



Clustering radar tracks to evaluate efficiency indicators

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Outline

- 1 Introduction
- 2 Clustering Flight Tracks
- 3 KPI: Idealized Flight Time

Current Section

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- 3 KPI: Idealized Flight Time

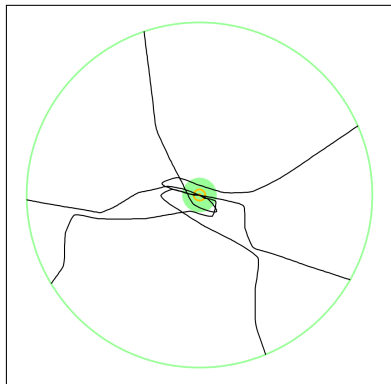
Key Performance Indicators for inbound traffic

- The Airport Sequencing and Metering Area (ASMA) contains the TMA and roughly the airspace needed for separation of aircraft
- The ASMA is realized as simple as possible as a 100NM radius circle around the ARP
- Key Performance Indicators (KPIs) for measuring the performance of handling inbound traffic
 - ASMA-flight time median
 - ASMA-flight time variance
 - relative variance and
 - **idealized flight time** (virtual optimal flight time)

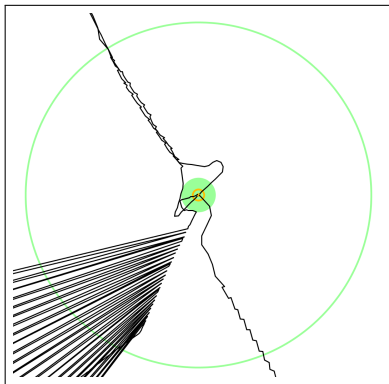
Data base for this analysis

- The data consists of a set of Airport locations and a set of flight tracks
- Each flight track consists of a series of points which in turn hold several information
 - 3D-Location
 - Time
 - Velocity
 - Starting Airport, Destination Airport
 - etc.
- More than 1000 Airports involved, 65 of which with more than 500 total approaches within time frame
- NOT in Data base
 - Airport layout of any kind
 - TMA layout

Data examples



typical flight tracks



flight tracks with errors

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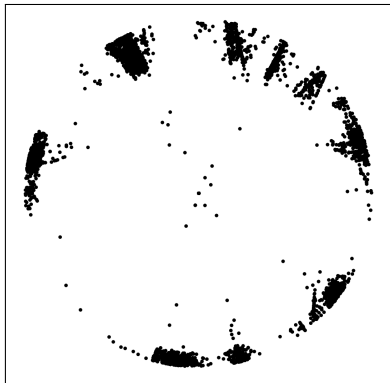
Motivation for Clustering

- ASMA Flight time depends on the combination of entrance direction and landing direction
- Aircraft approaching an airport from different directions or landing on different runways are not comparable
- First task: find groups of aircraft that use similar routes (clustering)
- For each approach cluster (group of routes of similar routed aircraft), cluster dependent KPIs are calculated
- The final KPI is calculated as a weighted sum of the cluster dependent KPIs with the fraction of total flights as weight
- Two different clustering approaches are proposed

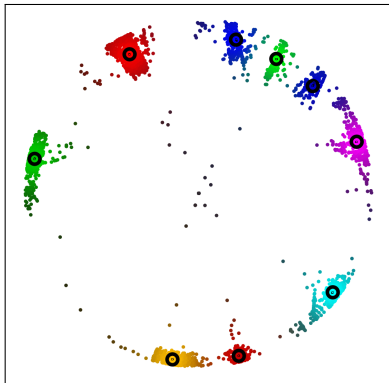
First approach: Clustering ASMA entrance and landing locations

- Two steps of clustering are required: ASMA-Entrance Point and landing point
- For the ASMA-entrance point clustering, the first recorded radar point inside the ASMA is used
- Filter routes out where the first recorded radar point is lonely or too far in the centre
- Calculate the location of the aircraft at 6NM from the ARP and use this position for a second clustering step
- Each combination of entrance cluster and runway cluster forms an approach cluster
- Example: approach cluster 1 = [4, 1]

Clustering entrance points



unclustered entrance points

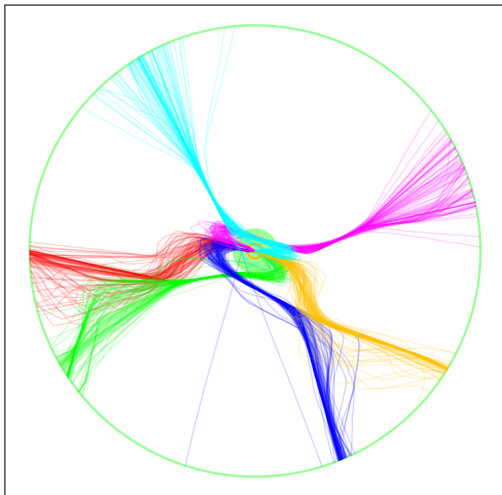


clustered entrance points

Modified Fuzzy c-Means for clustering

- Clustering landing points and entrance points is very similar
- Each approach route is assigned with a degree of membership for each cluster
- Use the highest degree of membership to determine the cluster affiliation
- Problem: number of clusters must be known in advance for Fuzzy c-Means
- Use a modified version of the algorithm that requires the diameter of the clusters instead

