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Keio University

Thesis Abstract

No.

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Title of Thesis:

Distance Measures of Autoregressive Models for Structural Damage Detection

Summary of Thesis:

The key to damage detection of civil engineering structures is to find an effective damage indicator. The damage indicator is expected to promptly detect the damage and accurately identify the damage state. For this purpose, a novel damage indicator defined as the distance measures of AR models was proposed.

The AR model has been successfully applied to parameterize the dynamical responses, typically the acceleration response. The premise of this approach is that the distance between the AR models, fitting the dynamical responses from the damaged and undamaged structures, may be correlated with the information of the damage, including the damage location and severity.

The distance measures of AR models have been widely used in speech recognition even if they are not known in civil engineering application. This research attempted to explore the feasibility of using the distance measures of AR modeling as the damage indicators. Two distance measures were considered as the damage indicators: one is the cepstral distance, and the other is the Itakura distance.

However, the current distance measures are limited to single-input single-output (SISO) models. In civil engineering, the structures are in general multi-input multi-output (MIMO) models. When dealing with the MIMO with mutually correlated excitations, the distance measures are able to detect the damage but not damage localization. To overcome the difficulty, the pre-whitening filter is introduced to remove the mutual correlations among the multiple outputs. Thus, we propose a damage detection methodology combining the distance measures of AR models and the pre-whitening filter.

To evaluating the proposed methodology, numerical and experimental data have been both tested. The structure models for the evaluations are both five storey models. In numerical evaluations, we consider different types of ambient excitations including mutually uncorrelated and correlated excitations. The damage scenarios are simulated by the different levels of inter-storey stiffness reduction, from 2% to 10%, and by the damages on different storey. The measurement noises are also considered by adding measurement noises with 10% level to the original acceleration outputs. In experimental evaluations, the damages scenarios include the cases of removing the columns and the braces. Results of the evaluations indicate that the distance measures of AR models are qualified for the damage indicators, and that the pre-whitening filters are crucial for the distance measures to carry out damage detection, especially for damage localization.