# A Simplified Framework for Air Route Clustering Based on ADS-B Data

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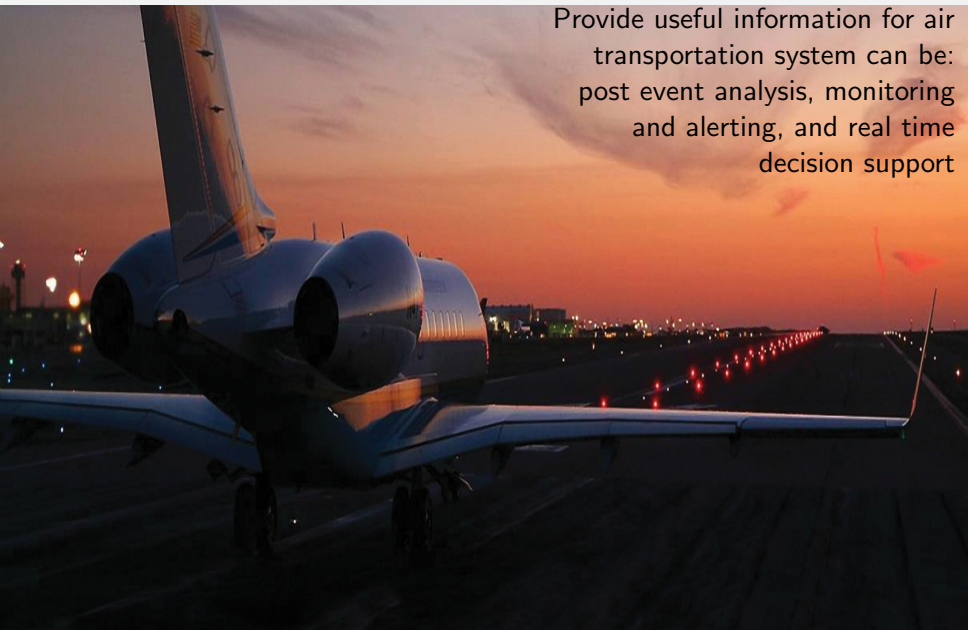Nanyang Technological University

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# OUTLINE

# Air Route Analysis



Provide useful information for air transportation system can be: post event analysis, monitoring and alerting, and real time decision support
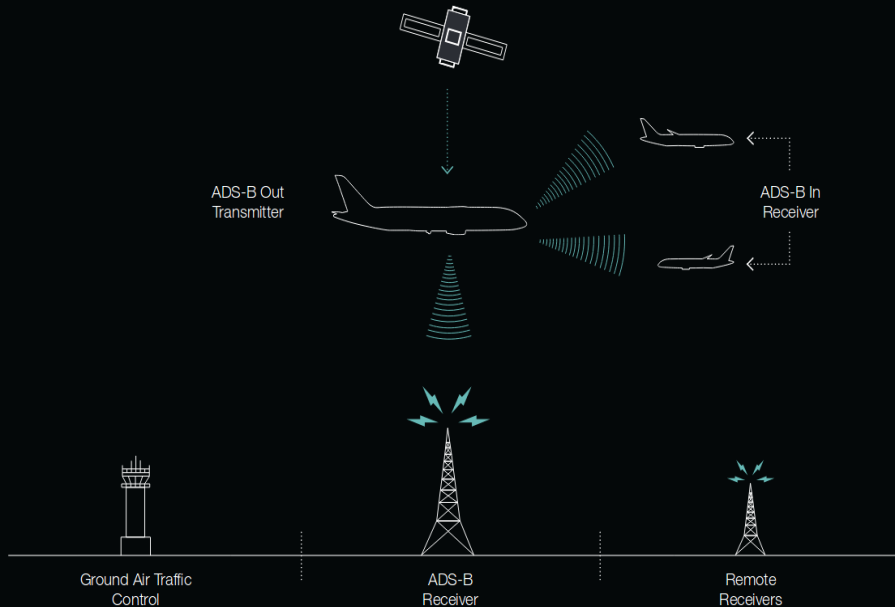
# ADS-B Technology

