Emission Analyzer

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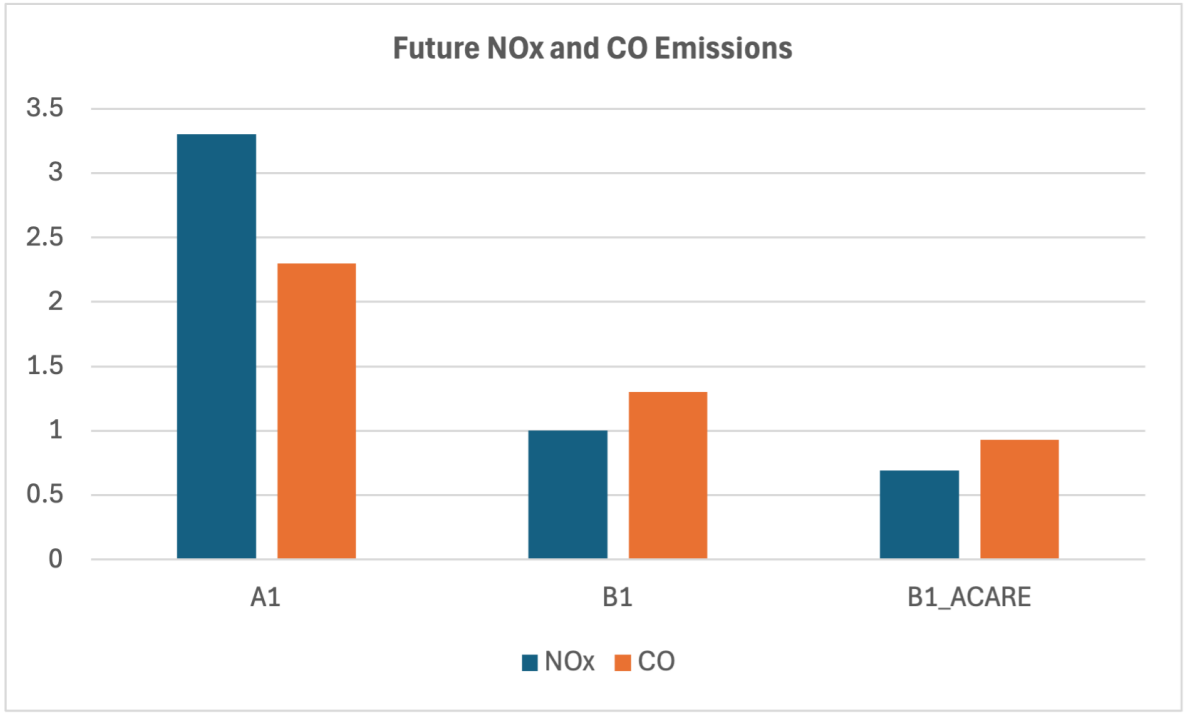
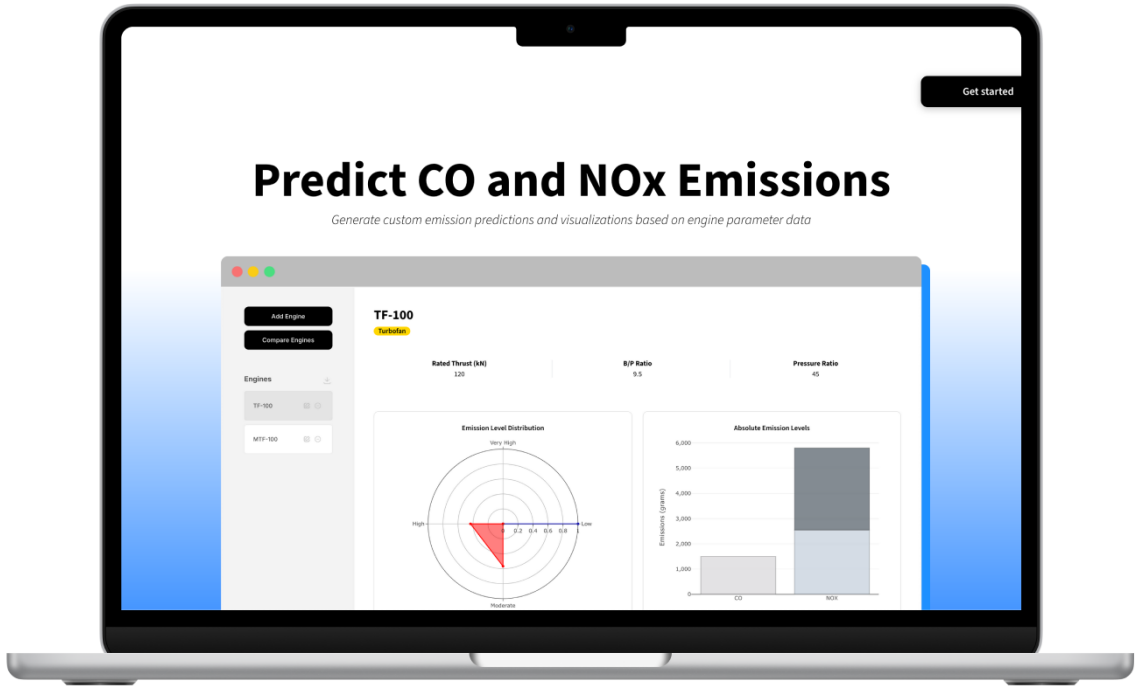
The Problem

