FOREST MONITORING SYSTEM

BTech Miniproject Report

by

Amaresh S - TRV20EC007

Rahul S Kumar - TRV20EC045

Siddharth Sanjay - TRV20EC054

Ananthapadmanabhan M - TRV20EC009

Under the Supervision of

Dr. Sanil K Daniel

Department of Electronics and Communication Engineering

GOVERNMENT ENGINEERING COLLEGE BARTONHILL

Thiruvananthapuram - 695035, India

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING
GOVERNMENT ENGINEERING COLLEGE, BARTON HILL
THIRUVANANTHAPURAM
2022 - 2023

Project Report

on

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CERTIFICATE

Certified that the project report entitled **Forest Monitoring System** is a bonafide record of the work done by the team comprising **Rahul S Kumar** (TRV20EC045), **Amaresh S** (TRV20EC007) , **Siddharth Sanjay** (TRV20EC054) and **Ananthapadmanabhan M** (TRV20EC009). This report is submitted to the **Dept. of ECE - GEC Barton Hill** in partial fulfilment of the requirement for the award of the **B.Tech Degree in Electronics and Communication Engineering** under the **APJ Abdul Kalam Technological University** during the year 2022 - 23. This report in no form has been submitted to any other University or Institute for any purpose.

Project Guide	**Project Coordinator**	**Project Coordinator**
Dr. Sanil K Daniel Associate Professor Dept. of ECE, GECBH	Prof. Aparna S Thampy Assistant Professor Dept. of ECE, GECBH	Prof. Smitha S Assistant Professor Dept. of ECE, GECBH

Head of Department:

Dr Hari R
Professor and HoD
Dept. of ECE, GECBH

GEC Barton Hill, Trivandrum
Date: 03-07-2023

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We declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Amaresh S - TRV20EC007

Rahul S Kumar - TRV20EC045

Siddharth Sanjay - TRV20EC054

Ananthapadmanabhan M - TRV20EC009

Abstract

The Forest Monitoring System project aims to develop an innovative and integrated solution for effective monitoring and management of forest ecosystems. Forests play a vital role in maintaining ecological balance, providing habitat for diverse species, and contributing to global climate regulation. However, rampant deforestation and forest fires pose significant threats to these valuable resources. The proposed system leverages advancements in fire sensing technologies, power management, data analytics, and real-time monitoring to address the challenges faced in forest conservation. The project integrates long range communication device (LoRa) , ground-based sensors and microcontrollers to collect comprehensive and up-to-date information about forests. This multi-faceted approach ensures a holistic understanding of the forest ecosystem dynamics, including vegetation cover, deforestation activities, wildlife habitats, and fire risks. Furthermore, the Forest Monitoring System incorporates data analytics techniques to process and analyze the collected information sensors and imaging devices are employed to detect and classify changes in forest cover, identify potential deforestation hotspots, and predict the spread of forest fires. These insights enable early intervention and timely decision-making for effective forest management and conservation efforts. The system also emphasizes real-time monitoring and reporting to enhance responsiveness and enable proactive measures. A web-based interface provides stakeholders, including forest managers, environmental agencies, and policymakers, with access to the system's data and analysis results. This facilitates informed decision-making and supports policy formulation. The Forest Monitoring System project holds significant potential to contribute to environmental conservation efforts and the sustainable management of forest resources. By providing accurate and timely information, stakeholders can implement appropriate measures to combat deforestation, protect wildlife habitats, and mitigate the risks associated with forest fires. The integration of technology, data analytics, and real-time monitoring offers a powerful tool for preserving our forests and ensuring a sustainable

Contents

Chapter 1

Introduction

1.1 Introduction

When we look around in our surroundings and environment, we can see N number of natural calamities. One of the major extinction of natural resources is due to wildfire. In the past few years, we can see the continuous happenings of wildfire around the globe. Most of the wildfires in India take place due to the extreme changes in climatic conditions and human interventions. From 2019 till recently, over 30000 forest fires were reported all over India, and sadly 95 percent of the forest fires in India are on account of human activity. The Forest Survey of India released a report last year, analysing areas in India prone to fires. Out of the total 7,12,249 square km of forest cover, 1,52,421 square km (21.40 percent) is either highly or extremely fire-prone. The forests of Mizoram, Chhattisgarh, Manipur, Odisha, and Madhya Pradesh are most vulnerable.

To address this issue a FOREST MONITORING SYSTEM is proposed which solves the above stated issue by analysing the forest fire prone areas and sending regular updates to the base station or the authority. Basically this system has a sending part, receiving part which is a base station, a database and a webpage.

A node which consists of various sensors such as temperature, humidity, flamer and smoke sensors are put together in an Arduino Nano to form the sending part. The values collected from these sensors are sent to the base station via LoRa (Long Range) Protocol. LoRa protocol supports a range of 15-50 kilometres which is helpful in our case. The node also consists of a camera to take the pictures at regular intervals and to analyse the topography of that region.

The receiving part consists of a LoRa receiver which is connected to an ESP32 module. The sensor values from the node gets received here and subsequently those values are updated in a firebase realtime database. The values from the firebase realtime database gets logged to a database management system and to a webpage.

The sensor values which get logged in the database can be used to conduct studies and experiments for various researches and studies. These data's could be also used in machine learning to implement various algorithms on it and predict the behaviour of that particular in the future.

The sensor values get automatically updated to a webpage when the sensor value changes. The webpage could be accessed from any part of the world and could see the sensor of that particular node at realtime.

Chapter 2

Literature Review

This literature survey aims to provide an overview of the existing research on forest monitoring systems, including methodologies, technologies, and challenges. The information is gathered from various sources, such as academic papers, books, conference proceedings, and relevant publications. The following review incorporates works from different authors and sources.

2.1 Remote Sensing-Based Approaches

Remote sensing techniques have significantly contributed to forest monitoring. Smith et al. (2018) in their paper "Remote sensing of forest ecosystems: concepts and case studies" published in the journal Remote Sensing of Environment, discuss the use of satellite imagery and aerial sensors for assessing forest cover, land use changes, and biomass estimation. They highlight the integration of remote sensing with Geographic Information Systems (GIS) for spatial analysis and decision support systems.

2.2 Ground-Based Monitoring

Ground-based monitoring techniques are crucial for gathering detailed forest information. Andersen et al. (2019) present a comprehensive overview in their book "Forest Inventory: Methodology and Applications" discussing field surveys, forest inventories, and ecological measurements. The authors emphasize the importance of data collection on tree species composition, size distribution, carbon stocks, and biodiversity.

2.3 Sensor Networks and IoT

Sensor networks and Internet of Things (IoT) technologies are emerging as valuable tools for real-time forest monitoring. Rajanen et al. (2020) explore this topic in their paper "Wireless Sensor Networks for Environmental Monitoring: A Review" published in the journal Sensors. The authors discuss the deployment of wireless sensor networks in forests, collecting continuous data on environmental variables such as temperature, humidity, and soil moisture.

2.4 Data Analysis and Modeling

Data analysis and modeling techniques play a critical role in extracting meaningful insights from forest data. Wulder et al. (2019) provide a comprehensive review in their article "Landscape-Scale Forest Monitoring from Space" published in the journal Remote Sensing of Environment. They discuss the application of advanced statistical methods, machine learning algorithms, and spatial analysis techniques for analyzing and interpreting forest data, enabling improved understanding of forest dynamics.

2.5 Challenges and Future Directions

Addressing challenges and exploring future directions in forest monitoring is essential. Kankare et al. (2019) examine the topic in their paper "Challenges and Prospects of Remote Sensing in Boreal and ArcticEcosystem Studies" published in the journal Remote Sensing. The authors discuss the challenges of data integration, uncertainties in remote sensing data, and the importance of incorporating socio-economic factors into monitoring frameworks

2.6 Summary

So by addressing challenges and exploring future directions, the research community can develop robust and integrated forest monitoring systems, contributing to improved forest management and conservation efforts

Chapter 3

Problem Statements

3.1 Statement 1

Lack of Real-time Forest Monitoring System Current forest monitoring practices often rely on periodic assessments, leading to delayed detection of forest changes and inadequate response to emerging threats. There is a need for a real-time forest monitoring system that provides timely information on forest health, disturbances, and threats to support effective management and conservation efforts.

