Sandia Flight Trajectory Analysis

Andrew Zehr, Matt Single, Maxwell Low, Neil Sharma, Patrick McKinley & Trent Marchand

PURDUE UNIVERSITY

Introduction and Motivation

What We Do: We examine flight trajectories and paths of airplanes to find patterns, groupings, and outliers.

Why We Do it: For defense and security, it is important to know the major flight paths and behaviors as well as how to spot outliers.

What's Tracktable?: Tracktable is a Python kernel designed to make analyzing flight data easier. In this poster we showcase many of Tracktable's capabilities.

Reader and Builder

These are two functions that are best used consecutively at the start of the notebook to form trajectories.

Reader

- Adaptable function that can assign and isolate our points of interest in the data for trajectory formation
- Transforms inputted .CSV data into point objects readable to the builder function

Builder

- A function that builds trajectories from the points given by the reader function
- Groups each set of points belonging to the same flight
- Constructs trajectories from these points

R-Tree

- Used to sort values by known bounds to isolate a range of values and diminish the amount of values passed to later sorting methods
- Can be applied to an Nth dimensional characteristics (as many as you want)
- Example with 2 dimensions
- The altitude range is from 8000 feet to 15000 feet and the airspeed is from 800 to 1000 km/hr

as seen in Figure 1.

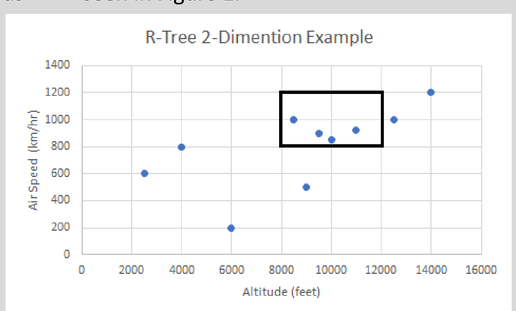

Figure 1: R Tree Visualization

Feature Vectors

- A vector containing aggregate features or descriptors of a trajectory
- A vector is specific to a trajectory 1:1
- Examples of individual features include: total length, end to end length, maximum airspeed, average altitude, etc.
- Feature vectors are used as a way of comparing trajectories with both R-tree filtering and clustering

Calculated from trajectory A:
<580, 8900, 2000, 2500, 0.8>

<max. airspeed, avg. altitude, end to end dist, total dist, straightness ratio>

Distance Geometry

Distance geometry calculates the length of the trajectory along increasingly short segments. Include all the segment lengths up to a certain depth in a single feature vector. An example is given for the given trajectory (shown in black) and going to a depth of 3. See Figure 2 for a visual of the segmentation of the trajectory. Figure 3 shows the corresponding positions of each segment within the eature vector.

Figure 2: Depth Example

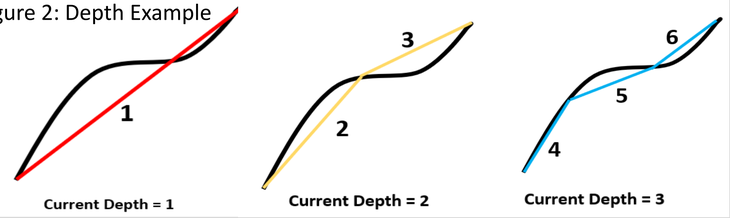

Figure 3 Resulting Feature Vector

[1, 2, 3, 4, 5, 6]

Length of Each Line Segment

This vector can be normalized by dividing each entry by the maximum possible value of that entry. This maximum value is calculated by dividing the total length of the trajectory by the current depth. This yields a feature vector where all values exist from 0 to 1 like the vector shown in Figure 4.

Example of Normalized Vector

[0.5, 0.234, 0.7, 0.98, 0.1, 0.4]

Figure 4: Normalized Feature Vector

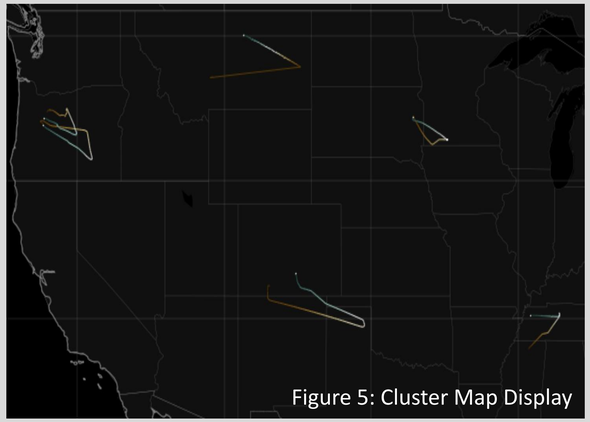

Figure 5: Cluster Map Display

Clustering

- Once we have successfully created our feature vectors containing the desired trajectory characteristics, then we can use clustering to filter out the vectors with uninteresting attributes
- This is incredibly useful for finding specific patterns, unusual shapes, and abnormalities!
- You can then use clustering to group feature vectors together based on whatever you choose and then you can visually display them to see the similarities of the flight paths contained within the different cluster groups. See Figure 5 above.

Conclusion:

We have worked towards the ability to extract interesting information from trajectories using Trackable and applying distance geometry.

Future Goals:

- Onboard new members
- Use these tools to predict the future characteristics of trajectories
- Explore unanswered questions about trajectory characterization and look for correlations between different characteristics

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