

Flight trajectory data analytics for characterization of air traffic performance

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• Air Traffic Management (ATM) - key element of air transportation



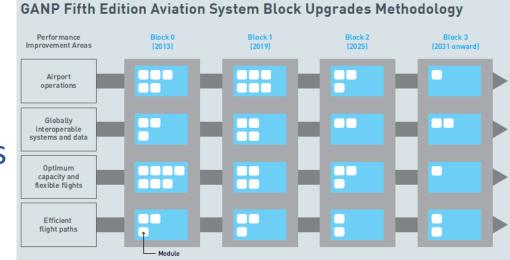
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- Global air traffic has doubled once every 15 years since 1977
- Demand will double by 2035, reaching 7.2 billion passengers



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- Technological and operational improvements for modernization of the ATM system have become necessary





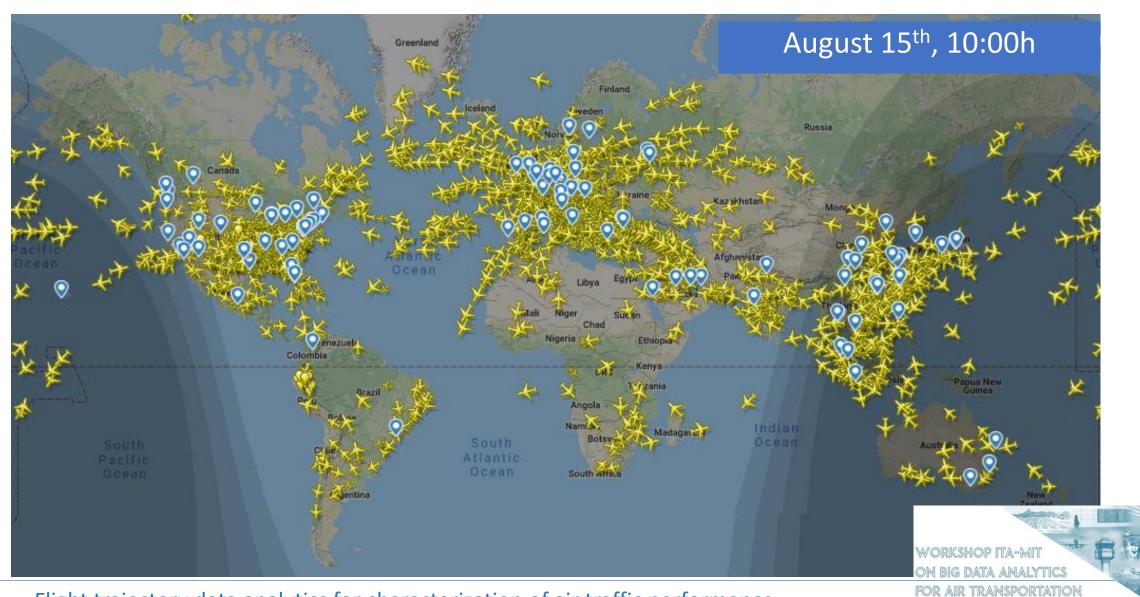






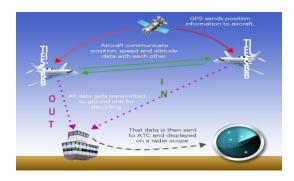
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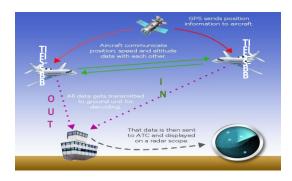
Flight trajectory data analytics for characterization of air traffic performance





New technologies and operational procedures



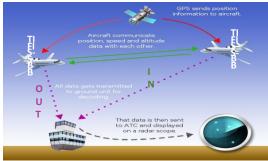


New technologies and operational procedures









New technologies and operational procedures

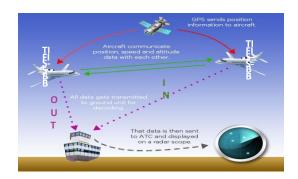


Leveraging operational data is also key to improve ATM and increase the performance of air traffic operations









New technologies and operational procedures



Leveraging **operational data** is also key to improve ATM and increase the performance of air traffic operations







