opening an electrical circuit. They can be added or removed to modify the function or performance of PC components. A collection of jumpers is sometimes referred to as a jumper block. While modern computers often come with pre-set jumpers due to plug-and-play functionality, some manufacturers provide jumper settings in the instruction manual for users who wish to customize performance [6].

Figure 7: Jumper Wires

IV. PROPOSED SYSTEM

The system utilizes Node MCU, Soil Moisture Sensor, Temperature Sensor, and DHT11 Humidity Sensor to predict and detect forest fires. By monitoring humidity levels in the air and soil moisture, it can anticipate fire risk. Additionally, changes in light intensity can trigger fire detection through the LDR sensor. The goal is to alert people near forests to evacuate promptly in case of fire, ultimately saving human and animal lives. Automating the process enhances accuracy, cost effectiveness, and predictability, ensuring the safety of forest edge communities. Forest fires, whether termed wildfires, bushfires, or rural fires, pose significant risks, and this project aims to mitigate those dangers. The following flowchart as shown in Fig.8 will describe the working of the device, more effectively and efficiently. Device connections are shown in Fig.9.

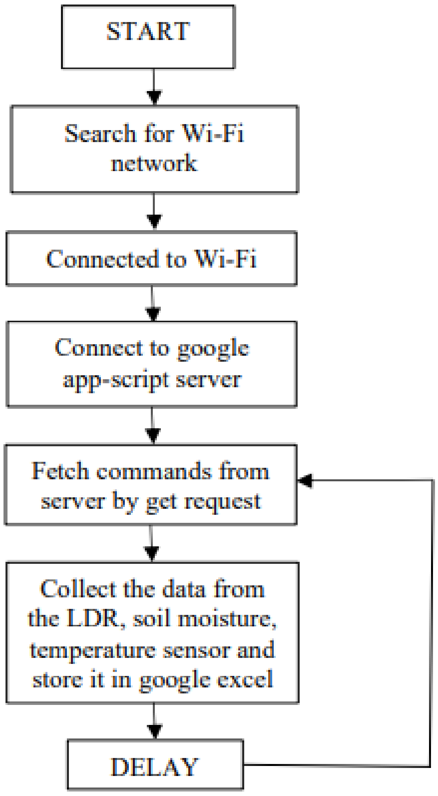

Figure 8: Flowchart of the proposed system

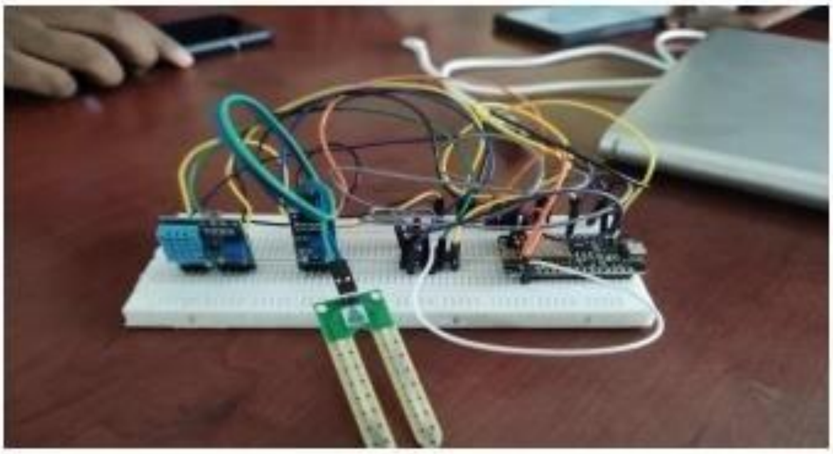

Figure 9: Device

The below block diagram as shown in Fig.10 will help to understand the circuit diagram and circuit analysis more effectively and efficiently. The block diagram used here is only used as a reference to also understand the work-flow or data-flow. Fig. 11 shows the circuit diagram.