ADS-B is intended to transform air traffic control by providing more accurate and reliable tracking of airplanes in flight and on the ground. In the plan to transform ATC from radar-based to satellite-based system[1]

- The earliest known mandate for ADS-B equipage is Nov 2010 in Canada's Hudson Bay
- In Dec 2013, Australia is the next mandate
- The United States plans on mandating ADS-B Out by Jan 2020 for all airplanes
- China is exploring ADS-B Out in NRA

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[1]C. Dean and Obrien, "New Air Traffic Surveillance Technology. Avionics and Air Traffic Management".

# HOW ADS-B WORKS

# DATA EXPLORATION

- Making sense of data
  - Identify interpretable patterns
  - Make predictions about the future
- In many situations, knowledge discovery is enabled by data visualization tools through interactive processes[2].
- **Clustering** is a common method in detecting patterns from big data

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[2]Dimitriadou, Papaemmanouil, and Diao, "Explore-by-example: An Automatic Query Steering Framework for Interactive Data Exploration".

# Problems

- The limited studies on clustering algorithm support for spatial-temporal ADS-B data
- Challenging on automatically estimate algorithm's parameters for discovering patterns of data points in space

# Solution

Propose & implement a data mining framework for identifying the air route structure, and adapting for ADS-B data
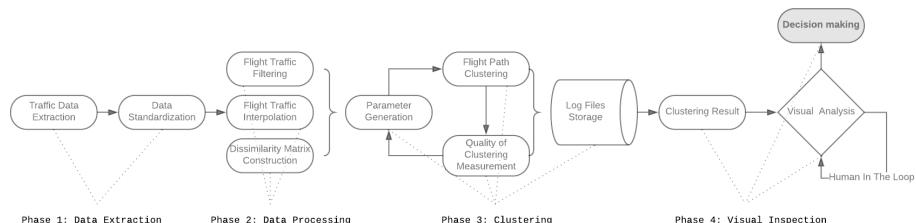


FIGURE 1: A simplified framework for air route clustering based on ADS-B data

# SETTINGS

- For comparison: Re-implement the benchmark method from Adria[3] in the case of ADS-B
- All flights' trajectories are crawled from *FlightAware*[4]
- The used methodologies in this works

| Step | Methods |
|------|---------|
| Trajectory data | ADS-B |
| Distance between curve | Fréchet distance |
| Clustering | DBSCAN |
| Decide Number of Cluster | Silhouette and Davies-Bouldin |

- Generated 100 values for $\epsilon$ combined with the real observed *MinPts* value for running the DBSCAN algorithm

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[3]Torne, "Route Clustering for Strategic Planning in Air Traffic Management".
[4]https://flightaware.com
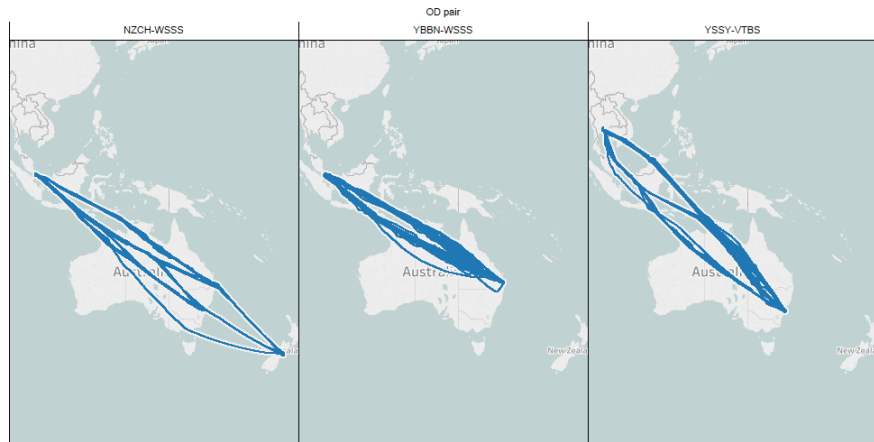
# TRAJECTORY VISUALIZATION



