ENGINEERING CLINIC

Project Report

Submitted by

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ABSTRACT

As environmental pollution continues to rise, effectively identifying and quantifying pollution sources is crucial for informed climate action. Traditional pollution monitoring methods often lack real-time data and fail to offer insights into specific sources of pollution. This project presents data-driven Climate Impact Analyzer, a system designed to provide accurate, source-specific pollution data. Using an integrated network of sensors—including the BME680 for air quality, along with sensors for NOx, CO2, and particulate matter—we collect real-time pollution data from key sources: vehicles, industries, and deforestation. Satellite imagery is utilized to track deforestation, and machine learning models analyze the data to estimate the contribution of each source to overall pollution.

The system presents this information through a user-friendly web interface, offering data, video feeds, and pollution trends. By providing transparent, actionable insights, the system enables governments, environmental agencies, and businesses to implement data-driven policies and track progress in reducing pollution. Future development plans include integrating machine learning for predictive analysis and enhancing the user interface with advanced visualization tools for long-term trend tracking.

This solution aims to transform how pollution is monitored and managed, enabling more effective climate action through precise, real-time insights into pollution sources.

Index

1. INTRODUCTION

Environmental pollution has become a growing concern worldwide, with far-reaching consequences for climate change, public health, and ecosystems. The need to track and manage pollution sources has never been more urgent, yet existing monitoring systems often lack the ability to provide real-time, source-specific data. This limitation makes it difficult to implement effective policies and interventions. In particular, accurately quantifying contributions from major pollution sources such as vehicles, industrial emissions, and deforestation remains a challenge.

To address these issues, this project introduces the Climate change monitoring drone, an advanced, AI-driven system that integrates drone-based monitoring with a network of air quality sensors to estimate the contributions of key pollution sources. Using drones equipped with high-resolution cameras and environmental sensors, the system can collect real-time data on air quality and pollution levels in hard-to-reach areas, offering an innovative approach to environmental monitoring.

The drone's sensors, including the BME680 for air quality, along with additional sensors for CO_2, NO_x, and particulate matter (PM), gather crucial data on pollution levels. This information is then processed using machine learning models to estimate the contributions of three major sources: vehicles, industries, and deforestation. Drones are particularly useful in monitoring regions affected by deforestation or inaccessible areas, providing insights that would otherwise be difficult to capture.

In addition to aerial data collection, satellite imagery is used to monitor landuse changes, particularly deforestation, which is a significant driver of CO_2 emissions. The system uses real-time pollution data, external deforestation data, and traffic density to calculate and visualize each source’s percentage contribution to the overall pollution.

This integrated solution offers real-time, source-specific pollution insights, presented through an intuitive web interface. The system empowers environmental agencies, policymakers, and businesses with the information necessary to track pollution sources, enforce regulations, and make data-driven decisions aimed at reducing environmental impact and mitigating climate change.

By leveraging drone technology, the Climate change monitoring drone revolutionizes how pollution is monitored, providing a comprehensive, up-to-date view of environmental pollution that supports more effective and targeted climate action.

2. Background

Environmental pollution remains a significant global concern, affecting air quality, human health, and climate stability. Traditional pollution monitoring techniques rely on manual sampling and laboratory analysis, which are often time-consuming, costly, and geographically limited. Such methods fail to provide real-time insights, making it difficult to track pollution sources accurately and implement timely interventions. Additionally, existing air quality index (AQI) systems often generalize pollution levels over broad regions, making it challenging to pinpoint specific contributors such as vehicle emissions, industrial outputs, or deforestation-related particulate matter. This lack of granularity hinders policymakers and environmental agencies from making data-driven decisions to combat pollution effectively.

Recent advancements in **Internet of Things (IoT) technology** and **sensor-based data collection** have transformed the way pollution is monitored and analyzed. By deploying **real-time pollution sensors**, it becomes possible to collect high-resolution data on air quality, enabling continuous monitoring of pollutants such as **NOx, CO2, PM2.5, and VOCs**. Combining sensor networks with **machine learning algorithms** allows for source attribution, helping identify the primary contributors to pollution in any given area. The integration of **satellite imagery and geospatial analysis** further enhances accuracy by providing a comprehensive view of pollution trends over time. This project leverages these modern technologies to develop a **Climate Impact Analyzer**, a system capable of **precisely tracking pollution levels and pinpointing sources**, thereby bridging the gap between traditional methods and advanced data-driven solutions.