- Aviation, particularly commercial jet engines, is a significant contributor to air pollution and climate change.
- CO and NOx emissions are interdependent—reducing one often leads to an increase in the other
- **How do we handle co-regulation?**



Our Solution

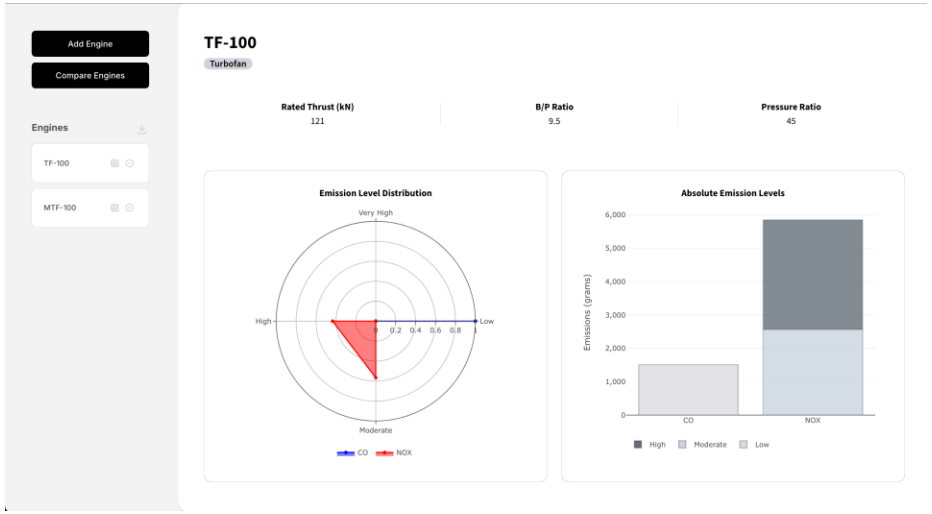
- A web application that predicts the CO and NOx emissions of commercial jet engines using three key operational parameters
  - Rated thrust
  - B/P ratio
  - Pressure ratio
- Provide intuitive visualizations of emission predictions to support user analysis and decision-making



Key Features

Users can:

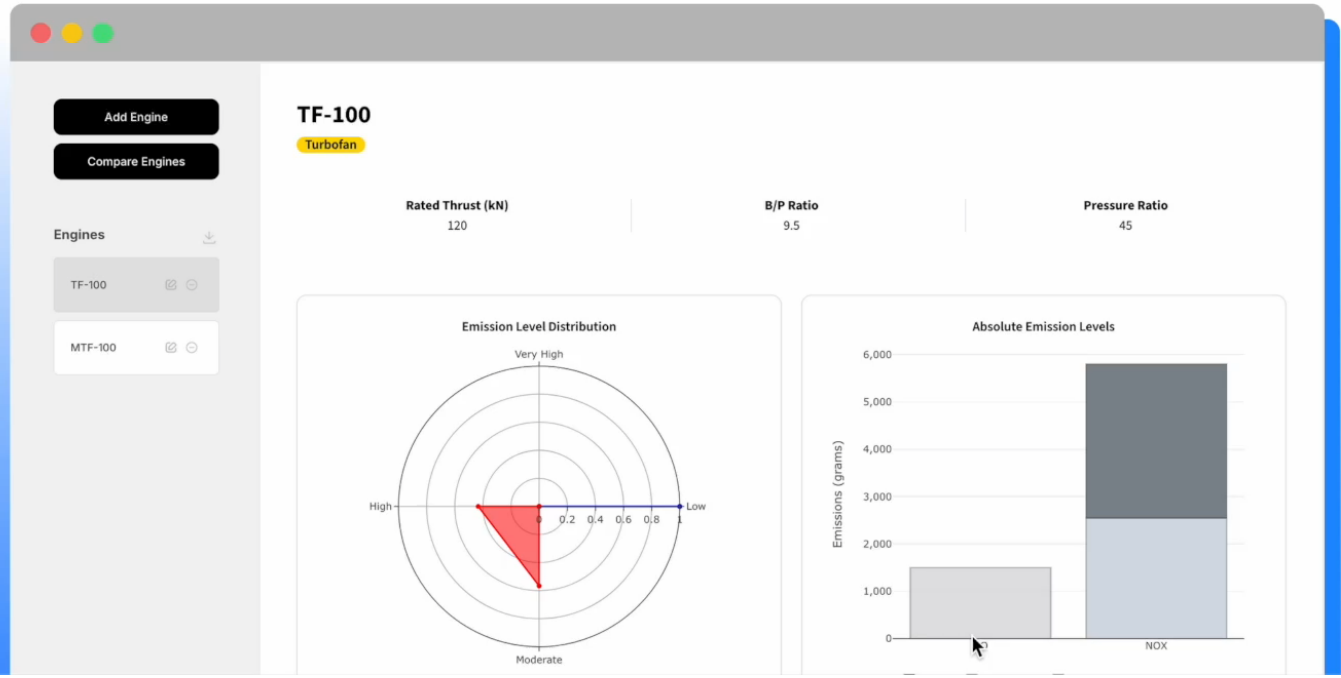
- Manage the engines associated with their account by adding, editing, and deleting them
- Download the prediction data for all engines
- View data visualizations of the emission predictions
- Compare the CO and NOx emissions of multiple engines



Get started

Predict CO and NOx Emissions

Generate custom emission predictions and visualizations based on engine parameter data



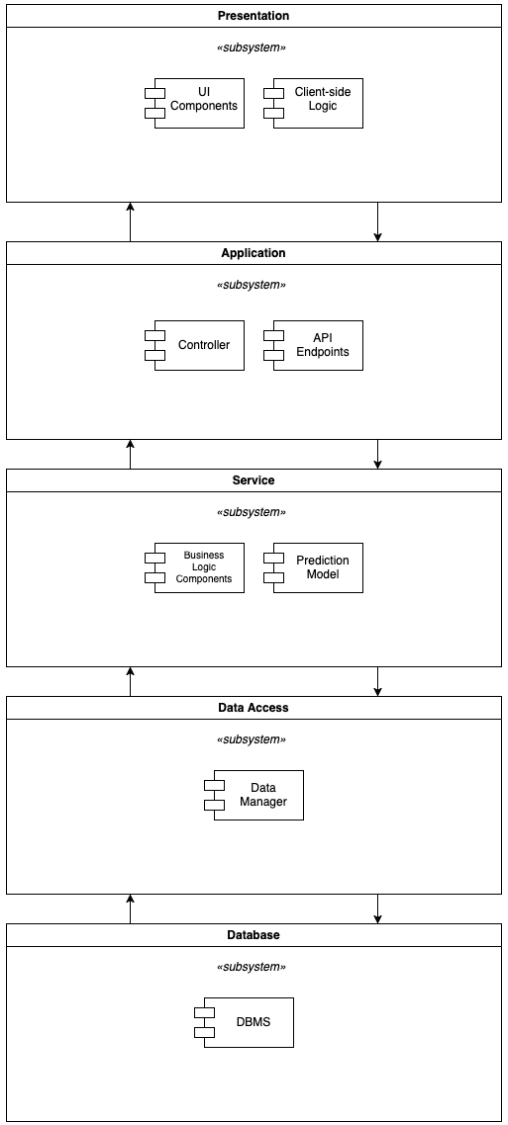
Stakeholders

- Aerospace researchers
  - Quickly visualize emission profiles
  - Propose innovation to reduce pollutants
- Engine manufacturers and engineers
  - Must design engines that meet environmental regulations
  - Can use the app to compare engines
- Environmental analysts
  - Evaluate broader environmental impact of engine emissions
  - Support data-driven reporting