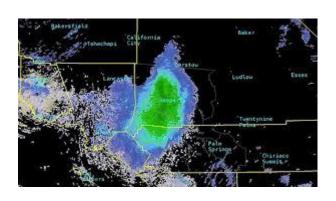


Motivation

 Analytics techniques - assessing the air traffic performance at different dimensions and better understanding how this performance is affected by various operational factors

$$HTE_{kt} = \theta_1 DEMAND_{kt} + \theta_2 LIFR_{kt} + \theta_3 WX_{kt} + \theta_4$$

$$GUSTS_{kt} + \theta_5 MIT_{kt} + \theta_6 NC_{kt} + \theta_7 k_t + u_{kt}$$





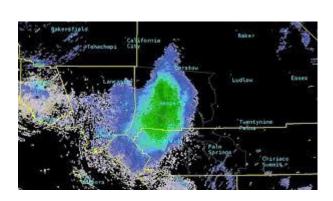


Motivation

- Analytics techniques assessing the air traffic performance at different dimensions and better understanding how this performance is affected by various operational factors
- Sources of inefficiencies / new models and tools better predict and control the performance of the system

$$HTE_{kt} = \theta_1 DEMAND_{kt} + \theta_2 LIFR_{kt} + \theta_3 WX_{kt} + \theta_4$$

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Literature review

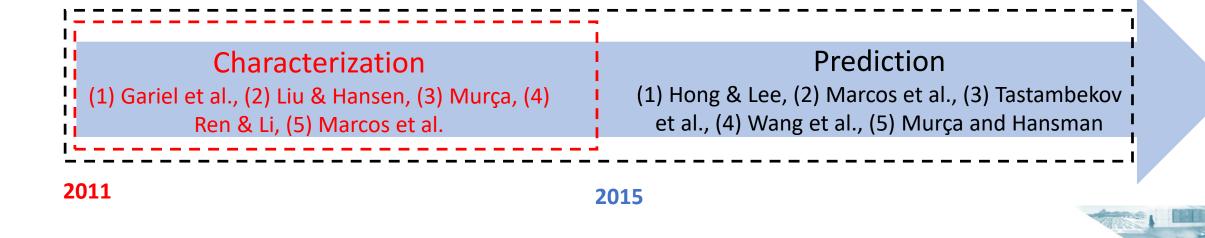
• Trajectory data mining - variety of domains (vehicles, people, animals etc)



Literature review

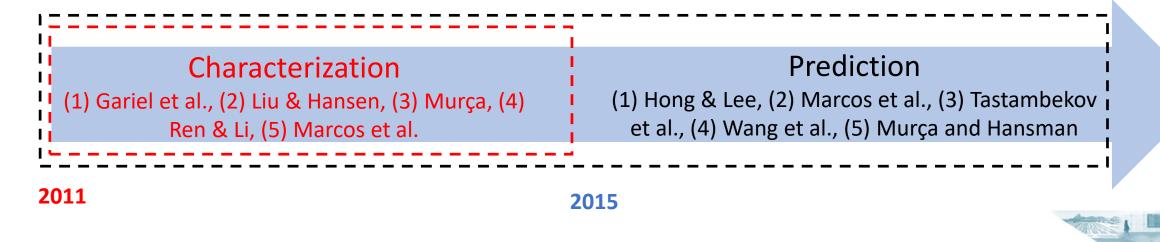
FOR AIR TRANSPORTATION

Trajectory data mining - variety of domains (vehicles, people, animals etc)



Literature review

- Trajectory data mining variety of domains (vehicles, people, animals etc)
- Previous work on flight trajectory data analytics has focused on a single flight phase
- Air traffic behavior and performance dependencies between different scales are not explored



Data description

Main dataset

- The raw dataset 44 days (2017)
- FlightRadar24 tracking service
- flight ID timestamp, latitude, longitude, altitude, speed, origin airport, destination airport and aircraft type

Complementary datasets

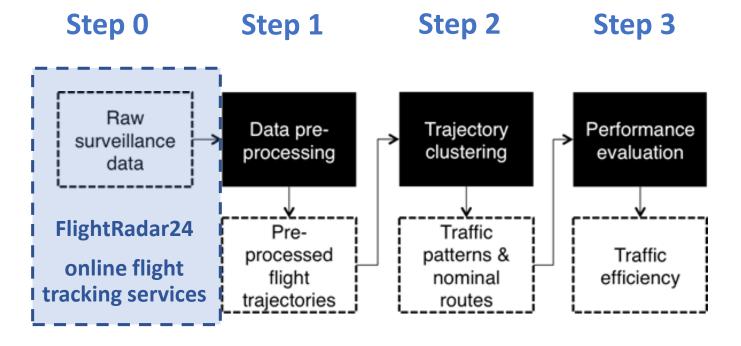
- Meteorological Weather Report (METAR)
- Historical traffic management initiatives from Brazilian Air Navigation Management Center (CGNA)



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Air traffic performance characterization