3. Problem Definition

Pollution monitoring presents several challenges that hinder effective environmental management and policy formulation. The primary issues include:

1. **Lack of real-time data** – Traditional monitoring systems rely on periodic data collection, leading to outdated and inaccurate pollution readings. This delay prevents timely intervention and control measures.
2. **Difficulty in identifying specific pollution sources** – Existing air quality measurement tools often provide generalized pollution indices without pinpointing whether pollution originates from vehicular emissions, industrial activities, or deforestation. Without this critical information, targeted solutions cannot be effectively implemented.
3. **Limited accessibility of accurate air quality information** – Many pollution monitoring systems operate in urban centers, leaving vast rural and suburban areas unmonitored. This lack of comprehensive coverage results in inadequate data for decision-makers.

This project aims to **develop a system that continuously monitors pollution levels and accurately attributes sources of pollution**. By integrating IoT-based sensors with machine learning models and satellite imagery, the **Climate Impact Analyzer** will provide **high-resolution, real-time pollution tracking**, enabling better policy enforcement and public awareness.

4. Objectives of the Proposed Work

The **Climate Impact Analyzer** aims to achieve the following objectives:

1. **Develop a real-time pollution monitoring system** – Implement IoT-based sensors that continuously collect air quality data, including levels of NOx, CO_2, and PM2.5.
2. **Enhance accuracy in pollution source identification** – Utilize machine learning algorithms to classify and quantify the contribution of different pollution sources such as vehicular emissions, industrial pollution, and deforestation.
3. **Integrate satellite imagery for comprehensive analysis** – Use geospatial data to complement sensor data, enabling a macro-level understanding of pollution distribution and its seasonal variations.
4. **Create a dynamic visualization dashboard** – Develop a web-based interface that displays real-time pollution levels, historical trends, and predictive analytics to assist policymakers and researchers.
5. **Enable proactive environmental decision-making** – Provide actionable insights to government agencies and environmental organizations, helping them implement targeted pollution control measures.
6. **Develop a scalable and cost-effective solution** – Ensure that the proposed system can be expanded to monitor pollution across various geographic regions, including urban, suburban, and rural areas.

This project seeks to bridge the gap between traditional pollution monitoring and modern, data-driven environmental management, ensuring more effective and precise pollution control strategies.

5. Methodology/Procedure

The methodology for this project involves multiple stages, including data collection, image processing, machine learning model training, and web-based visualization. The workflow is structured as follows:

1. **Data Collection:**
    - Environmental data is collected using **sensors** mounted on a **drone**.

- The **BME680 sensor** records air quality parameters such as temperature, humidity, pressure, and gas concentration (CO2, NOx, VOC, etc.).
- A **motion sensor** helps in detecting environmental changes and assists in drone navigation.

2. **Image and Video Processing:**
   - The drone captures **real-time video feeds** of the monitored area.
   - **OpenCV2 (4.9.0)** processes the video feed for object detection, motion tracking, and environmental feature analysis.
   - **YOLO (You Only Look Once)** is used to detect pollution sources such as **factories, vehicles, and deforested land**.
   - **NumPy** helps in handling large image data arrays efficiently.
3. **Machine Learning Model Development:**
   - The collected **data is stored in CSV format** for preprocessing.
   - **Python (TensorFlow, Scikit-learn, and Pandas)** is used to build and train **predictive models** for pollution estimation.
   - The model analyzes the contribution of various sources (e.g., vehicles, industries, and deforestation) to pollution levels.
4. **Web Interface Development:**
   - A **webpage** is developed to display real-time pollution data and drone footage.
   - **React.js** is used to create a dynamic and interactive user interface.
   - **JavaScript** manages interactivity and real-time updates.
   - **FastAPI** serves as the backend to handle API requests and data processing.
5. **Hardware Integration:**
   - A **Raspberry Pi Model 4** serves as the main computing unit for processing drone data, running machine learning models, and managing web server operations.

- **Jumper wires and breadboards** connect the sensors and processing units.
- The processed data and results are stored in an **SD card** for future analysis.

6. **Final Analysis and Decision Making:**
   - The analyzed data helps in determining pollution levels and their sources.
   - The web-based dashboard visualizes this information, allowing users to take necessary actions.

