Advanced Autoplanner — A Competent Digital Colleague

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Introduction

In the Advanced Autoplanner project we set out to find out if it is technically possible to develop a model that, with the help of Artificial Intelligence (AI), predicts future conflicts between aircraft and suggests air traffic control instructions to maintain the minimum separation between aircraft. It is expected that the use of AI within air traffic management can lead to increased operational efficiency and decreased air traffic controller workload, while maintaining or increasing safety and quality of service.

The Project

In the project, resources from LFV and IBM got together to develop an AI model that provides air traffic control instructions for one En-route sector in the Swedish airspace. The model was developed using the Design Thinking methodology [1] and was named the Advanced Autoplanner—AAP, Fig. 1.

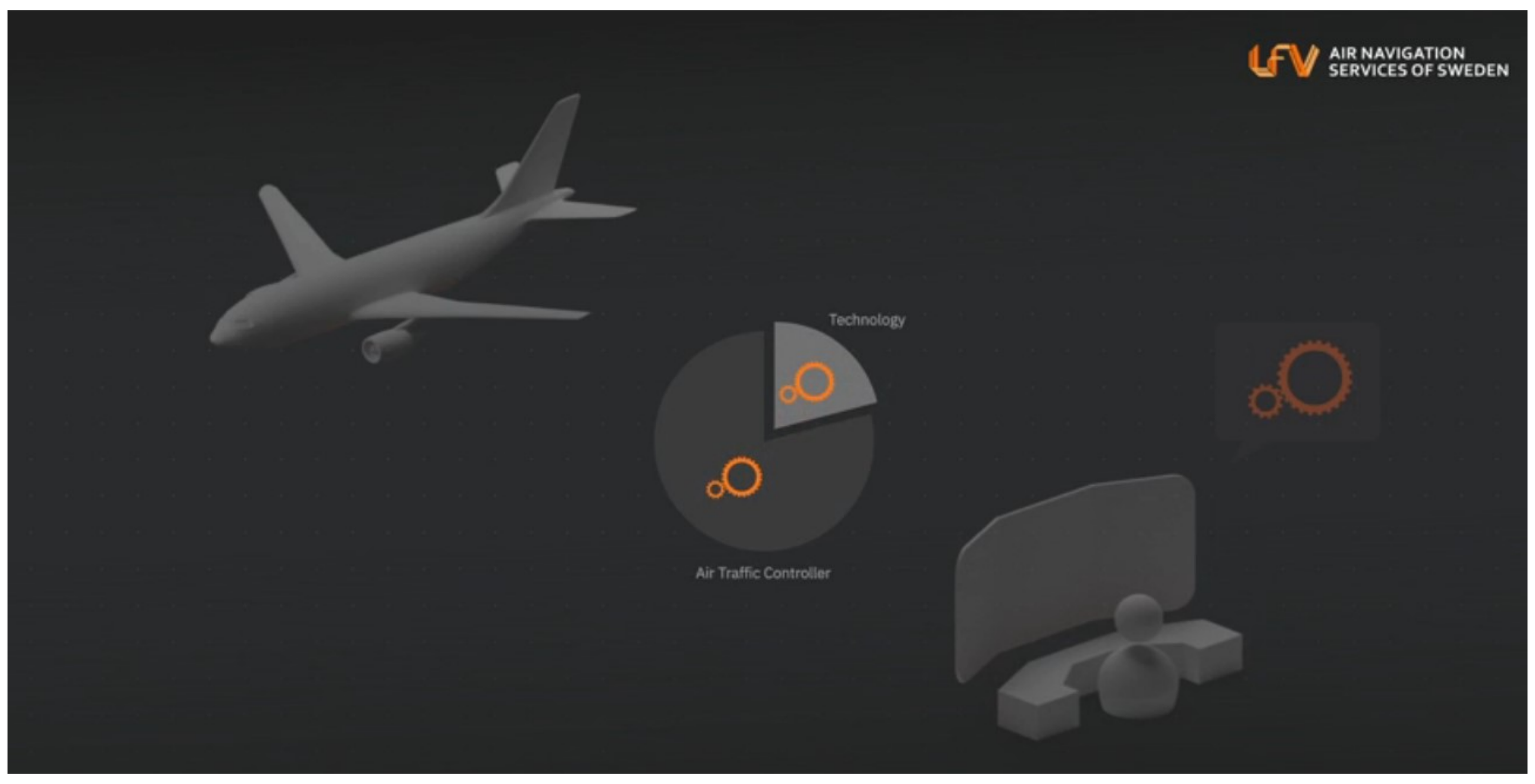

Figure 1: AAP concept overview that shows how the air traffic controller and the AI may work together in the future to control the air traffic.