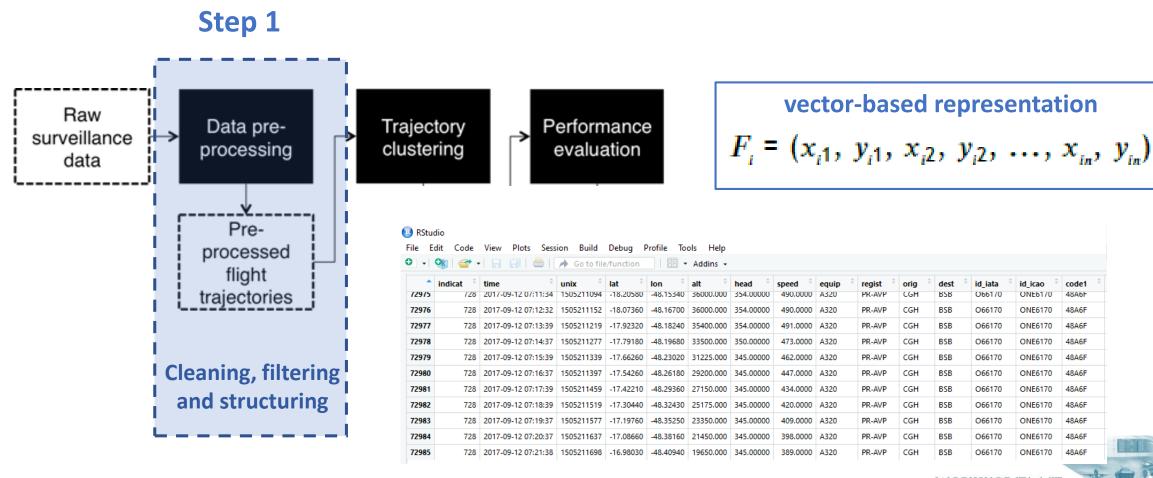
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Automatic extraction of data

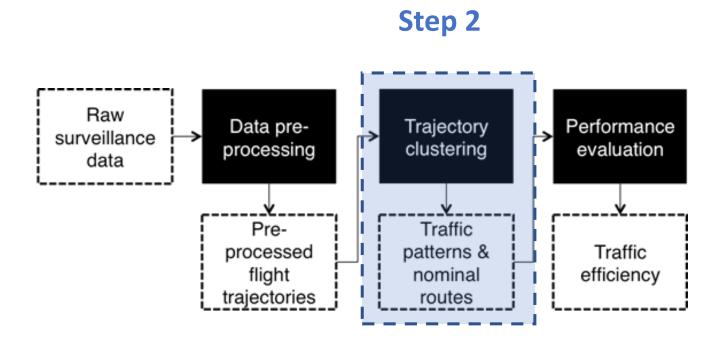


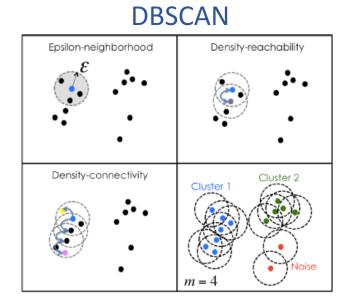


Air traffic performance characterization



Air traffic performance characterization

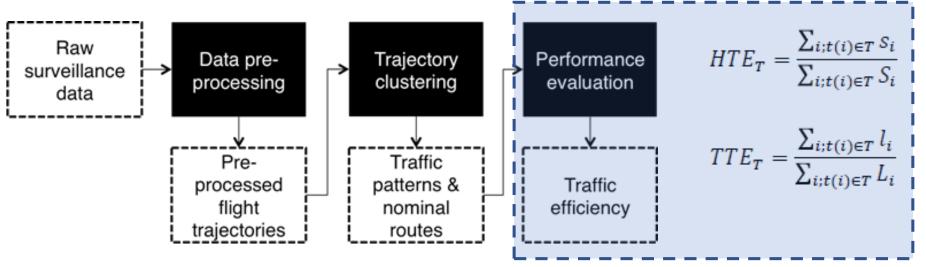




Clustering is an unsupervised learning method that aims at identifying groups of similar observations without prior knowledge

