FOREST FIRE DETECTION SYSTEM

Quad Core Crew

Version 1.0

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Maintenance Manual

Version 1.0

Contents

A. Introduction

1. Purpose Document

The Forest Fire Detection System is composed of various sensors that will detect a fire nearby. These sensors include photoelectric, ionization, a camera, GPS, wind, temperature, and humidity. Along with these sensors, the use of cellemetry is needed to notify Command, Control, and Dispatch that a potential fire is present. This manual is intended to cover how to install, configure, use, and manage the Forest Fire Detection System.

2. Audience

The primary audience of this Forest Fire System Detection plan is system administrators that will be responsible to onlook all systems deployed. This is known as Command Control. The secondary audiences of the plan will include staff, fire departments, and individuals using the website.

B. System Description

1. Key Features

Some key features that the Forest Fire Detection System has are sensors that will be used to detect the presence of wildfire nearby.

- Photoelectric sensor: It will be triggered when it detects combustion particles from a fire nearby. This will then alert Command Control that there is a presence of combustion particles.
- Ionization sensor: It will be triggered when it detects combustion particles from a fire nearby. This will then alert Command Control that there is a presence of combustion particles.
- Temperature and Humidity sensor: The temperature and humidity sensor will be set at a threshold of 58 degrees Celsius and will be triggered if the fire reaches a higher degree of temperature and if there is a change in humidity. This will then alert Command Control that there is a jump in temperature in the area.
- GPS: The GPS will return the fire's location and send it to Command Control. This will be done by the triangulation of each system, so a better location can be located.
- GSM: The GSM Module will return the fire's location and send it to Command Control in case GPS does not work. This will be done by the triangulation of each system, so a better location can be located. The GSM module will also transmit the sensor data to the wildfire website.
- Wind Vanes: The wind vanes will determine the direction and speed of the current wind. It will allow Command Control to determine which direction the fire is coming from and where it might spread.

- Camera: The camera will record once all sensors have detected a fire nearby. This will then be sent to Command Control so they can view how big the fire might be.

With all these sensors, Command Control has a better chance of stopping a fire from increasing. The data from these sensors will be sent to a website, so users can better locate where a fire might be coming from.

2. Inventory

The Forest Fire Detection System's inventory will include files from the video recordings made by the camera. These files will remain saved on the SD card until a maximum of 20 have been recorded. If the SD card no longer reads videos, then a replacement will be needed. A maximum of 2 SD cards will be needed in case a malfunction happens to one of the three boxes that are deployed.

As for the device, there will need to be these items on inventory in case of an emergency: wind direction sensor, anemometer, ionization and photoelectric sensor, humidity sensor, camera, GPS, and GSM. A maximum of 2 extras of these items will be needed in case a malfunction happens to one of the three boxes that are deployed.

To keep the systems running, a maintenance check will be needed to see if any of the deployed boxes need a replacement.

