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Modelling Subjective Complexity through Cognitive Transitions

Extended Framework

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How Perceived Complexity Shapes Behaviour

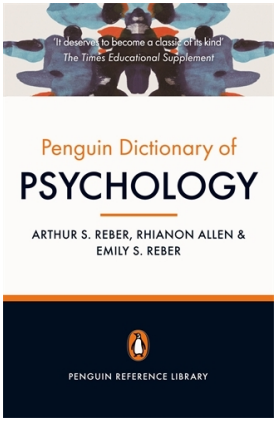


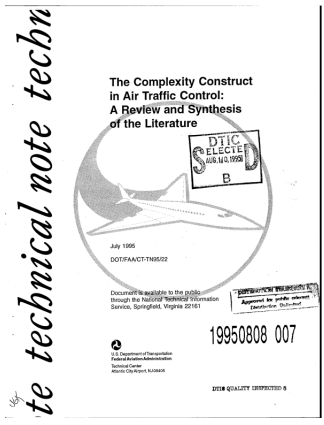
- A juggler juggles 3 objects (easy).
- Juggler is **composed**.(not observable)
- Balls follow a **tight** path.(measurable)



- A juggler juggles 5 objects (hard).
- Juggler is **overwhelmed**. (not observable)
- Balls follow a **loose** path. (measurable)

Introduction







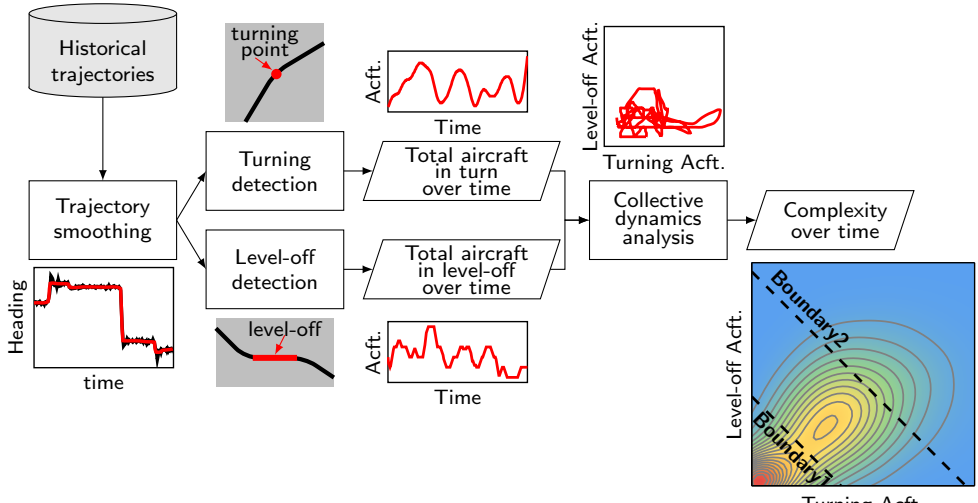
①**Construct** is an internal process that is not directly observable but produces **measurable phenomena**.

②**ATC complexity** can be defined as a construct.

③**Operational outcomes** can be treated as measurable phenomena to measure the complexity (a construct).

Previous Work

Transitional phenomena in arrival traffic was observed and utilized.