Air traffic performance characterization

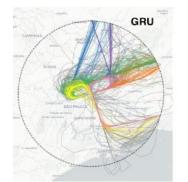
Step 3



Horizontal and Temporal
Traffic Efficiency

- Performed trajectory
- Cluster centroid

- GANP's indicators
- Other indicators according to the interest of the user

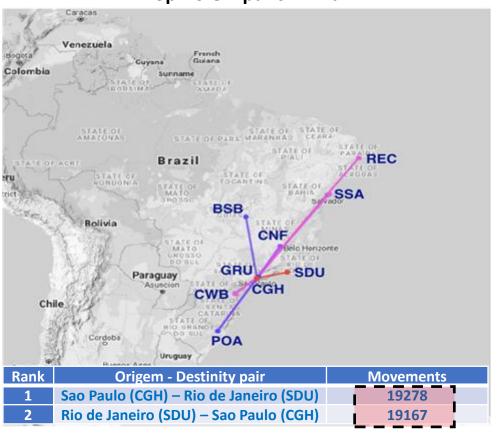




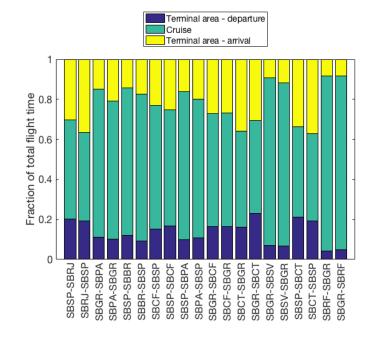


Case study

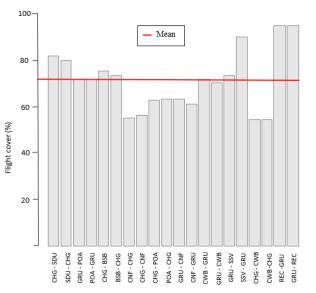
Top-20 OD pairs in Brazil



Flight time by flight phase



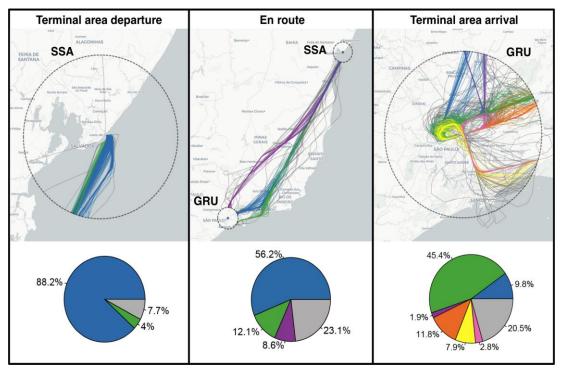
Coverage of flight operations (%)



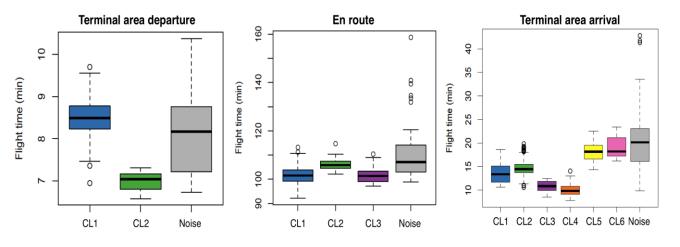


Identification of air traffic patterns

Clusters of trajectories identified for the SSA-GRU pair



Distribution of flight times for the SSA-GRU pair

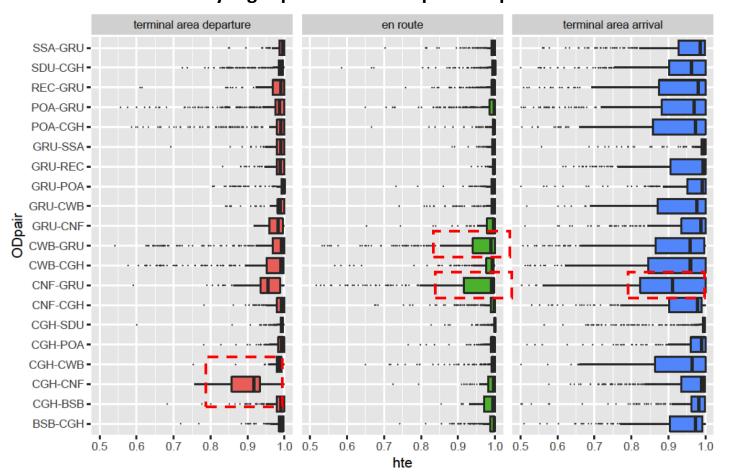


- Number of clusters identified by flight phase
- % of noise



Assessment of traffic flow efficiency

HTE by flight phase for the top-20 OD pairs in Brazil



HTE 0.0 (Totally inefficient → 1.0 (Full efficient)

