CO-SIMULATION APPROACH FOR COUPLING A STATE ESTIMATOR WITH AEROELASTIC MULTI-BODY MODELS

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ABSTRACT

Modern aircraft have many sensors on board that are used for both control of the aircraft and monitoring the aircraft's condition. For health monitoring applications, nowadays, an assessment is performed in order to detect the criticality of the loads on the aircraft's structure using look-up charts or neural network algorithms based on external parameters such as vertical and lateral acceleration, aircraft mass, roll, pitch, and yaw rate (Wilson, 2013). However, since the conditions of the real event in general will differ from the simulations used to create the look-up charts or neural networks, these black-box approaches are limited in their capability of classifying events. This paper discusses the use of aeroelastic multi-body models in a discrete extended Kalman filter. By using multi-body models in nonlinear state observers, the loads acting on the aircraft structure could be accurately estimated from measurement data of sensors that are commonly available on modern aircraft, such as accelerometers on the wing, rate gyros and strain gages. An advantage of this method is that the underlying model of the estimator is fundamentally physics based, as opposed to the current table look-up or neural network models.

An FMI-based co-simulation approach is proposed to transform the multi-body differential-algebraic continuous-time equations into a set of discrete ordinary differential equations, for use in an ODE type of state estimator such as the extended Kalman filter. FMI is a standard for cosimulation and model exchange and defines how to the couple two or more simulation tools. This standard also specifies a set of functions to couple a model with a state estimator. The proposed approach is validated numerically with an industrial-size high-fidelity model of a fixed-wing aircraft, which contains a flexible airframe and detailed multi-body models of the nose and main landing gear, for a hard landing case. It is expected that this approach will improve health monitoring

applications by providing a method for virtually observing unmeasurable quantities such as internal structural loads.

REFERENCES

Wilson, T. (2013). Application of Uncertainty Management to Improve Reliability of Hard Landing Criticality Assessment Criteria. In International Forum on Aeroelasticity and Structural Dynamics.