3.2 Statement 2

Inadequate Monitoring of Illegal Logging Activities Illegal logging poses a significant threat to forest ecosystems, biodiversity, and sustainable forest management. The lack of efficient monitoring systems to detect and track illegal logging activities hinders effective enforcement and prevention. Developing a monitoring solution that utilizes advanced technologies and data analysis techniques can enable the timely identification and intervention of illegal logging activities

3.3 Statement 3

Limited Understanding of Forest Fire Dynamics Forest fires have devastating impacts on ecosystems, human lives, and property. However, there is still limited understanding of the underlying dynamics of forest fires, including fire spread patterns, ignition sources, and fire behaviour. Developing a comprehensive forest fire monitoring system that incorporates sensor networks, and modelling techniques can enhance the understanding of forest fire dynamics and aid in proactive fire management strategies.

3.4 Statement 4

Lack of Participatory Monitoring and Community Engagement Engaging local communities and stakeholders in forest monitoring is crucial for effective conservation and sustainable management. However, there is a lack of participatory monitoring approaches that involve local communities in data collection, validation, and decision-making processes. Developing a community-based forest monitoring system that empowers local communities and integrates traditional knowledge with scientific techniques can enhance the effectiveness and inclusivity of forest monitoring efforts.

3.5 Statement 5

Fragmented Data Integration and Lack of Standardization Forest monitoring often involves the collection of diverse data from multiple sources and platforms. However, the lack of standardised protocols and fragmented data integration hinder the seamless analysis and interpretation of forest data. Developing a standardised data integration framework that facilitates interoperability and harmonisation of data from different sources can enhance the efficiency and effectiveness of forest monitoring, enabling comprehensive analysis and decision-making.

3.6 Statement 6

Forested areas often lack reliable connectivity and communication infrastructure, making it challenging to establish real-time communication between monitoring devices, field teams, and centralised control centres. The lack of robust communication networks hinders timely data transmission, coordination, and decision-making in forest monitoring projects. Developing a strong wireless communication system using LoRa mesh network can enhance the efficiency of communication in remote areas

3.7 Statement 7

Battery Life and Replacement: Monitoring devices powered by batteries may have limited battery life, requiring frequent replacement or recharging. Using energy-efficient components and selecting batteries with longer lifespan or higher capacity can extend the operational time between replacements. Additionally, employing low-power modes or sleep modes during periods of inactivity can further conserve energy.

Chapter 4

Objective

4.1 LoRa Node Development for Flame and Smoke Detection

Develop a LoRa Node capable of collecting flame sensor and smoke sensor data to detect the presence of a flame in a forest environment. This involves designing and building a hardware module that can interface with the sensors, collect data, and transmit it using LoRa communication technology.

4.2 Integration of Temperature and Humidity Sensor for Ecological Monitoring

Integrate a temperature and humidity sensor into the LoRa Node to collect historical data on temperature and humidity in the specific forest region, enabling the study of ecological changes. This requires selecting and connecting a suitable sensor, implementing data acquisition and processing algorithms, and ensuring accurate and reliable measurements.

4.3 Camera Integration for Forest Monitoring and Activity Detection

Incorporate a camera module into the LoRa Node to capture regular images of the forest region, facilitating monitoring of forest changes and detection of any unusual activities. This involves selecting a compatible camera module, configuring image capture settings, and integrating the camera module with the LoRa Node to enable image transmission and storage.

4.4 Implementation of Local Image Storage Capability

Design and implement local storage capabilities within the LoRa Node to store the captured images, enabling onsite retrieval and analysis. This involves developing a storage mechanism, such as an SD card, and implementing a data management system that allows for efficient storage and retrieval of images.

4.5 Development of Web-Based Interface for Data Visualization

Develop a web-based interface that allows users to access and visualise the historical data of temperature and humidity in a graphical form, providing an intuitive way to interpret the ecological changes in the forest. This requires designing a user-friendly interface, implementing data visualisation techniques, and integrating it with the LoRa Node to fetch and display the collected data.

4.6 Design and Integration of Off-Grid Power System

Design and integrate a self-sustaining power system for the complete LoRa-based system using built-in batteries and solar panels, ensuring off-grid operation and long-term sustainability. This includes selecting appropriate batteries and solar panels, designing a power management system, and integrating it into the LoRa Node to provide continuous and reliable power supply.

4.7 Designing LoRa Gateway for Cloud Data Upload

Develop a LoRa Gateway to act as a central communication hub, receiving data from the LoRa Node and uploading it to the cloud. Implement necessary protocols and interfaces for seamless data transmission and ensure reliable and secure connectivity.

Chapter 5

Existing Solutions

5.1 Impact By Honeywell Smoke detector

Honeywell is a well-known company that produces a wide range of products, including smoke detectors.

5.1.1 Fire Safety

Smoke detectors play a crucial role in fire safety by detecting the presence of smoke and alerting occupants to potential fires. Early detection allows people to evacuate the premises quickly and contact emergency services, reducing the risk of injury or loss of life.

5.1.2 Property Protection

Smoke detectors can help protect your property by providing early warning of a fire. By alerting occupants and authorities promptly, the chances of containing the fire and minimizing damage increase significantly.

5.1.3 Peace of Mind

Having functioning smoke detectors installed in Forests could provide peace of mind to local people by knowing that they have an additional layer of protection against potential fires. This can help alleviate concerns and allow occupants to feel safer in their environment.

5.1.4 Compliance with Regulations

Smoke detectors are often required by local building codes and regulations.In Forests also,they are set under certain regulations .

5.1.5 Integration with Forest Office Automation

Some modern smoke detectors can integrate with Forest office automation systems, providing added convenience and functionality. For example, they can send alerts to your smartphone or smart home hub, allowing us to monitor the status of detectors remotely.

5.2 Halonix Shield fire alarm

Halonix Shield Fire Alarm is an innovative plug use fire alarm. The Fire Alarm only sounds when smoke reaches a certain level of danger. It will start to ring loudly and the red light indicator will start to blink continuously. It will not go off unless the smoke exceeds the present value. It fits into a B22D or E27 bulb holder. Type: Carbon Monoxide, Smoke In Forests Fires,It will play a crucial role in early detection.Surrounding Forest Temperature can also be kept under surveillance. The "Halonix Shield Fire Alarm" is proficient in detecting smoke apart from carbon monoxide, LPG, methane and hydrogen gases and uses a powerful, loud alarm to alert the users to any fire or gas leak.

Very innovative yet cost-effective, "Halonix Shield Fire Alarm" comes with a simple yet unique design that can easily fit into an ordinary bulb holder. The users are just required to install the Halonix Shield Fire Alarm in the bulb holder and switch it on.

The Fire Alarm will be in set-up mode for first two minutes and the red-light indicator on the device will glow continuously. After initial startup mode, the red-light indicator will start to blink after fixed time interval indicating a successful set-up. No further action is required and the consumer can enjoy the assurance of an active smoke alarm system. The Plug Use "Halonix Shield Fire Alarm" are also widely applicable in Homes, Kitchens, Clinics, Office Premises, Warehouses Shops. Outstandingly designed Halonix Shield Fire Alarm sets off only when the smoke exceeds the preset value.

5.3 Agni Suraksha Smoke detector

This detector has an inbuilt smoke sensor to detect fire. The device can be installed on the top of monitering system with the help of screws. The detector adopts the special structure with dustproof mothproof design.The detector is suitable to detect smoke in a house, shop, hotel, restaurant, office building, school, bank, library, computer house and storehouse etc also.The detector is meant for working with a fire alarm control panel and needs to be connected to the panel .

5.4 Agni Fire Response System

The Agni Suraksha Fire Alarm Response system/Panel is an advanced fire alarm control panel used to detect and alert people of a fire emergency in a building or premises,Forests etc. It is designed to monitor various fire detection devices, such as smoke detectors, heat detectors, and manual call points, and coordinate their responses to ensure prompt and effective action during a fire incident.