3. Environment

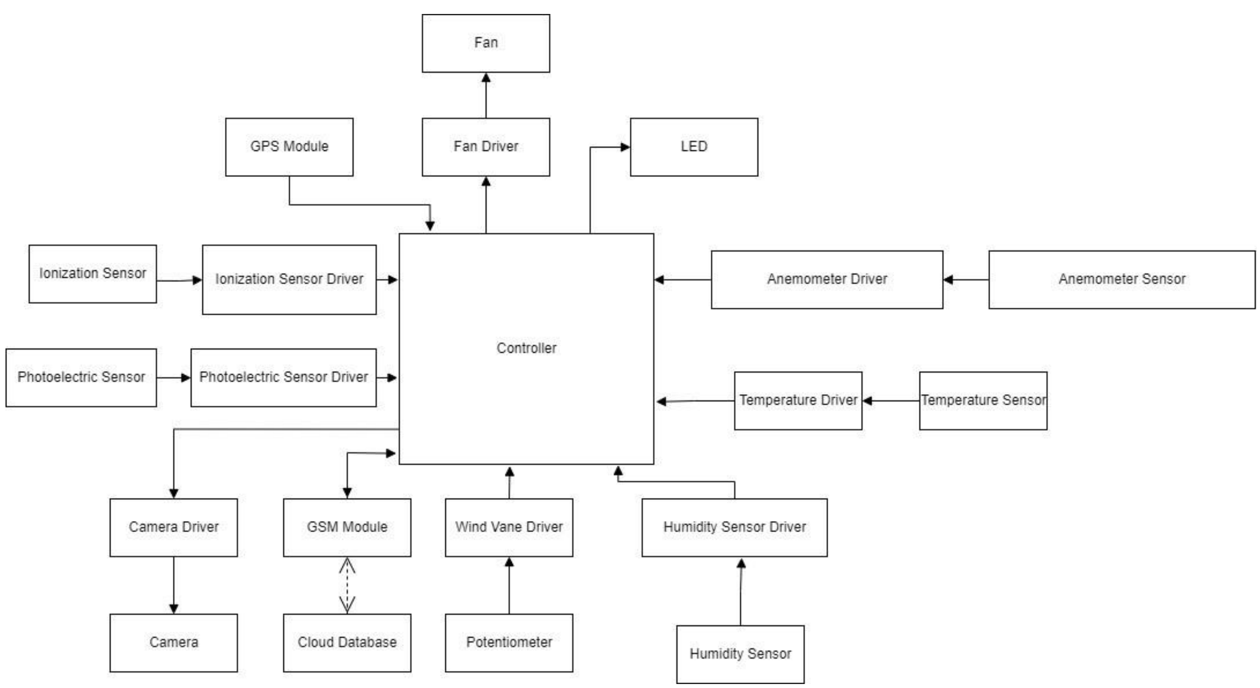
The Forest Fire Detection System will be in an open environment which includes the following: forests, wilderness, open land, and any outdoor environment that can cause a massive fire to spread. As for the hardware that is on the system, the fire will need to cause activation of fire sensitive sensors. The photoelectric and ionization sensors will need to be activated when the presence of combustion and smoke particles reach them. These activated sensors will alert the camera that there is a fire nearby and will cause the camera to turn on and begin recording its surrounding areas. This video will then be saved onto an SD card and sent to Command Control. Along with these sensors, the temperature and humidity sensor will also alert Command Control that there has either been a spike in temperature or humidity has lowered. When Command Control is sure that there is a fire present, they will want to get the coordinates of where the fire has begun and will use the GPS and GSM to get the approximate location of the fire. To prevent the fire from spreading, the wind vane will help determine in which direction the fire might go.

Once the data is passed to Soracom, it is sent to the appropriate table and storage container within AWS services. The database receives the uploaded data, triggering a Lambda function that checks the alert value. If it identifies a potential or active fire, the system notifies subscribed users about the detecting device. Meanwhile, the website updates every 60 seconds to provide the latest information on the Home page and validate sensor data for the Admin page.

4. System Operations

The Forest Fire Detection System operational usage and activities is based on all the sensor components it has. During the day and night, the system will be used the same. Its components will only be activated when there is a fire nearby. The first ones that will be alerted of a nearby fire are the photoelectric and ionization sensors. These two sensors will be able to detect combustion and smoke particles before the temperature and humidity detect an increase/decrease in values. To get video footage going, the photoelectric and ionization sensors will trigger the camera to turn on and start recording what is happening in the surrounding area. As the video is saved on the SD card, it begins the process of sending it through an S3 bucket where it will then send to the website so Command Control can view it. When a fire is confirmed, Command Control will begin to get the coordinates from the GPS and GSM to detect where approximately this fire will be by using triangulation. To prevent the fire from growing, the wind vane will be used to determine in what direction the wind is going to see where the fire will go. During the night, this same process will be used. The only difference will be that there will be light supplied to see in the dark through the video recordings. When there is no fire detected, the system will be on rest/off mode to conserve power. This will only apply to the camera, GPS, and GSM which will be turned on when the other sensors detect a fire nearby.

5. System Architecture



The “Wildfire” system is modeled after IOT devices, consisting of a microcontroller and interfaced modules, sensors and actuators that process input and give the according output, which are connected to a cell network. The major components of the "Wildfire" system are as follows.

Major Hardware Components:

GSM Module – allows for communication with the cellular network. Allows for sending/receiving data and for triangulation purposes.

Camera – engages on when in the presence of a possible wildfire. Records video which is sent to command control to verify that there is a fire.

Photoelectric sensor – fire alarm optical sensor that detects smoldering fires and combustible particulate.

Ionization sensor – fire alarm sensor that utilizes smoke to detect a fire.

GPS Module – allows finding the location of the "Wildfire" device with precision.

Fan – used to cool down the "Wildfire" device if it overheats, as well as routing smoke to a chamber where sensors are housed.

