DART

Data Driven Aircraft Trajectory Prediction Research

NEWSLETTER

No. 2 -November 2017

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?**
- **How can this insight be used to optimize the ATM system**

SHAPING THE FUTURE: DART VISION

DART explores the applicability of a **collection of machine learning** and **agent- based models and algorithms** to derive a **data-driven trajectory prediction capability**. Advanced **visual analytics techniques** are used to facilitate data exploration, quality assessment, and algorithms parameters and features selection.

During the 1st consultation meeting we had with stakeholders on September, we shaped **the DART vision**: To advance **collaborative decision-making processes that support multi-objective optimization** taking the **requirements of the different actors in the ATM system** into account **at the planning phase** (i.e. few days before operation):

- **Aircraft Operators (AOs)**: Minimizing the cost thought maximizing the adherence to the airlines preferred FPs.
- **Network Manager (NM):** Decide which flights to modify to resolve sector imbalances and potential conflicts.
- **Air Navigation Service Providers (ANSPs):** Minimizing the sector imbalances and potential conflicts.

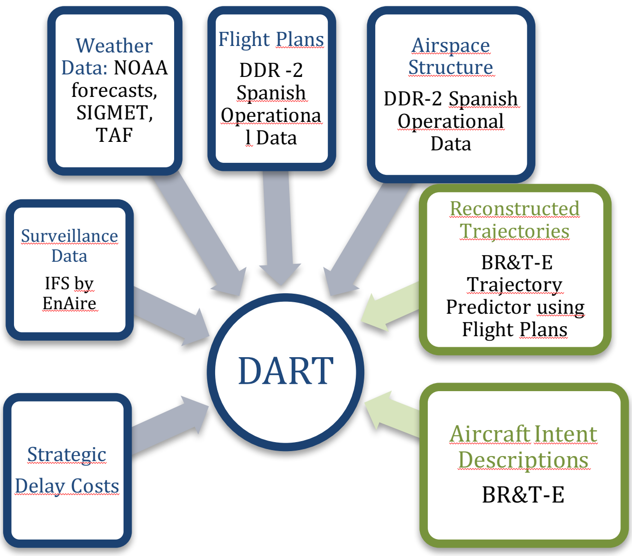
The overall workflow in collaborative decision making is shown in the following picture.

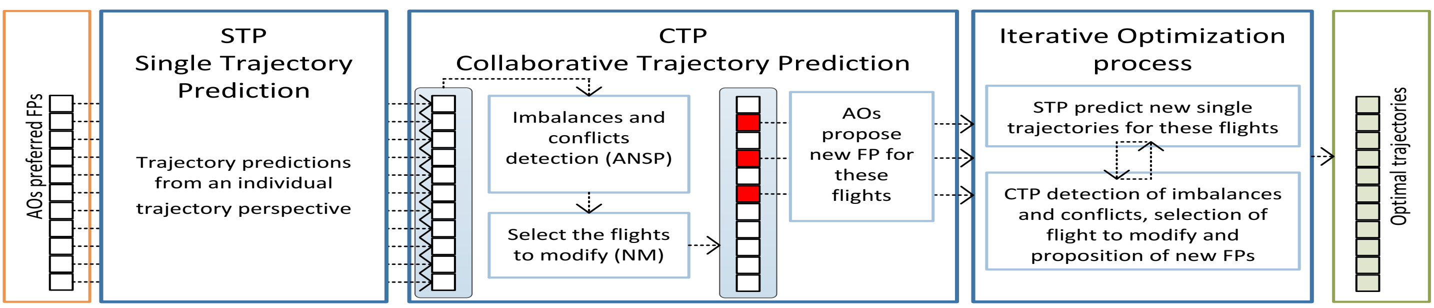
DART AT A GLANCE

Call	SESAR-2-2015
Objective	Data Science in ATM
Duration	June 2016-June 2018
Contact	**Project Coordinator**
	Prof. George A. Vouros University of Piraeus Research Center, Greece georgev@unipi.gr
	Scientific Manager
	Dr Georg Fucks IAIS Fraunhofer, Germany georg.fuchs@iais.fraunhofer.de

URL: **http://www.dart-research.eu**

DART DATA SOURCES (UPDATED)

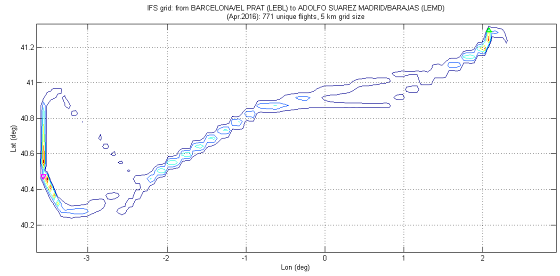




DART ALGORITHMS

HIDDEN MARKOV MODELS (HMM): trajectory prediction using discrete spatio-temporal state-transition models.