The Agni Suraksha Fire Alarm Panel typically consists of a central control unit that receives information from connected fire detection devices through a network of wiring or wireless communication. It analyzes the incoming signals and triggers appropriate responses, such as activating audio-visual alarms, initiating sprinkler systems or fire suppression systems, and sending signals to monitoring stations or emergency services.

5.5 Hasthip Smoke detector

This smoke detector is combining with the function of smoke detector and carbon monoxide detection.It also equips with RGB light LCD screen which can show the real time carbon monoxide concentration in the air. Once the concentration over the safe range(over 2.4ppm(3 mg/m^3)), it will give warning signals by red flash light and sound alarm.

This carbon monoxide smoke detector uses reliable high tech electric chemical Carbon Monoxide sensor and infrared photoelectric sensor, delievering a senstive detection for carbon monoxide concentration and smoke in air. With the 360° inhale airlet hole design can provide an efficient and timely detection in all direction. This smoke alarm does not contain any radioactive material. In Forests,It will play a crucial role in checking the CO concentration under control also help in controlling the overall forest temperature.

Chapter 6

System Description

6.1 System design and workflow

In this project, we proposed a system which is an extraordinary headway in technology because of its highlights like minimal expense, usability and data acquiring.

Forest Monitoring System consists of a node which comprises a temperature sensor, humidity sensor, flame sensor, smoke sensor and a camera module. The value read from each of the sensors will be sent to the firebase realtime database. The pictures taken by the camera module at a regular interval of time will be recorded locally on the node which could be used for the further analysis of the topography of that region.

The sensor values sent to the firebase realtime database will be logged onto a database system. The sensor values of all these sensors could be logged onto this database and we could use these large sets of data values for further studies and research.

The sensor values are displayed on a web page whenever there is a change in the sensor values. Whenever the sensor values get updated in the firebase realtime database it gets automatically updated on the web page. If the flame or smoke value surpasses a threshold value it gets notified in the webpage and we could alert the concerned authorities regarding this.

6.2 Node

The node consists of a temperature sensor, humidity sensor, flame sensor, smoke sensor and a camera module.

The temperature and the humidity sensors are analog sensors. They read the sensor value as an analog input value. We use the DHT 11 sensor to read the temperature and humidity analog values and therefore we use the "dht.h" library to get the temperature and humidity values.

The smoke sensor and the flame sensors are digital sensors. Whenever they detect a smoke or flame their digital value gets set to "HIGH". When the value of smoke or flame gets high there is a fire taking place there or a possibility of a fire that is going to take place. Once any of these are sensed, an alert is sent to the webpage.

The camera module in the node captures the pictures of the topography in which the node resides. It takes pictures of the area at a specified interval of time and stores those images in the SD card which is inserted into the camera module. These images could be used to analyse the changes in the topography of that particular region over the passage of time.

6.3 Firebase and Database

The various sensor values from the node get entered into the firebase realtime database. The values get automatically updated onto the firebase realtime database through the firebase credentials fed onto the code. With the help of those credentials the sensor values reach there. In the firebase realtime database are in the form of a JSON tree. All the values in the realtime database are in the form of a key-value pair. We created a field called "node-1" in the realtime database and all the sensor values get updated under this.

The sensor values reaching here get logged onto a database. The sensor readings at different time periods get stored onto the database and we can acquire a large set of data from these sensor values. These large sets of data can be used to perform various studies and they could also be used to predict the future values of these parameters.

6.4 Web Page

The webpage is used to view the various sensor parameters. The sensor values will be fetched by the webpage at a regular interval of time of 2 seconds. The webpage will automatically reload itself every 2 seconds in order to fetch the data and there is no need to refresh it manually, it updates on its own. The web page is developed using HTML, CSS and javascript.

The contents in the web page was developed using HTML. It consists of all the contents that have to be displayed in the webpage. The styling and the design for the webpage is done in CSS. It consists of all the designing aspects, the colour gradients and attributes, etc The additional functionalities that are to be done by the webpage such as fetching the data in a particular interval of time is done with the help of javascript. The fetching of data from the firebase realtime database and displaying that on the webpage without refreshing the whole web page is done with the help of javascript. The webpage is hosted in Github Pages which is deployed for free and we can view the webpage by clicking the web address given below.

Chapter 7

System Design

7.1 Introduction

Our entire project is divided into four parts: 1. The Transmitter(LoRa node) 2. The Receiver(Lora Gateway) 3. Firebase Database 4. Webpage for Displaying Data.

The working of the LoRa-based forest monitoring system involves the transmission of data from the LoRa Node to a cloud-based Firebase database via the internet. The process can be summarized as follows:

Transmitter: The LoRa Node acts as the transmitter in the system. It collects data from the various sensors, including flame sensors, smoke sensors, temperature and humidity sensors, and a camera module. The collected data is processed and packaged into messages for transmission.

LoRa Protocol: The transmitter uses the LoRa protocol to send the data messages wirelessly over long distances. The LoRa protocol provides low-power, long-range communication capabilities, making it suitable for transmitting data from remote forest regions.

Receiver: The receiver collects the data which are received from the loRa node and send it to the firebase cloud data base for storage and later retrieval. These values are simultaneously sent to the thingspeak server so that the received values could be monitored in real time

Firebase Database: Once the receiver captures the LoRa signals, the messages containing the collected data are extracted and forwarded to a cloud-based Firebase database. Firebase is a real-time database platform provided by Google, which offers easy integration and storage for web and mobile applications.

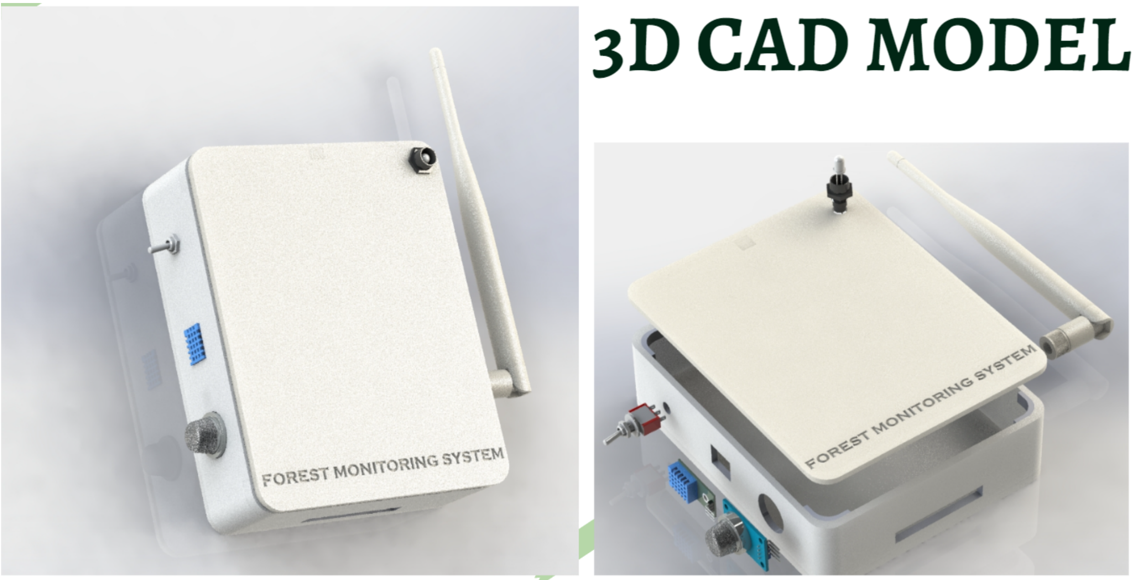
HTTP Protocol: To communicate with the Firebase database, the receiver uses the HTTP protocol over the internet. The data messages are sent as HTTP requests, allowing them to be securely transferred to the Firebase database.

Cloud Storage and Web Interface: The data received by the Firebase database is stored securely in the cloud. From there, authorized users can access and view the data using a web interface. The web interface provides a user-friendly platform to visualize, analyze, and interpret the collected data in real-time. Users can monitor flame and smoke status, view temperature and humidity trends, and access the captured images for forest monitoring purposes.