LED – indicates status of the "Wildfire" device.

Anemometer sensor – allows to detect speed of wind, possibly of a wildfire.

Temperature sensor – measures temperature of "wildfire" device, temperature is used to control when the fan engages.

Humidity Sensor – measures relative humidity where the "wildfire" box is located.

Wind Vane – allows to determine the direction of the wind.

Major Software Components:

DynamoDB – Database used store necessary information such as field data, user login, subscribers, and video footage from hardware devices.

AWS Amplify– JavaScript SDK Package to allow access to AWS services in development environment.

Next.js - JavaScript Framework for building server-rendered React applications.

Arduino IDE – IDE used for developing software for the Arduino processor.

C. Product Installation

1. First-Time Users

For first time use, the Forest Fire Detection System will need time to configure settings. The device needs to be powered on at the site where it will be used. When powered, the device will connect to the GSM network. Then, location coordinates are attained by the GPS and GSM module. The status LED will blink when the device is configuring. The LED will stop blinking and just stay on when the device is operating.

2. Access Controls

To properly get the camera working, there will need to be an installation of libraries. Download the code for the camera and make sure that you include the extra files. When all the files are downloaded, run the main code and check if the camera is detected. These code files should be able to detect the camera, the SPI, and the SD card. If this fails, make sure to follow all the modifications made to the code.

For the sensors to work, download their respective code. Once the code is downloaded, make sure to test it. Some might need to have modifications made to it such as downloading extra libraries. Once all the sensors are working correctly, download the final code file. Make sure all the components are plugged in correctly and run the code to see if access has been given. If it runs with no errors, then the system is ready to be deployed.

3. Installation

The Wildfire Detection device is easy to install. First, a location for the device must be found where it is under sunlight. Next, mount the device on a pole or tree with provided mounting parts, making sure the wind vane faces north. After, turn on the ON switch on the device to initialize the device. The LED on the device will blink for 5-10 minutes, then will stop blinking and be on whenever the device is operational and ready to detect fires.

4. Configuration

Internal default configuration is already done upon powering on the device. This includes attaining the location of the device, and making sure that the device can connect with the GSM network. The device along with the wind vane must be pointing north, to get accurate results from the wind vane. There are no configuration options or other custom configurations, as the device has only 2 modes – functioning mode and troubleshooting mode.

5. Starting the System

To start the system, you must first place the device in the area where it will be used. Next, press on the “ON” switch to begin operation. The status LED will blink while the device is configuring and booting up.

6. Stopping the System

To properly stop the system, The switch that was used to turn on the device can be pressed to turn off the device. This cuts the power to the system and completely stops it, disconnecting it from the GSM network. Command control will be notified that the system is off.

7. Suspending the System

To suspend the system, a troubleshooter must be on site. The troubleshooter will plug in their computer into the serial port of the device, enter a command to suspend, and then the device will be suspended. The suspended device can be troubleshooted, as it will not be connected to any networks.

D. System Usage

1. Instructions

Once a user has installed the device and registered on the website, the device will monitor the area for fires and notify the user if there are signs of a fire.

2. Conventions and Error Messages

Error: The device will search for a location for 8 minutes. If a location has not been found within those 8 minutes, the LED on the device will blink a series of 3 short blinks, then a pause over and over. When this is encountered, simply power off the device, then power it on to try to get a location again.

Error: The camera will do a run through to see if it is detected, along with the SD card and SPI. If there is a detection error with either the camera, SD card, or SPI then there will need to be a reset on the system. If the reset does not work, then power off the device and power it on again to see if there is another error. If the SD card error keeps repeating, then a replacement SD card will be needed.

Error: If there is no mention of a video being saved on the SD card, then there will need to be a check on the SD card formatting. Make sure the SD card format is set to FAT32 instead of exFAT. The system will only run on a FAT32 SD card. If everything is correct, check if the pin location of SD card is open and set. This should fix the ongoing error of it.

E. System Management

1. Change Management

To effectively manage the codebase, we recommend using Visual Studio Code as the code editor, installing Node.js, cloning the repository through GitLab/GitHub, and following the steps in the README file to run the codebase. Our tech stack includes Next.js, React, AWS Amplify, and TypeScript.

For new management onboarding:

1. Set up an AWS account and grant the necessary permissions for the user to access the required AWS services for the project, such as AWS Amplify, AWS DynamoDB, AWS S3, Lambda Functions, and CloudWatch.
2. Create a user account on the website, wildfiretracker.link, and add the email used for login into the codebase, which contains a list of Admin Emails.

