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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.

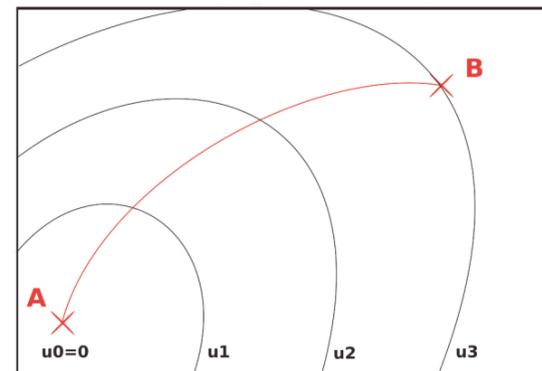
Our methodology : Front Propagation method

Relied on **Ordered Upwind Algorithm**: technique to track the propagation by solving a partial differential equation known as the **Hamilton-Jacobi equation**:

$$\begin{cases} \|\nabla u\| F\left(x, \frac{\nabla u}{\|\nabla u\|}\right) = 1, & \text{where } u \text{ is the optimal cost and } F \text{ is the speed of the front} \\ & \text{in the normal direction} \\ u = 0 & \text{on the initial point} \end{cases}$$

Principle:

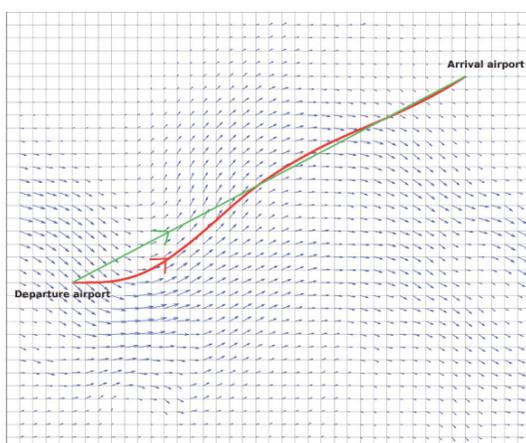
- 1 - Start at the initial point with the cost $u=0$;
- 2 - Compute the propagation of the front from the initial point corresponding to the minimal cost u ;
- 3 - Construct the optimal path by tracing backward.



One aircraft

Without Obstacle

Speed of the front: $F = \text{Aircraft Ground Speed}$

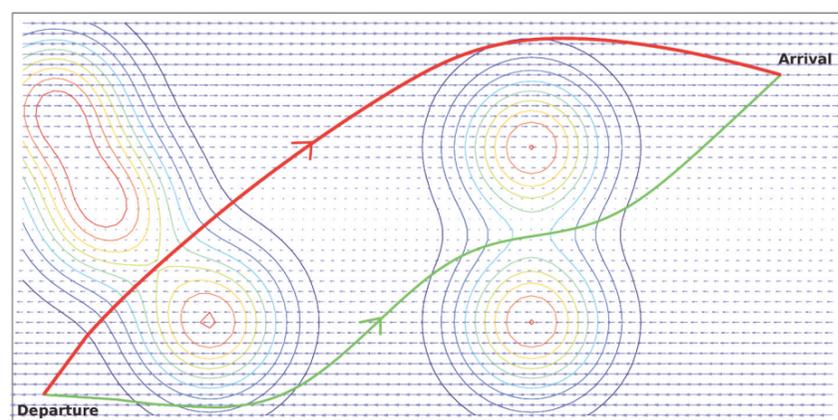


	Time (seconds)
Optimal route	1470
Direct route	1498

➔ **Profit:** ≈ 30 seconds for 30 min of flight time; 1.9% of time saved for the trajectory.

With Obstacles

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



No obstacle (blue) Impassable obstacle (red)

Optimal path without wind (green)
Optimal path with wind (red)
Wind (blue arrows)

➔ A different optimal path with or without wind.

Several aircraft

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

Example: for two aircrafts, state space $\mathfrak{R}^4 - \Delta$ with $\Delta = \{(x_1, y_1) = (x_2, y_2)\}$ and $(x_1, y_1, x_2, y_2) \in \mathfrak{R}^4$ 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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