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**:

$$
\nabla u \cdot F(x, \nabla u) = 1, \text{ where } u \text{ is the optimal cost and } F \text{ is the speed of the front in the normal direction}
$$

$$
u = 0 \text{ on the initial point}
$$

**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:** ≈ 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 $\Delta = \{(x, y, x_1, y_1) \text{ and } (x_1, y_1, x_2, y_2) \in \mathbb{R}^4 \}$ 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.