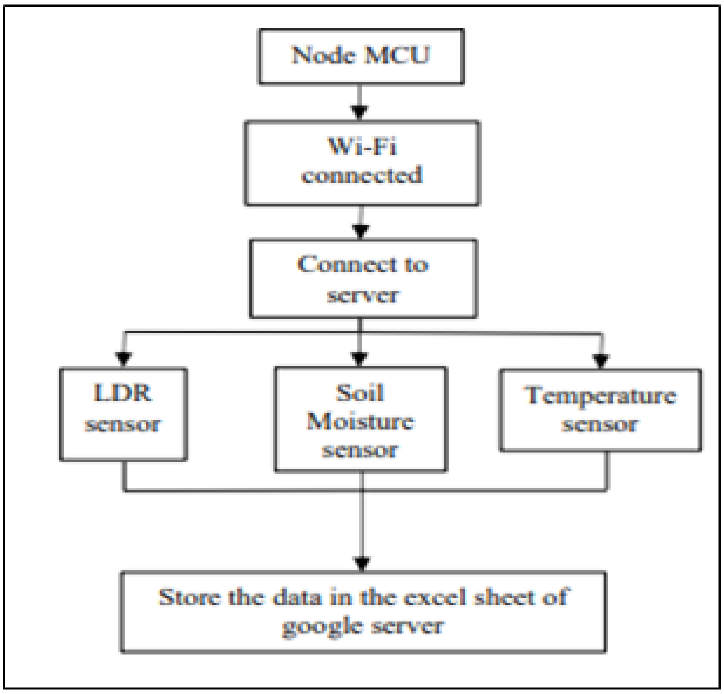

Figure 10: Block diagram

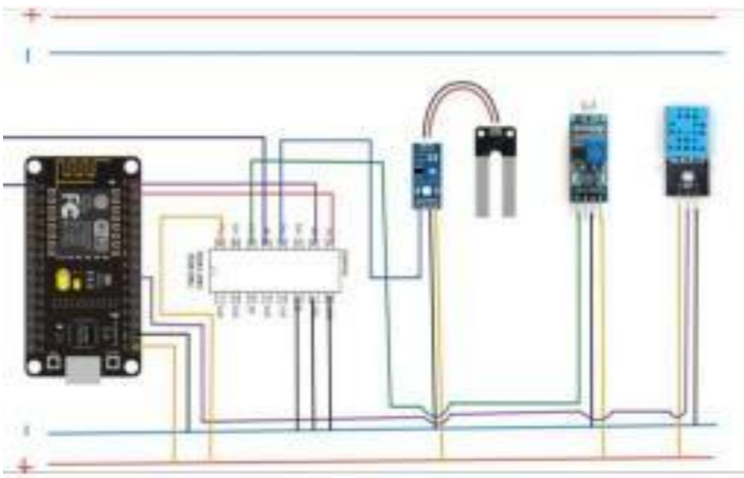

Figure 11: Circuit Diagram

For the circuit we used node MCU board, bread Board, one 74 HC 4052 IC, soil moisture sensor and a temperature sensor. First of all, we connected the voltage and ground pin of Node MCU with the following voltage and ground pin of the bread board. Then we connect the voltage and ground pin of the sensors with the voltage and ground line of bread board. We have used an IC by which we converted the digital pins of node MCU to an analogue pin, for that we connected the E, Vee and GND pin with the ground line and the VCC pin with the voltage line of bread board. Then do, d1 and AO pin of node MCU is connected with the So, S1 and 1 Z pin of the IC simultaneously. Then the analogue pin of sensors will have connected with the 1y1 and 1yo analogue pin of the IC. Implemented setup is shown in Fig. 12.

