Senior Design Proposal

Forest Fire Sensor

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1 Introduction

The Great Fire of 1910 took out more than 3 million acres across Idaho and Montana. It killed 84 people and injured many more. Luckily, there was enough warning for most of the women and children to escape. Over the last century, people have misconstrued the importance of forest fires. The result has been a buildup of underbrush that is more prone to catching fire. There needs to be a way to warn people, as they did leading up to the Great Fire of 1910, of potential danger and advise when a controlled burn could prevent catastrophe.

2 Problem Description

Along the West Coast and the Inland Northwest, wildfires have become fairly out of control over the last few years. This is mostly due to forest mismanagement, i.e., we have tried to prevent fires despite them being natural to large forest environments. The forest undergrowth (bushes, grass, and small trees) has been able to grow in the absence of frequent fires, leading to huge forest fires that cover upwards of 300,000 acres.

Forest fires require a dry environment and a spark, but also depend on wind (especially how it relates to terrain), humidity, and temperature trends. The main cause of danger in regards to forest fires is the lack of detection. Those that live in nearby areas and would be in danger due to fires need to be given ample notice to protect themselves and their property. Keeping track of trends can also help advise firefighters as to when to perform a controlled burn. Forest fires are a natural occurrence in nature and healthy for the foliage, which is why detection is necessary.

3 Proposed Solution

Our proposed solution comes in the form of many sensors placed around high risk areas, i.e. areas where forest fires are most prevalent. These sensors will send signals to a centralized station that will analyze the information based on data of previous fires. This is accomplished by sensing the key indicators of an environment and conditions that will likely cause a forest fire, keeping everyone ahead of the curve. It will sense temperature, humidity, and wind, and then send the signals by transceiver using RF signals. In our project demo, we will use LoRa frequency ranges, but in actuality government frequencies will likely be used as this is the likely customer.

4 Demonstrated Features

- Accurate detection of temperature, wind, and humidity by the device
- Successful RF communication with LoRa between the device and the centralized station, with a transceiver connected to the device and a transceiver connected to a computer. The computer will serve as the centralized station.
- Ability to access database on computer containing information on property/life in surrounding area of device
- Analysis of temperature, wind, and humidity trends in a particular environment to predict forest fires by program on computer
- Analysis of whether a fire is worth fighting against by program on computer
- Alert of forest fire risk after simulating conditions that would likely lead to forest fire

5 Available Technologies

Temperature and Humidity Sensor: **SHT30-DIS-B2.5KS**

The SHT30 is a combined temperature/humidity sensor that is accurate enough for our project. It is one of the lowest cost sensors on the market at $3.98 on Digikey, and is available to ship immediately. It has native support for I^2C, which will make integrating the device into our project easier than other sensors.

Datasheet

Wind Sensor: **Adafruit Anemometer**

This anemometer is the lowest cost anemometer on the market ($44.95 on Digikey) that can be directly integrated into our project. It outputs an analog signal which we will have to parse appropriately, so some testing and calibration in our software will be required. The sensor is not listed as waterproof, so we will have to properly seal the sensitive components in our enclosure.

Datasheet

Pressure Sensor: **LSP22**

This sensor is among the lowest cost pressure sensors at $3.79 on Digikey. It has both an I2C and SPI interface natively, which will make integration with the rest of our project simple. Its operating range covers what we will need for environmental sensing. It is small which may make for a bit of a challenge soldering, but we should be able to make it work using the reflow oven.

Datasheet

Communication: **RFM96W LoRa Transceiver**

This transceiver can be used for both transmitting and receiving, so we will not need to find two separate components to implement our communication link. It has an SPI interface which will make communication with the device straightforward. The device is among the lowest cost transceivers on the market at $8.12 on Digikey.

Datasheet

Communication: **ANT-916-HETH Antenna**

In the event that we need an antenna to increase our wireless link performance, here is a low cost ($1.33) surface mount antenna that should do the job. We will likely need to consult someone with more antenna experience to confirm before choosing this one, but it seems like a good start.