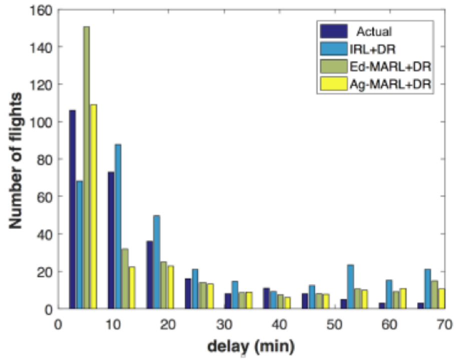
SIMILARITY-BASED RETRIEVAL (CLUSTERING): trajectory prediction by means of an N-dimensional clustering task of data series.



REGRESSION MODELS: trajectory prediction using an N-dimensional regression task w.r.t. data series.

REINFORCEMENT LEARNING: Markov Decision Process (MDP/POMDP): trajectory prediction using a state-action-reward model in order to obtain an optimal policy on any instant of the flight.

JOINT (COLLABORATIVE) TRAJECTORY PREDICTIONS: Formulate the problem as a multi-agent Markov-Decision-Process and solve it via collaborative, decentralized reinforcement learning methods.



Distribution of delay(*mins*) to flights achieved by RL methods compared to the actual ones.

COMMUNICATION & DISSEMINATION ACTIVITIES

SESAR INNOVATION DAYS

- DART Presented in **SID 2017**, Belgrade, Servia, the article **DART: A Machine-Learning Approach to Trajectory Prediction and Demand-Capacity Balancing**

USA & Europe ICRAT International Conference on Research in Air Transportation

- Alongside the **International Conference for Research in Air Transportation (ICRAT) 2018**, DART (in collaboration with datAcron project) will be organizing a workshop on **Data-Enhanced Trajectory Based Operations**.
  Please visit the following webpage for additional details: http://icrat.org/icrat/upcoming-conference/data-tbo-workshop/

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.

Visually supported detection of clusters of trajectories and flight plans :

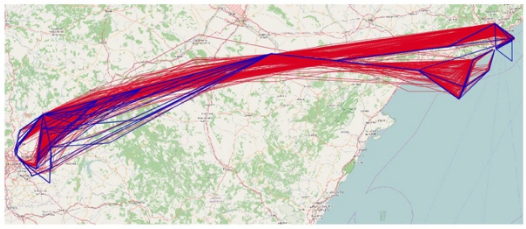
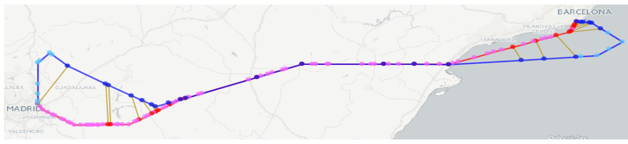
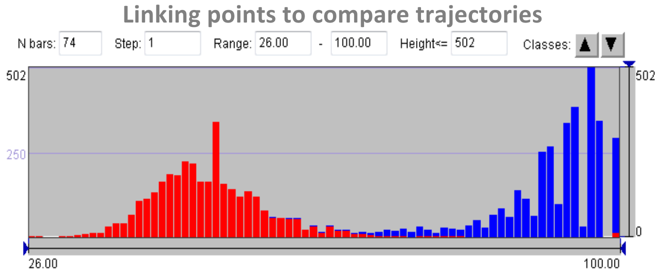


Illustration 2: LEMD2LEBL 703 flights, in blue flight plans and in red true flight routes

Historical data provide **recurrent patterns of trajectories** (enriched with contextual information – e.g. weather) that data-driven methods learn.
Prediction of a single trajectory involves **choosing the pattern that fits better a flight plan w.r.t. contextual data**.
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.



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).

RESULTS & BENEFITS

•Data-driven trajectory prediction capabilities;

•Agent-based multiple trajectory prediction abilities;

•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