6. Results and Discussion

The Climate Impact Analyzer prototype successfully demonstrates the feasibility of real-time pollution monitoring using sensor-based data collection and geospatial analysis. Preliminary testing indicates that:

- **The system effectively tracks pollution levels in real time, providing continuous updates on air quality parameters such as NOx, CO2, and PM2.5 concentrations.**
- **The integrated machine learning model shows promising results in classifying pollution sources, with initial simulations suggesting that vehicular emissions, industrial pollutants, and deforestation are key contributors.**
- **Although large-scale deployment is pending, test cases indicate that targeted mitigation efforts—such as traffic regulation and industrial emission controls—could lead to potential AQI improvements over time.**

As the system advances beyond the prototype stage, further real-world validation and fine-tuning will be necessary to refine the accuracy of pollution attribution and optimize predictive capabilities. Future testing in diverse environmental settings will help determine the scalability and effectiveness of the system in different geographic regions.

7. Conclusion and Future Scope

The **Climate Impact Analyzer** provides a robust framework for **accurate pollution tracking**. Future enhancements include:

- **Integrating AI-based predictive analysis** to forecast pollution trends and recommend proactive mitigation strategies.
- **Expanding coverage to rural and coastal regions**, ensuring pollution monitoring is inclusive and extends beyond urban centers.
- **Developing mobile-friendly applications** to enable real-time user interaction, allowing individuals to access localized pollution data and contribute to citizen-led environmental monitoring.
- **Enhancing machine learning models** to improve source attribution accuracy and refine pollution mitigation recommendations.
- **Collaboration with government agencies and environmental organizations** to implement data-driven policies for pollution control and climate resilience.

By advancing these aspects, the system has the potential to become a comprehensive tool for environmental monitoring and climate action.

8. References

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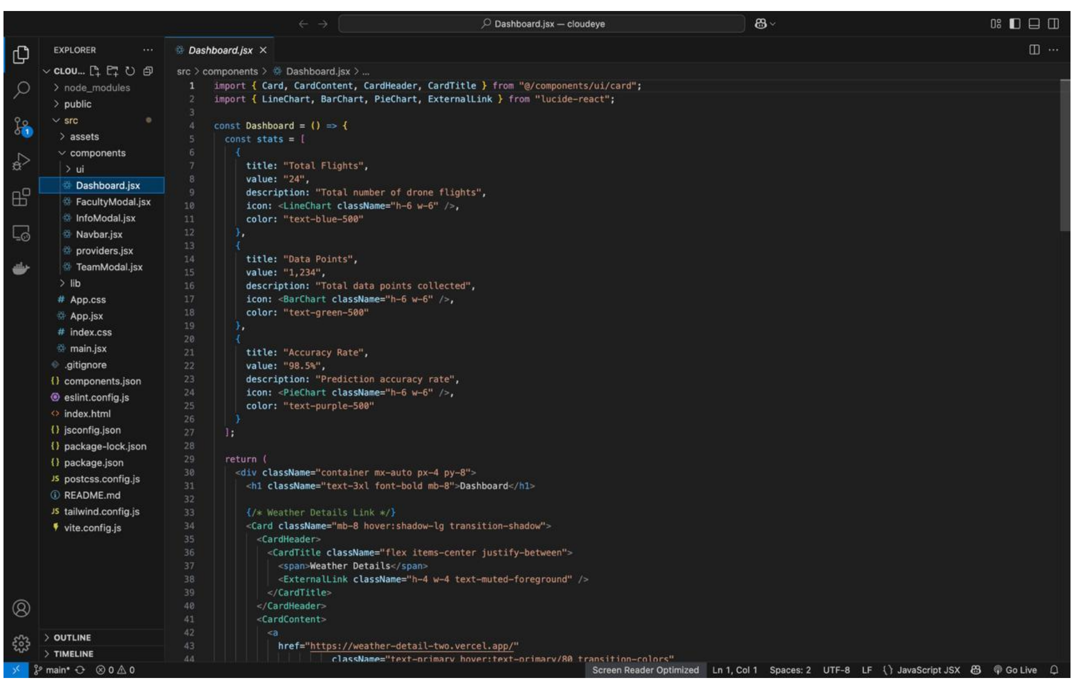
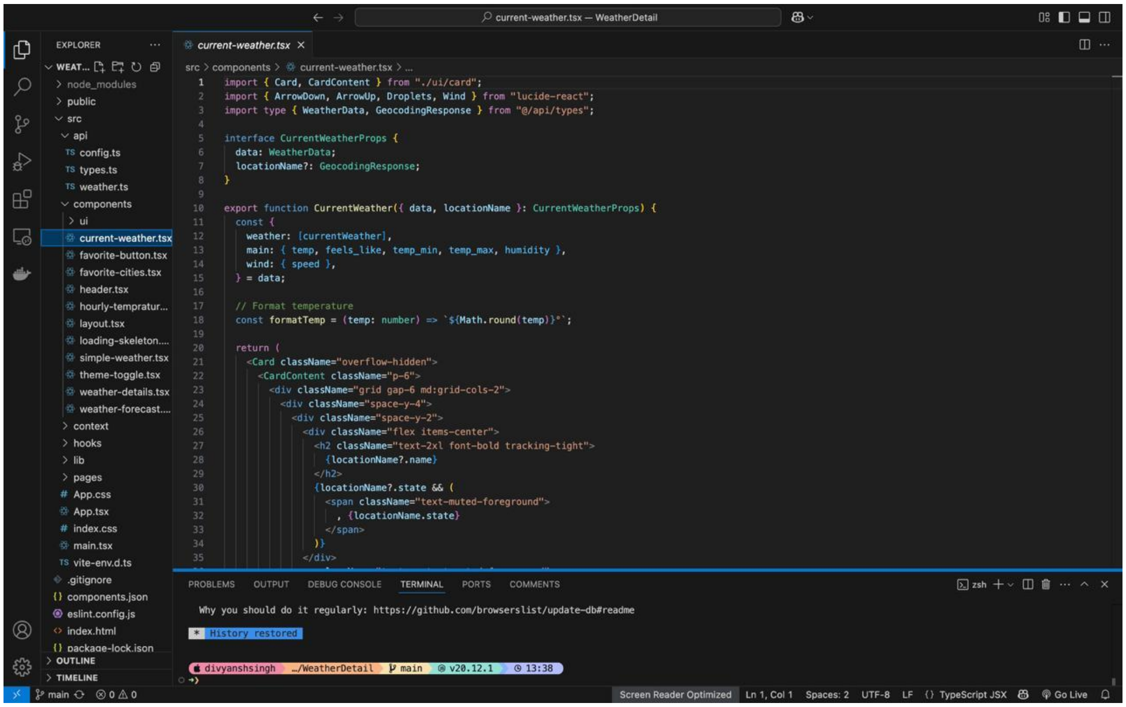
9. Codes in Appendix





