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Aircraft Runway Acceleration in the Presence of Severe Wind Gusts[1]

Nikolai D. Botkin, Varvara L.Turova

Technical University of Munich

botkin@ma.tum.de

Abstract: Aircraft runway acceleration in heavy wind conditions is a complicated problem because the pilot has to control such crucial parameters as the lateral deflection and its rate (runway overrun danger) and to keep the roll angle in a certain range to avoid the wing contact with the ground. It should be noticed that an aircraft in runway acceleration is very sensitive to wind disturbances, and therefore unpredictable wind gusts may cause a crash. Thus, it is reasonable to consider runway acceleration as a conflict-control problem based on the concept of guaranteed result. Such an approach has been implemented in [1] where a linearized non-stationary model consisting of five equations was considered. The control parameter was the rudder angle whose magnitude and rate of change were restricted. It was assumed that the nose gear rotation angle is equal to one third of that of the rudder. The aim of control was formulated as bringing the side deflection and its time derivative to a prescribe target set at the and of runway acceleration.

In the paper presented, a more general runway acceleration model is considered. In particular, phase constraints are imposed on all of the variables, nonlinear dynamics equations are used, and more control factors are accounted for. The approach is based on the theory of differential games. Optimal control laws and the worst-case wind behavior are constructed using the value function that is a viscosity solution of an appropriate Hamilton-Jacobi equation. It should be noticed that grid methods can stably solve Hamilton-Jacobi equations arising from conflict-control problems with state constraints in up to four spatial dimensions (see e.g. [2]). Therefore, different ways of reduction of the original model to four or less dimensions are discussed. The results are compared with those from [1].

[1] Botkin N. D., Krasov A. I. Feedback control of an aircraft during runway acceleration, in: Guaranteed-Result Positional Control (in Russian), Ural Department of the Academy of Sciences of USSR, Sverdlovsk (1988), pp. 22–32.

[2] Botkin N. D., Hoffmann K.-H., Turova V. L. Stable numerical schemes for solving Hamilton-Jacobi-Bellman-Isaacs equations. SIAM Journal on Scientific Computing 33 (2), 992–1007, 2011.

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