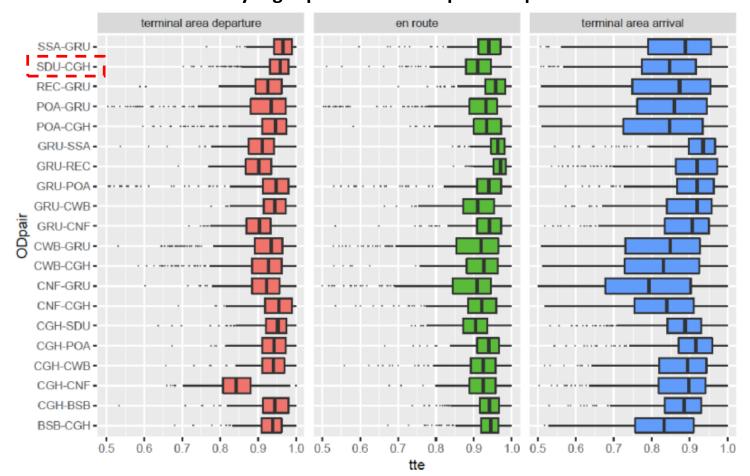
- Terminal area arrival phase lowest efficiencies on average and highest variability in traffic flow efficiency; trajectories are less predictable; more complex operations
- Some traffic flows stand out



Flight trajectory data analytics for characterization of air traffic performance

Assessment of traffic flow efficiency

TTE by flight phase for the top-20 OD pairs in Brazil



- Similar behavior HTE and TTE tend to be correlated
- SDU-CGH suggest that delays on this route are more likely to be absorbed with speed control than route changes

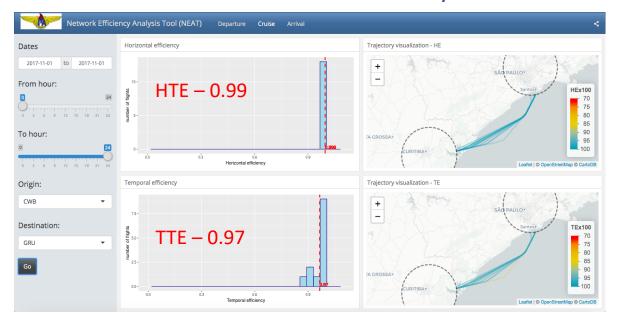


interactive prototype tool for air traffic performance analysis

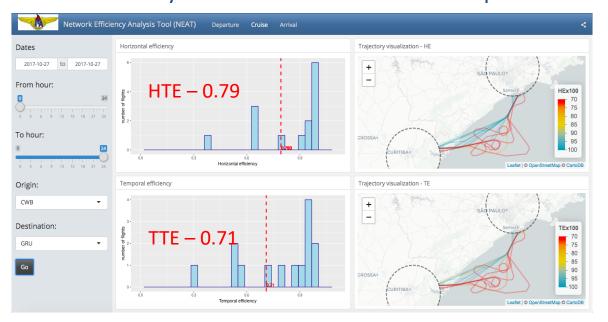


Network Efficiency Analysis Tool (NEAT)

Case 1 - clear weather day



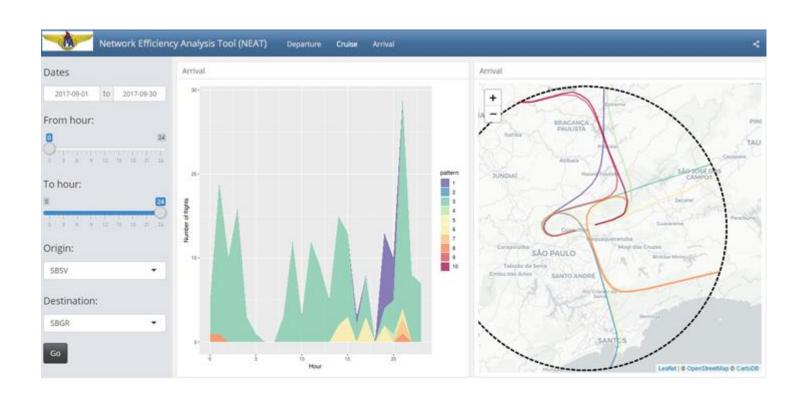
Case 2 - day with convective weather impacts



Functionality 1 - Assessment of traffic flow efficiency



Network Efficiency Analysis Tool (NEAT)





NEAT's prediction

Airspace design (complex)

Functionality 2 - Predict the performance of the system



Summary and next steps



- assessing the air traffic performance
- better understanding how this performance is affected by structural/operational factors
- sources of inefficiencies / new models and tools
- predict and control the performance of the system



prototype tool improvement by including new indicators/features





Thanks a lot!

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Brazil, August 20 and 21

Workshop ITA-MIT on big data analytics for air transportation