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In this paper the problems of doing automatic modal parameter extraction of ambient excited civil engineering structures is considered. Two different approaches for obtaining the modal parameters automatically are presented: The Frequency Domain Decomposition (FDD) technique and a correlation-driven Stochastic Subspace Identification (SSI) technique. Finally, the techniques are demonstrated on real data.

THE FREQUENCY DOMAIN DECOMPOSITION (FDD) TECHNIQUE

Though it is still popular to works directly with spectral densities it is cumbersome to deal with all the auto- and cross spectral densities, and the accuracy of the modal parameter estimates extracted will depend very much on how well-separated the modes are. The Frequency Domain Decomposition (FDD) technique is a way to solve these two problems.

The technique simplifies the user interaction because the user has only to consider one frequency domain function - the singular value diagram of the spectral density matrix. A mode is identified by looking at where the first singular value has a peak, let us say at the frequency f_0. This defines in the simplest form of the FDD technique - the peak picking version of FDD - the modal frequency. The corresponding mode shape is obtained as the corresponding first singular vector.

The FDD peak picking can be automated by the following procedure:

1. Identify a peak on the first singular value line representing a maximum
2. Check if the peak is likely to be physical
3. If so, establish the modal domain
4. If not define a noise domain around the peak
5. Exclude the modal domain or noise domain from the search set
6. Continue until the search set is empty, the peak is below the predefined excitation level, or a specified number of modes has been estimated

SSI MULTIPATCH MERGING

The multipatch subspace approach is based on the fact that merging Hankel matrices from different measurement setups is only possible if setups share common reference sensors and the excitation is the same for all setups. If the first requirement is impossible to be avoided and is common for many identification methods, it has been shown that the second requirement can be dropped if proper normalization is applied to the Hankel matrix of each setup.

This approach has been coupled with the usual subspace approach where identification is performed on each setup, and modes are extracted automatically. Usually subspace diagrams are noisy, but the multipatch diagram is much clearer, allowing determining the structural modes easily. By coupling both diagrams, using some automated extraction approach described below, one can extract modes and reconstruct modes and mode shapes. Future works will focus on improving the numerical efficiency of the method.

The identification provides a stabilization diagram. This diagram must be analyzed in order to distinguish physical from computational modes. The algorithm must also provide the frequency, the damping and the mode shape.

The proposed automated extraction algorithm is very fast and very robust, so that it can be used for a monitoring routine. Finding and extanding the linear part can be complex with the usual subspace algorithm because of the presence of many spurious modes. For the multi patch merging technique, the decrease in the number of spurious modes makes the automated extraction pretty trivial.

EXAMPLE – Z24 HIGHWAY BRIDGE

The two automatic approaches have been tested on a fairly large set of real data. The data is from the Z24 Bridge of the SIMCES project, and the test case used is the one called Progressive Damage Test no. 10. This case consists of 9 setups each with 33 channels, except setup 5 having only 27 channels. Five common reference channels where used and these have been selected as the Projection Channels in the analysis. The data has been sampled at 100 Hz with a measurement time of 655 seconds, resulting in 65516 samples per channel.

The automatic FDD algorithm found 8 modes between 0 and 50 Hz and is capable of detecting modes at places where the peaks are not very distinct.

The multipatch technique is compared with the traditional correlation driven SSI method of one of the nine setups. The multi patch stabilization diagram is much clearer, and therefore of course much easier to work with for the automatic mode identification algorithm, that in this case identifies the six modes below 14 Hz.