Popular science summary of the PhD thesis

PhD student	Mikkel Tandrup Steffensen
Title of the PhD thesis	Quantification of Uncertainty in Structural Dynamic models
PhD school/Department	Department of Civil and Mechanical Engineering

Science summary

In structural dynamics, vibration analysis is crucial for various engineering applications, including the design of mechanical components, structural health monitoring, remaining lifetime estimation, and virtual sensing. To determine the dynamic properties of a structure, such as modal parameters (natural frequencies, damping ratios, and mode shapes), both experimental and theoretical methods can be employed.

In the experimental method known as Experimental Modal Analysis, the structure is excited, and both the excitation force and response are measured. To estimate the modal parameters, a modal parameter estimation algorithm, which can operate in either the time or frequency domain, is used. For frequency domain algorithms, the measured excitation and response signals are utilized to estimate Frequency Response Functions (FRFs), which serve as inputs to the modal parameter estimation algorithm. The FRFs are often estimated using conventional FRF estimators in spectral analysis: H1, H2, and Hv. These estimators have different statistical properties depending on the noise in the excitation and response signals.

Since uncertainty is inevitable in experiments, the estimated FRFs and modal parameters will also be uncertain. This work focuses on the uncertainty in the FRFs estimated using conventional FRF estimators and the modal parameters estimated using the poly-reference Least-Squares Complex Frequency-domain (pLSCF) algorithm. Various methods to estimate the uncertainty in the excitation and response signals are presented, along with derived uncertainty expressions for the FRFs (using conventional FRF estimators) and the modal parameters (using the pLSCF algorithm). These uncertainty expressions are derived using the statistical first-order Delta method. The uncertainty expressions are validated using a simulated experimental setup and Monte Carlo simulations, as well as partially through small laboratory Monte Carlo experiments, where the estimated uncertainties are compared to the sample uncertainty.

The estimated uncertainties can be used for reliable predictions and analyses in various engineering applications to assess the quality of the estimated FRFs and modal parameters, thereby improving the robustness of models used in these applications.

Please email the summary to the PhD coordinator at the department