

Machine Learning Applications to Extend AGENT's Conflict Resolution Capabilities

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Following the path set by AGENT

Can learning improve conflict resolution?

Conflict resolution with Reinforcement
Learning

MAIN OBJECTIVE:

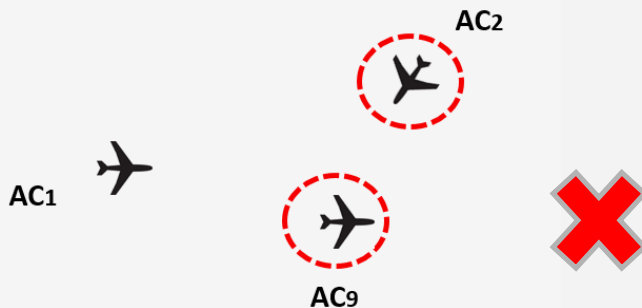
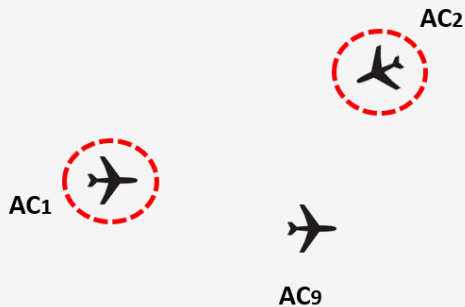
Assist controllers in their conflict resolution
duties



Conflicts and Complexity

The resolution of a conflict should not lead to a more complex situation

...Or worse, to a new conflict



Traffic as a Graph

We propose a spatio-temporal graph theoretic approach to measure sector complexity

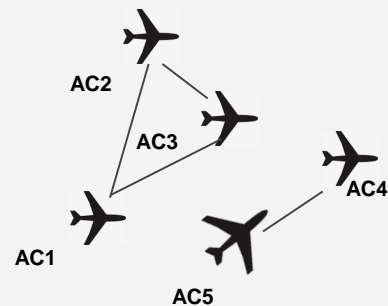
Defining interdependencies:

$$wh_{i,j} = \begin{cases} 1 & \text{if } dh_{i,j} \leq H \\ 0 & \text{if } dh_{i,j} \geq thresh_h \\ \frac{thresh_h - dh_{i,j}}{thresh_h - min_h} & \text{otherwise} \end{cases}$$

$$wv_{i,j} = \begin{cases} 1 & \text{if } dv_{i,j} \leq V \\ 0 & \text{if } dv_{i,j} \geq thresh_v \\ \frac{thresh_v - dv_{i,j}}{thresh_v - min_v} & \text{otherwise} \end{cases}$$

$$w_{i,j} = \begin{cases} \frac{wh_{i,j} + wv_{i,j}}{2} & \text{if } wh_{i,j} > 0 \ \& \ wv_{i,j} > 0 \\ 0 & \text{otherwise} \end{cases}$$

Modeling traffic as a graph:



• • Spatio-Temporal Complexity Indicators

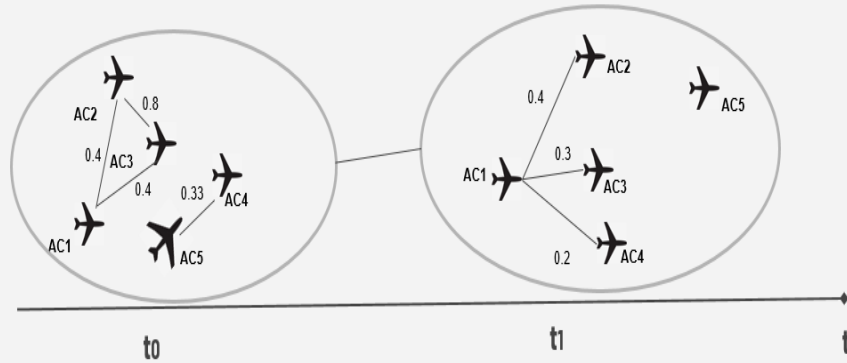
Define complexity analogous to graph connectivity

Edge Density: $ED(G) = \frac{\sum_{(i,j) \in E} w_{i,j}}{A(V)}$
 where $A(V) = \frac{|V|(|V|-1)}{2}$.

