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Study and application of virtual flight simulation for rolling control of vehicles

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Highlights

- A newly coupling simulation method was established to evaluate the performance of Flight Control system. The new method would completely consider the unsteady aerodynamic effect induced by rapid motion of vehicles or unsteady flow, while in the old engineering method, only less or even none unsteady effect is considered.
- The simulation results firstly demonstrate that the traditional method may underestimate the lag of the control system, and the new established method is suitable far more than traditional method especially for a vehicle under the rapid maneuver.

Abstract

The unsteady effect of aerodynamics is inadequately considered in the evaluation of performance of Flight Control System (FCS) using traditional engineering technique based on the aerodynamic model or database. To improve the evaluation accuracy, especially for the strong unsteady effect of aerodynamics, the coupling simulation technique of PID (Proportional-Integral-Differential) controller, CFD (Computational Fluid Dynamics) and RBD (Rigid Body Dynamics) is founded. The aerodynamic model in engineering technique is instead by the real-time unsteady aerodynamic forces/moments in the new coupled technique including unsteady effect of aerodynamics induced by motion of vehicle and deflection of aileron. Therefore, the evaluation accuracy of flight control system can be improved.

The control process in roll on a square cross section vehicle is carried out using the engineering technique and the coupled technique, and the study shows that, the simulation results with different method correspond well with each other at slow maneuver condition where unsteady effect of aerodynamics is weak. However, the time lag of FCS using engineering technique is much smaller than that using coupled technique at rapid maneuver state, i.e. the time lag of the FCS may be underestimated with traditional method. This indicates the necessity of the coupled technique in the evaluation of FCS for strong unsteady effect state such as high angle of attack or rapid maneuver.

Keywords: PID controller; CFD/RBD/FCS; unsteady effect; coupled method; rolling control