Working principle of the AAP

The core idea behind the AAP is to use a pre-defined search space and intelligent pruning of low quality subspaces to gain efficiency, to produce high quality resolutions, and to ensure explainability of the automatized decisions. The algorithm uses a geodesic interpolation technique with a set of tracklets according to flight plans to search and detect future conflicts. When a conflict is detected between two aircraft, the AAP visit resolution nodes in a search hierarchy. Evaluation is performed for each node in the search path, assessing feasibility and quality of the resolution. Depending on the evaluated results along the nodes, and stopping criterions, the search is bound to a subset of safe and efficient resolutions. A visualization of the search strategy is presented in Fig. 2. The algorithm then chooses the best resolution in the resolution set according to a prioritizing scheme derived by air traffic control expertise. With the information of which nodes were visited and evaluated, conclusions can be drawn from the AI reasoning, hence achieving explainability.

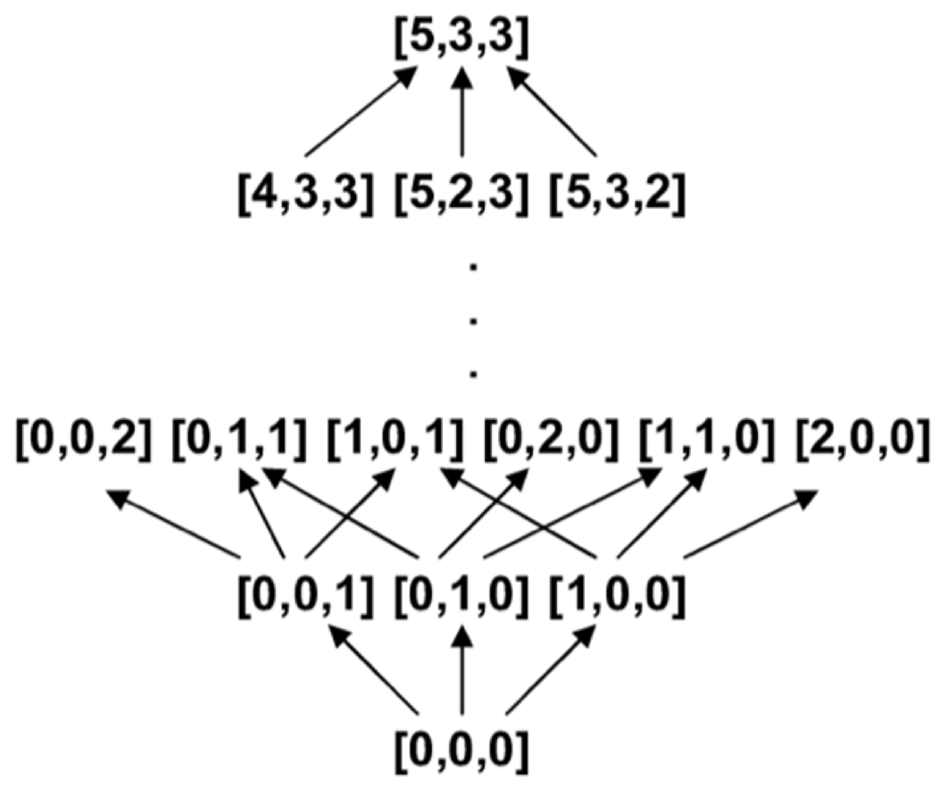

Figure 2: The search strategy can be thought of as a lattice structure with nodes representing a proposed resolution in three dimensions [ΔSPD, ΔHDG, ΔALT]. Arrows indicating node inter-reachability i.e. if they can be compared with each other. The AAP algorithm traverses the lattice in the resolution search by visiting the nodes in a down-up, left-right manner. The algorithm discriminates sub-sets of nodes that defines resolution of lower quality according to the node-hierarchy and a defined set of rules. When a defined number of feasible resolutions are identified, the algorithm chooses one resolution from the feasible set according to a prioritizing scheme.

Results and Future Work

The AAP algorithm demonstrates promising results during validation in a typical Swedish En-route airspace sector [2][3]. The algorithm is indicating good performance in normal traffic density as well as for increased traffic density with only a small number of occurred conflicts. It was concluded that the resulted conflicts were due to poor predictive capability on aircraft behaviour due to that the AAP was lacking certain information on aircraft performance characteristics and due to delay when searching for resolutions and/or in the communication from the model to the simulator. Even though this minor setback, the AAP is seen as a promising solution approach for higher levels of automation within air traffic control, to be further developed and improved to meet the safety standards of aviation.

LFV will continue to work on the solution together with RISE (Research Institutes of Sweden) and Linköping University in the Advanced Autoplanner 2 project. As well as addressing the issues described above, we also intend to integrate the model into a tool that can propose the instructions to an air traffic controller in preparation for future implementation. Some of the other factors that will be of interest are to adjust certain input parameters to the model, to assess the use of a Machine Learning component, explore time dimension (i.e. tactical planning ability) and include weather and no-fly-zones.

Acknowledgements

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References

[1] IBM Design, https://www.ibm.com/design/approach/design-thinking/

[2] Sofia Rydell, Advanced Autoplanner Final Report, 2021-03-24, https://fudinfo.trafikverket.se/fudinfoexternwebb/pages/PublikationVisa.aspx?PublikationId=4600

[3] Demonstration video for the project: https://lfv.se/en/news/news-2020/ai

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