Change Management Process:

- Version Control: Use GitLab/GitHub for version control and to maintain a history of code changes.
- Code Review: Implement a code review process to ensure all changes and updates meet coding standards, security requirements, and maintainability guidelines.
- Testing: Conduct thorough testing, including unit tests, integration tests, and end-to-end tests, to verify the stability and functionality of the system.
- Continuous Integration and Deployment: Employ CI/CD tools and processes to automate code deployment for faster, more consistent, and less error-prone updates.
- Documentation: Keep documentation up to date for the codebase, including code comments, technical specifications, and user manuals.

3. Configuration Management

To configure any system data, authorized credentials are required. From there, you can make necessary changes to the AWS console or through the codebase. It is essential to maintain proper documentation and versioning of the application to address potential issues, errors, or unexpected downtimes. Utilizing automation tools such as Puppet is beneficial for managing and maintaining consistency across environments.

4. Release Management

When releasing a new feature, create a new branch from the repository and commit your changes to this branch. Once completed, create a pull request to merge the changes into the development branch, which is connected to a pipeline. Upon merging, the pipeline will fetch the codebase from the repository, build, check for errors, and host the website with the associated domain.

5. Security Administration

The codebase and AWS services are all protected with two-step authentication. An additional security measure is to establish requirements for pull requests to be reviewed and processed by another developer before merging. Ensure the proper handling of sensitive data and maintain compliance with relevant industry standards and regulations. Use tools like AWS Identity and Access Management (IAM) to manage user access and permissions.

6. System Administration

- We recommend using AWS CloudWatch to effectively monitor and log the system, including database, function, and storage services associated with the application.

- Here is a resource link: https://docs.aws.amazon.com/AmazonCloudWatch/latest/monitoring/WhatIsCloudWatch.html

F. System Maintenance

System maintenance will primarily consist of preventative maintenance. It is highly recommended that each WildFire Detection Device be tested by a troubleshooter once every three months. Preventative maintenance should be done more frequently whenever it is forest fire season. The troubleshooter will connect their computer to the device and poll every sensor and confirm that all values output by the sensor are within range.

Corrective maintenance will be required whenever a sensor is malfunctioning. The troubleshooter will poll all the sensors and confirm that all values output by the sensors are realistic and within range. Sensors that are malfunctioning will need to be replaced. If no replacements are available, a new device must be installed.

G. Database Administration and Maintenance

These Items can be found in the Amazon Web Services Console

- DynamoDB (Beam Data): Perform a monthly database check and delete data with timestamps older than 5 days from the current date. For instance, on April 5, 2023, remove all records with timestamps earlier than April 1, 2023.
- DynamoDB (Subscriber Data): Conduct a monthly database inspection and remove entries with the _isDeleted attribute set to true. This action will eliminate unnecessary data belonging to users who have unsubscribed from text message alerts.
- S3 Bucket (Device Videos): Perform a monthly database check and delete data with title timestamps older than 5 days from the current date.

H. Backup and Recovery

- Website (UI Components/Data Fetching): The current website is hosted on an S3 bucket, with the latest version accessible in our GitHub/GitLab repository. These resources enable downloading and cloning of the complete codebase, and the README file provides instructions for running the site.
- AWS Services: Presently, DynamoDB tables, such as Beam Data and Subscriber Data, are set up with backup and recovery features, allowing data retention for up to 35 days (approximately 1 month and 4.5 days). This ensures restoration capabilities in case a table is wiped out or becomes unavailable. For services like Lambda and S3, AWS technical support can provide guidance on backup and restoration procedures.

System Backup and Recovery Procedures:

Backup Routines:

- DynamoDB: Enable Point-In-Time Recovery (PITR) for continuous backups or create on-demand backups.
- S3: Enable Versioning for object-level backups and Cross-Region Replication (CRR) for geographic redundancy.
- Lambda: Regularly export function code and configurations to a secure location, such as an S3 bucket.

Media Type:

- DynamoDB: Backups are stored as a snapshot in a separate DynamoDB table.
- S3: Backups are stored as versioned objects within the same or a different S3 bucket.
- Lambda: Backups are stored as compressed archives (e.g., .zip files) in an S3 bucket.
- Storage Locations:
- DynamoDB: Backup data is stored in the same AWS region as the source table.
- S3: Versioned objects are stored in the same bucket or replicated to a different bucket in another region.
- Lambda: Backups are stored in a designated S3 bucket.

