A cluster-based flight data analysis and visualization software

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Opportunities arise from an abundance of flight data

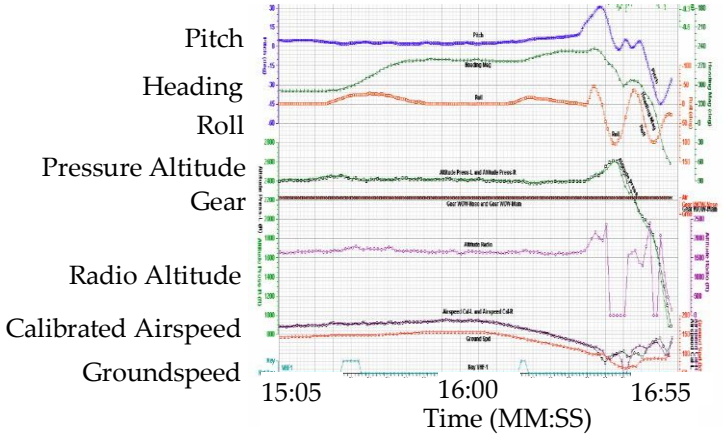
- Airlines monitor flight operations extensively
- An abundance of data available from Digital Flight Data Recorder (the Black Box) and Quick Access Recorder
- Limited for accident investigations in the past
- Advancement in data storage, access, and analytics offer new opportunities

Illustration of flight data devices

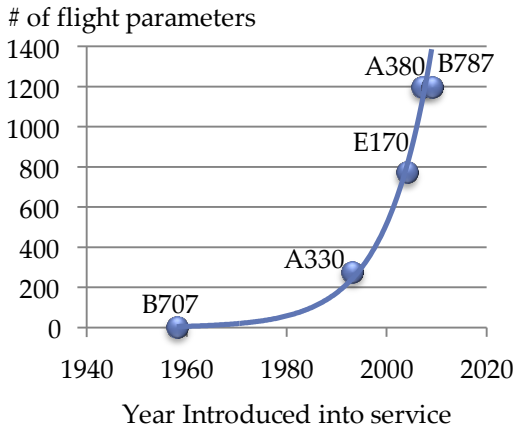
Quick Access Recorder

Flight Data Recorder (The Black Box)

Flight Data Example



Evolution of FDR data capacity



Limited existing analytical tools, leaving valuable information in the data untapped …

ClusterAD

- Current flight data analysis tools are based on "Exceedance Detection" (ED)
  - It detects unsafe events based on a pre-defined list of "exceedance events", which are known issues of safety concerns
  - e.g. a "Excessive Power Increase" event is detected when
  - "HAT < 500 feet, Δ of N1 > x"

- ED cannot respond to emerging, previously unidentified issues that are potentially dangerous; The risks are high if the list is not updated in time

We aim to develop a cluster-based flight data analysis and visualization software: ClusterAD

ClusterAD

Highlights

- A software tool for flight data analysis and visualization using data mining methods
- Enable airline decision makers to grasp latent patterns and obtain valuable insights about their flight operations for safety management and pilot training:

  Identify common patterns of current flight operations

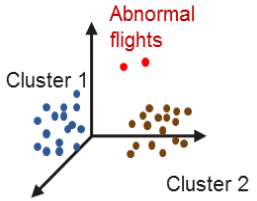
  Detect anomalies without specifying any exceedance criteria

