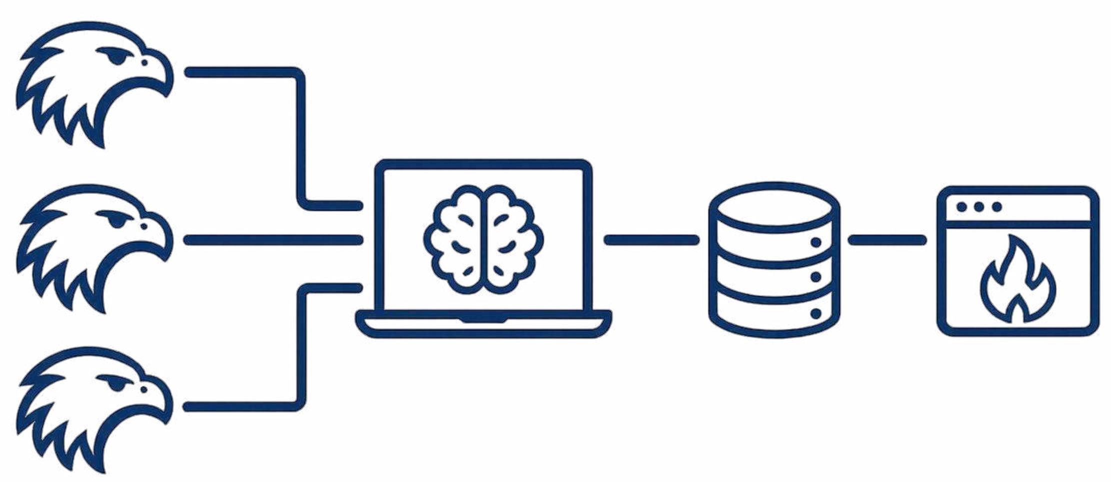
EMBERWATCH

DISTRIBUTED FIELD MONITORING FOR FIRE RISK MANAGEMENT

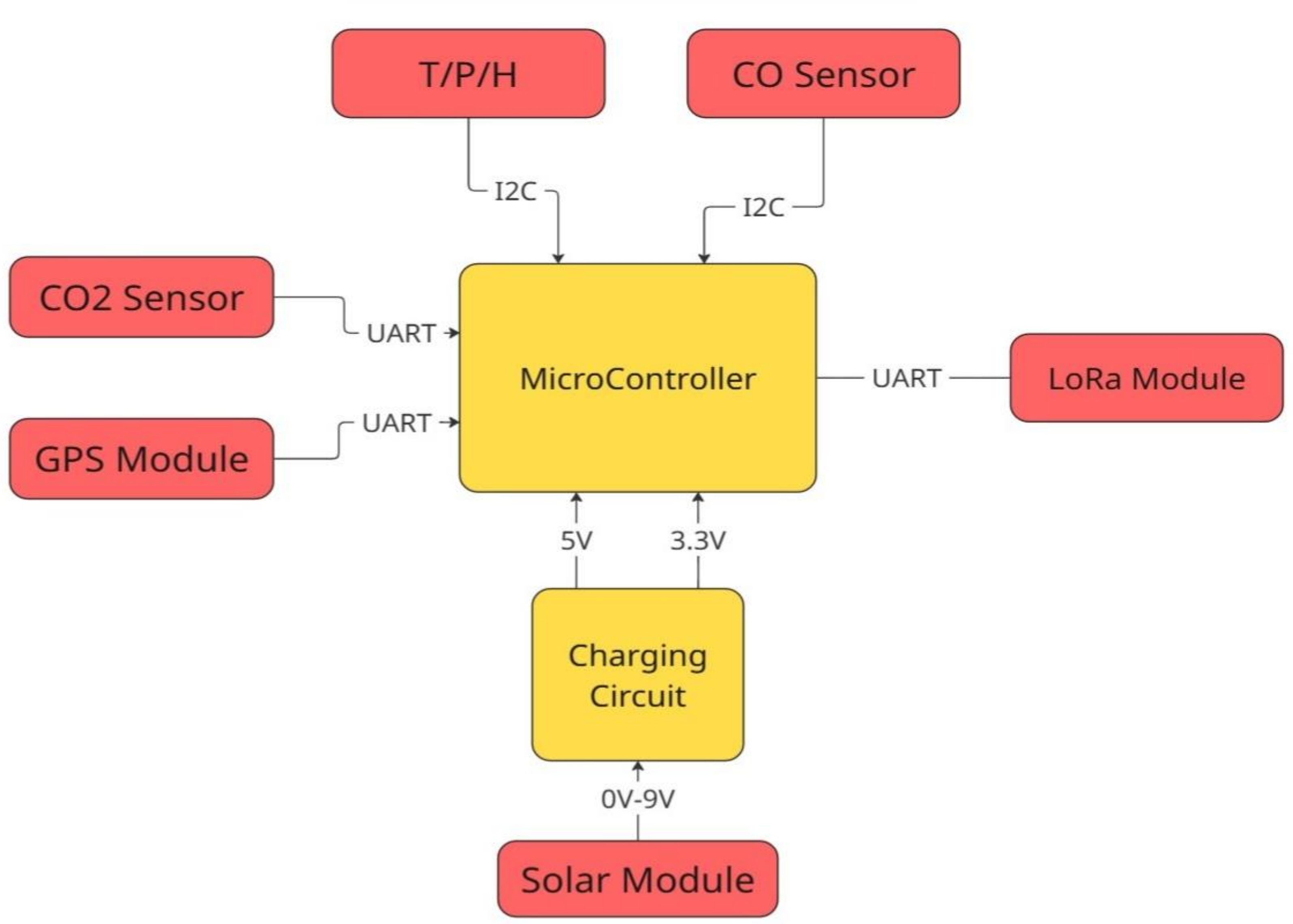
Kevin Yu | Jake Gilbert | Manny Lemus | Aliston Ma | Frank Xiao