Schedules:

- DynamoDB: PITR provides continuous backups, while on-demand backups can be scheduled as needed.
- S3: Versioning and replication occur automatically once enabled.
- Lambda: Schedule exports using CloudWatch Events, based on your preferred backup frequency.

I. Service Management

WildFire Device Hardware:

- The troublelshooter will plug in their computer to the device, open a serial console on Arduino and enter the 'z' character to enable troubleshooting mode. The troubleshooter then will enter a character to poll the sensor that is needed to be polled. The following are the character commands to poll the sensors;

  'q' - quit menu that you're currently in

  'c' - Camera, takes a short video and prints out the details of the video. Video is stored on the SD card ‘t’ - Temperature and humidity sensor, prints out the temperature and humidity

‘g’ - GPS module, print out the GPS coordinates

‘s’ - GSM module, print out the GSM module coordinates

‘i’ - Ionization sensor, prints out the status of the sensor

‘p’ - Photoelectric sensor, prints out the status of the sensor

‘m’ - activate photoelectric sensor to test

‘n’ - turn off photoelectric sensor test

‘k’ - activate ionization sensor to test

‘j’ - turn off ionization sensor to test

‘f’ - Fan, engage the fan

‘l’ - LED, blinks the status LED

‘a’ - Anemometer, prints out current wind speed

‘v’ - Wind vane, prints out current vane direction

DynamoDB:

- Table management: Create, update, and delete tables using the AWS Management Console, AWS CLI, or SDKs.
- Backup and restore: Enable Point-In-Time Recovery (PITR) for continuous backups or create on-demand backups. Restore tables using the AWS Management Console, AWS CLI, or SDKs.
- Monitoring: Use Amazon CloudWatch to monitor metrics, set alarms, and receive notifications for table performance.

S3 Buckets:

- Bucket management: Create, configure, and delete S3 buckets using the AWS Management Console, AWS CLI, or SDKs.
- Versioning and replication: Enable Versioning for object backups and Cross-Region Replication (CRR) for geographic redundancy.
- Monitoring: Use Amazon CloudWatch and Amazon S3 Storage Class Analysis to monitor and analyze storage usage.

Lambda functions:

- Function management: Create, update, and delete Lambda functions using the AWS Management Console, AWS CLI, or SDKs.
- Monitoring: Use Amazon CloudWatch to monitor metrics, set alarms, and receive notifications for function performance and errors.
- Triggers and event sources: Configure event sources and triggers to invoke Lambda functions automatically.
- For more detailed information on managing these services, refer to the respective AWS service documentation:

Resource Links:

- DynamoDB: https://docs.aws.amazon.com/amazondynamodb/latest/developerguide/Introduction.html
- S3: https://docs.aws.amazon.com/AmazonS3/latest/userguide/Welcome.html
- Lambda: https://docs.aws.amazon.com/lambda/latest/dg/welcome.html

J. Key Contacts

- Edwin Hernandez: Edwinhernandez2@my.unt.edu – Software Lead
- Luis Guevara: Luisguevara@my.unt.edu - Hardware Lead
- Matthew Wilson – matthewwilson10@my.unt.edu – Team Lead
- Lluviana Vasquez: lluvianavasquez@my.unt.edu – Reporter

K. Roles and Responsibilities

- Dr. Robin Pottathuparambil (Project Manager)
- Matthew Wilson (Team Lead)
- Edwin Hernandez (Software Lead)
- Luis Guevara (Hardware Lead)
- Lluviana Vasquez (Reporter)

L. Regulatory Requirements

The Forest Fire Detection System will include an enclosure that will follow the standard IP67. This enclosure will be needed to protect all the electrical components that are in the system to avoid damage. This includes, but is not limited to, extreme weather conditions.

M. FAQs

Q: Do videos get deleted from the SD card or will there be a need for a replacement?

A: Videos will get deleted from the SD card after 20 recordings are detected. There is no need to get a SD card replacement.

Q: Can there be false alarms?

A: False alarms can happen. But, with all the sensors that are in the system it can be prevented. Running a quick test to see if any other sensors have been alerted can show if there is a wildfire nearby.

Q: How long can the device be powered by a fully charged battery with no sunlight?

A: The device can operate for 48 hours off the battery without any sunlight.