Figure 12: Setup Picture

To understand the algorithm or functioning of the device we need some mappings or keywords, which are explained below:

- St – Start.
- E – End.
- Io1 – Input/Output: Define libraries, constants, pins, variables).
- Io2 - Input/Output: Initialize serial communication at 9600 baud rate.
- Io3 – Input/Output: Connect to Wi-Fi network using SSID and password.
- Op1 – Operation: Wait until Wi-Fi is connected.
- Io4 – Input/Output: Print Wi-Fi is connected.
- Op2 – Operation: Set client into insecure mode.
- Op3 – Operation: Set pin modes for sensors and multiplexer.
- Op4 – Operation: Set multiplexer to select soil moisture sensor.
- Op5 – Operation: Initialize DHT 11 sensor.
- Op6 – Operation: Check if last update time is greater than equals to interval.
- Op7 – Operation: Read analog value from soil moisture sensor and convert to percentage.
- Op8 – Operation: Set multiplexer to select LDR.
- Op9 – Operation: Read analog value from LDR.
- Op10 – Operation: Read humidity and temperature values from DHT 11 sensor in both Celsius and Fahrenheit values.
- Op11 – Operation: Call send-data function.
- Op12 – Operation: Reset last update time to zero.
- Op13 – Operation: Wait for 1000 ms.
- Op14 – Operation: Increment last update time by 1000 ms.
- Op15 – Operation: Check if client can connect to host and port.
- Io5 - Input/Output: Print host is connected.
- Op16 – Operation: Construct query string with data value as parameters.

- Op17 – Operation: Send GET request to web app using path and query string.
- Io6 - Input/Output: Print data is sent along with query string.
- Io7 - Input/Output: Print error in connecting the host.
- Cond1 – Condition: Wi-Fi connected?
- Cond2 – Condition: Check if last update time is greater than equals to interval?
- Cond3 – Condition: Client connected to host?

Following Fig. 13 is the path-flow on which the algorithm will work.