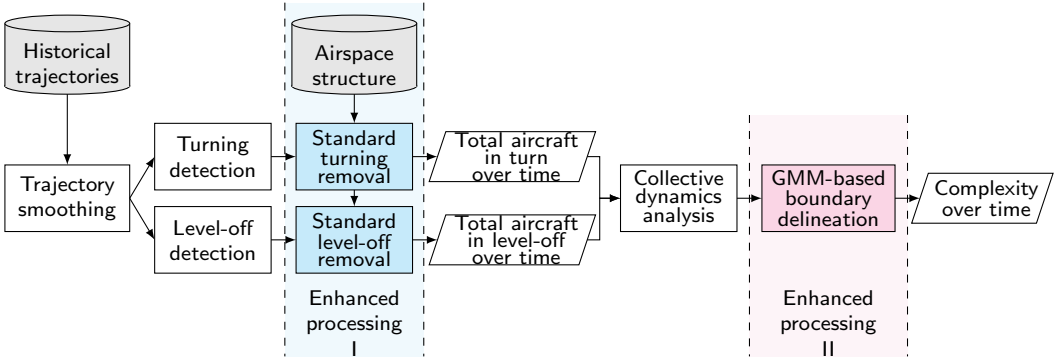


Existing Limitations

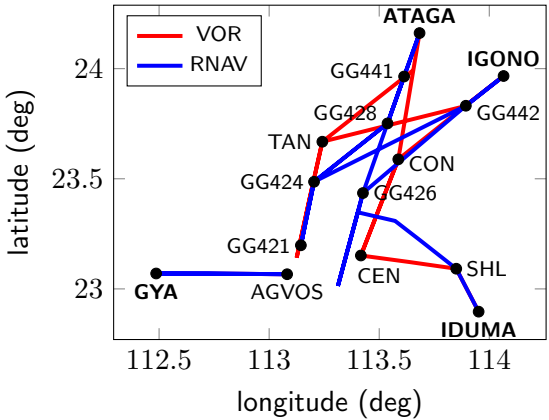
- The collective dynamics analysis of arrival traffic considers all arrival aircraft at each timestamp, including those in turns and level flight, **without excluding standard turns and standard level-offs** that are part of the STAR design, as these are unlikely to increase controllers' workload;

- Although the collective dynamics analysis revealed a distinct multi-peaked distribution, the boundaries between the regions were **manually defined**, without a systematic methodology for their determination.

Extended Framework



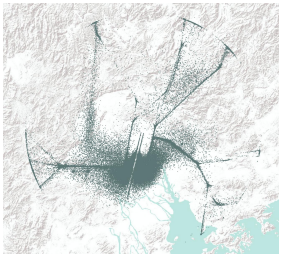
Enhanced Processing I - Standard turning removal

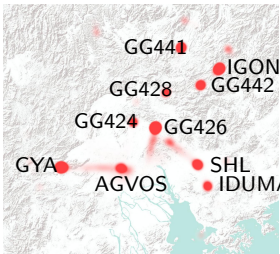


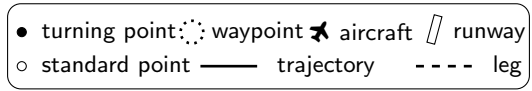
Route ID	Waypoint	Alt.(ft)
ATAGA-1C	ATAGA	
ATAGA-1C	GG441	
ATAGA-1C	GG428	
ATAGA-1C	GG424	
ATAGA-1C	GG421	4900
⋮	⋮	⋮

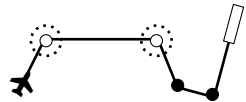
The STARs at Guangzhou Baiyun International Airport (ICAO: ZGGG).