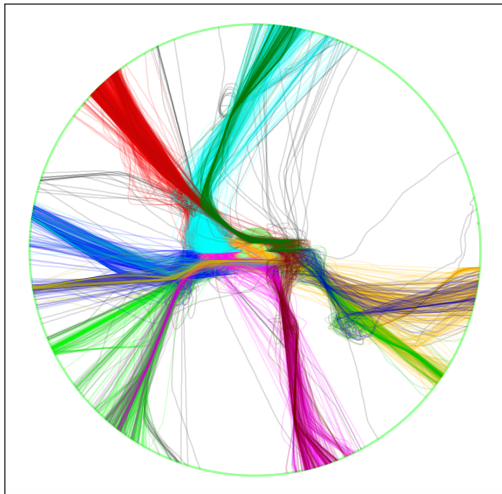
Clustered flight tracks



Second approach: Clustering flight tracks by flight track similarity

- Define a distance (dissimilarity) function for flight tracks.
Possible simple distances:
 - Area in between the flight tracks
 - Maximal distance of flight tracks
- Used Distance function: weighted point-wise distance to increase the influence of flight track difference near the ARP
- The DBScan algorithm is used to cluster the aircraft with the defined distance measure

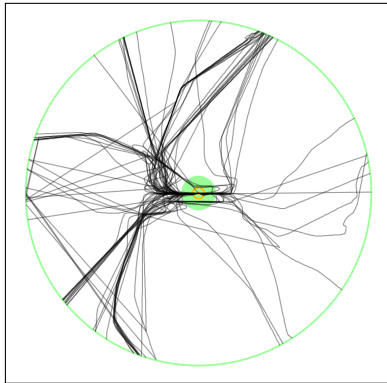
Data set, clustered by flight track similarity



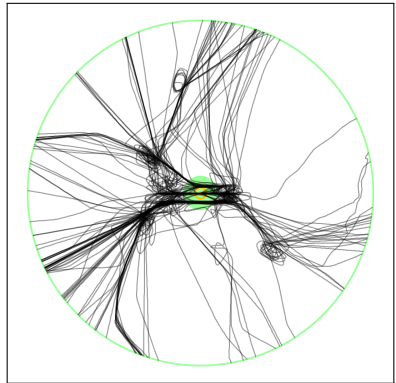
Comparing clustering methods

- Noise data objects are data objects that seemingly belong to no particular group
- Noise clusters are quite different for both approaches
- Removing noise data objects acts like a filter as these data objects are removed
- Clustering by flight track similarity filters rare approach routes
- Clustering by entrance and landing points filters infrequent used entrance points

Noise data from clustering



entrance/landing point



flight track similarity

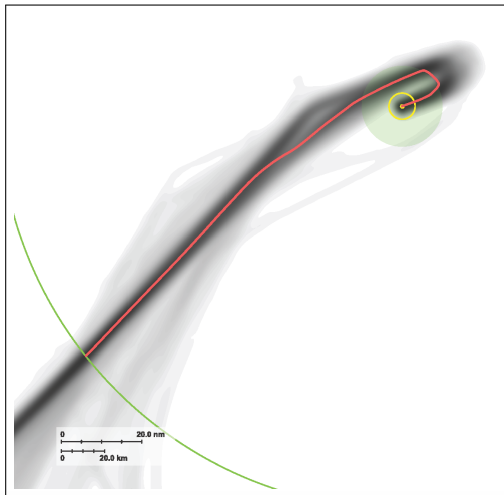
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Idealized approach route and time

- With the approach clusters, the KPIs Flight time median, variance and relative variance are easy to calculate
- The KPI idealized flight time is more difficult
- For each approach cluster, a fuzzy overflight frequency map (OFM) is generated
- For each OFM, an idealized approach route is calculated
- It should be short, smooth, flyable and it should represent the data
- The idealized approach route can be used for simulations without knowing the exact airspace structure
- The idealized flight time is calculated, using the idealized approach route and the median of velocity

Idealized approach route example



Conclusions

- Clustering provides insight into airspace usage
- Different queueing strategies are analysable and comparable
- Clustering provides the tools to calculate the idealized flight time
- Results are usable for simulations and performance monitoring



Thank You for your attention