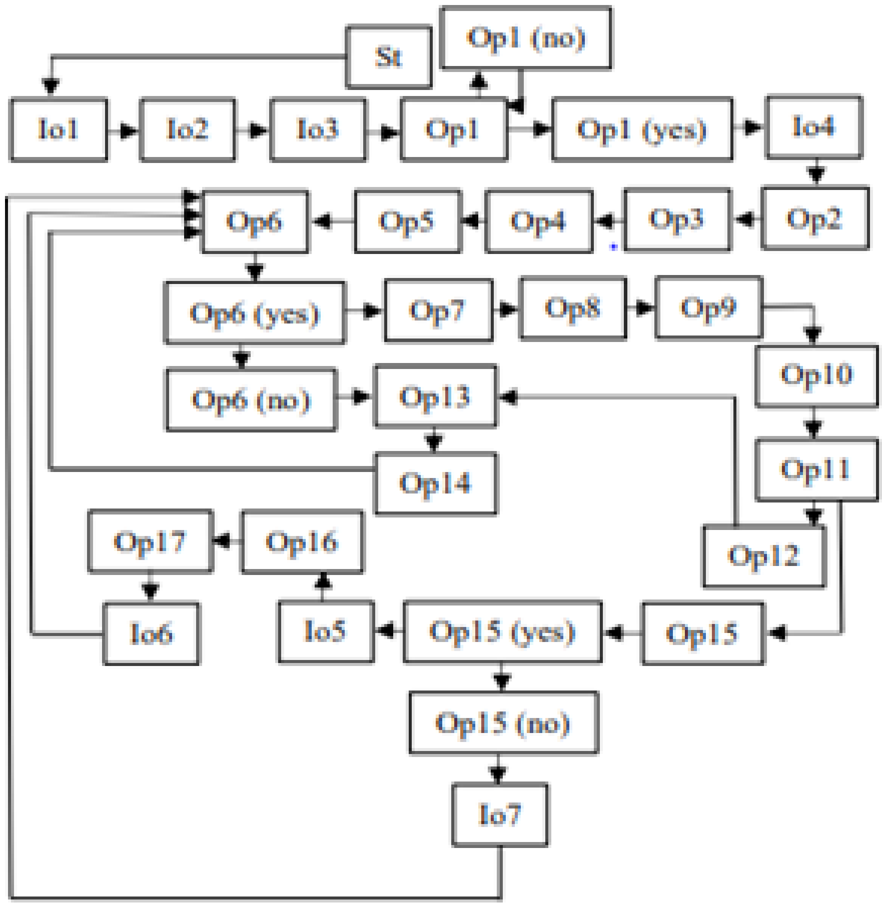

Figure 13: Path flow of the algorithm

V. RESULT ANALYSIS

The following values collected from the sensors (in realtime) are stored in google app-script server in google excel sheets and based on those data, the following upper mentioned graphs are plotted automatically.