Datasheet

Microcontroller: **ESP32-C3**

The ESP32 is familiar to our group because of the exercises we've done this semester, so it will integrate smoothly into our project. We don't have plans to use the WiFi or Bluetooth capabilities at the moment, but perhaps if there is time we can make our hub connect to a computer wirelessly. The price of the ESP32 is very good at $1.10 on Digikey.

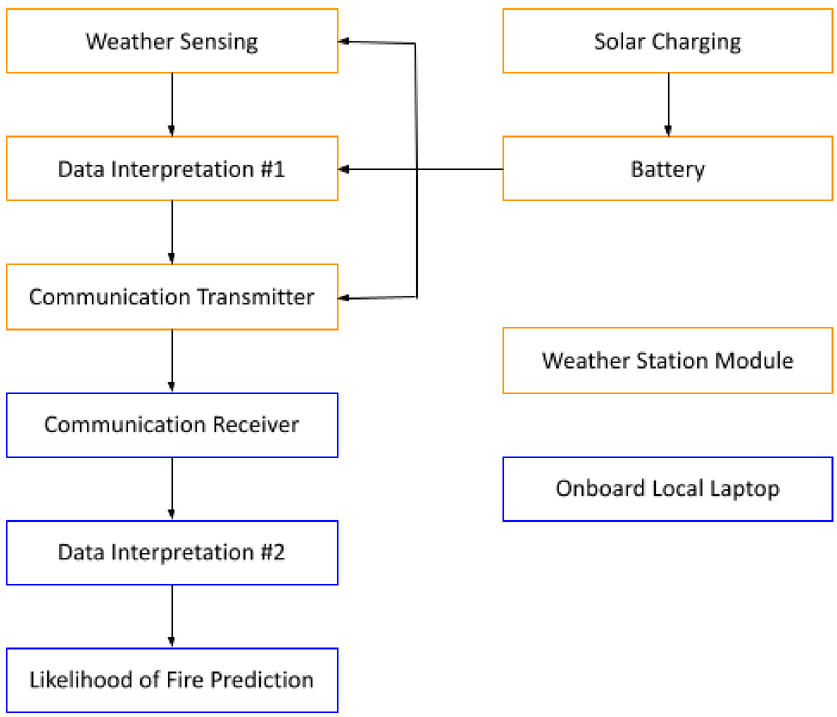
Datasheet

Power: **ADP1109AAN-3.3**

This cheap ($0.44) DC-DC converter will be useful for getting the necessary 3.3V from the batteries we use on our sensor device. There is not much reason to use this specific regulator, so if at the time of purchase another device with similar capabilities is available for cheaper or faster we should consider it.

Datasheet

6 Engineering Content



Solar Charging/Battery: This will provide power for the Weather Station Module. There will likely be a good amount of design and testing required to figure out whether solar power is feasible in the environment, and, if so, sizing the solar panels appropriately and designing the proper charging circuitry.

Weather Sensing: We must create hardware that accurately measures atmospheric changes. We have decided on temperature, humidity, pressure, and wind speed. We will need to do some exploration to figure out how accurate this data must be and how we can best arrange our sensors to get the accuracy we desire.

Data Interpretation #1: This section will use our microcontroller to store data, in order to measure trends in weather patterns. We will have to do some engineering to figure out how much computation should be done on device and how much can be offloaded to the host computer.

Communication Transmitter/Receiver: This functional block will transmit data through LoRa to a laptop. We will have to do testing on range and line of sight requirements, as well as ensuring redundancy in the communication link in different weather conditions.

Data Interpretation #2: This section will use a local computer to compare the measured values sent from the Weather Station Module to data gathered from historical fires. We will do the bulk of the analysis here to decide the probability of a fire.

Likelihood of Fire Prediction: This final functional block will present the user with a prediction of possible fires as well as a nicely organized summary of the weather trends. We will integrate any notification and reporting procedures here as well. This part will require lots of software work to perfect the interface.

7 Conclusion

In essence, we will design a remote weather station with the unique implementation of monitoring for potential forest fires. With advanced detection, it is possible to save lives and protect nature. We will combine the hardware component of the sensor for the collection of data with a significant software component for the transmission and analysis of data. The result will be an implementable technology that will protect forest environments and the people who live in them.