Engineering Risk Analysis Group
Prof. Dr. Daniel Straub

Master's Thesis – Computational Mechanics

Structural reliability and parameter identification of bridge systems using Bayesian updating

Joshua Schorr, November 2016

Background

With recent bridge collapses and the large number of infrastructure assets around the world needing extensive refitting and repairs, the concept of structural health and safety monitoring of bridges has been brought to the forefront. The major problem preventing the effective use of such systems has been how to incorporate large amounts of uncertain data. Bayesian Updating is a technique which treats this problem by 'updating' the prior distribution with measurement data to determine the posterior (conditional) distribution.

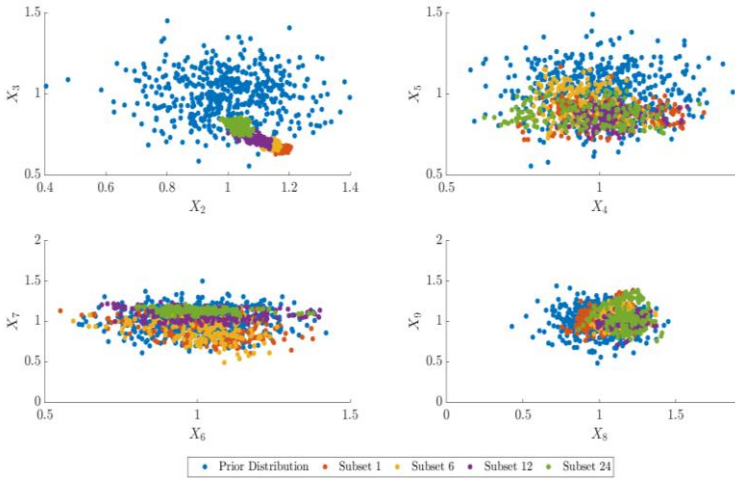

Figure 1: Convergence of the Conditional Samples to the Failure Domain

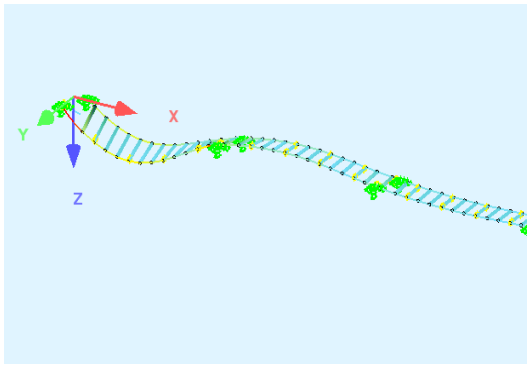

Figure 2: Identified FE Model

Methodology

The methodology includes the implementation of the algorithm, Bayesian Updating with Structural Reliability Methods (BUS), with the Subset Simulation Sampling method and the Markov Chain Monte Carlo, Adaptive Conditional sampling algorithm. The Bayesian Updating framework is coupled to the Finite Element Solver, SOFiSTiK to evaluate the likelihood function, or probability of observing the measurement given a set of structural parameters and the failure limit state function of a given model. Two examples were investigated, an Idealised bridge, consisting of a three span, continuous beam with simple supports and the *Yondae Bridge* in South Korea. The work considers the use of static deflection of the bridge spans, the modal shapes and the natural frequencies of vibration.

Results

The posterior distributions of the bridge parameters were identified, and used to estimate the probability of failure. It was found that the uncertainty of the dynamic information prevents it from being used effectively to update the structural model, and that for it to be useful techniques to reduce uncertainty should be employed. Modelling errors were also found to be significant, and should be minimised to ensure a physically representative posterior distribution. BUS was shown to not only be a computationally inexpensive method of performing the parameter identification and structural reliability estimation, but also to be able to be incorporated into an automatic bridge monitoring system.

Supervised by Dr.-Ing. Hyun-Joong Kim, Prof. Dr. Daniel Straub