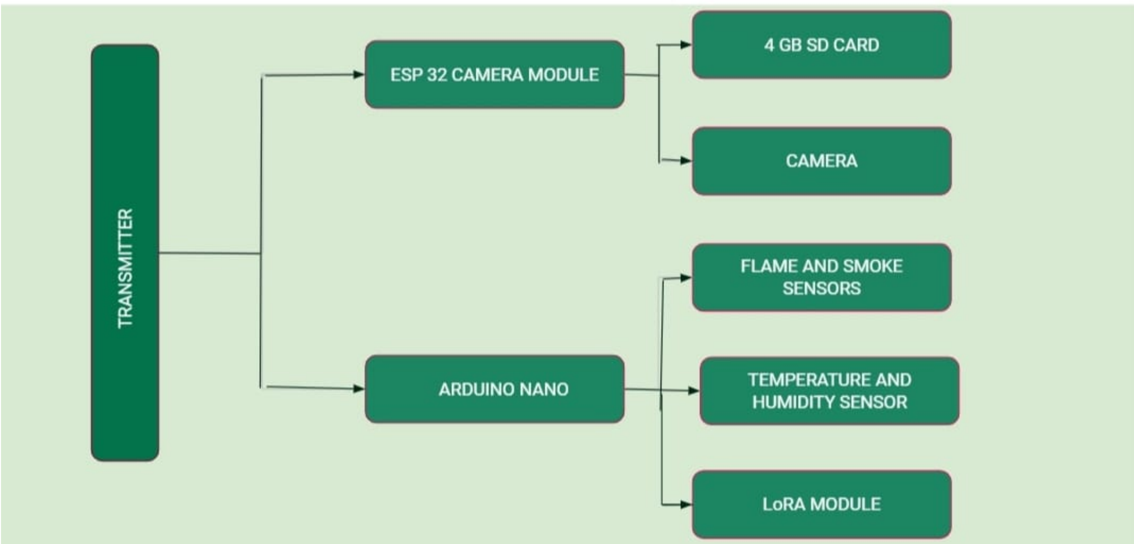
By utilizing the LoRa protocol for wireless transmission and the Firebase database for secure cloud storage, the system enables efficient and reliable collection, storage, and visualization of data from the forest monitoring sensors. The combination of these technologies ensures real-time access to the collected data, facilitating timely decision-making, and proactive measures for forest fire prevention and ecological studies.

7.2 Hardware

This part of the report contains all the information regarding the hardware part of the system



7.2.1 The Transmitter (LoRa Node)



7.2.1.1 Description

The LoRa node is a device designed for forest monitoring purposes. It is fully solar-powered and can operate off-grid as long as there is sufficient solar radiation. Additionally, it incorporates an integrated battery to sustain its functionality during night time. The node is equipped with a range of sensors to monitor various aspects of the forest's current state. These sensors include:

DHT11: This sensor enables temperature and humidity monitoring. MQ-02 Smoke Detector: It detects the presence of smoke, particularly useful for identifying potential forest fires. Flame Sensor: The flame sensor detects flames and immediately notifies the relevant personnel for prompt action. Camera: The node is equipped with a camera that captures images at regular intervals, storing them in its built-in storage system. For demonstration purposes the interval of image capture is set to 10 images per minute which could be changed as required. These images can be retrieved either when the storage reaches capacity or during regular inspection sessions.

Additionally, the node continuously transmits data such as sensor readings and battery health to the base station or LoRa gateway. The gateway serves as a relay, forwarding the data to the Firebase database for storage and future retrieval.

7.2.1.2 Components used

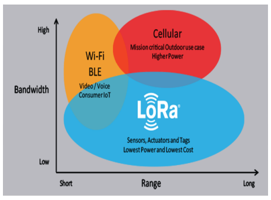
- Arduino nano

The Nano Board R3 with CH340 chip without USB Cable chipboard is based on the famous Arduino platform and does all the functions of Uno, but with a smaller footprint. The Nano Board R3 with CH340 chip without USB Cable is vital for your small project where you don't need much of pin-outs but the small size is very important to make it look good. This Nano equips a low-cost MINI USB-Serial Chip that makes it less in price than Nano with FTDI USB-Serial Chip used on older versions of Arduino Nano. The Nano Arduino is a small, complete, and breadboard-friendly board based on the ATmega328 (Nano R3). It has more or less the same functionality of the Uno but in a different package. It lacks only a DC power jack and works with a Mini-B USB cable instead of a standard one. The Nano can be powered via the mini-USB connection, 6-20V unregulated external power supply (pin 30), or 5V regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source. The size of Nano V3.0 with CH340 Chip is only 43 mm x 18 mm; it comes with 6 PWM I/O from a total of 14 digitals I/O, 8 analog inputs, 16Mhz clock speed, and 32kB of flash memory.

- Ra-02 LoRa module

The LoRa Module allows you to communicate to the LoRaWAN wireless network, a network made for the IoT. This technology makes it possible to communicate from a battery-powered device directly to a server, even for several years.

Advantages of LoRa module



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- ESP 32 Camera

The node is equipped with a camera that captures images at regular intervals, storing them in its built-in storage system. For demonstration purposes the interval of image capture is set to 10 images per minute which could be changed as required. These images can be retrieved either when the storage reaches capacity or during regular inspection sessions.

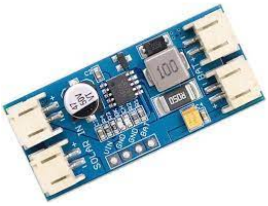
Technical Details

The ESP32 CAM WiFi Module Bluetooth with OV2640 Camera Module 2MP For Face Recognization has a very competitive small-size camera module that can operate independently as a minimum system with a footprint of only 40 x 27 mm; a deep sleep current of up to 6mA and is widely used in various IoT applications. It is suitable for home smart devices, industrial wireless control, wireless monitoring, and other IoT applications. This module adopts a DIP package and can be directly inserted into the backplane to realize rapid production of products, providing customers with high-reliability connection mode, which is convenient for application in various IoT hardware terminals. ESP integrates WiFi, traditional Bluetooth, and BLE Beacon, with 2 high-performance 32-bit LX6 CPUs, 7-stage pipeline architecture. It has the main frequency adjustment range of 80MHz to 240MHz, on-chip sensor, Hall sensor, temperature sensor, etc

- 18650 Li Ion battery (2500mAh)

Orange is well known for its high-quality Li-PO batteries and the ability to withstand heavy-duty RC applications. Since finding a branded 18650 Li-Ion battery is nearly impossible and the market is full of suppliers who are offering the clone lithium-ion batteries under the names of famous brands. Those batteries are rated the same as standard lithium-ion batteries yet no one guaranty about their lifespan and also their performance is not as good as you expect. To overcome this issue and supply our customers with high-quality and best performing lithium-ion batteries, Orange has launched its own 18650 Lithium-Ion batteries. This Orange ICR 18650 2500mAh 25C Lithium-Ion Battery gives value for your money. It is a single cell, compact, and powerful battery cell with 2000 mAh capacity. It is very convenient to install in your project to fulfill the 3.7 Volt requirement with high capacity. The battery terminals can use in any compatible battery adapter/holder or it can be permanently soldered to your applications power source wires

- 6v Li Ion solar charge controller



This is a maximum power point tracking (MPPT) solar charger for single-cell LiPo batteries. This MPPT solar charger provides you with the ability to get the most possible power out of your solar panel or other photovoltaic device and into a rechargeable LiPo battery. Set-up is easy as well, just plug your solar panel into one side of the solar charger and your battery into the other and you are good to start charging! Solar maximum power point tracking (MPPT) is to ensure that the light intensity change, photovoltaic cells output maximum power, to make full use of solar energy. In general, need to use a switch-mode DC-DC converter to realize the MPPT function, keep the output voltage, and charging current product maximize (output). The output of the Solar Charger is intended to charge a single polymer lithium-ion cell. The load should be connected in parallel with the battery. Each Solar Charger comes equipped with a CN3791 power tracking battery charging circuit and pre-installed four 2-pin JST/PH2.0 connectors.