Strength: $s(i) = \sum_{j=1}^N w_{i,j}$

Clustering Coefficient: $CC(i) = \frac{1}{(s(i)(deg(i)-1))} \sum_{j,h} \frac{(w_{i,j} + w_{j,h})}{2}$

Nearest Neighbor Degree: $NND(i) = \frac{1}{deg(i)} \sum_{j=1}^N w_{i,j} deg(j)$



- •
- • **A Methodology to Understand Air Traffic Complexity**
- • **through Spatio-Temporal Indicators**
- •
- •

Several advantages

Evaluate:

Show that all indicators are needed

- Flown traffic
- Miles-in-Trial

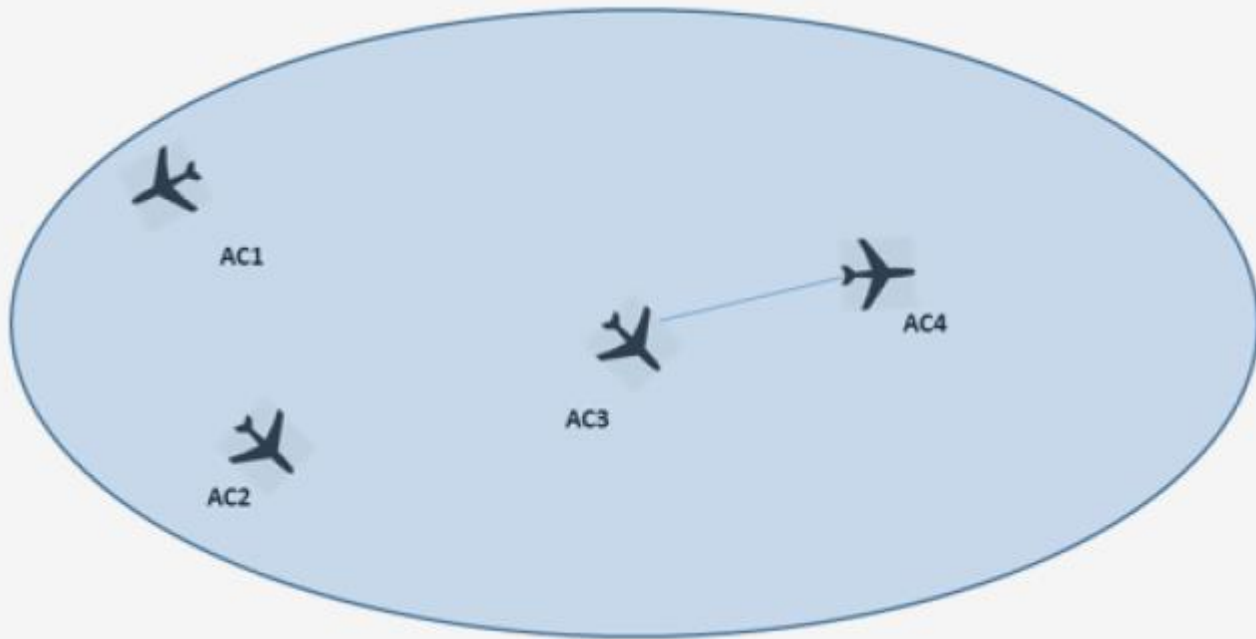
Future work:

