Towards an intelligent decision-support tool for air traffic controllers

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Research team

The thesis takes place within the **OPTIM team** of the ENAC research laboratory.

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Context

One of the objectives currently targeted in ATM is to allow air traffic controllers to manage traffic in a context of less structured routes with a high demand rate. However, the control tasks still rely much more on human experience than on computing power. Current research targets decision support tools that could help reduce air traffic controllers workload while improving the traffic flow. Nevertheless, they all encounter a major issue related to the lack of accuracy of the trajectory prediction model and therefore of conflict detection.

Goals

- Develop **intelligent algorithms** to help resolve air conflicts on a classic control sector ;
- Suggest solutions in **consistency with the operating mode of human controllers**, in order to make the tool acceptable and useful ;
- Integrate constraints and **environmental costs** into the algorithm, to favor solutions with less impact in terms of carbon.

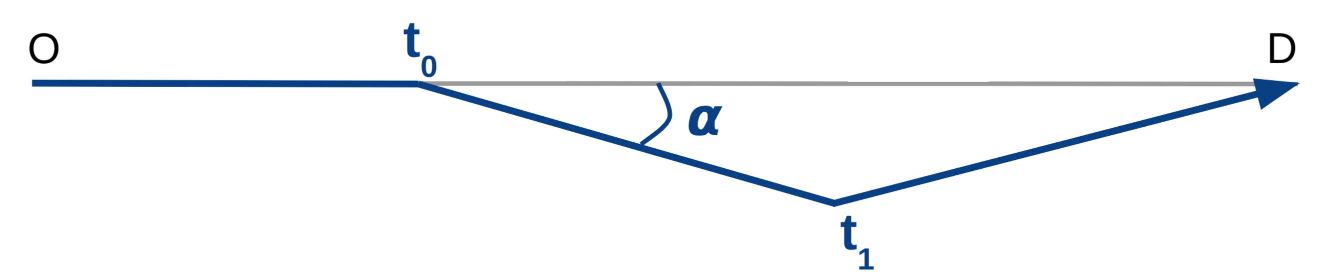
Method

Artificial Intelligence (AI) methods will be used to develop these algorithms, combining **metaheuristics** and **machine learning**.

→ An **Evolutionary Algorithm** (**EA**) developed at the ENAC optimization laboratory already offers automatic conflict resolutions using simple maneuvers similar to human controllers practice.

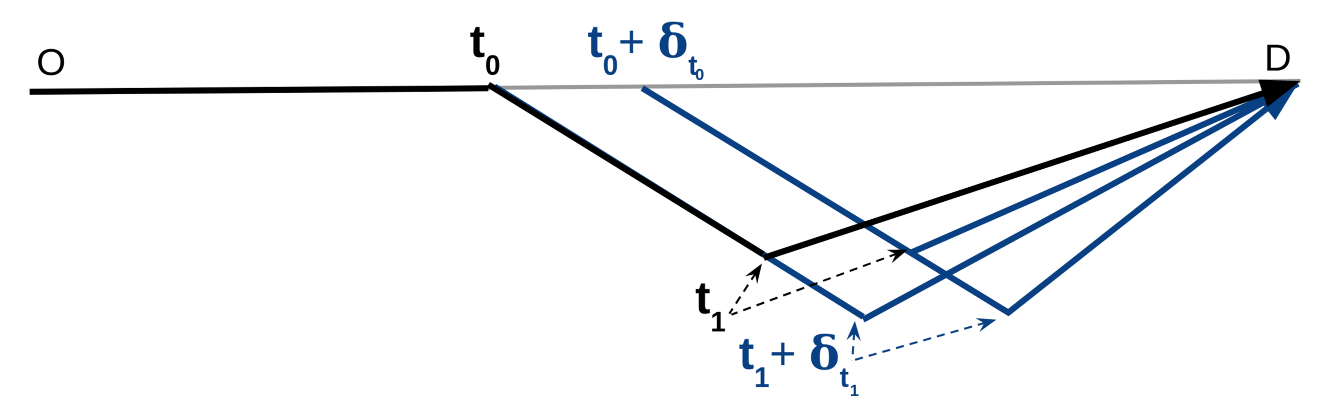
Modelization

To model maneuvers, we introduce **sources of uncertainties** in trajectory modeling.
A maneuver is a change of heading of α degrees, from time t_0 to time t_1 as we can see in the following illustration. The aircraft initially goes directly from O to D, but changes heading at time t_0 and returns to its original destination at time t_1.