Overview

Wildfires pose a significant threat to ecosystems, communities, and infrastructure. In 2025 alone, more than 5 million acres across the United States were burned by forest fires. This work presents the Ember Watch System, a distributed environmental sensing network designed to detect early signs of wildfires. Each low-power remote node measures temperature, humidity, CO, CO2, and pressure, transmitting data via LoRa radio up to 10 kilometers to a central monitoring station. A trained model evaluates each data payload for fire risk, generating alerts when ignition conditions emerge. By combining distributed sensor collection, energy-efficient node design, and long-range communication, EmberWatch enables wildfires to be detected earlier and promotes mitigative efforts through an environmental data dashboard.



Block Diagram



Hardware Components

Microcontroller

A low-power embedded processor built on the STM32L476RGT6, featuring a 32-bit Arm Cortex-M4 core. It handles sensor polling, data processing, and wireless control.

GPS Module

The NEO-6M receiver determines the geographic coordinates of each remote node by acquiring signals from up to 22 navigation satellites.

CO Sensor

The SEN0466 electrochemical sensor detects carbon monoxide concentration in the surrounding air. CO is a critical early-warning indicator for the fire risk model.

CO2 Sensor

The Senseair S88 uses non-dispersive infrared (NDIR) technology to measure CO_2 levels by detecting infrared absorption at wavelengths specific to carbon dioxide molecules.

T/P/H Sensor

The BME280 measures ambient temperature, relative humidity, and barometric pressure. These three atmospheric readings help the system identify environmental conditions correlated with elevated wildfire risk.

