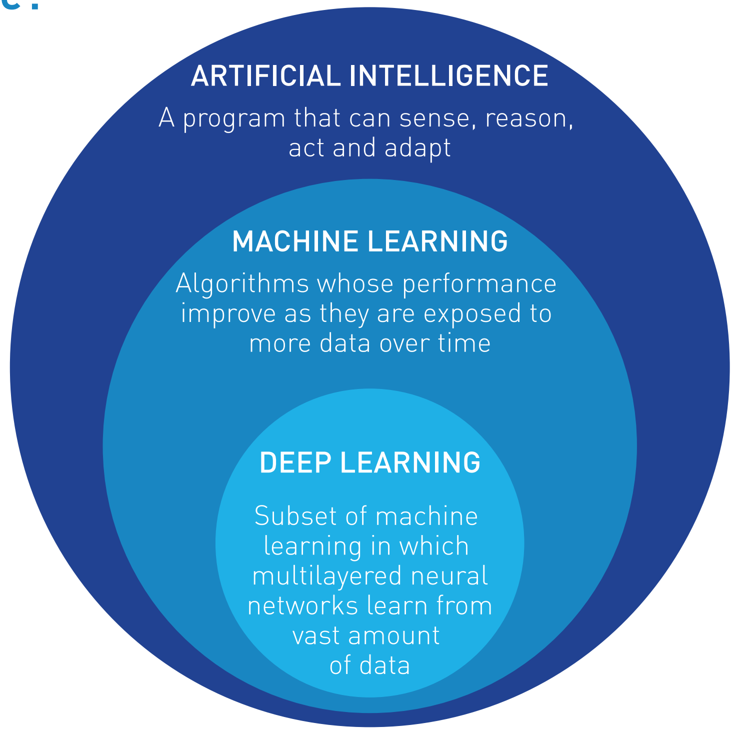
Artificial intelligence in air traffic management

I. What is artificial intelligence?

Artificial intelligence (AI) is a branch of computer science that aims to create intelligent machines. It has become an essential part of the technology industry.

Machine learning is a core part of AI. It uses data to train algorithms and give computer systems the ability to "learn" (i.e. progressively improve performance on a specific task) with data, without being explicitly programmed.

Deep learning is the most advanced type of machine learning. In recent years, the availability of large amount of data ("big data") and the leap forward in computing power have paved the way towards unprecedented levels of performance, allowing for new levels of automation.



II. AI in SESAR

The SESAR Joint Undertaking has funded a number of exploratory research projects, which have applied AI to address a variety of issues faced by air traffic management in Europe. These include the need to increase the predictability of traffic at different phases of flight, improve passenger flows at airports, and enable greater automation of the system. The use of advanced technologies to modernise aviation and ATM is at the heart of SESAR's digitalisation strategy. In the future, more projects will be launched to further investigate the application of AI, clockchain, and internet of things (IoT) to enhance the overall performance of aviation (safety,efficiency, security...).

III. Better predictability of air traffic in Europe

a. Performance trade-offs

INTUIT (Interactive toolset for understanding trade-offs in ATM performance) explored the potential of visual analytics and machine learning techniques to improve our understanding of the trade-offs between air traffic management key performance areas (KPAs)* and to identify cause-effect relationships between indicators. The work of INTUIT was structured in the form of case studies (CS), machine learning was applied in two of them:

*Safety, environment, capacity, efficiency

Identifying sources of en-route flight inefficiencies

This case study investigated the causes of inefficient routes in the European air traffic network and their effects on performance. A machine learning model was trained in order to assess performance for a certain airspace area, in particular at air traffic control (ACC) level. Performance was modelled as a function of flight properties derived from both the flight plan and the ideal route, such as heading, altitude and airspace crossed. The novelty of this assessment is that it is not based on globally calculated performance indicators, but on interrelationships found through machine learning techniques. In order words, the model was able to detect patterns that were not previously known and up until now had not been taken into account when establishing key performance indicators.