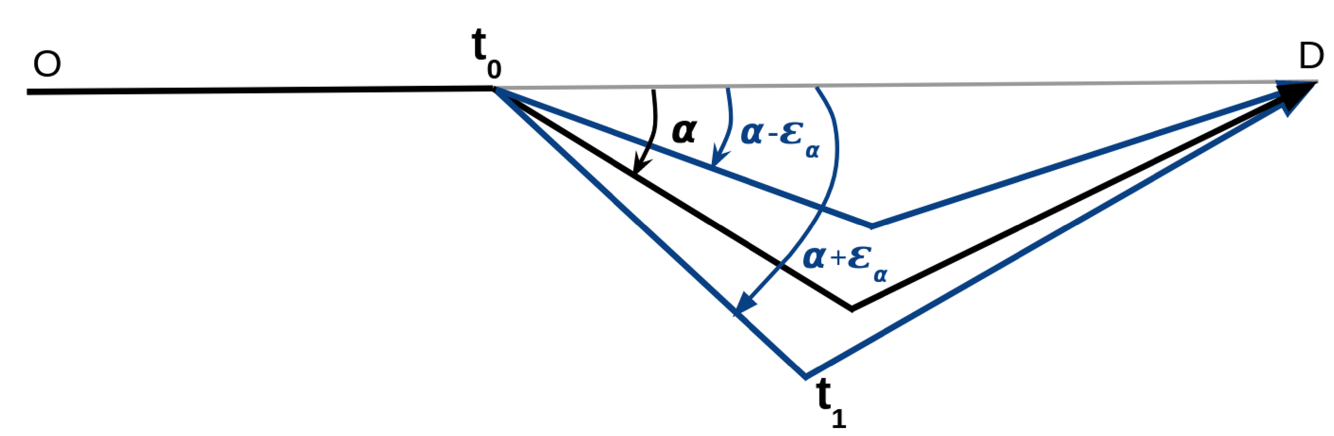


There are **4 main uncertainty parameters** :

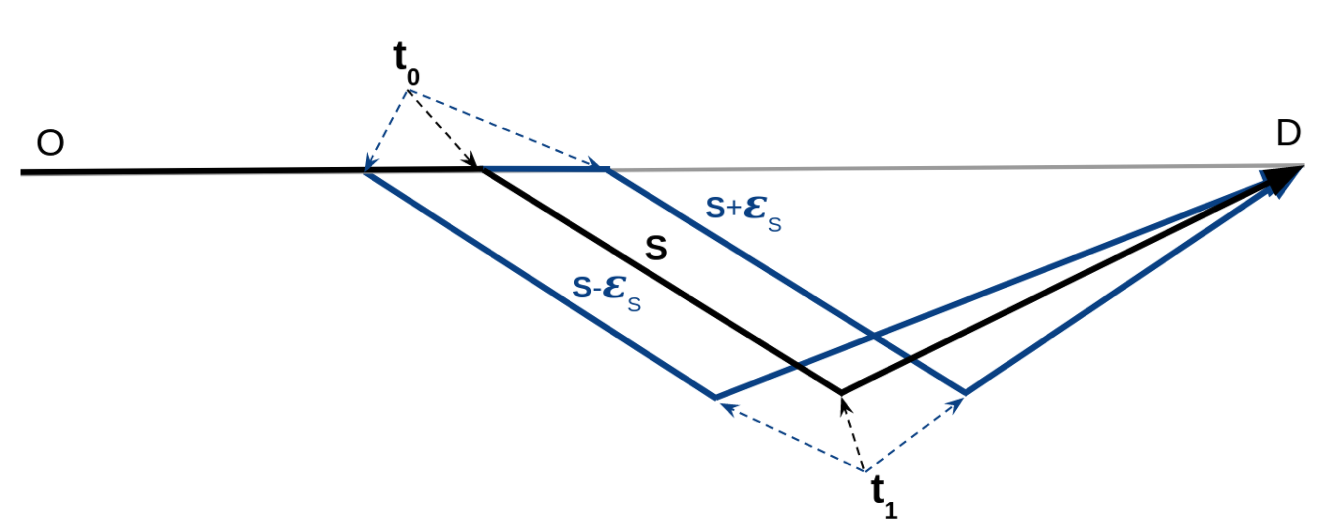
- δ_{t_0} : the maximum reaction time for beginning a maneuver ;
- δ_{t_1} : the maximum reaction time for resuming the initial route ;