- 6v Solar panel

Name : Solar for DIY Square shape 6V 100MA MINI SOLAR PANEL wire attached with solar (70x70x3mm) Number of Ports : 2 Working models of science projects kits Solar panel for science experiment kit to make working models / projects Solar power experiments solar connect with wire it is a 70 x 70 x 3mm square shape solar

- 5 channel Flame sensor

  The flame sensor detects flames and immediately notifies the relevant personnel for prompt action.

Technical Details

5-Channel Flame Sensor Module is a 5 station fire sensor module used to discover flame in bigger place (>120 degree). If you require a robot that ought to detect any fire round, then this module will be quite helpful for you. It finds that the flame with 5 fire detectors that are organized with 30 levels. This module outputs analog signal, that might be precisely, as well as digital sign which would be simpler to use, you can fix the electronic output signal sensitivity from the on-board potentiometer. The 5 LED signs are useful in your debugging, the high-precision resistors makes this detector more exact than other fire detectors. This module is sensitive to the flame and radiation.

It also can detect ordinary light source in the range of a wavelength 760nm-1100 nm. lighter flame test distance of 80cm, for the greater the flame, the farther the distance test.

- MQ-02 Smoke detector

  It detects the presence of smoke, particularly useful for identifying potential forest fires.

Technical Details

Operating voltage : 5V Load resistance : 20 Kilo ohm Heater resistance : 33 ohm $\pm$ 5 percent Heating consumption $<$ 800mw Sensing Resistance : 10 Kilo ohm – 60 Kilo ohm Concentration Range : 200 – 10000ppm Preheat Time : Over 24 hour

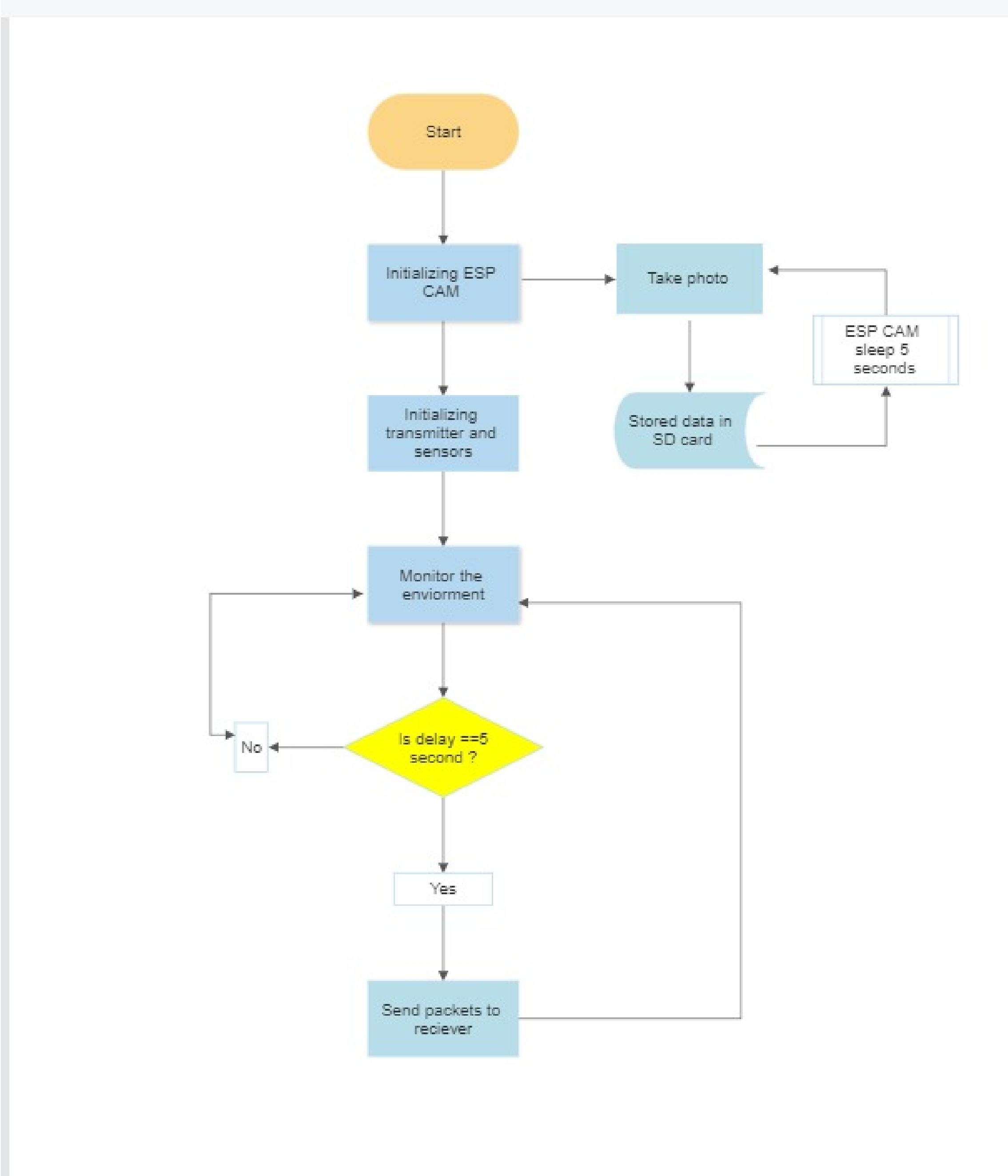
- DHT11

  This sensor enables temperature and humidity monitoring.

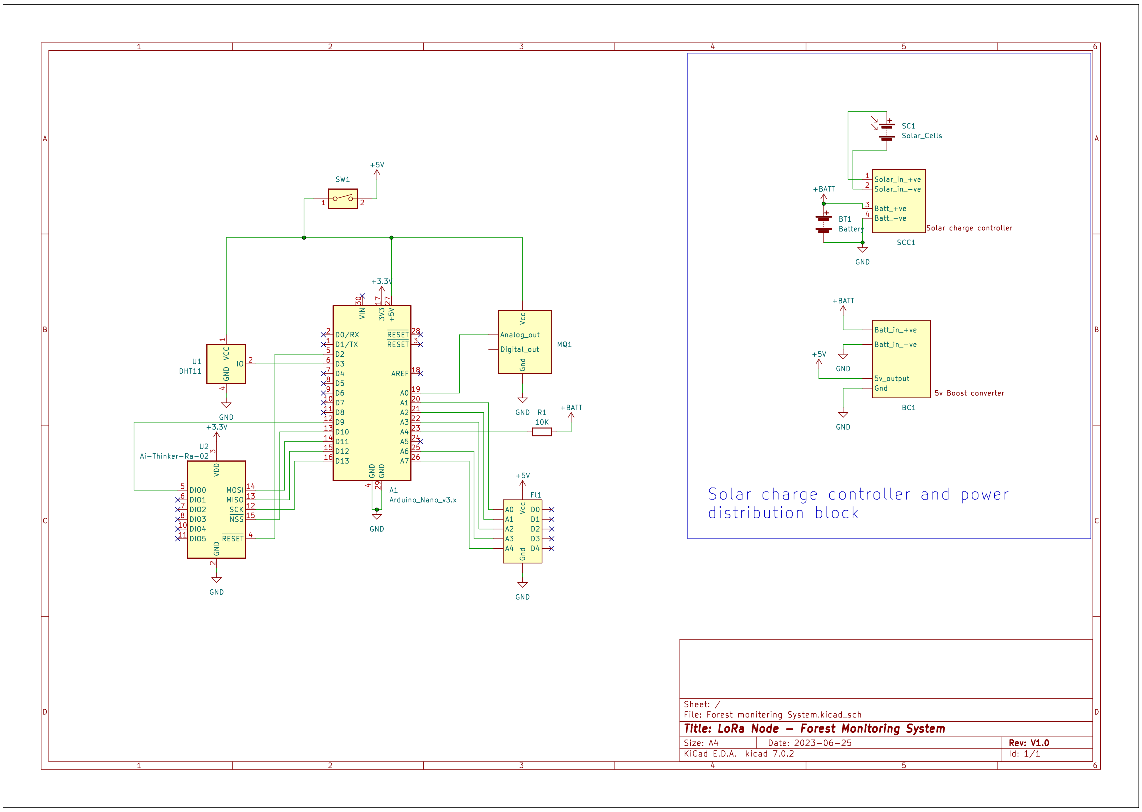
Low cost 3 to 5V power and I/O 2.5mA max current use during conversion (while requesting data) Good for 20-80Good for 0-50°C temperature readings ±2°C accuracy No more than 1 Hz sampling rate (once every second) Body size 15.5mm x 12mm x 5.5mm 4 pins with 0.1" spacing