Modelling airline route choices

In this case study models were developed to predict traffic during the strategic planning phase, when no flight plan is available to know which route the airline will choose. Machine learning was used to analyse recorded data in order to identify airlines' decision criteria. These criteria could be used to predict route choices also in case of changes in environmental conditions (e.g. changes of route charges). Better predictability allows Europe's Network Manager to make a more stable plan for the airspace, with fewer adaptations made in the short-term, all of which is more cost effective.

b. Trajectory prediction

While INTUIT predicted which routes airlines will take before the flight plan is filed, the COPTRA project focused on predicting the trajectory closer to the time of take-off or during the flight. More precisely predicting when aircraft will enter into a particular part of airspace. COPTRA built probabilistic models for the prediction of the occupancy and demands of the European airspace and airports, taking into account the uncertainty in planned flight trajectories to support improved demand-capacity balancing (DCB).

Machine learning was used to estimate the intended cruise speed of an aircraft when they are still climbing. This information about the trajectory was fed into a model that was previously trained with recorded trajectories. Based on the predicted trajectories, congestion indicators were calculated for use in DCB decision making.

Another project, DART (Data-driven aircraft trajectory prediction research) explored the applicability of a collection of data mining, machine learning and agent-based models and algorithms to derive a data-driven trajectory prediction capability. Those algorithms are expected to provide increased levels of accuracy while considering ATM network effects in the prediction process, which have been rarely introduced by current state-of-the art solutions.

IV. Better passenger flow at airports

Big data is becoming a big deal for airports, as it is increasingly used to better analyse market demand, optimise security control and customise the passenger experience. The use of big data analytics is now being put to work to better understand how passenger behaviour can impact air traffic management. Research in these areas has so far been constrained by the limited availability of behavioural data, typically obtained from static demographic and economic datasets, often consisting of very small samples, and usually complemented with assumptions about behaviour.

Thanks to the growth of smart devices and interconnected services, researchers now have large-scale, detailed longitudinal (dynamic) data allowing them to test hypotheses about passenger behaviour. Partners from the BigData4ATM project investigated how different passenger-centric geo-located data can be analysed and combined with more traditional demographic, economic and air transport data to identify patterns in passenger behaviour, door-to-door travel times, and choices of travel mode. Machine learning methods were used to support the analysis of the data-sources. The project is also exploring applications of this data and how it could be used to inform ATM decision-making processes.

Machine learning has also been applied in SESAR in a live trial to improve to improve passenger flight connections at Heathrow.

V. Improving airport operations efficiency

Nowadays, air traffic control (ATC) instructions at the airport are usually still given via voice communication to the pilots. But ATC systems, to be safe and efficient, need up-to-date data. Therefore, it requires lots of inputs from the air traffic controllers (ATCOs) to keep the system data correct. Automatic speech recognition converts speech to text and is, therefore, an alternative input modality. Tools such as AcListant® and AcListant®-Strips have been tested in Dusseldorf and Vienna, and have shown that they can help reduce time taken to keep data up to date and increase ATM efficiency (fuel savings of 50 to 65 litres per flight).

Currently, modern models of speech recognition require manual adaptation to local environments. The project MALORCA (Machine Learning of Speech Recognition Models for Controller Assistance) designed a low-cost solution that adapts the speech recognition tools for use at other airports. The solution automatically learns local speech patterns and controllers models from radar and speech data recordings which are then automatically encoded into the recognition software.

VI. Future applications of AI in aviation and ATM

In the future, Europe's skies will be extremely busy and complex. As the numbers of air vehicles increase along with their levels of automation, so will the need to further automate the air traffic management system, while keeping the human in the loop.

One potential future research area is the application of machine learning to improve the automation of ATM functions, with a view to increasing the efficiency of the system. Specifically, AI leading to automation would enable the definition and application of smart strategies for managing air traffic and ensuring a high degree of air-ground integration. Automation would also allow for certain tasks to be offloaded, enabling pilots and air traffic controllers to focus on safety critical tasks.

However, ATM still remains a safety critical industry and the introduction of such technologies must undergo rigorous research to ensure they can meet with the high safety and security requirements of aviation. In this respect, the SESAR programme will continue to explore advances in this domain and develop applications that can further improve air traffic management and aviation in Europe.

VII. Resources

More about the projects:

- http://coptra.eu/
- http://dart-research.eu/
- https://www.intuit-sesar.eu/
- https://www.bigdata4atm.eu/

Material from broader industry perspective:

- Machine learning, artificial intelligence and air traffic management (NATS)
- AI and aerospace (AIRBUS)