DART

Data Driven Aircraft Trajectory Prediction Research

NEWSLETTER

No. 3 -May 2018

CHALLENGE

DART aims to deliver data-driven techniques to improve the performance and accuracy of single and multiple trajectory predictions, accounting for ATM network complexity effects.

RESEARCH ISSUES

• What are the supporting data required for robust and reliable trajectory predictions?

• What is the potential of data-driven machine learning algorithms to support high-fidelity aircraft trajectory prediction?

• How the complex nature of the ATM system impacts the trajectory predictions?

DART CONTRIBUTIONS

- DART contributes to providing individual trajectory predictions, which in combination can be used for assessing the impact of the network on individual flights' delays: These developments contribute directly to enhanced Traffic/Demand Forecast services from long term planning in 4D Trajectory Management context.

- DART agent-based methods contribute to the integration of 4D constraints issued from multiple sources replacing current slot allocation (based on first planned/first served principle) to resolving DCB problems, while providing the common baseline for AU and ATM Network operations to reach agreement on Shared Business Trajectories.

- DART methods contribute to realizing tools (for use in strategic and pre-tactical timeframes) that provide functionality for simulating, evaluating and resolving imbalances between demand and capacity at a future time and date, given the applicable environment. Appropriate visualizations proposed provide the basis for the display tools to be used.

- Evaluation results show that DART agent-based methods have the capacity to fully resolve DCB problems at the planning phase, while they enable a better utilization of available resources, also incorporating stakeholders' preferences on flight delays.

- Agent based methods developed in DART provide the basis for tools for assisting NM decision-making by identifying, arbitrating and resolving multiple imbalance and hotspots, towards optimizing delays and utilization of airspace resources.

DART AT A GLANCE

CALL	SESAR-2-2015
OBJECTIVE	DATA SCIENCE IN ATM
DURATION	JUNE 2016 – JUNE 2018
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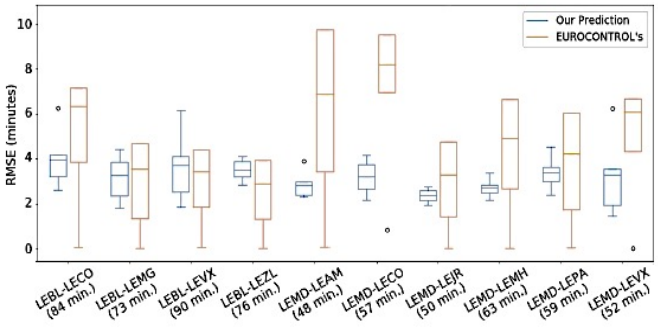
MAIN RESULTS FOR TRAJECTORY PREDICTIONS AND DCB RESOLUTIONS

PREDICTIONS WITH HIDDEN MARKOV MODELS (HMM):

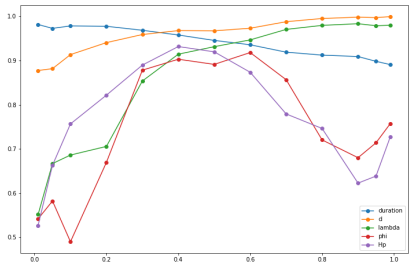


HMM vs EUROCONTROL ETA prediction:
RMSE values in minutes for each route between our predictions versus Eurocontrol's prediction show that our predictions yields better median scores, in most of the cases, while the standard deviation values in Eurocontrol's ETAs are much larger, resulting in larger windows of predictability at arrival.

PREDICTIONS USING ENRICHED TRAJECTORIES EXPLOITING FLIGHT PLANS:

Introducing flight plans and their waypoints as reference for the learning models introduces significant results to improved prediction performance, producing 3-D prediction errors consistently in the order of 2-3 km per waypoint.