  Monitor pilot proficiency / competency

ClusterAD framework

Flight Data

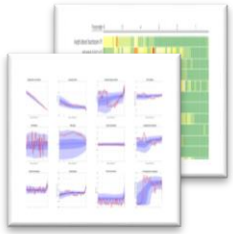
Cluster-based Anomaly Detection



Abnormal Flights

Common Patterns

Expert Review

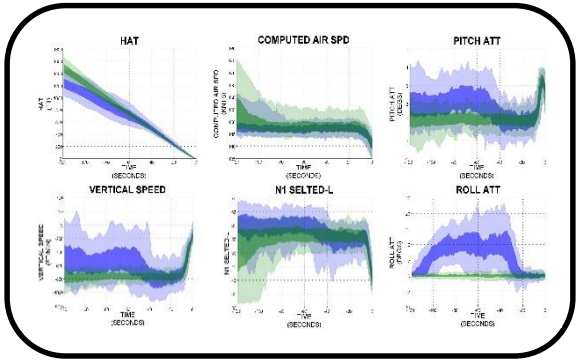


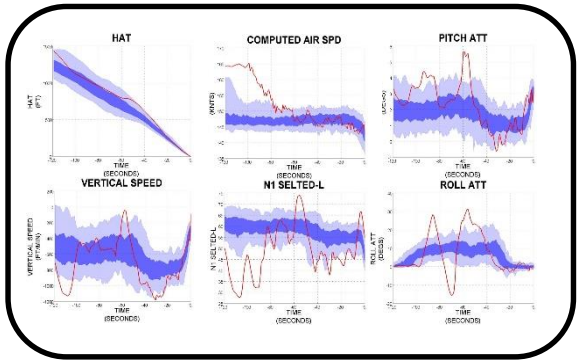
Benign Cases

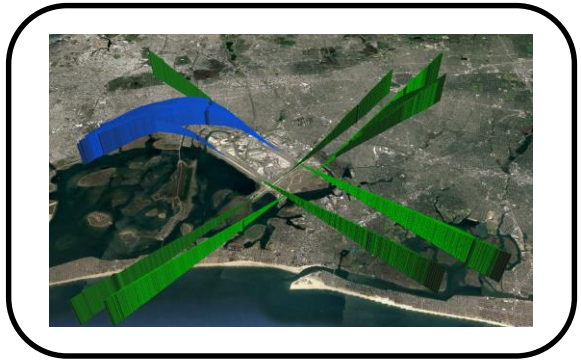
Watch Cases

ClusterAD helps airlines see and understand flight data

- Flight data monitoring
  - Broaden the tool set to allow more flexible, broad-reaching, analysis of data
- Safety
  - Understand patterns of current operations better
  - Identify abnormal flights with operational significance
  - Suggest risks unknown to conventional diagnosis
- Efficiency
  - Gain insights on potentials for fuel efficiency improvements

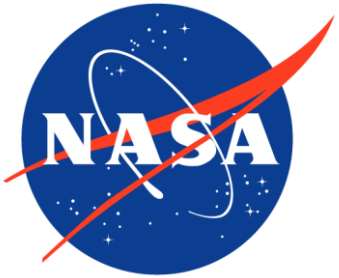






ClusterAD has been tested with a number of airlines via research collaborations

ClusterAD



Selected papers related to ClusterAD:

1. Lishuai Li, Santanu Das, R. John Hansman, Rafael Palacios, and Ashok N. Srivastava. "Analysis of Flight Data Using Clustering Techniques for Detecting Abnormal Operations," *Journal of Aerospace Information Systems.* Vol. 12, No. 9 (2015). pp. 587-598. doi: doi:10.2514/1.I010329 [PDF]
2. Lishuai Li, R. John Hansman, Rafael Palacios, and Roy Welsch. "Anomaly Detection via a Gaussian Mixture Model for Flight Operation and Safety Monitoring," *Transportation Research Part C: Emerging Technologies.* Vol.64 (2016). pp. 45-57. doi: 10.1016/j.trc.2016.01.007 [PDF]
3. Florent Charruaud, Lishuai Li. "Flight Operations Monitoring through Cluster Analysis: A Case Study," *Intelligent Systems, IEEE.* Vol. 30, No. 6 (2015). pp. 24-29. doi: 10.1109/MIS.2015.111 [PDF]