- Miscellaneous components (Wires, dot PCB, etc)

7.2.1.3 Flowchart



7.2.1.4 Schematic



7.2.2 The Receiver (LoRa Gateway)

7.2.2.1 Description

The system receiver consists of an ESP 32 WROOM module, LoRa module and a 1.3 inch OLED display. The LoRa module receives the sensor values and battery health data from the transmitter in json format. Once recieved the values are decoded. The decoded information will be displayed on the OLED screen, this is done so as to know the transmitter status directly from the receiver side. But directly displaying the status will not record the the transmitter status over a period of time. The ESP 32 WROOM module provide internet connection, the decoded data are sent to the fire base database at regular intervals, this works like a real time data base to store the transmitter status. These information sent over a period of time helps to analyze the forest climate, probability of occurrence of forest fire etc.., the battery status received is also recorded for knowing the health of battery. The system also has its own web app that fetches the data from fire base at regular intervals and display the forest status in its home page.

7.2.2.2 Parts

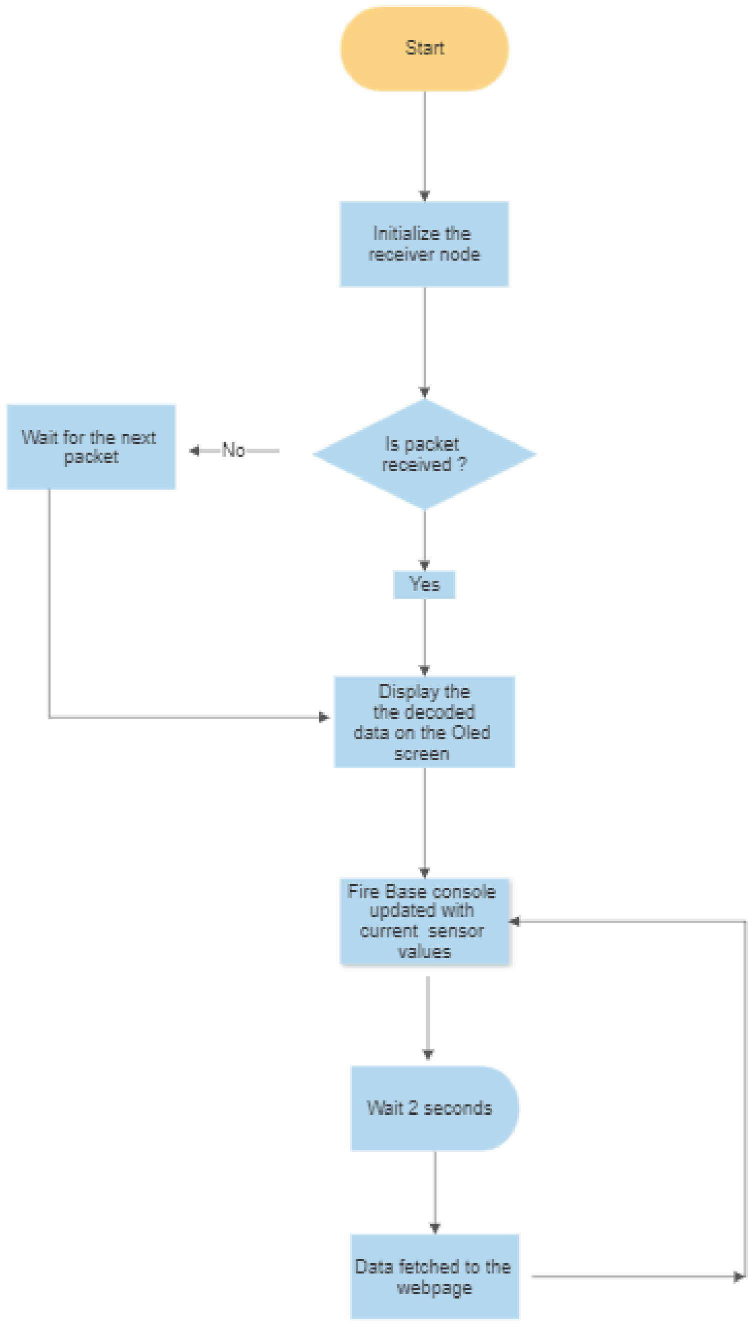
- ESP-32

This is ESP WROOM 32 MCU Module. ESP WROOM 32 is a powerful, generic WiFi-BT-BLE MCU module that targets a wide variety of applications, ranging from low-power sensor networks to the most demanding tasks, such as voice encoding, music streaming, and MP3 decoding. At the core of this module is the ESP32S chip, which is designed to be scalable and adaptive. There are 2 CPU cores that can be individually controlled or powered, and the clock frequency is adjustable from 80 MHz to 240 MHz. The user may also power off the CPU and make use of the low-power coprocessor to constantly monitor the peripherals for changes or crossing of thresholds. ESP32S integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, low-noise sense amplifiers, SD card interface, Ethernet, high-speed SDIO/SPI, UART, and I^2C. Using Bluetooth, users can connect to their phone or broadcast low energy beacons for its detection. The use of Wi-Fi enables a large physical range, as well as a direct connection to the internet via a Wi-Fi router. Perfect for wearable electronic or battery-powered applications, the ESP32 chip uses less than 5µA. In addition, this module can support data rates of up to 150 Mbps and 22 dBm output power at the PA in order to allow for the widest physical range.

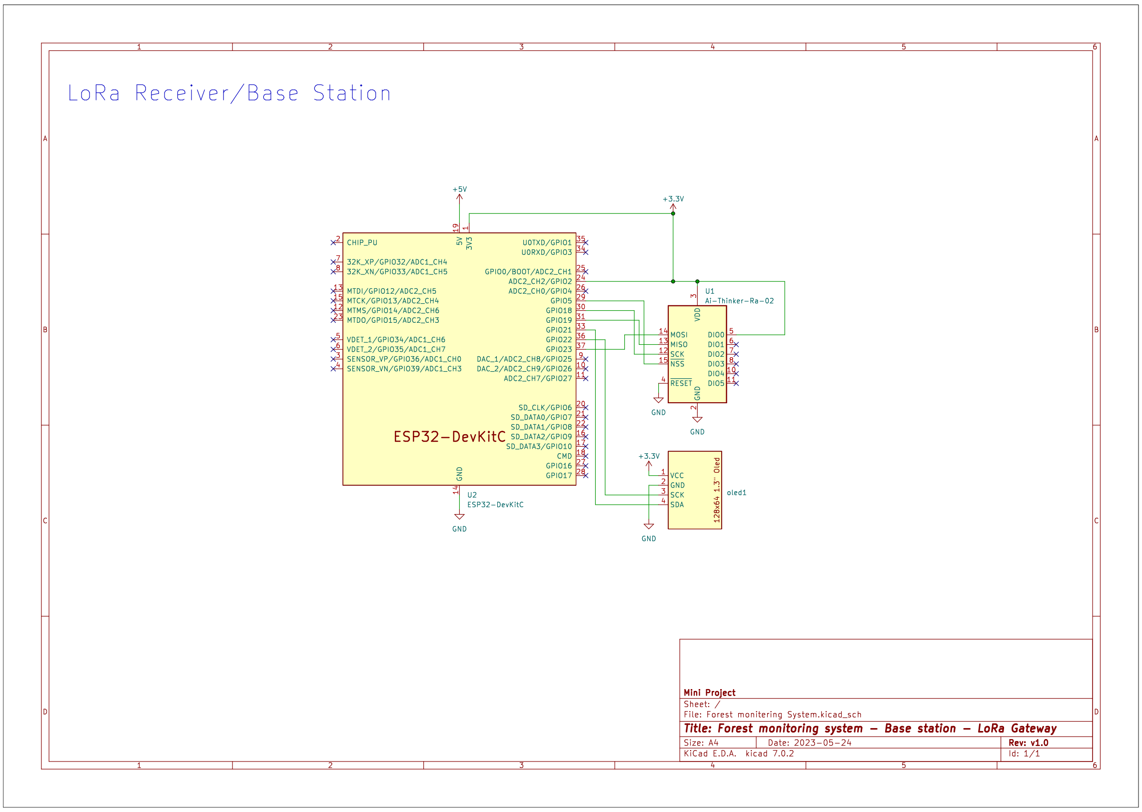
- Oled Display

This 1.3 I2C OLED Display is an OLED monochrome 128x64 dot matrix display module with I2C Interface. It is perfect when you need an ultra-small display. Comparing to LCD, OLED screens are way more competitive, which has a number of advantages such as high brightness, self-emission, high contrast ratio, slim outline, wide viewing angle, wide temperature range, and low power consumption. It is compatible with any 3.3V-5V microcontroller, such as Arduino.