Enhanced Processing I - Standard turning removal

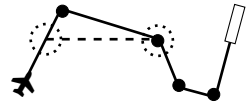




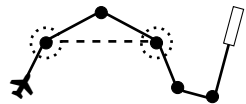




(a) Trajectory following a STAR



(b) Trajectory with a path-stretch 1

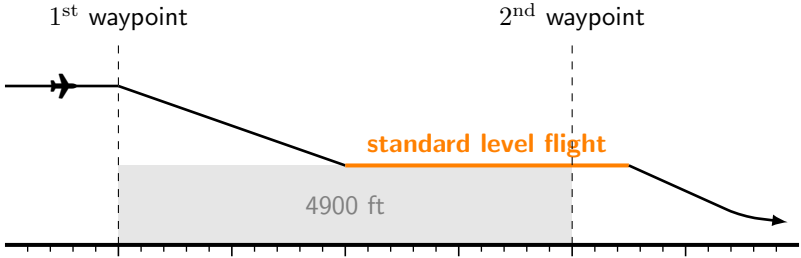


(c) Trajectory with a path-stretch 2

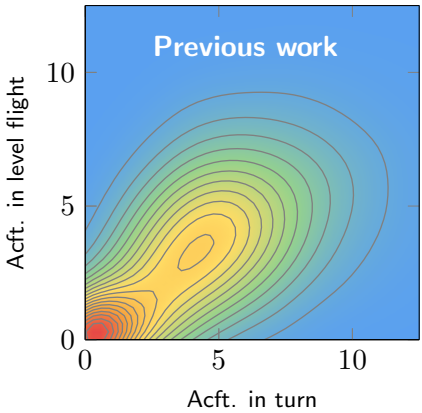


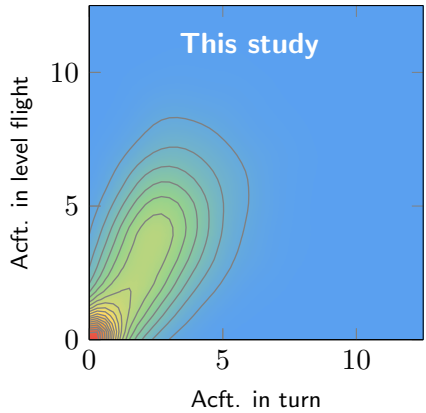
(d) Trajectory with a short-cut

Enhanced Processing I - Standard level-off removal

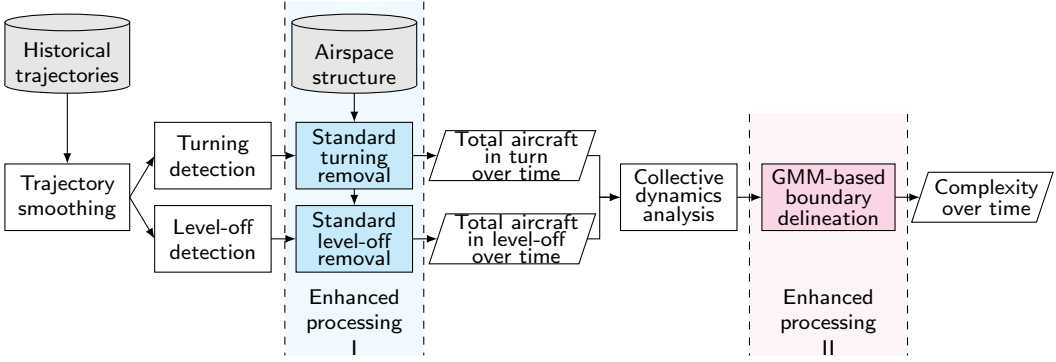


Improvement Visualisation

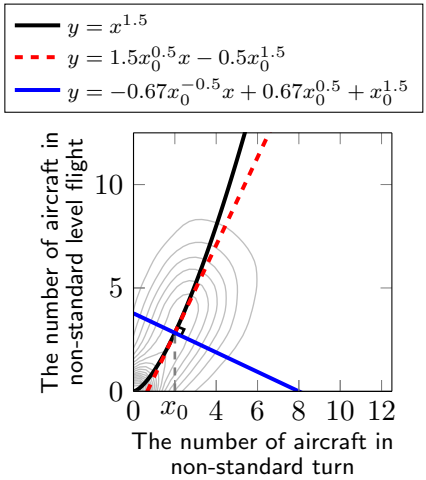




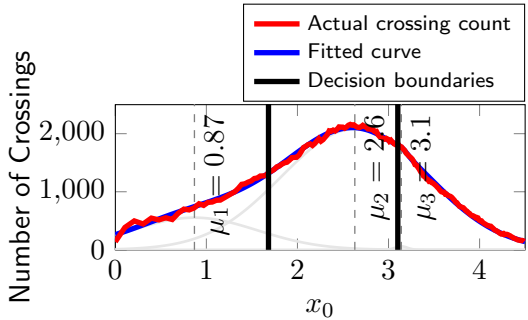
Extended Framework



Enhanced Processing II - Boundary delineation



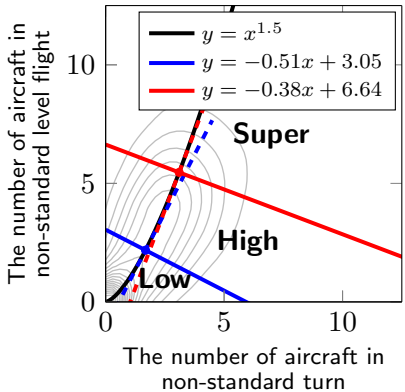
Candidate decision boundary generation.