Case study 1: Takeoff analysis using ClusterAD

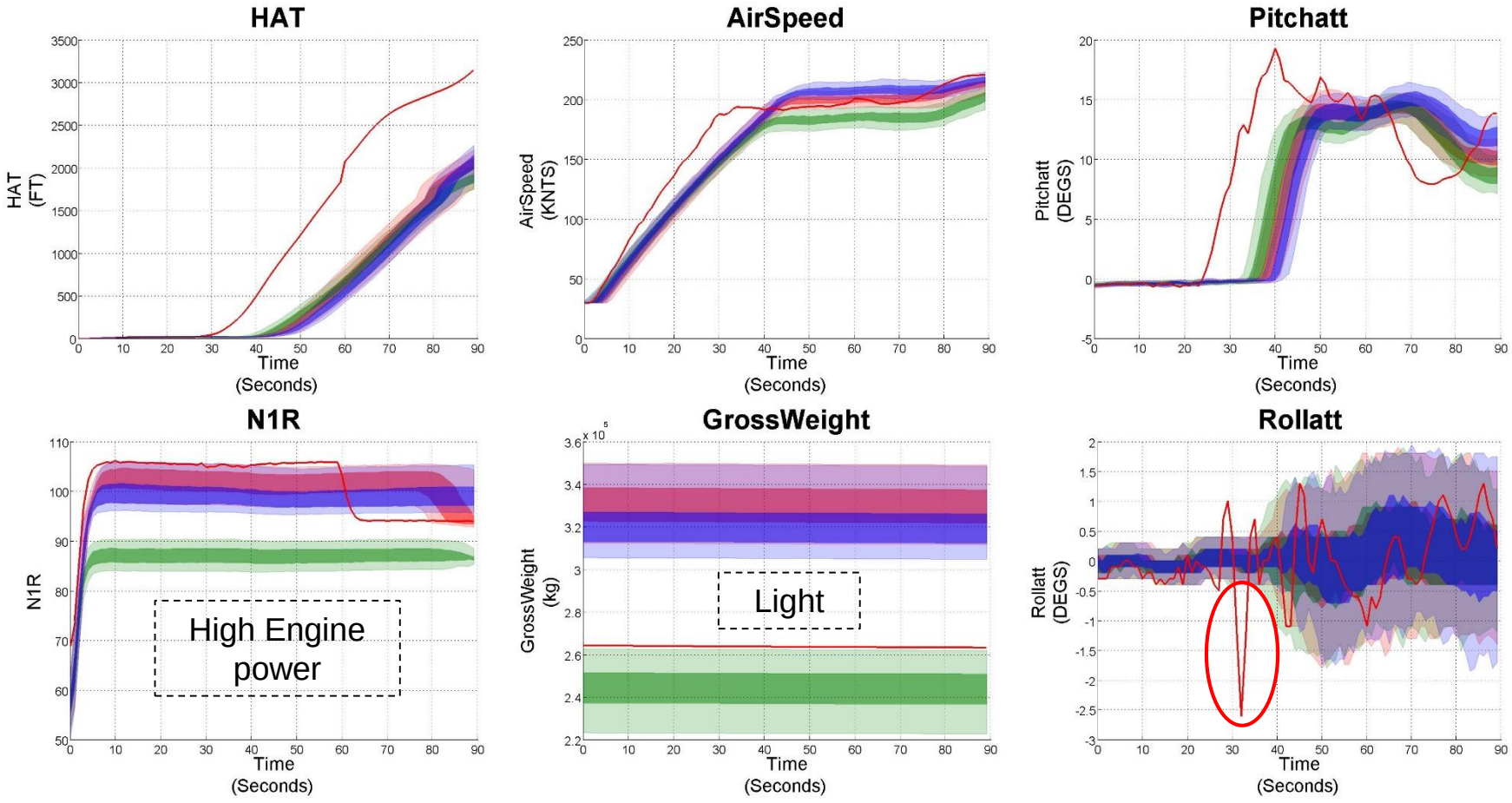
ClusterAD

- Objective:
  - Can we **identify common patterns** and **detect anomalies** of flights taking off from a selected airport via ClusterAD?

- Dataset:
  - 957 flights, B777-300ER

- Flight parameters included in the analysis:
  - Airspeed, HAT, groundspeed, normal acceleration, lateral acceleration, longitudinal acceleration, N1, gross weight, pitch attitude, roll attitude, fuel flow, cross wind, head wind, flap angle, angle of attack, vertical speed

