Optimal Approach Trajectories for Multiple Aircraft Considering Disturbances and Configuration Changes

Abstract:
In the paper at hand, cost-index-optimal trajectories for multiple aircraft approaching an airport in the presence of wind disturbances are calculated. The optimization is based on optimal control techniques using the full trapezoidal discretization scheme implemented in FALCON.m1[1], and the gradient based numerical optimization software IPOPT[2]. The main result presented here is a modeling technique and a multi stage solution process for large scale trajectory optimization problems from the field of ATM. In the first stage of this process, each trajectory is optimized individually, before afterwards multiple problems for an increasing number of aircraft are solved. Finally, optimal trajectories for all aircraft in the scenario result, that adhere to the flight envelopes and separation limits while minimizing the total cost index summed up over all aircraft in the scenario. The aircraft dynamics are simulated using point mass simulation models in three dimensional space with the aerodynamics and the fuel flow models taken from the Base of Aircraft Data Family 4 (BADA 4) published by EUROCONTROL [3]. The considered scenario – part of the approach to Tokyo International Airport – is based on real trajectories extracted from MLIT CARATS Open Data published by the Japanese Ministry of Land, Infrastructure, Transport and Tourism. Besides, the scenario includes the influence of wind, modeled based on data from the Earth System Research Laboratory. In the scenario, the optimal
state and control histories for 18 aircraft as well as the optimal points in time for deploying the flaps are
determined. The inherent discrete decision problem of sequencing the aircraft is automatically solved by
the numerical optimization algorithm in parallel to the calculation of the trajectories. The optimization
stops prior to the final approach fix.

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