Data-driven trajectory imitation with reinforcement learning

Executive summary

Building on the knowledge gained from the DART SESAR ER-2 project on enhancing our trajectory prediction abilities, and aiming at building a straightforward data-driven approach following deep reinforcement learning techniques, we approached the learning process (a) as an imitation process, where the algorithm tries to imitate ‘expert’, demonstrated trajectories, (b) exploiting raw trajectory data enriched with contextual data that provide information relevant to the evolution of trajectories, and (c) based on reward models that are learned during imitation.

It is the objective of this project to learn models for the evolution of trajectories, exploiting historical, demonstrated trajectories, which (models) can be used for predicting future trajectories. Towards this goal we formulated the trajectory imitation problem as a Markov Decision Process and applied deep reinforcement learning (DRL) methods.

Contributions made are as follows:

a) We approached the flight trajectory prediction problem as an imitation problem, using DRL models learnt from historical data: According to our knowledge, this is the first time that these state-of-the-art machine learning techniques are used for the prediction of the trajectories. We delivered two methods, which have been evaluated using short (single-FIR) and long (multiple-FIR) trajectories, with very promising results.

b) We have used advanced algorithms for identifying the features relevant to airspace users for evolving flight trajectories, towards learning their reward model. Tactical interactions and conflicts between trajectories are not explicitly addressed.

c) We have built a generic methodology and computational framework for the prediction of trajectories, comprising methods for identifying patterns of demonstrated trajectories (modalities of behaviour), identifying the features relevant to following different modes of behaviour, classifying future trajectories, and predicting trajectories using DRL methods.

Contributions to the ATM Master Plan are as follows:

a) Increased abilities for flight prediction and planning, by means of learning models of trajectories planned and flown by airspace users.

b) Improved operations productivity via contributions to improved flight prediction and planning.

We believe – based on the outcomes produced – that this project will serve as a catalyst for the use of deep reinforcement learning methods to predict short/long trajectories in ATM, either at the pre-tactical or at the tactical stages of operations, following an imitation learning approach: The project surely matured the ideas and advanced the data-driven trajectory prediction methods produced in DART, as well as improved the state of the art in data-driven trajectory prediction.

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