Case study 1: Three common patterns and anomalies are automatically identified



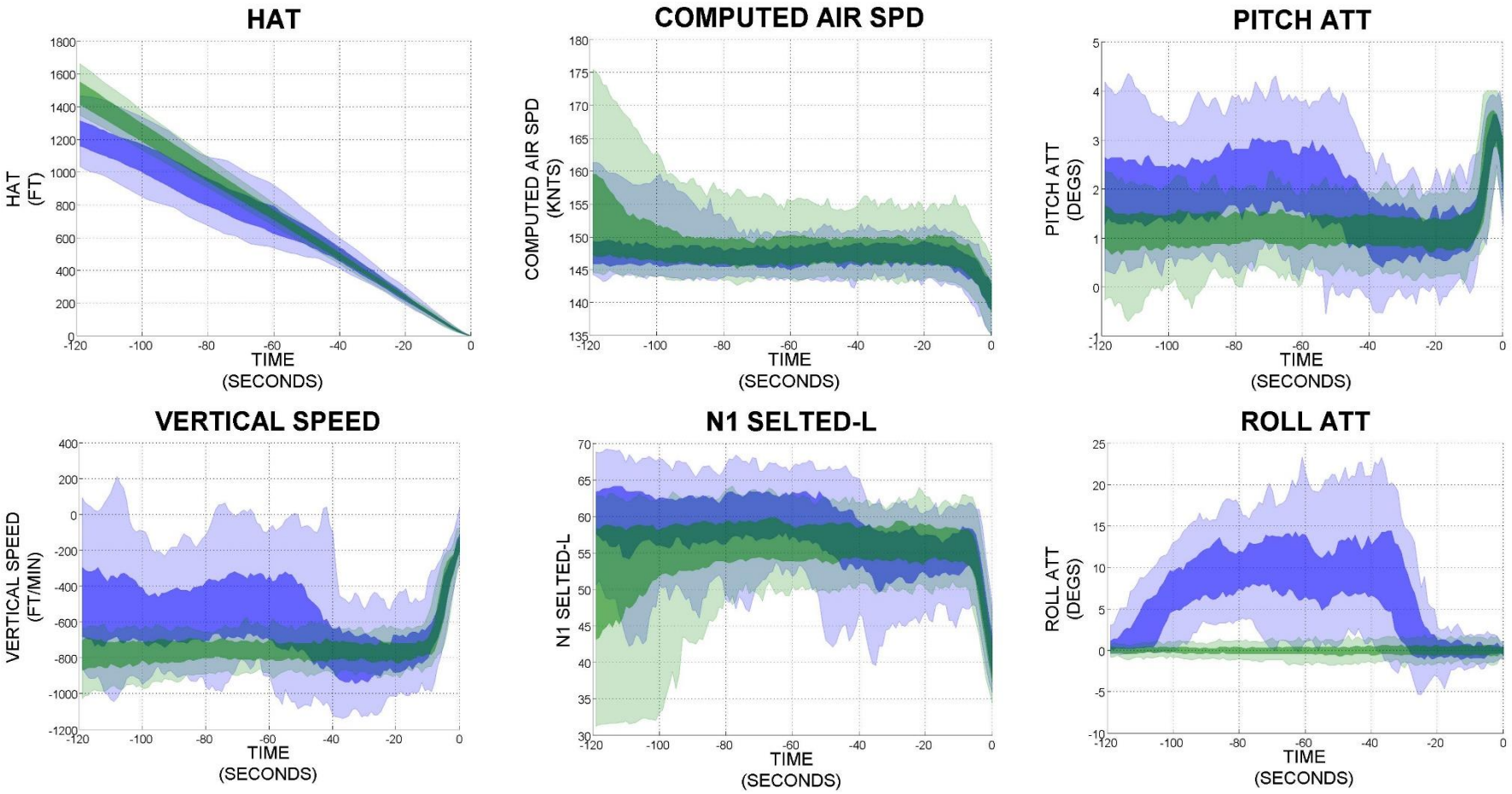
Case study 2: Landing analysis using ClusterAD

- Objective:
  - Issues have been reported regarding the Canarsie VOR approach at JFK airport. Can we identify the issues and reveal related causes using ClusterAD?