Architecture & Tech Stack

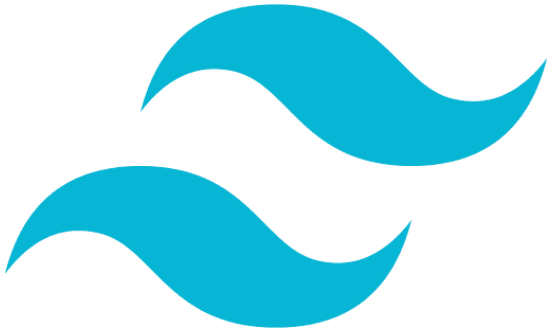
Architecture

- 5-tier layered architecture
  - Presentation
  - Application
  - Service
  - Data Access
  - Database



Frontend

- **Frameworks and Libraries**
  - React + Vite: Built dynamic front-end interfaces using reusable components, props, and state management.
  - Tailwind CSS: Streamlined styling through utility-first, in-line classes for responsive design.
  - Axios: Handled HTTP requests and integrated APIs for data fetching and submission.
  - Plotly.js: Developed interactive Radar and Stacked Bar Charts for visualizing analyzed data.
- **Primary Features**
  - Provides a user-friendly interface for users to manage their engines and visualize prediction data



Backend

- **Frameworks and Tools**
  - Django: Developed API endpoints to allow users to perform various actions
  - Postman: Verified that endpoints worked as expected through testing with various request payloads
  - PostgreSQL: Stored results from various user actions and endpoint tests into corresponding tables in the database
  - Docker: Containerized the server, database, and prediction model for portability
- **Primary Features**
  - Data persistence
  - API endpoints that allow users to
    - Add, edit, and remove engines
    - Predict CO and NOx emissions

Prediction Model

Dataset:

ICAO Aircraft Engine Emissions Databank from the EASA (EU Aviation Safety Agency)

Tools:

MATLAB R2023A

Methodology:

1. Imported ICAO dataset into MATLAB
2. Cleaned/repaired data using MATLAB's analysis tools (e.g., removing outliers, filling gaps with approximations)
3. Used PCA (Principal Component Analysis) to reduce data dimensionality and select feature subset
4. Used MATLAB's Classification Learner toolset to train both CO and NOx emission models using 3 primary features
5. Selected bagged tree ensemble approach for highest predictive power and highest validation/test set accuracy
6. Used MATLAB Coder to generate hardware-optimized C code for both models
7. Customized and cleaned generated code to add interactivity with web backend

Conclusion

- The Emission Analyzer provides a powerful tool for predicting/visualizing the co-regulation of CO and NOx emissions (Jet Engines)
- Key achievements:
  - User-friendly interface & Interactive visualizations for single-engine analysis and multi-engine comparison
  - Accurate prediction model using bagged tree ensemble approach
  - Comprehensive 5-tier architecture (Robustly Test)
- Mistakes:
  - Feature Handling / Hyperparameter tuning could have been done better for better accuracy/precision
  - Handling Scope and Finer Design Details was a challenge
- Empowers Industry (aerospace researchers, engine manufacturers, and environmental analysts) to make data-driven decisions
- Future work could include expanding the model to predict additional pollutants, incorporating more operational parameters (Frontend/Backend), more visuals.

References

- https://www.easa.europa.eu/en/domains/environment/icao-aircraft-engine-emissions-databank
- https://www.icao.int/environmental-protection/pages/aircraft-engine-emissions.aspx
- https://acp.copernicus.org/articles/22/11987/2022/acp-22-11987-2022.pdf

Any Questions?