Remote Sensing for Forest Fires
Project Completion Document

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Executive Summary

This document presents a comprehensive overview of the project, with details of technical design and implementations. The technical information is organized into four sections: data collection, data transmission, data storage and processing, and data display. Each section outlines the tools and components employed, offering a clear view of how each contributes to the project's overall functionality and objectives. This comprehensive structure ensures a thorough understanding of the project’s technical framework

1. Project Overview

FireWatch is a wildfire prediction and detection system designed to address the threat of wildfires in British Columbia and Canada. This solution involves a deployable prototype that exploits IoT sensors to collect near real-time data in remote forests and satellite data that monitor wildfires. These data will be displayed on our web application to users and send notifications of high risk areas.

2. Technical Details

This section introduces the technical details of FireWatch, which includes data collection, data transmission, data storage and processing, and data display.

2.1. Data Collection

The FireWatch system enhances wildfire detection and prediction through a strategic integration of IoT sensors and satellite imaging. We employ the BME688 IoT sensor, which collects critical environmental data including temperature, humidity, pressure, CO2 levels, and Volatile Organic Compounds (VOCs). These sensors are vital for near-real-time monitoring, enabling early wildfire detection and facilitating prompt response actions.

To supplement the data collected by the BME688 sensors and address their limitations in providing comprehensive environmental assessments, we incorporate satellite data obtained via the OpenWeather API. This satellite data includes the Fire Weather Index (FWI), which is essential for evaluating wildfire risk factors such as fuel availability and fire intensity.

The combination of BME688 sensor data and FWI from satellite imaging creates a robust data collection framework. This framework not only provides immediate environmental readings but also enriches these readings with detailed risk analysis, enhancing our predictive capabilities. This integrated approach ensures that the FireWatch system offers a comprehensive and effective solution for managing wildfire threats through improved data accuracy and enhanced predictive analytics.

2.2. Data Transmission

2.2.1. Long Range Data Transmission

The FireWatch system utilizes the Long Range Wide Area Network (LoRaWAN) for its crucial long-range data transmission capabilities, vital for reaching the web server from remote monitoring locations devoid of conventional Wi-Fi coverage. The chosen SenseCAP M2 Multi-Platform LoRaWAN Indoor Gateway enables our system to function over the long distances typically found in wildfire-prone areas. LoRaWAN's extensive range—more than 10 kilometers—and the ability to connect multiple devices to a single gateway make it highly scalable and well-suited for the expansive network required by FireWatch. Additionally, LoRaWAN's operation on the free public spectrum negates the need for a frequency license, further simplifying the deployment.

The use of the EU868 ISM band was selected for the gateway to benefit from its slightly better range and penetration capabilities, necessary for the varied terrains where wildfires might occur. This choice ensures reliable transmission of data from the BME688 sensors, which continuously monitor critical environmental conditions.

2.2.2. Microcontroller

On the sensor device, the microcontroller is responsible for the transmission of the collected data to the gateway. With the adoption of LoRa as the primary transmission method, a microcontroller with a LoRa radio is essential. For this reason, the Wio-E5 mini Dev board was chosen. It features the required LoRaWAN capability and is built around the STM32 microcontroller, the same MCU that will be employed in our final product's PCB design.

The Wio-E5 mini Dev board provides several benefits, including cost-effectiveness, low power consumption, and compact size, making it an excellent fit for the FireWatch system. Its inherent LoRaWAN capabilities enable efficient data transmission across long distances, which is key to the system's design. The microcontroller's seamless integration ensures that the critical sensor data is reliably communicated to the gateway, then on to the web server and web application for real-time monitoring and analysis.

2.3. Data Storage and Processing

2.3.1. Amazon Web Services (AWS)

Amazon Web Services (AWS) provides the backbone for our data storage and processing needs, ensuring a scalable, secure, and reliable infrastructure. We leverage AWS Lambda functions to seamlessly integrate data ingestion from both the OpenWeather API and our sensor network. These functions process the incoming data, transforming it into a structured format suitable for analysis and storage in our Amazon DynamoDB database. This setup ensures high availability and quick data retrieval, essential for real-time applications such as wildfire monitoring and prediction.

2.3.2. Machine Learning Model

The core of our predictive capability lies in a sophisticated machine learning model that analyzes sensor data to assess wildfire risk. Utilizing a Random Forest classifier, this model has been trained to accurately distinguish between high-risk and low-risk scenarios, achieving a remarkable prediction accuracy of 99.8%. The model continuously learns from incoming data, enhancing its predictive accuracy over time and thereby providing a crucial tool in our arsenal for early wildfire detection and proactive response strategies.

2.4. Data Display

The FireWatch system features a web application that presents both sensor and satellite data to end users, developed using the React.js framework. Data stored in Amazon DynamoDB is retrieved via AWS Lambda functions, which securely transmit this information to the front end through AWS API Gateway. This ensures a seamless and efficient flow of data to our user interface. Additionally, we employ Amazon Simple Notification Service (SNS) to promptly alert users when our machine learning model identifies a high risk of fire. This integrated notification system is crucial for timely response and effective risk management, enabling users to take immediate action based on real-time data and predictions.