Probabilistic information Integration in Uncertain data processing for Trajectory Prediction ('PIU4TP')

Executive summary

The PIU4TP project aims to develop a data - driven methodology named P4T (Prediction for Trajectory) for the prediction of the flight trajectory in terms of selection of the most likely sequence of waypoints in the strategic and pre-tactical phases, starting weeks before the flight execution with the declared flight intention of the airspace users and ending few hours before the estimated off blocks time.

The tactical management of an ordered, efficient and safe air traffic is currently highly affected by a number of uncertainties, which will finally require many modifications to flight plans and can produce relevant delays on the schedule of flights.

The P4T methodology aims to investigate how flight plans can be better predicted, from long to short term before scheduled time of flight, by considering historical data and uncertainties on current forecasts of some relevant parameters. This methodology, providing reliable predictions of flight plans, is expected to allow ATFCM centres to perform a sound management of the uncertainties affecting the air traffic and to limit changes to the plans in the tactical phase, so improving ATM efficiency, punctuality and reducing environmental impact. Safety will be also affected by limiting ATCO workload and reducing the risk of hotspots occurrence.

Actually, there is a large number of parameters that can affect the optimal flight plan selection. A few of these, among the most relevant ones, have been considered in the project, specifically the weather forecast and the estimated take-off weight. Indeed, the project is a proof of concept. Its objective is to consider some parameters that mainly affect the selection of the optimal flight plan and to investigate how the information about these parameters and related uncertainties, which characterize the parameters forecast before the flight, can be exploited in an integrated approach to perform in advance a reliable prediction of the flown trajectory. Although the developed methodology is demonstrated considering few uncertain inputs, it is generic and applicable also to a wider set of uncertain inputs. Indeed, all the steps that define the methodology developed in this project can be applied to different use cases, which consider different sets of uncertain inputs (if the historical data and current prediction of these uncertain inputs are available). Obviously, the models obtained with the applied techniques need a new training, considering the new input variables, and this need for re-training is a primary requirement of Machine Learning, due to its data-driven character. This re-training step allows us to always maintain a high prediction accuracy.

The idea of P4T is to build the predictive model of flight trajectories by applying Data Mining and Machine Learning (ML) techniques. Instead of programming explicitly a computer to solve a difficult problem, ML uses algorithms to learn from past experience (historical data) how to obtain behavioural models based on complex but statistically reliable rules. This model, once implemented, will use as input the weather forecast and take-off aircraft mass estimation, with related uncertainties. Indeed, the exploitation of the uncertainties on the inputs allows associating probabilistic information to the predicted trajectories and this is the main innovative feature of the proposed methodology. Therefore, PIU4TP represents a change of perspective. The project aimed to demonstrate that the **uncertainty** inherently present in a weather forecast and that also normally affects the take-off weight data before the flight, could augment the knowledge base available to the Network Manager (NM) transforming the uncertainties in a valuable information for a more efficient flight trajectory planning and allocation.

The trajectory prediction capability can allow the network manager anticipating air traffic flow requests, supporting the decision-making process of flight distribution among sectors and flight

routes, and thus avoiding an excessive tactical management of the flights. On this path, the project starts from very low TRL and moves from the concept to TRL 2, first designing a methodology for flight plan prediction and then performing a preliminary demonstration based on simulated data and a simplified use case. This allows evidence to be provided of the proposed methodology applicability, and potential benefits arising from its use.

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