- Dataset:
  - 202 flights (76 Canarsie VOR approach and 126 other), B773ER

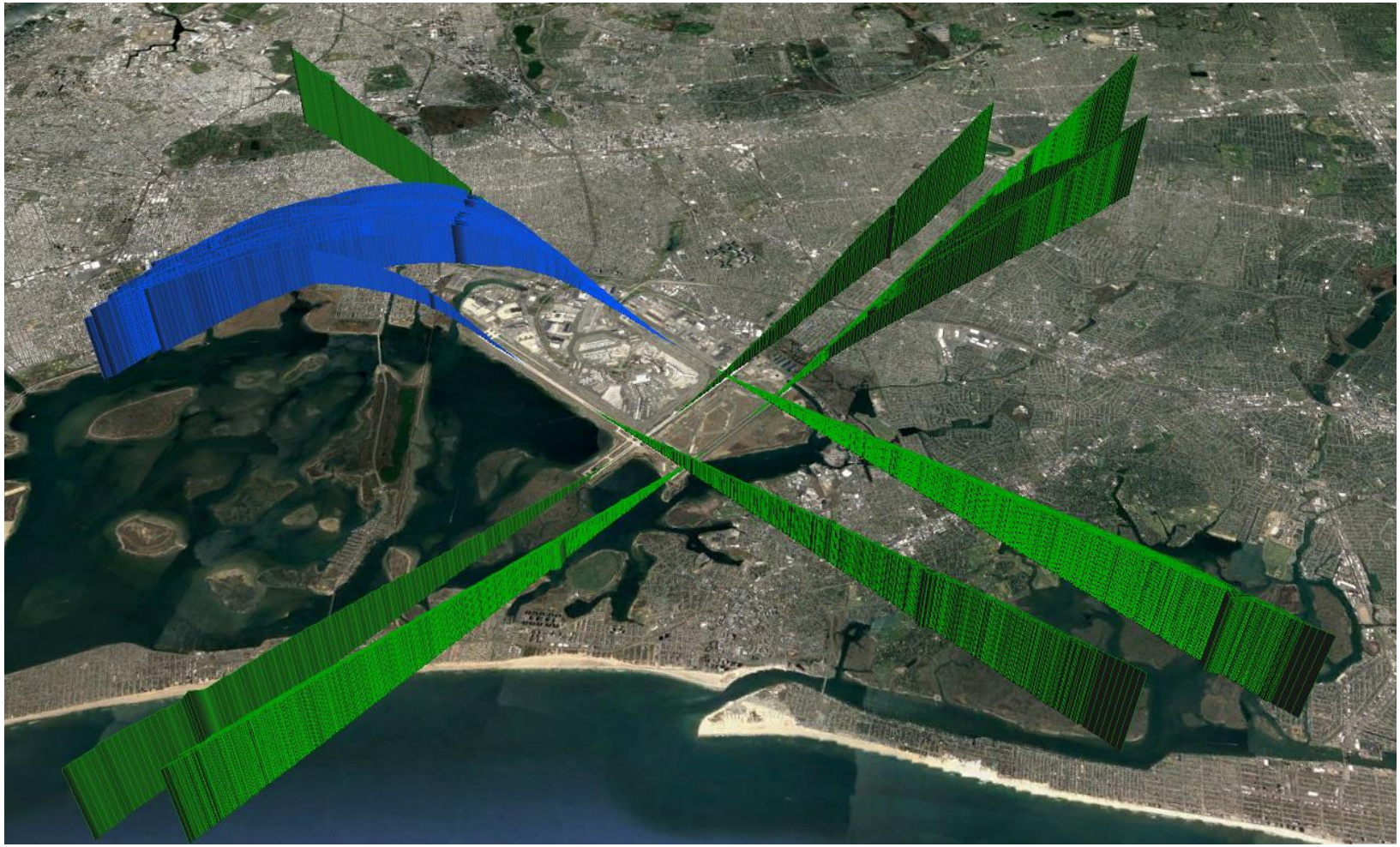
- Flight parameters:
  - Airspeed, HAT, groundspeed, normal acceleration, lateral acceleration, longitudinal acceleration, N1, gross weight, pitch attitude, roll attitude, fuel flow, cross wind, head wind, flap angle, angle of attack, vertical speed

Case study 2: Canarsie approach compared with other JFK approach



Case study 2: 3D visualization of JFK approaches

ClusterAD



Thank you! Questions?

ClusterAD

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