- ε_α : is associated with the heading change angle α ;



- ε_s : the speed uncertainty.



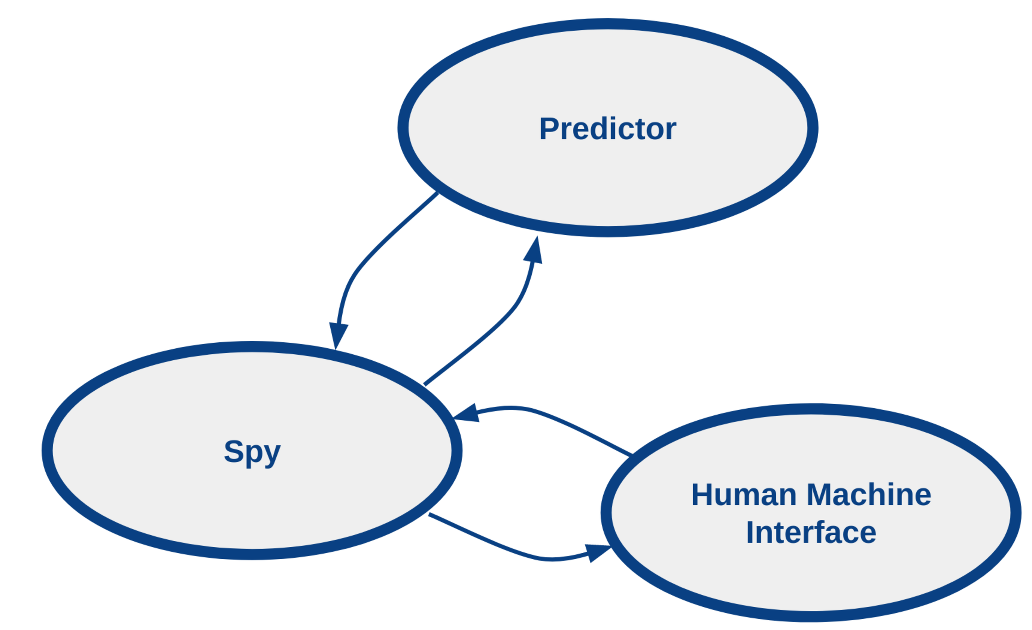
Theoretical approach

A dynamic optimization problem: One of the goals is to properly calibrate the uncertainties previously defined, and to continuously suggest solutions to the air traffic controller. Therefore, we will compare different approaches.

- **Naive approach** : reset the evolutionary process when a change occurs [1].
- **Explicit memory approach** : use external memory to store past items that may be useful in future stages of the evolutionary process. For example, after each execution of the EA, the final population is saved and it is reused at the next launch of the solver [2].
- **Innovative approach** : continuously run our EA and scale its population every X generations depending on the current situation.

Operational issue

The objective is to define a decision support tool which would communicate (via a program called Spy on the diagram) with the controller's HMI.



References

[1] Kalmanje Krishnakumar. "Micro-Genetic Algorithms For Stationary And Non-Stationary Function Optimization". In: *Intelligent Control and Adaptive Systems*. Ed. by Guillermo Rodriguez. Vol. 1196. International Society for Optics and Photonics. SPIE, 1990, pp. 289–296. DOI: 10.1117/12.969927. URL: https://doi.org/10.1117/12.969927.

[2] J. Branke. "Memory enhanced evolutionary algorithms for changing optimization problems". In: *Proceedings of the 1999 Congress on Evolutionary Computation-CEC99 (Cat. No. 99TH8406)*. Vol. 3. 1999, 1875–1882 Vol. 3. DOI: 10.1109/CEC.1999.785502.