Aerospace Europe Conference 2023
Joint 10th EUCASS – 9th CEAS Conference

Abstract #XXX *(to be filled by the organizers)*
Preferred Topics: SUSTAV / SYSINT / FDGNCAV
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Type: Oral
Status of corresponding author: Regular

Title

Single and Multi-Agent Reinforcement Learning Approach to Optimise Aircraft Ground Trajectories in Airports

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Abstract

Today, airports are vital nodes that connect countries and people around the world. Unfortunately, with the projected increase in air traffic over the next two decades, the global airport ecosystem is likely to be disrupted. Indeed, most major airports are currently operating at the limits of their capacity, and an increase in the number of aircraft will have an impact on ground operations, resulting mainly in flight delays, inefficient routing, and excessive fuel consumption. In addition to the operational issues, there is also an environmental issue because by burning large amounts of fuel, aircraft engines emit various pollutants that affect the air quality around airports.

Recognizing this dual operational and environmental problem, the aviation industry has initiated a reflection to revolutionize traffic management, and thus move towards a more efficient and environmentally friendly trajectory management.

The objective of this study is to present a methodology based on the use of reinforcement learning to optimize the ground trajectories of aircraft in an airport. Basically, reinforcement learning is a machine learning technique that allows an agent to learn to make the best decisions in the form of actions in an environment that may be unknown. In this study, an agent represents an aircraft on the ground, while the environment represents the airport in which the aircraft is moving. In addition, the airport is created using a graph structure, where each node of the graph represents a geographical point, and each segment connecting two nodes is a portion of a taxiway (or runways) that the aircraft can used to navigate. For this purpose, a tool was developed to automatically create the graph structure of an airport using its ICAO code and open-source data obtained from OpenStreetMap. Currently, a database of over 5000 airport graphs has been created. As a first step of the study, aircraft were trained to find the shortest path between a departure point (for example a gate) and destination point (for example, runway entry point). Different reinforcement learning algorithms (ex. PPO, A2C, etc.) were tested and compared to determine the one that was the most appropriated for the problem. Similarly, an analysis was also conducted to determine a suitable neural network structure for the agent.

Preliminary results showed that out of 400 simulations, the agent was able to find the shortest path in 95% of the cases. In 4% of the cases, the agent chose another path, which was not the shortest but was still acceptable. In only 1% of the cases, the agent did not reach its destination. Several simulations were also tested considering 10 to 20 agents in the same airport. For each agent, random departure and arrival points were set. In most cases, it was observed that the agents were able to reach their destination by following the shortest path. The preliminary results are very encouraging and highlight that the use of reinforcement learning can be a good solution to move towards a more efficient and sustainable management of aircraft trajectories on the ground.