- Single aircraft complexity
- Ecosystem complexity
- Reinforcement learning

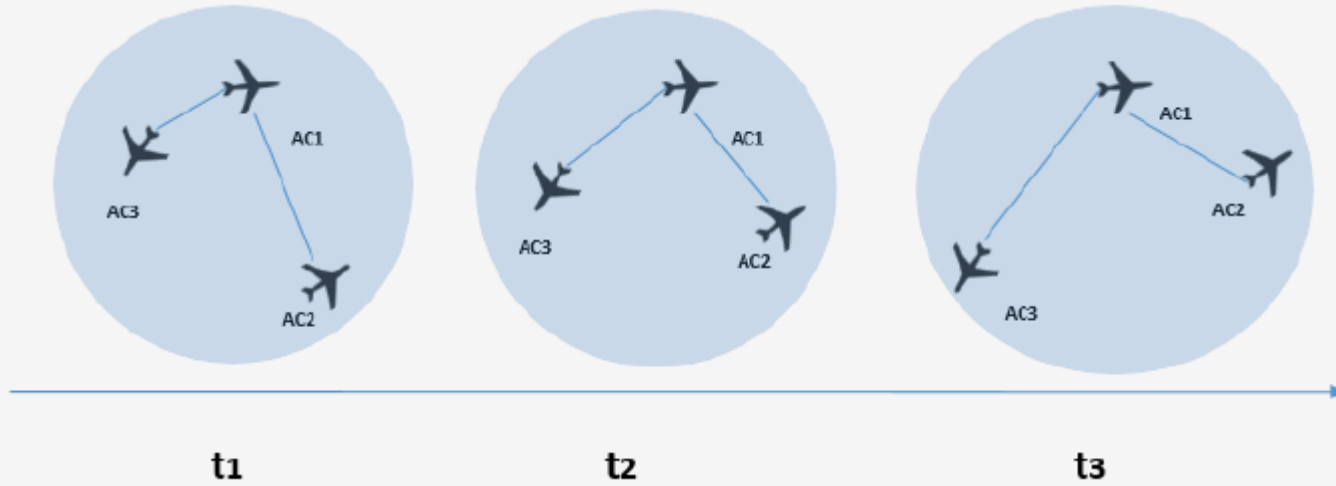
The image features a minimalist design with two thin, dark gray lines. One line starts at the bottom left corner and extends diagonally upwards towards the top left. The other line starts at the bottom left corner and extends diagonally upwards towards the top right, creating a wide, open angle. The text "THANK YOU!" is centered within this angle.

THANK YOU!

