Simulator aircraft model fidelity evaluation based on pilot control behavior

Background

Pilots conduct a major part of their flight training in flight simulators. The main reason for this is the safe training environment, the increased efficiency in repetition and the reduced costs compared to in-flight training. The fidelity of the simulator is a key factor to guarantee the effectiveness of simulator-based training.

One crucial factor that determines a flight simulator’s fidelity is the quality of the mathematical simulation model that is used to emulate the aircraft’s flight dynamics. This model is constructed based on flight test and wind tunnel data made available by aircraft manufacturers.

Current official regulations for aircraft model fidelity are given in terms of the model objective fidelity, by enforcing maximum possible deviations of a model’s response from flight test data. However, how these deviations affect pilot control behavior, task performance and training effectiveness are not considered.

Progress

The current work is on evaluating difference between pilot control behavior with and without motion feedback for different controlled elements. Since it is supposed that each channel of the pilot is fully used when the schematic representation of a close-loop is built, to evaluate whether this is true or not is crucial when pilot controls certain controlled elements. And it is expected that for some controlled elements, motion feedback is fully utilized by pilot, however, for some other controlled elements, pilot only uses visual signal to execute the control task even when the motion feedback is provided.

Why is manual control still needed?

To quantitatively study pilot control behavior, the pilot model is built based on McRuer’s theory in this case:

\[ H_v = \frac{H_{ve}}{1 + \tau \omega} = \frac{1}{\omega^2 + \tau^2} \]

\[ H_m = \frac{H_{me}}{1 + \tau \omega} = \frac{1}{\omega^2 + \tau^2} \]

Generally, pilot adjusts his/her control strategy when controlling different controlled element by tuning the equalization term which includes gain, lead and lag terms, and always being limited by the time delay and neuromuscular terms.

Pilot model identification

Currently, two identification techniques are used here: 1. Fourier Coefficient Method (FC) 2. Genetic-Maximum Likelihood Method (MLE). FC is a non-parametric method from which the pilot frequency response function (FRF) can be obtained at frequency set of the forcing functions. MLE is based on maximizing the possibility of obtaining the pilot’s real output data gathered from experiment. In order to overcome the shortcoming of nonlinear optimization, genetic algorithm is used to generate the initial parameters for MLE.

Paper being working on

T. LU, D. M. Pool, M. M. van Paassen, M. Mulder, “Effect of the Motion Feedback on Pilot Control Behavior in Compensatory Tracking for Different Controlled Elements.”