Engineering Risk Analysis Group
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Master's Thesis - Civil Engineering

Stiffness and damage identification by Bayesian updating of a multi-component steel frame

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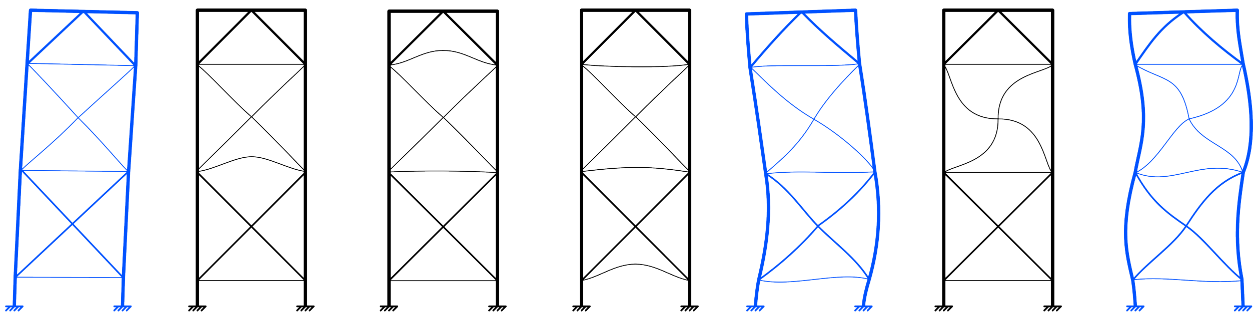
Background

Due to the development of more sophisticated sensor technologies and the increase of computational power, structural health monitoring becomes more and more popular. In this thesis, the dynamic behaviour of an imaginary multi component steel frame is monitored by a biaxial accelerometer. The goal is to backtrack the results of measurements, whether damage has occurred, which element of the structure is affected and how high the degree of damage is. Thus, it is an inverse problem.



First seven mode shapes of the undamaged steel frame. Blue mode shapes are considered to be global and detectable by the measurements.

Methodology

It is assumed that at most one inner frame member is damaged. Thereby damage is understood as a reduction of stiffness of more than 10 [%].
Since the steel frame is only idealized, the measured accelerations are simulated by a transient analysis. The measurements are then filtered and natural frequencies and ratios of movement at the sensor location corresponding to global mode shapes are extracted.
The inverse problem of damage identification is tackled by the probabilistic approach of Bayesian Updating. It requires a prior belief of the model ahead of the observation and a likelihood function describing the observation. The posterior belief is then calculated using Bayes' theorem. This, however, cannot be done analytically. Instead, it is approximated through sampling techniques. In particular, an algorithm based on Subset Simulation is used for this task.
All calculations were carried out via a batch work environment consisting of the computer algebra system MATLAB and the Finite Element software ANSYS.

Results

The detection capabilities vary to a great extent depending on the actual location and degree of damage. Over all damage at the horizontal members cannot be identified, whereby the detection of damage at the diagonal members is well captured. The crux of the matter is how significantly a stiffness reduction in one member changes the observed quantities.

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