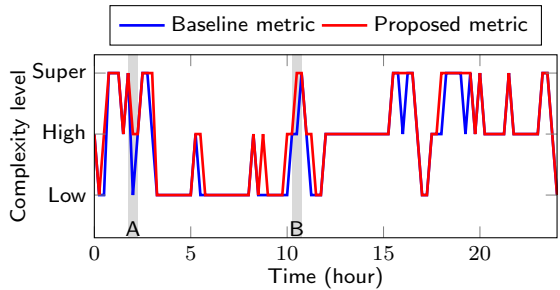
Decision boundary determined based on fitted Gaussian functions. Each decision boundary is determined by

$$x = \frac{\mu_1\sigma_2 + \mu_2\sigma_2}{\sigma_1 + \sigma_2}$$

Complexity measurement

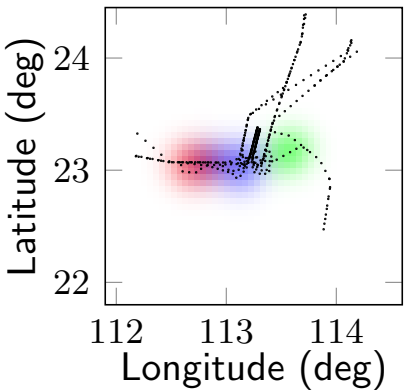


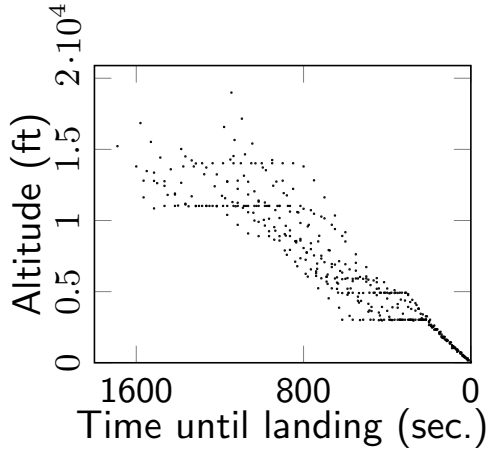
Complexity level determination.



Applying the proposed metric to real air traffic operations. The trends of both metrics exhibit similar profiles.

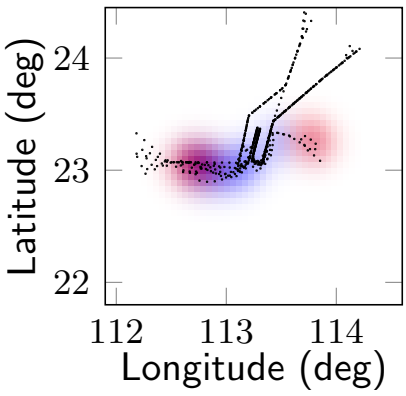
Case Study - Period A

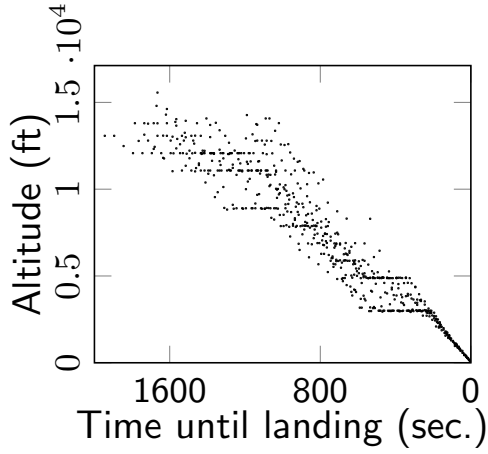




Emphasize different manoeuvres with different colours: red for **HOLDING**, blue for **PATH-STRETCH**, and green for **SHORT-CUT**.

Case Study - Period B





Emphasize different manoeuvres with different colours: red for **HOLDING**, blue for **PATH-STRETCH**, and green for **SHORT-CUT**.

Conclusion

Experimental results reveals the two enhancements:

- **Accuracy Improvement**: eliminating standard manoeuvres enhances the metric's sensitivity to workload variations;

- **Automation**: the automatic decision-boundary method achieves results comparable to manually defined boundaries.

Thank you for your attention.

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