Engineering Risk Analysis Group
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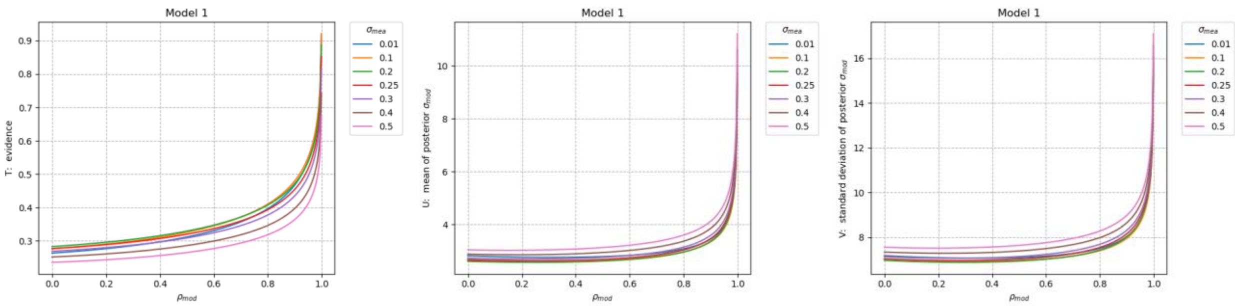
MSc thesis

The influence of measurement error and modeling error in Bayesian inference: An exemplary comparison for a selected beam model

Jiyi Wu, November 2018

Background

Probability logic with Bayesian updating provides a rigorous framework for quantifying modeling uncertainties. Based on Bayes' theorem, probability density functions of model parameters are updated through the likelihood function, accounting for uncertainties in the prior information, as well as uncertainties in the data and the model predictions. Measurement and modeling uncertainties are taken into account by modeling the respective errors as random variables.



Evidence, mean of posterior σ_{mod}, standard deviation of posterior σ_{mod} for Model 1 in case σ_{mod} is uncertain with a non-informative prior.

Methodology

Four simple mechanic models of a cantilever beam are employed, for which both the prior distribution and the likelihood function are Gaussian. Numerical integration and conditional distribution method are used for the evaluation of the evidence which is thought of as the central ingredient in performing Bayesian model updating. The effect of measurement error and modeling error on the results in Bayesian inference is studied for different scenarios. One scenario is that σ_{mod} is fixed to maximize the evidence, and the other is that σ_{mod} is uncertain with a non-informative prior.

Conclusion

Both methods for the evaluation of the evidence show the same results, since numerical methods could lead to the results that are infinitely close to the exact solutions if a huge amount of samples are employed. In addition, non-informative priors for uncertain parameters that describe measurement error and modeling error are not an appropriate modeling approach. Furthermore, the optimization of model parameters is sometimes only mathematically possible, which is often not the case in engineering applications and must be specified with care.

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