Generating optimal aircraft trajectories with respect to weather conditions
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Generating optimal aircraft trajectories with respect to weather conditions

Goal: Compute optimal routes in Cruise Flight.

Why? Increase Air Traffic Capacity and reduce time travel and fuel consumption.

Assumption: Constant Air Speed and Constant Flight Level.

Our methodology: Front Propagation method
Relied on Ordered Upwind Algorithm: technique to track the propagation by solving a partial differential equation known as the Hamilton-Jacobi equation:

\[
\|\nabla u\| F = \frac{\nabla u}{\|\nabla u\|} = 1, \text{ where } u \text{ is the optimal cost and } F \text{ is the speed of the front in the normal direction}
\]

Principle:
1 - Start at the initial point with the cost \( u=0 \);
2 - Compute the propagation of the front from the initial point corresponding to the minimal cost \( u \);
3 - Construct the optimal path by tracing backward.

One aircraft

Without Obstacle
Speed of the front: \( F = \text{Aircraft Ground Speed} \)

With Obstacles
\( F = \text{function(Aircraft Ground Speed, Obstacles)} \)

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Optimal route</th>
<th>Direct route</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal route</td>
<td>1470</td>
<td></td>
</tr>
<tr>
<td>Direct route</td>
<td>1498</td>
<td></td>
</tr>
</tbody>
</table>

Profit: \( \approx \) 30 seconds for 30 min of flight time; 1.9% of time saved for the trajectory.

Several aircraft

Idea: Propagate the front in the configuration space of several aircraft.

Example: for two aircrafts, state space \( \mathbb{R}^4 - \Delta \) with \( \Delta = \{(x_1, y_1) = (x_2, y_2)\} \) and \( (x_1, y_1, x_2, y_2) \in \mathbb{R}^4 \) the coordinates of both aircraft.

Problem: Curse of dimensionality.

Proposed solution: Use Approximate Dynamic Programming methods to compute good approximations and not the exact optimal trajectories.

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