7.2.2.3 Flowchart



7.2.2.4 Schematic



7.3 Software

This part of the report contains all the information regarding the hardware part of the system

7.3.1 Description

The webpage is used to display the various parameters such as temperature, humidity, flame sensing, smoke sensing. The values read from the node will be sent to the firebase realtime database and those sensor values will be fetched by the webpage at a regular interval of time of 2 seconds. The webpage will automatically reload itself every 2 seconds in order to fetch the data and there is no need to refresh it manually, it updates on its own.

The webpage is hosted in Github Pages which is deployed for free and we can view the webpage by clicking the web address given below. We could have a specialised domain name for the server by buying a domain name from a domain name service provider.

The web address for accessing the web page is : Forest Monitoring System Web Page

The web page is developed using HTML, CSS and javascript. The code for the web page : Web Page Code

7.3.2 Software used

The code for the webpage was written in Visual Studio Code (VSCode). The source code is written in the VS Code and saved as an HTML file. The written file is opened in a browser inorder to view the web page.

7.3.3 Programming Languages used

The programming languages used for developing the web page are HTML, CSS and javascript.

HTML : The HyperText Markup Language or HTML is the standard markup language for documents designed to be displayed in a web browser. It is often assisted by technologies such as Cascading Style Sheets (CSS) and scripting languages such as JavaScript. Web browsers receive HTML documents from a web server or from local storage and render the documents into multimedia web pages. HTML describes the structure of a web page semantically and originally included cues for its appearance.

CSS : Cascading Style Sheets (CSS) is a style sheet language used for describing the presentation of a document written in a markup language such as HTML or XML (including XML dialects such as SVG, MathML or XHTML).[1] CSS is a cornerstone technology of the World Wide Web, alongside HTML and JavaScript.[2] CSS is designed to enable the separation of content and presentation, including layout, colors, and fonts.[3] This separation can improve content accessibility; provide more flexibility and control in the specification of presentation characteristics; enable multiple web pages to share formatting by specifying the relevant CSS in a separate .css file, which reduces complexity and repetition in the structural content; and enable the .css file to be cached to improve the page load speed between the pages that share the file and its formatting.

Javascript : JavaScript often abbreviated as JS, is a programming language that is one of the core technologies of the World Wide Web, alongside HTML and CSS. As of 2022, 98JavaScript is a high-level, often just-in-time compiled language that conforms to the ECMAScript standard.[10] It has dynamic typing, prototype-based object-orientation, and first-class functions. It is multi-paradigm, supporting event-driven, functional, and imperative programming styles. It has application programming interfaces (APIs) for working with text, dates, regular expressions, standard data structures, and the Document Object Model (DOM).

7.3.4 Algorithm

The contents in the web page was developed using HTML. It consists of all the contents that have to be displayed in the webpage. The styling and the design for the webpage is done in CSS. It consists of all the designing aspects, the colour gradients and attributes, etc The additional functionalities that are to be done by the webpage such as fetching the data in a particular interval of time is done with the help of javascript. The fetching of data from the firebase realtime database and displaying that on the webpage without refreshing the whole web page is done with the help of javascript. Once the above steps are done, we upload this file to a github repository and deploy this file on the github pages. When all these steps are followed we could see the webpage getting successfully deployed and we could view the webpage by typing the web address given above in a browser.

Chapter 8

Conduction and working

The Detailed working of the forest monitoring system is detailed below:

8.1 Data Collection

The LoRa node has a plethora of sensors namely smoke sensor, gas sensor, temperature sensor, humidity sensor and a camera. The values from the sensors are acquired at regular intervals and processed. These values are compared with the threshold values to check whether they are under the limit and if it goes above the limit an appropriate error signal is generated.

8.2 Data Storage

The Images that are taken from the module could be used later for research purposes and to study about the ecological changes happening in the forest. These images are stored in the local storage medium which is in this case an SD card. These images could be retrieved and processed during timely on-site inspections.

8.3 Data Transmission

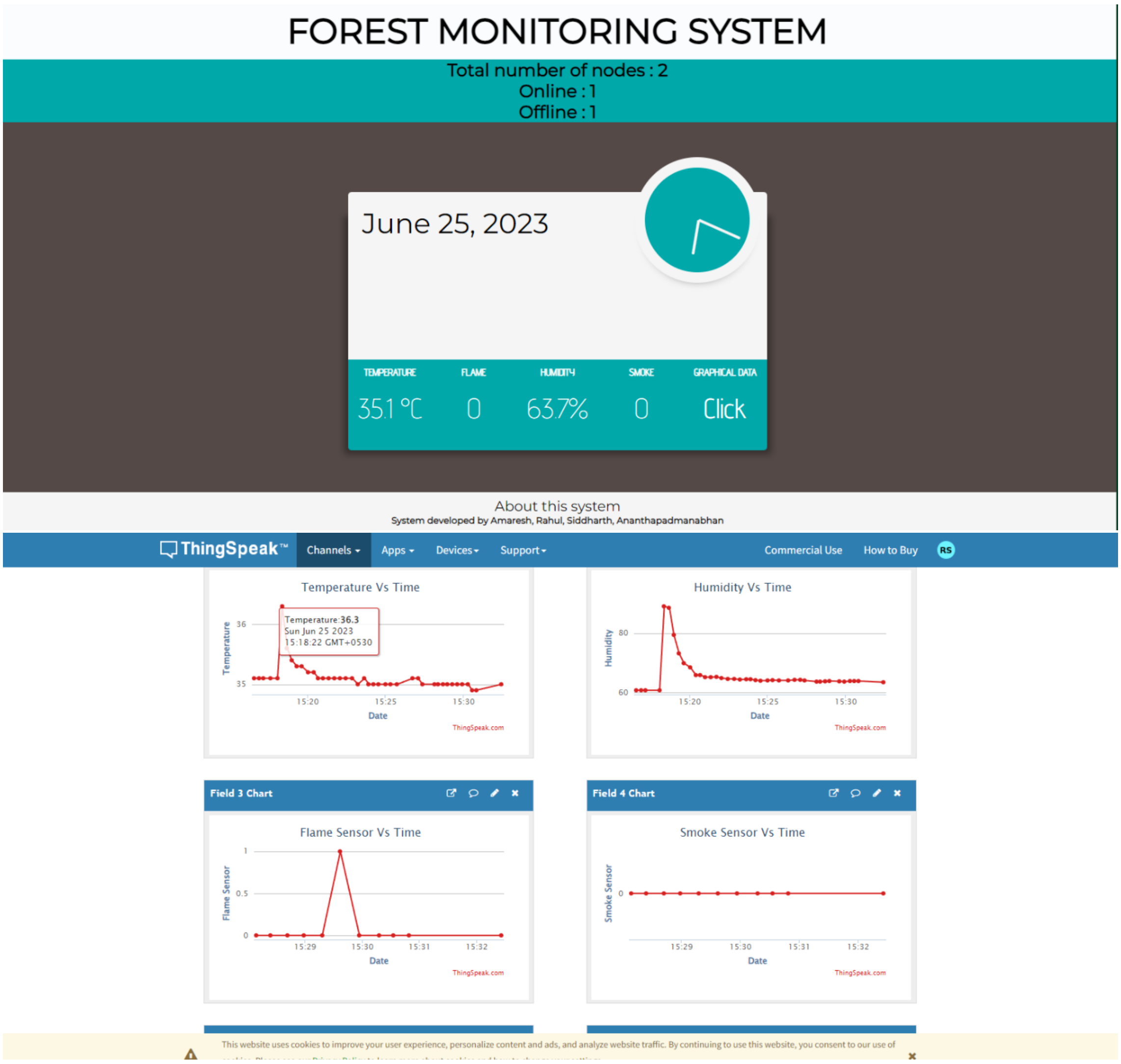
The data from the sensors, namely the temperature, humidity, flame and smoke sensors which are collected, are sent to the base station for upload via loRa protocol. The LoRa protocol provides low-power, long-range communication capabilities, making it suitable for transmitting data from remote forest regions.