FIGURE 2: The original trajectory for three pairs of airports are visualized on real map by using Tableau
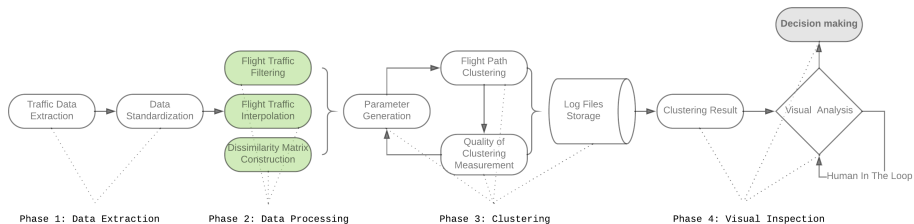
# Data Processing



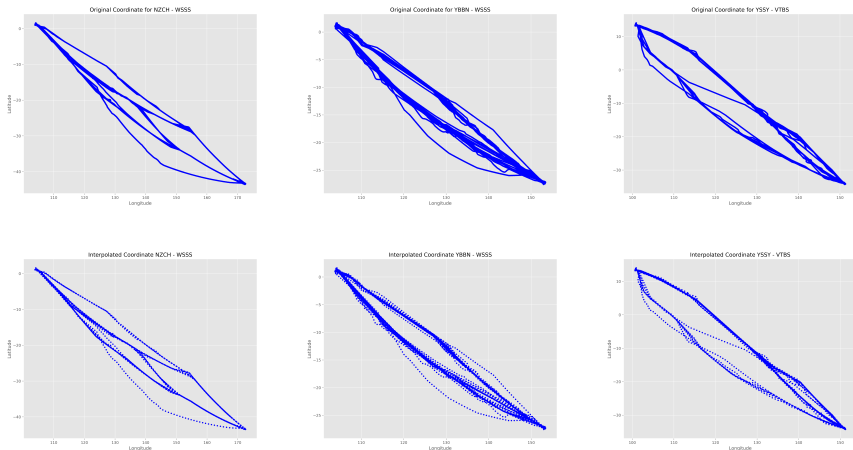Figure 3: Phrase 2 of pipeline - Data Processing

# Data processing visualization



FIGURE 4: The Visualization of Trajectories in Data Processing Step performed by the framework.
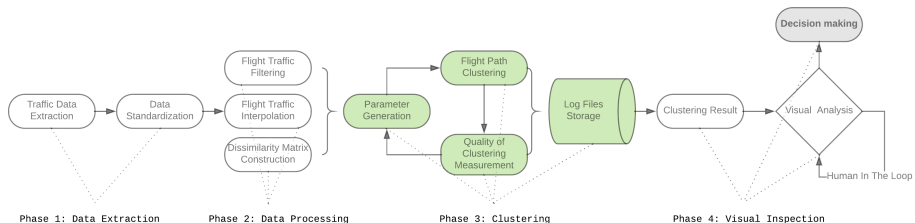
FIGURE 5: Phrase 3 of pipeline - Clustering
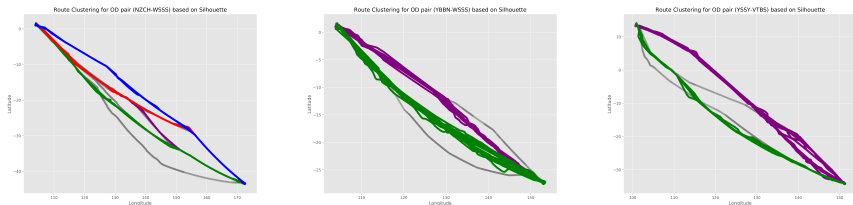
# Benchmark Results



FIGURE 6: Clustering result from benchmark method used single Silhouette, adapted to ADS-B data.