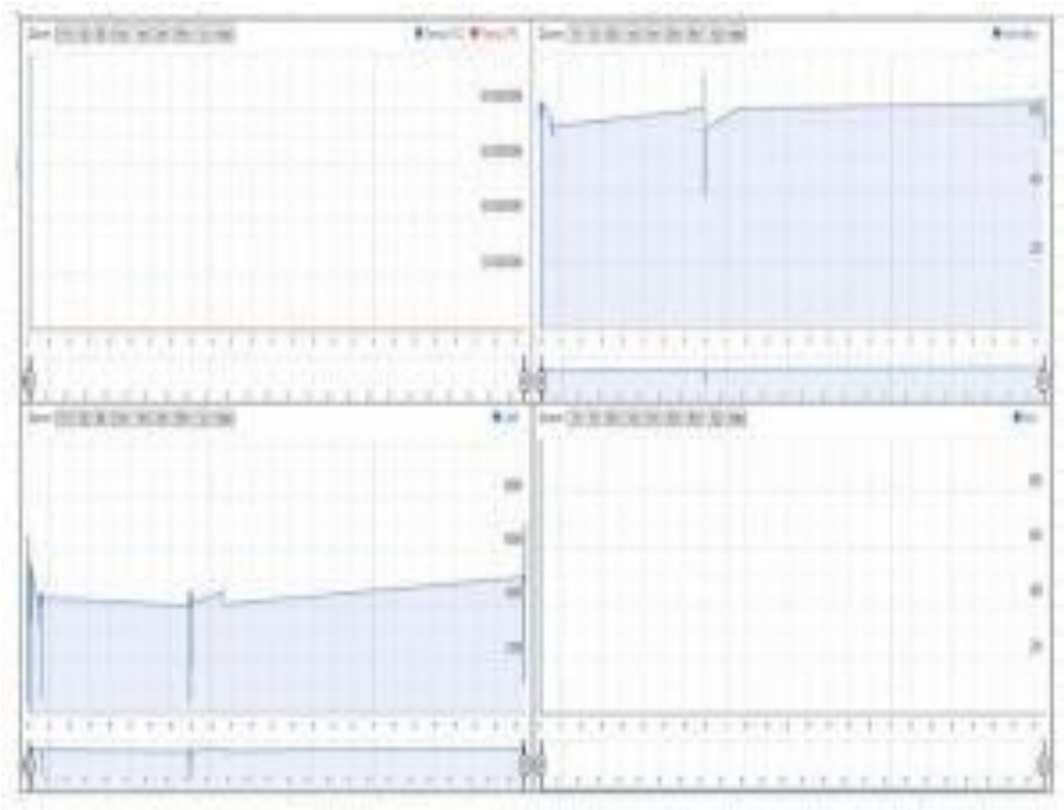

Figure 14: Graph of the values collected from sensors

- **Temperature Sensor Graph:** The temperature sensor graph will show a spike when there is sudden rise in the surrounding temperature. Here the temperature is normal that is why there is a straight base-line. While forest fire as the surrounding temperature will rise suddenly above its threshold it will indicate a situation of forest fire.
- **Humidity Sensor Graph:** In the humidity sensor graph here we see a sudden dip. This is because when there is a fire in the surrounding there will be sudden dip the humidity of the surroundings below the normal humidity level.
- **LDR Sensor Graph:** In the LDR sensor graph there we see a sudden hike in the graph that is because when there is a forest fire there will be huge light emission which will result in the spike of the LDR graph. Thus, will indicate a possibility of forest fire.
- **Soil Moisture Sensor Graph:** When there is very low soil moisture level the graph will show a very low reading. Thus, it will indicate that the soil is dry, as well as the surrounding is dry. Thus, it will show a possibility of forest fire.

These are the following applications of forest fire prediction system –

- It helps to prevent forest fires by estimating the probability of fire occurrence based on various factors. It enables the analysis and forecasting of the extent and severity of fire damage using past data on burnt areas.
- It monitors and reports the weather conditions in the region that may affect the fire behavior and spread.
- It alerts the authorities and the public about the presence and location of forest fires [7][8].

VI. CONCLUSIONS

This paper gives a brief overview of a forest fire application that uses a well-known routing algorithm called SPIN. The SPIN protocol in Forest Fire Detection application was only tested in a basic way because of time and resource limitations. More work could be done to solve the problem with the time synchronization module that would allow the simulator to measure the network latency. More detailed simulator runs would also help to evaluate the protocol better. It is also important to compare this application with other applications that use different protocols. This comparison and implementation of other applications could be done in the future. This project shows that there is still a need for a good networking component for Tiny OS. Future works may focus on improving the protocol that was developed in this project and creating new networking components for the system [9]. Wildfires can reach high into the tree tops and destroy large parts of the forest. Sometimes people start these fires, and they can have a big impact on the economy and the environment. The changing climate, with different rain patterns and higher average temperatures, may make wildfires more frequent. As more people live in or near forested areas in the Southern United States, the risk of damage from wildfires may increase [10]. Some wild land fires are good for the environment and some ecosystems need them to stay healthy. These good fires burn low to the ground and usually do not kill big trees. Forest managers sometimes use fire on purpose to keep some ecosystems healthy. These ecosystems are named as fire dependent ecosystems, because they need fire to survive [11].

REFERENCES

[1] D, A., Shah, N., A, P., K, S., Dhanjal, I.S. and Mehendale, N., 2021. Firefighting robot with deep learning and machine vision. Neural Computing and Applications, 34, pp.2831-2839.J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.
[2] https://link.springer.com/article/10.1007/s10694-020-01056-zK.
[3] https://www.ijeea.in/wp-content/uploads/Volume-9-Issue-1-Paper-4.pdf
[4] IOT INTEGRATED FOREST FIRE DETECTION AND PREDICTION USING NODE MCU
[5] by M. K, V. R, and K. , *simultaneously* in Journal of Electronics Engineering and Applications in 20212.
[6] IOT BASED FOREST FIRE PREDICTION SYSTEM by S. S. Patil, A.S. Patil, and A. S. Patil
[7] published in Journal of Emerging Technologies and Innovative Research in 20205
[8] https://www.wikipedia.com
[9] S, V.E., Cho, J., S, M. et al. Forest fire and smoke detection using deep learning-based learning without forgetting. fire ecol **19**, 9 (2023). https://doi.org/10.1186/s42408-022-00165-0
[10] Sharma, Richa & Rani, Shalli & Memon, Imran. (2020). A smart approach for fire prediction under uncertain conditions using machine learning. Multimedia Tools and Applications. 79. 10.1007/s11042-020-09347-x..
[11] A multimodal framework for Forest fire detection and monitoring – Springer.
[12] https://defenders.org/blog/2020/07/fire-adapted-plants-and-animals-rely-wil dfires-resilient- ecosystems
[13] https://static.colostate.edu/client-files/csfs/pdfs/ColoradoFireEcologyOverv iew101712.pd