8.4 Off-grid power supply

Our system has a completely off grid power supply solution. It has a 6v solar panel which is used to recharge a 2500mAh li ion battery. The output from this battery is then taken and boosted to 5v which is required to run the whole system.

8.5 Cloud storage and data representation

The data which is collected and sent to the base station via lora protocol is sent to the firebase database. This data could be accessed by authorised personnel for any use from research to monitoring purposes. The website which is hosted in github connects to this database and prints the real time output of the sensors. For a historical representation of data, the collected data is also sent to thingspeak server which collects these values and represents the data in historical form.



8.6 Algorithm

8.6.1 For Ardino and sensors

1. The system is initialised
2. The system constantly monitors the temperature, humidity, flame status and smoke detector status value is constantly monitored.environment.

3. The values of the sensors are transmitted at regular intervals. When the value of the smoke sensor is more that the sensor threshold then the smoke detected signal is transmitted. Similarly if more than 2 flame sensors detect flame it is treated as flame is present and flame detected signal is transmitted.

8.6.2 For Esp32 cam

1. The Esp32 cam is initialised.
2. Images are taken from the camera at regular intervals
3. These images are stored in the sd card.
4. The esp32 goes to sleep mode for 1 minute
5. The steps from 2 to 4 are repeated endlessly

8.6.3 For Lora gateway

1. The esp32 is initialised.
2. The gateway waits to receive data.
3. When it receives data it transmits to firebase database and thingspeak server

Chapter 9

Conclusion and future scope

9.1 Conclusion

The Forest Monitoring System developed here integrates long range communication device(LoRa),ground-based sensors and microcontrollers to collect comprehensive and up-to-date information about forests.It also help to overcome the demerits of the Existing technologies of Forest Monitoring and Fire Detection. Compared to traditional forest fire monitoring system, the system is more good at flexible structure, low cost,Less time easy operating,wide expandable and have a better promotional value. It contains an integration of Temperature and Humidity Sensor for ecological monitering.A Camera a local image storage capability slot(Sd card) is also integrated for Forest Monitering and Activity Detection. For Data Visualisation,we have also developed a Web based interface.It systematically and repeatedly measure and observe forest resources, their management, uses and users. The forest monitoring system project has reached its conclusion with several key outcomes and achievements. Through the implementation of advanced technologies and data analysis techniques, the project aimed to enhance the monitoring and management of forest resources. The following are the key conclusions of the project:

1. Improved Data Collection: The forest monitoring system successfully established a robust data collection mechanism. It utilized ground-based sensors, to gather extensive and accurate data about the forest ecosystems.

2. Real-time Monitoring: The project enabled real-time monitoring of forest activities, including deforestation, illegal logging, and forest fires. By integrating data from multiple sources, the system provided timely alerts and notifications, allowing authorities to respond quickly to potential threats.

3. Enhanced Accuracy and Efficiency: With the aid of sensors the forest monitoring system significantly improved the accuracy and efficiency of data analysis. It was able to detect changes in forest cover, identify vulnerable areas, and predict potential risks with greater precision, enabling proactive measures to protect the forests.

4. Effective Decision-Making: The project empowered decision-makers with valuable insights and information for better forest management. The comprehensive data analysis and visualization tools provided a holistic view of the forest ecosystem, aiding in the formulation of evidence-based policies and strategies.

5. Scalability and Sustainability: The forest monitoring system demonstrated scalability and sustainability by establishing a framework that can be expanded and replicated in other regions and countries. The project's success serves as a model for future endeavors aimed at utilizing technology for forest monitoring and conservation purposes.

In conclusion, the forest monitoring system project proved to be a valuable initiative that leveraged technology to enhance the monitoring and management of forest resources. It provided accurate and timely information, facilitated effective decision-making, and fostered collaboration among stakeholders. The project's outcomes contribute to the preservation of forests and the sustainable development of our natural ecosystems.

9.2 Future scope

The forest monitoring system project has a promising future scope, with several potential areas for further development and expansion. Here are some key aspects to consider:

1. Integration of Advanced Technologies: As technology continues to advance, future iterations of the forest monitoring system can explore the integration of cutting-edge technologies. This could include the use of advanced satellite imaging, LiDAR (Light Detection and Ranging), hyperspectral imaging, and artificial intelligence algorithms for more accurate and detailed forest monitoring.

2. Enhanced Data Analytics: Improving data analytics capabilities will be crucial for the future of forest monitoring systems. By leveraging big data analytics, machine learning, and deep learning techniques, the system can identify complex patterns, predict forest dynamics, and provide more comprehensive insights into the health and status of forests.

3. Internet of Things (IoT) Integration: Incorporating IoT devices and sensors into the forest monitoring system can enable real-time data collection on various environmental parameters such as temperature, humidity, air quality, and soil moisture. This would provide a more holistic understanding of the forest ecosystem and its interactions with the surrounding environment.

4. Citizen Science and Crowdsourcing: Engaging local communities and citizens in the monitoring process can be a powerful tool for gathering data and increasing the scope of the project. By incorporating citizen science and crowdsourcing approaches, the system can leverage the collective efforts of a wider network of individuals to report forest-related incidents, contribute data, and participate in conservation efforts.

5. Early Warning Systems: Developing robust early warning systems for forest fires, illegal activities, and other potential threats is crucial. Integrating advanced fire detection technologies, such as thermal imaging and smoke detection, with the monitoring system can enable prompt response and mitigation measures, reducing the impact of forest fires.

6. International Collaboration: Forest ecosystems are not confined to national boundaries, and many environmental challenges require global cooperation. The future scope of the forest monitoring system project lies in fostering international collaboration and data sharing initiatives. This could involve creating a network of interconnected monitoring systems across different countries to facilitate the exchange of information and coordinate efforts for global forest conservation.

7. Policy Support and Decision-Making: Continued development of the forest monitoring system should focus on providing actionable insights and decision support tools for policymakers and government agencies. This could involve developing predictive models, scenario analysis tools, and policy simulation frameworks that assist in formulating effective policies for sustainable forest management and conservation.

8. Long-Term Monitoring and Impact Assessment: Implementing long-term monitoring programs and conducting periodic impact assessments are vital for evaluating

the effectiveness of forest conservation efforts. The forest monitoring system can incorporate methodologies to assess the long-term trends of forest cover, biodiversity, carbon sequestration, and other key indicators to measure the impact of interventions and guide future actions.

In summary, the future scope of the forest monitoring system project lies in embracing advanced technologies, enhancing data analytics capabilities, promoting citizen engagement, improving early warning systems, fostering international collaboration, supporting policy development, and establishing long-term monitoring and impact assessment frameworks. By continually evolving and adapting to new challenges, the project can contribute significantly to the conservation and sustainable management of forest ecosystems.

Bibliography

[1] Lovleen Gupta : Forest Fires in India : Research Gate

[2] how2electronics.com : Interfacing sx-1278 LoRa module with arduino

[3] all3dp.com : esp32 cam arduino tutorial

[4] circuitdigest.com : Interfacing with arduino flame sensor

[5] circuitdigest.com : Sending arduino data to webpage

[6] who.int : Wildfires