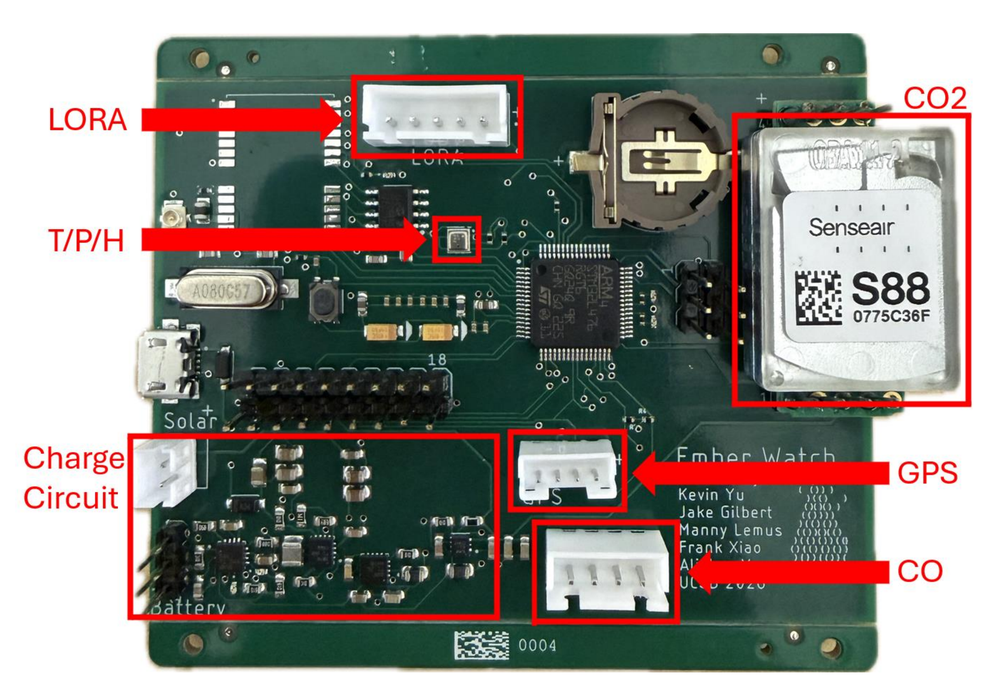
LoRa Module

The RYLR998 enables long-range, low-power wireless transmission of sensor payloads from remote nodes to the central monitoring station using LoRa modulation and AT command configuration.

Solar Panel

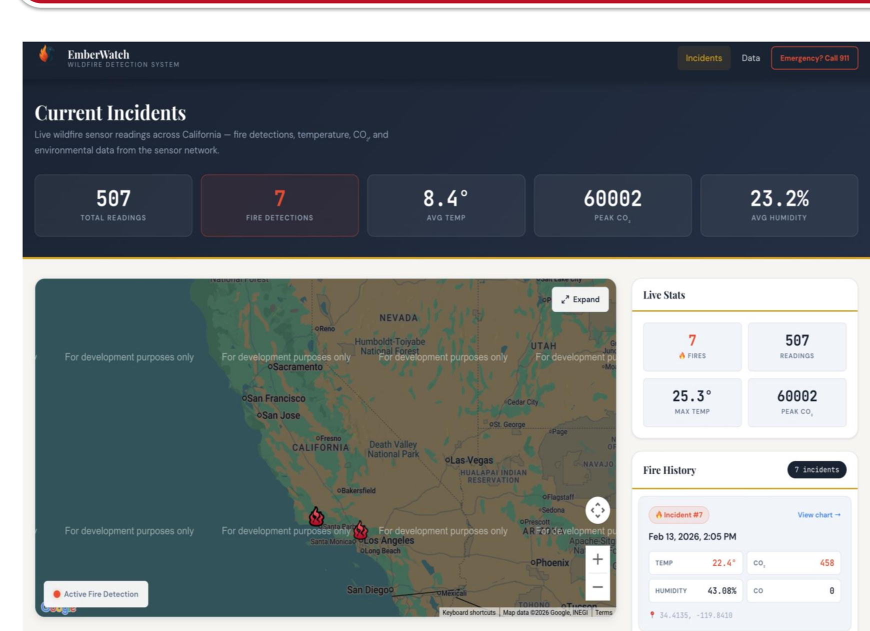
The P126 photovoltaic module provides up to 9V under optimal sunlight, feeding a charging circuit that manages battery replenishment and ensures long-term autonomous operation of the remote node in outdoor environments.

Printed Circuit Board

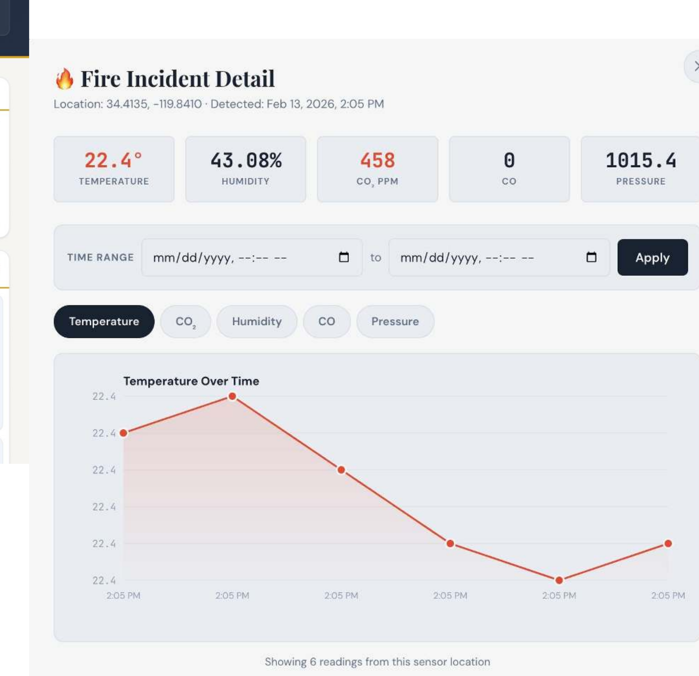


The 4-layer PCB is 6cm x 8cm, and all sensors are mounted or use JST connectors. It also contains a build in charging circuit and external battery source.