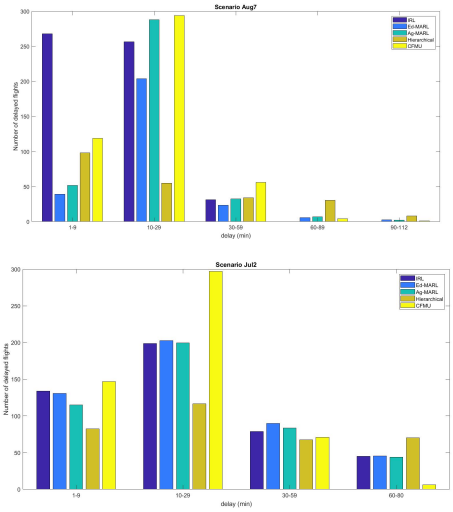
PREDICTIONS USING AIRCRAFT INTENT:



Random Forest R^2 scores (y-axis) vs. normalized flight duration (x-axis): As a general conclusion for all algorithms, these perform well in the cruise phase of flight where accuracy of prediction is very close to 100%, however algorithms have lower performance when predicting the trajectory for the phases of departure and arrival.

AGENT BASED MODELS FOR RESOLVING DCB PROBLEMS:

Agent based solutions to DCB problems introduce a new paradigm for reducing delays imposed to flights while at the pre-tactical phase, also w.r.t. stakeholders' preferences on flight delays.



The above figures provide indicative assessment of distribution of delays to flights in the Spanish airspace in two days: Results are from the 4 DART methods (resolving all hotspots) compared to CFMU regulations (type C - resolving few hotspots)

COMMUNICATION & DISSEMINATION ACTIVITIES

Alongside the **International Conference for Research in Air Transportation (ICRAT) 2018**, DART in collaboration with **datAcron** H2020 project will be organizing a workshop on **Data-Enhanced Trajectory Based Operations**.

http://icrat.org/icrat/upcoming-conference/data-tbo-workshop/

DART Publications in DASC 2018:

-C.Spatharis et al: Multiagent **Reinforcement Learning Methods for Resolving Demand-Capacity Imbalances**, accepted in DASC 2018.

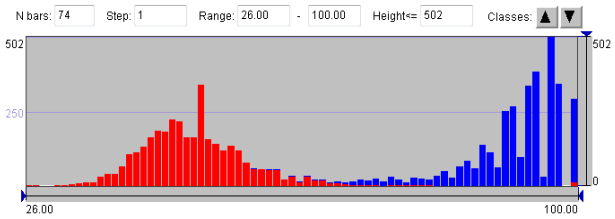
-E. Casado, A. Muñoz: **Data-driven Aircraft Trajectory Predictions using Ensemble Meta-Estimators**, accepted in DASC 2018

VISUALIZATIONS AND VISUAL ANALYTICS

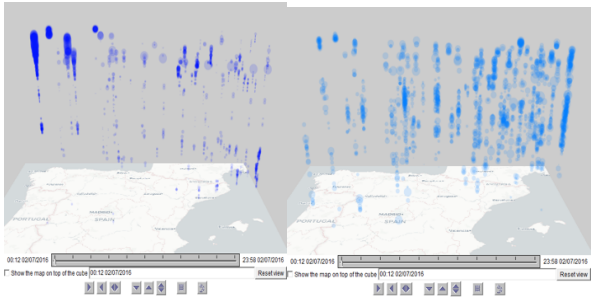
Visualization, interaction techniques and interfaces support the exploration and evaluation of results of trajectory prediction algorithms, particularly, comparison of predicted trajectories to real ones and comparison of predictions obtained with different algorithms or different parameter settings.

Visual exploration of results is beneficial for analysts and stakeholders (e.g. Aircraft Operators), to fine-tune prediction algorithms and to understand better the reasons for deviations.
The following figures provide indicative examples:

Linking points to compare trajectories



The above histogram shows the statistical distribution of the proportions of the matched points between trajectories (e.g. proportions are higher for the blue trajectory than for the red one).



Overview of an agent-based solution (left) in comparison to the CFMU solution (right) towards resolving DCB problems in a specific day, showing the intensity of delays in a space-time cube

(from bottom to top: start to end of the day)

RESULTS & BENEFITS

- Data-driven trajectory prediction capabilities;
- Agent-based methods for resolving DCB problems;
- Interactive visual interfaces for supporting interactive exploration of modelling results in space and time, supporting decision making.

DART CONSORTIUM

This project has received funding from the SESAR Joint Undertaking under grant agreement No 699299 under European Union's Horizon 2020 research and innovation programme