Edge Density



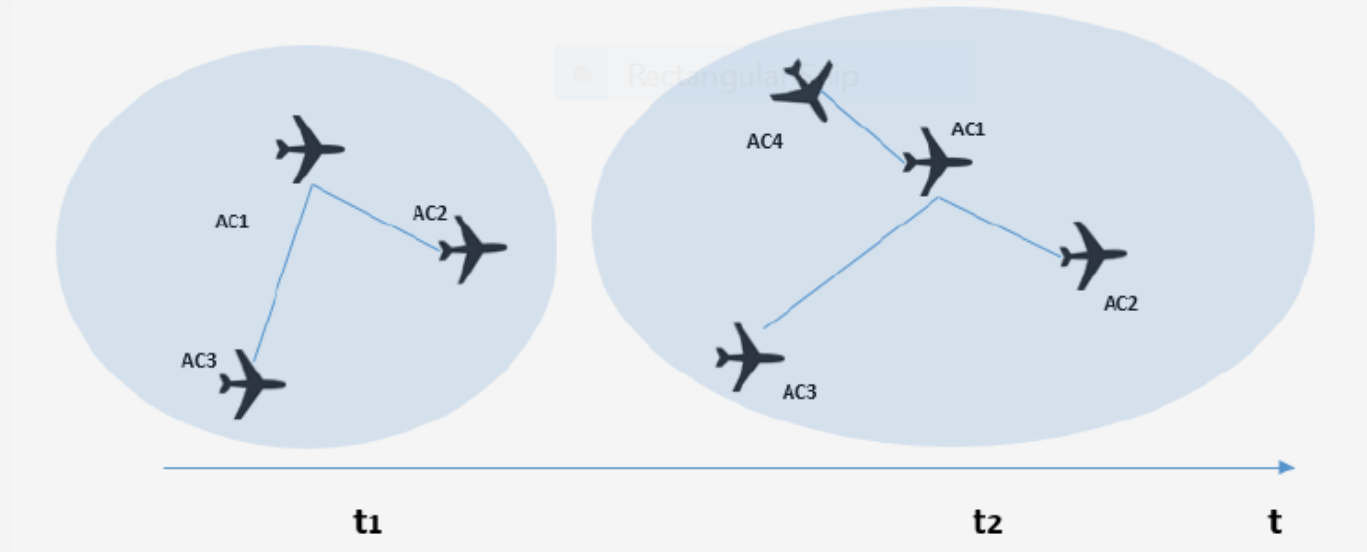
Strength



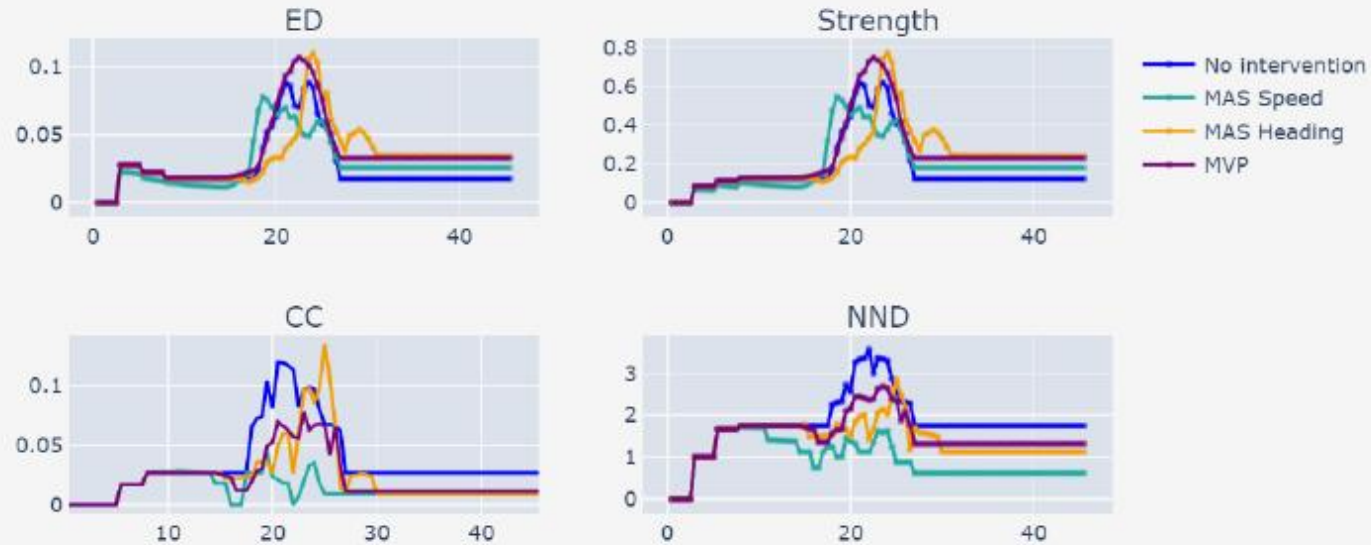
Clustering Coefficient



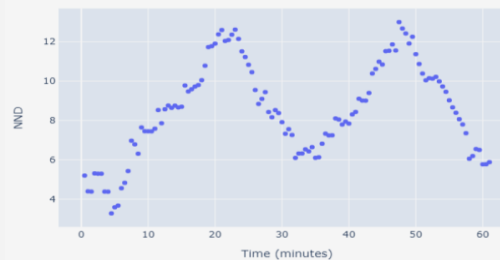
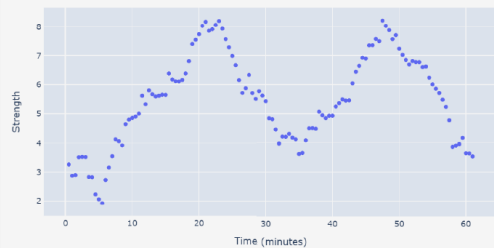
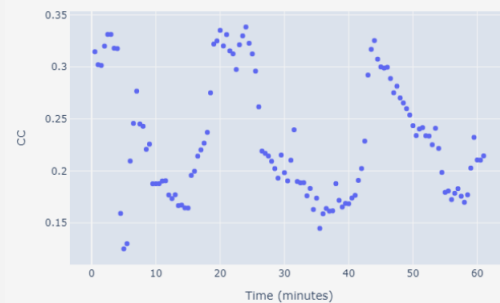
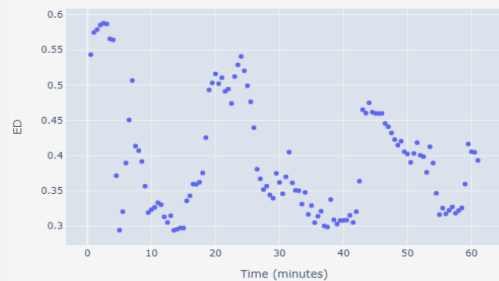
Nearest Neighbor Degree



Miles in Trail



Indicators



ED	Strength	CC	NND
0.39	0.86	0.64	0.88

Correlation Between Indicators

	ED	Strength	CC	NND
ED		0.65	0.54	0.61
Strength	0.65		0.83	0.98
CC	0.54	0.65		0.82
NND	0.61	0.98	0.82	