Unmanned Strategic Environmental Monitoring

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Introduction

The United States spent over 2.4 trillion dollars suppressing forest fires in the past ten years. Scientists expect this number to climb as climate change further propagates dry and hot environmental conditions. However, no widespread early detection systems are in place to alert people of wildfires. An early detection system would improve fire response time and ultimately reduce wildfire destruction.

Goal

This project aims to design a device that will monitor temperature, humidity, and air particle concentration in forest environments to detect possible wildfires.

Background

Early warning systems allow for immediate action and containment of forest fires. High temperature, low humidity, and increased particulate count indicate a possible forest fire. Implementing a cost effective and easily deployable early warning system that measures these values could help detect and prevent the spread of forest fires. This in turn can protect lives, property, and natural resources.

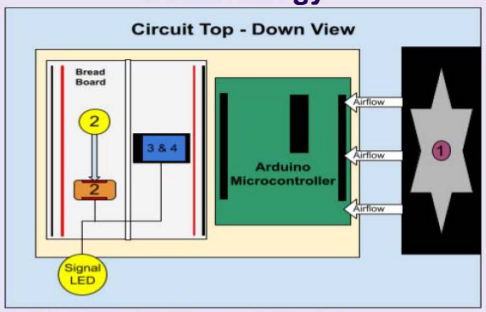
Materials

Hardware:
- Arduino Board (circuit board, bread board, LED, wires, temp.sensor, resistors, photoresistor, fan (Model AFB0612HH), hydrometer)
- FlashPrint 3D Printer

Materials:
- Box (3D printed)
- Hot Glue
- Zip Ties

Software:
- Arduino IDE (C++)
- FlashPrint 5
- Tinkercad

Methodology

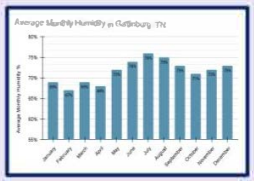


1. Airflow (3V DC Fan): Circulates air for testing.
2. Photoresistor and LED: When particles inhibit light from the LED, the photoresistor increases in resistance. The Arduino then moves on to the next stage of fire detection.
3. Humidity (DHT11): DHT11 measures and transmits the relative humidity level. If the relative humidity level exceeds 88%, the program interprets the reading as fog, avoiding false particulate readings caused by water vapor.
4. Temperature (DHT11): The DHT11 transmits the temperature in Fahrenheit every ten minutes and saves it as a global variable. The DHT11 subtracts the previously recorded temperature from the newest temperature and calculates the difference. If the difference is equal to or greater than 20 degrees, the DHT11 sends a signal reporting a temperature anomaly. After this, the new temperature saves as a global variable in place of the first.


Prototype

Results

The device was implemented with a low-cost Arduino microcontroller board and multiple sensors to monitor environmental conditions. Temperature, humidity, and air particle levels were all monitored by the device and compared with expected values. Upon reaching criteria indicative of a wildfire, an alert would notify safety personnel.



Average monthly temperature and humidity levels respectively for Gatlinburg, Tennessee, used as expected values for comparison with collected data

Conclusions

The device could accurately detect conditions synonymous with forest fires. Widespread usage of the device would greatly reduce the damage and loss of life associated with wildfires.


Final Model

Future Applications

In the future, the design can be improved to measure specific types of particulate matter in the air and calibrate air carbon levels. Implementing more sensors would make the box more reliable and foolproof. The early detection device could be used throughout the country in National Parks and Forests, hiking trails, camp sites, and wooded areas in general. In addition to improving the accuracy of the design, communication systems such as morse code, APRS reports, or SSTV imaging could be added to quickly spread crucial information about the location and severity of detected wildfires.

Acknowledgements

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