Executive Summary of Commercial Aircraft Trajectory Weather and Fuel Analysis

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GitHub Repository: FlightPathAnalysis (https://github.com/Flight-Path-Analysis/FlightPathAnalysis)

Overview:

The project focuses on analyzing the impact of weather on the flight trajectories of commercial aircrafts and the subsequent implications in terms of fuel consumption. Utilizing data from the OpenSky database for flight information and the Iowa State University Environmental Mesonet for weather data, our team has developed a comprehensive framework to assess how weather conditions influence flight paths and fuel efficiency.
Stakeholders: Airlines, Pilots and Flight Crew, Airports, Air Traffic Controllers, and Fuel Suppliers.

Methodology:

- **Data Integration**: We combined flight data with weather information for specific routes between airports within a selected date range into `sqlite` files for better organization.
  - We chose popular routes of varying length and looked at both summer and winter weather, in hopes of constructing a robust model.
- **Weather Influence Assessment**: Key weather quantities were computed for each flight at varying times and altitudes using customizable weather models, interpolating weather data from nearby weather stations. Those quantities were subsequently integrated through the flight paths.
- **Fuel Consumption Estimation**: The `traffic` python package was employed to estimate fuel consumption for different aircraft types based on their state vectors.
- **Optimal Flight Path Analysis**: We identified the most fuel-efficient flight paths (optimal flights) for each aircraft type and compared them with the actual flight paths to quantify deviations and extra fuel consumed due to weather avoidance.

Key Findings:

- **Model Development**: A RandomForestRegressor machine learning model was created to accurately predict expected fuel consumption based on estimated weather conditions along optimal routes.
- **Most Influential Factors:** The model finds that wind speed and cloud coverage are the two most impactful aspects when considering fuel efficiency.

Future Work:

- **Enhanced Data Diversity and Archival**: Future iterations could include a broader range of flight data covering diverse geographic regions and weather conditions, and the code would automatically transition to sqlite files for storage.
- **Advanced Model Features**: Incorporating direct raw data from weather stations and more sophisticated weather models for estimations.
- **HTC implementation**: The estimation of weather conditions for each flight takes a long time and would benefit from high parallelization.
- **Improved Fuel Consumption Estimation:** The initial mass of the planes was estimated due to current lack of access to information about the number of passengers on each flight. Further work could adjust this estimation computed using `traffic.`
- **Carbon Footprint Calculations**: Given the data and recent studies, we can provide estimates of environmental effects for the flights, which can be optimized.

Conclusion:

This project offers a novel approach to understanding the economic impacts of weather on commercial flight paths. By integrating flight data with weather models and employing advanced machine learning techniques, we provide valuable insights that can drive more efficient and cost-effective flight planning.