User Interface

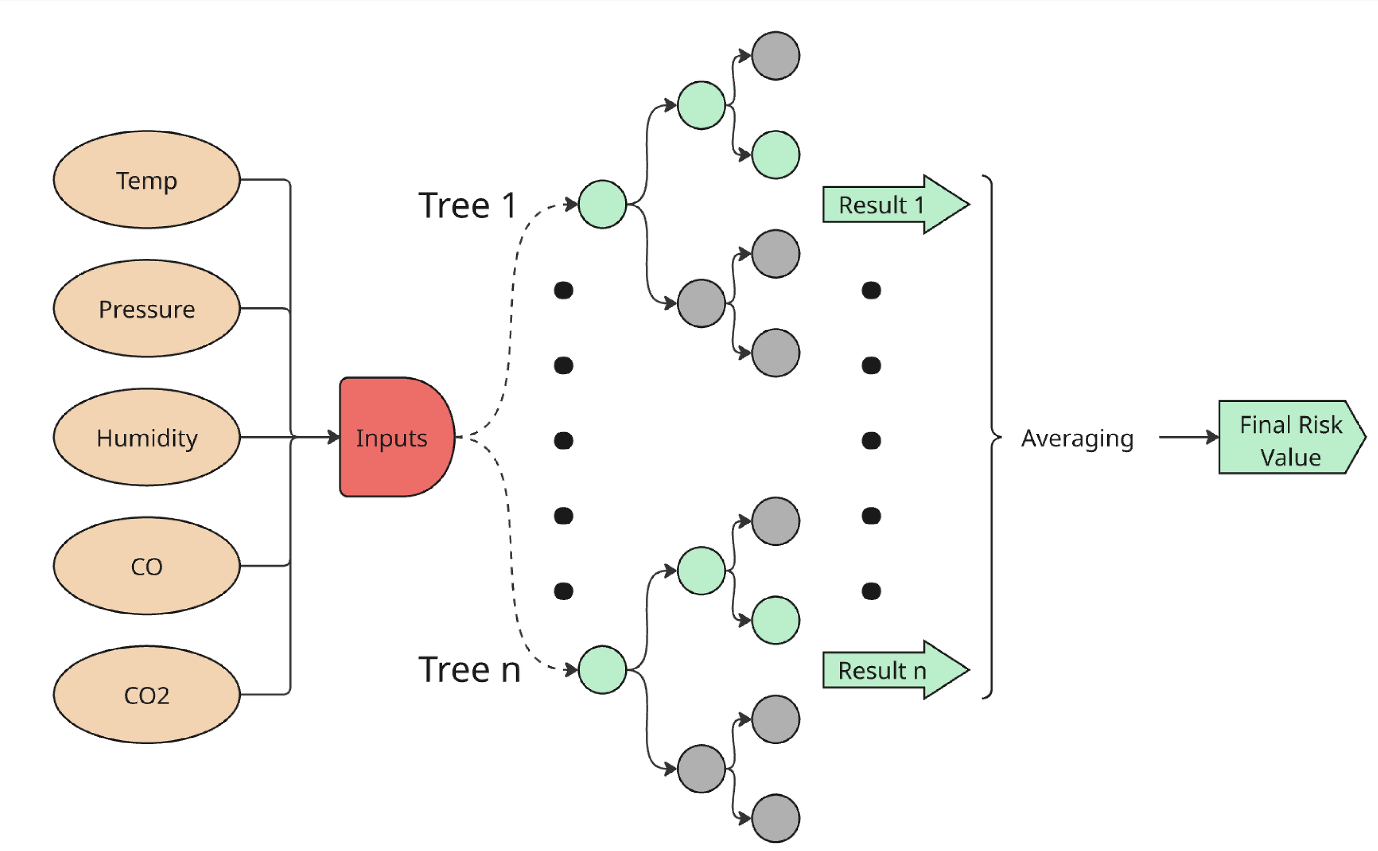


Interactive map with clickable nodes



Current sensor readings and historical sensor data charts

Random Forest Model



Final Product

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College of Engineering