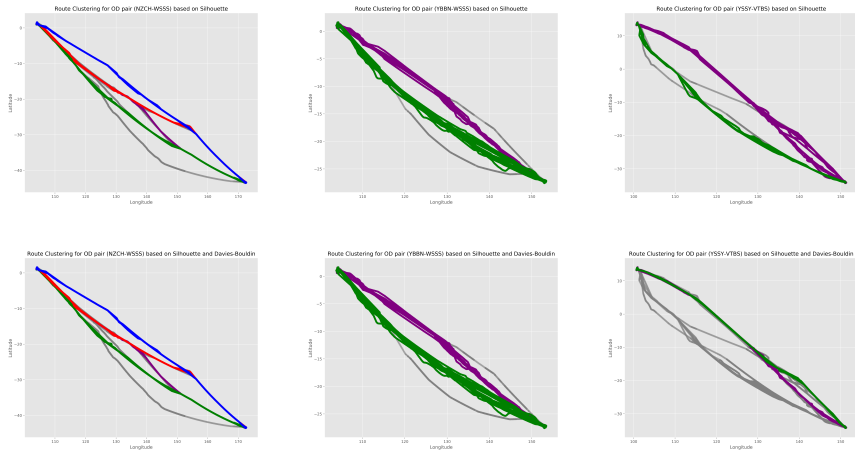# DETECTED CLUSTERS VIA SILHOUETTE AND DAVIES BOULDIN



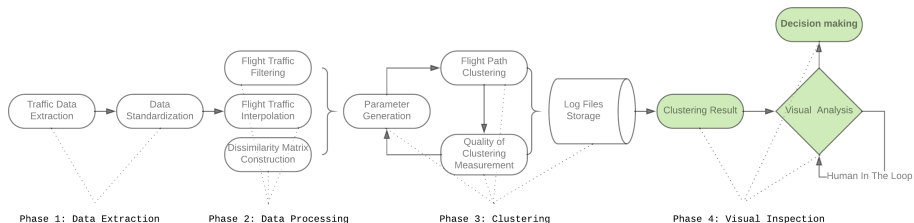FIGURE 7: Best clustering from different single and combined metrics

Figure 8: Phrase 4 of pipeline - Visual Inspection

# DATA EXPLORATION INCORPORATES HUMAN-IN-THE-LOOP
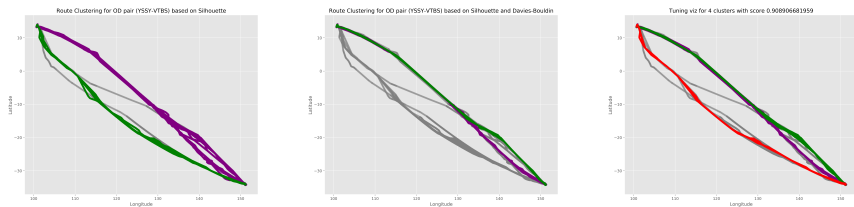


FIGURE 9: The result from our framework for the detected clusters from different scenarios, in case of Sydney-Suvarnabhumi airports

FIGURE 10: Aggregated Routes as a final output of our framework

# Contributions and Conclusions

- The whole framework's source code is made available in github[5]
- Proposed a simplified and workable framework for air trajectories clustering
- Show an analytical study from machine learning based approach for ADS-B data technology, as well as assessing the usefulness in combining multiple indices for evaluating clustering algorithm
- In this direction for the future research, we are going to consider the framework's extension to generate predictive capabilities in measuring the operation performance in air traffic management

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[5] https://github.com/quandb/atc

*Thanks for your attention!*
*Any questions?*