Project Proposal

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1. **Which tasks or problems in aviation domain will you study?**

Our task is on flight trajectory optimization based on wind data. Flight dynamics and wind dynamics models will be derived from data, and the real-time optimal trajectory between two points on a certain date and time in the future will be provided.

2. **Where will you get the data?**

The trajectory data at a specific date and time from 'Sherlock Open Data Portal' will be used for the identification of the flight dynamics model.

The wind data will be obtained from NOAA.

3. **How does the topic of your project relate to aviation and machine learning?**

In this project, fully data-driven modeling of a dynamics system will be used to find the real-time optimal flight trajectory between two points taking into account the effect of wind. The governing equations (flight dynamics model) will be derived from a series of trajectory and wind data by Sparse Identification of Nonlinear Dynamical Systems method [1]. The theory behind this methodology is the combination of PDEs and independent identically distributed Gaussian error entries (zero mean with a certain magnitude of noise). To set up the identification model, the difference between trajectory points and wind components should be approximated numerically. Least Absolute Shrinkage and Selection Operator (LASSO) method will be used for the generation of the error entries. The schematic of the process is described in Figure [1] below.

We will investigate how wind will change the optimal flight trajectory. When we are considering the effect of wind, we need to consider wind types including headwind, tailwind, and crosswind. Such winds directly affect the drag of the airplane.

We are using weather data provided by NOAA. It includes hourly collected data from multiple stations with different locations, across years. The data mainly consists of

time, coordinates (latitude, longitude, elevation), wind speed, and wind direction. Additionally, dataset includes data such as visibility, temperature, humidity, ceiling of cloud, etc. We are treating wind data as time series, thus forecasting wind based on historical data. Ideally, wind should have some correlation with seasonal patterns, and thus allows us to predict wind data at a given time and place.

Wheather data record according to Federal Climate Complex data documentation [3]. Wind data is structured as direction, direction quality code, type code, wind speed, speed quality code. Wind data example: 140,5,N,0052,5. We may also use temperature, visability, humidity and ceiling of cloud data to build the model.

Once the dynamics model and wind model are identified, the real-time optimal trajectory will be found and compared with the actual trajectories to see the gap between them. Actual trajectories will be clustered and analyzed to see which trajectories fall into the optimal trajectory cluster. Additionally, seasonal and annual trends of trajectories will be discussed in the project.

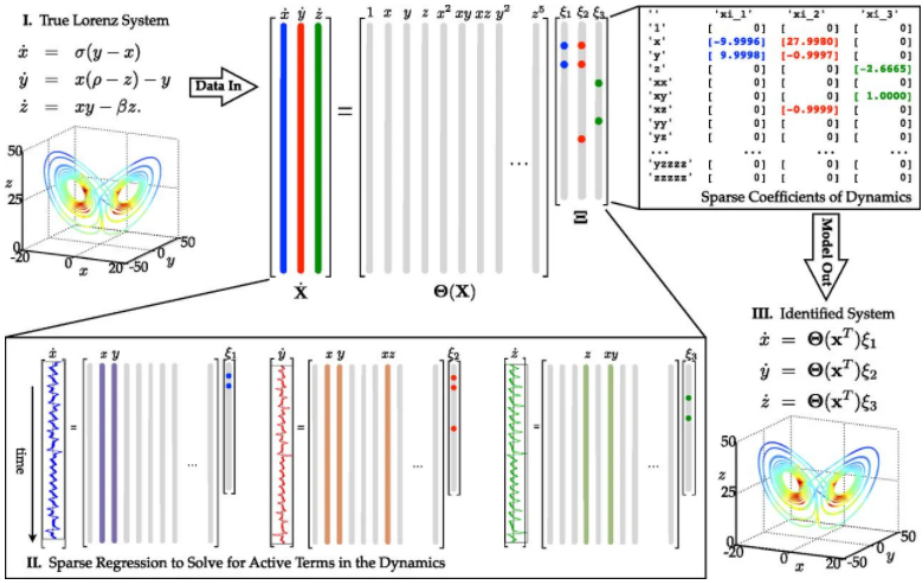

Figure 1. Sparse Identification of Nonlinear Dynamical System.

4. What is the related work or literatures to your research idea?

[1] Brunton, S. L., Proctor, J. L., & Kutz, J. N. (2016). Discovering governing equations

from data by sparse identification of nonlinear dynamical systems. *Proceedings of the National Academy of Sciences*, *113*(15), 3932–3937. https://doi.org/10.1073/pnas.1517384113

[2] Lahouar, A., & Ben Hadj Slama, J. (2014). Wind speed and direction prediction for wind farms using support vector regression. In 2014 5th International Renewable Energy Congress (IREC). 2014 5th International Renewable Energy Congress (IREC). IEEE. https://doi.org/10.1109/irec.2014.6826932

[3] FEDERAL CLIMATE COMPLEX DATA DOCUMENTATION FOR INTEGRATED SURFACE DATA (ISD), https://www.ncei.noaa.gov/data/global-hourly/doc/isd-format-document.pdf