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AN EFFICIENT FINITE ELEMENT MODEL UPDATING APPROACH BASED ON THE ENSEMBLE KALMAN FILTER WITH SYSTEM NOISE SWITCHING CONTROL

Abstract

This research addresses an efficient finite element model updating approach based on the ensemble Kalman filter (EnKF) with system noise switching control. Recently, many interests have been attracted for smart structural systems, where the spacecraft structure is designed to be adjustable using actuators on orbit. One of the key to constructing smart structural systems is to obtain accurate estimations of the current whole structural states for effective controls; however, the number of spacecraft sensors are usually inadequate to observe whole structural states. To compensate unobserved structural data, numerical simulations based on the finite element (FE) models play an important role. The FE models usually contains various uncertainties in the systems, such as uncertain structural parameters, and these uncertainties are often identified by using measurement data obtained during validation tests on the ground. In future space missions, such as those of highly precise large-scale space reflectors, the structural design requirements will tend to become increasingly severe, and the accuracy of the numerical models estimated based on the ground-based validation test could be insufficient. Thus, the FE models are desired to be updated by using operational measurement data in orbit. A family of Kalman filter, the unscented Kalman filter, has been effectively used for the finite element model updating. The author has also applied the ensemble Kalman filter (EnKF), an effective nonlinear filtering technique based on a Monte-Carlo simulation, to the model estimation of a planar deployable frame structure model. One of the difficulties in finite element updating based on the Kalman filter family is to find appropriate system noise levels that represent uncertainties of the models. If the noise level does not match the actual uncertainty of the model, the filtering results could be strongly deteriorated. In this paper, we propose a simple system noise switching control scheme. In this scheme, high and low system noise levels are set in accordance with finite element model uncertainties. The finite element model uncertainties are evaluated via the difference between the measurement and the numerical results calculated in the updated finite element model. If the difference is grated than a threshold level, the high system noise level is set for the EnKF, and vice versa. We conduct a finite element model updating of the planar space deployable frame structure system based on the EnKF with the system noise switching control to verify the effectiveness of the presented method.