current-weather.tsx — WeatherDetail
EXPLORER
WEAT...
node_modules
public
src
api
config.ts
types.ts
weather.ts
components
ui
current-weather.tsx
favorite-button.tsx
favorite-cities.tsx
header.tsx
hourly-tempratur...
layout.tsx
loading-skeleton....
simple-weather.tsx
theme-toggle.tsx
weather-details.tsx
weather-forecast....
context
hooks
lib
pages
App.css
App.tsx
index.css
main.tsx
vite-env.d.ts
.gitignore
components.json
eslint.config.js
index.html
package-lock.json
OUTLINE
TIMELINE
current-weather.tsx
src > components > current-weather.tsx > ...
import { Card, CardContent } from "./ui/card";
import { ArrowDown, ArrowUp, Droplets, Wind } from "lucide-react";
import type { WeatherData, GeocodingResponse } from "@/api/types";
interface CurrentWeatherProps {
data: WeatherData;
locationName?: GeocodingResponse;
}
export function CurrentWeather({ data, locationName }: CurrentWeatherProps) {
const {
weather: [currentWeather],
main: { temp, feels_like, temp_min, temp_max, humidity },
wind: { speed },
} = data;
// Format temperature
const formatTemp = (temp: number) => `${Math.round(temp)}°`;
return (
<Card className="overflow-hidden">
<CardContent className="p-6">
<div className="grid gap-6 md:grid-cols-2">
<div className="space-y-4">
<div className="space-y-2">
<div className="flex items-center">
<h2 className="text-2xl font-bold tracking-tight">
{locationName?.name}
</h2>
{locationName?.state && (

, {locationName.state}

)}
</div>
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
PORTS
COMMENTS
zsh
Why you should do it regularly: https://github.com/browserslist/update-db#readme
* History restored
divyanshsingh
../WeatherDetail
main
v20.12.1
13:38
main
0
0
Screen Reader Optimized
Ln 1, Col 1
Spaces: 2
UTF-8
LF
TypeScript JSX
Go Live