MASTER

Modeling of stewart platform dynamics for flight simulators

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Master Thesis

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Summary

Modeling of Stewart Platform Dynamics for Flight Simulators

In this report, three dynamic models of a Stewart platform that is used as a flight simulator training device (FSTD) are presented. These dynamic models are used to predict the perceived accelerations of a pilot inside the simulator. Each of the dynamic models contains various levels of detail in the dynamics of the prismatic actuators. The first dynamic model is a rigid body model that accounts for the rigid bodies in the actuators. The second dynamic model accounts for sliding friction phenomena in the actuator, and the third includes a model approximation of the first eigenmode of the actuator. In addition to the dynamic models, a kinematic model of the Stewart platform with actuators is used as a benchmark against which the capabilities to predict the perceived accelerations obtained from the dynamic models are compared.

The sliding friction and stiffness parameters in the dynamic models of the actuator have been determined and validated through experiments on a test rig. These validations show that in the test rig, model predictions of the actuator position and motor torques correlate. In addition to the test rig experiments, six actuator models are combined to form a Stewart platform model. In this model, the model parameters, which were identified in the test rig, are reused. Simulated and experimental results of motor torques, actuator positions, and perceived acceleration by the pilot of this Stewart platform are compared. From this comparison, it is clear that the models are capable of reliably predicting the accelerations perceived by a pilot on the platform, including the vibrations in accelerations caused by sliding friction phenomena and the first eigenmode of the actuators.

The dynamic models are then used to predict the outcome of the so-called objective motion cueing test (OMCT), which in the future might become mandatory in the commissioning of flight simulator training devices. In these flight simulators, so-called motion cueing algorithms are used to control the position of a moving platform such that the pilot perceives motion representative of that in the airplane. The OMCT tests the combination of the motion cueing algorithm and the dynamics of the Stewart platform using transfer functions and fidelity criteria in the frequency domain. The outcome of the OMCT, for two out of ten tests, obtained from the dynamic models are compared to the predicting capabilities of a kinematic model and the results obtained from experiments in this project. These comparisons show that, under some conditions of the controller, a kinematic model is sufficient to reliably predict the outcome of the OMCT in simulation. These conditions require the tracking performance of the moving platform's position to be sufficient, which can be verified by the dynamic models developed in this project. Moreover, it is shown that the dynamic models capture nonlinear effects in the time domain, which are true to the physical system, but negatively affect the results of the OMCT both in simulation and in practice. These nonlinear effects are not included in the kinematic model and are not captured by the OMCT, which inherently assumes linearity of the FSTD dynamics.