Chair for Reliability Engineering

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Bayesian Model Updating based on full-field measurement data

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Context

The design of functional components for use in demanding applications is largely founded on numerical approximations of the sets of differential equations that describe the physical processes in our everyday life. In this way, the dynamic and static responses of a complicated structural component to an estimated load can be predicted long before it has been produced. However, some criticism exists with respect to purely virtual deterministic design optimisations using numerical modelling schemes. This criticism finds its root in the various sources of uncertainty that are commonly encountered when designing structural components. Examples of uncertainties in this context include imprecisely defined parameters of the constitutive material models, unclearly defined boundary conditions or physical aspects of the material behaviour that are omitted from the models. These uncertainties need to be explicitly accounted for in the model to ensure its validity [1].

In parallel to these developments, also advanced material testing approaches such as Digital Image Correlation have found their entrance in engineering design practice. Opposed to classical coupon-based testing, these approaches allow for measuring the strain response of a designed component to a predefined load. This allows for not only validating the validity of the model, but also identifying and quantifying its governing uncertainties. The class of methods belonging to the field of Bayesian Model Updating [2] is particularly powerful in this context, but the application of full-field measurement data on a full-scale component has not been illustrated to date.

Objectives

The purpose of this thesis is to develop a computational framework to include strain measurement data coming from Digital Image Correlation (including an estimation of the uncertainty on these data) into a Bayesian Model Updating framework. This framework will be applied to a full-scale component, e.g., produced via Additive Manufacturing. Specific goals are:

- Develop a Bayesian Model Updating formulation that allows for the integration of high-dimensional measurement data
- Include all sources of uncertainty into this framework, both stemming from the modelling, as from the measurement data side
- Apply this framework to a component-scale case study that is produced using Additive Manufacturing

Required Skills

To develop this project, the following skills are considered a plus.

- Strong mathematical background.
- Knowledge of software for numerical analysis (e.g. Matlab / Python / Julia) and simulation (e.g. Abaqus).
- Reading and writing skills in English.

Application

In case that you are interested in this project, please follow these steps.

1. Read the associated bibliography (see below).
2. Prepare a short motivation letter addressing the following issues:
    a. Your interest in developing this project.
    b. The reasons that make you a good candidate for developing this project.
    c. Intended dates for working in the project.
3. Send the motivation letter to the supervisors via E-mail and ask for an exploratory meeting.

Bibliography

[1] Concepts of Model V&V, Los Alamos report LA-14167-MS

[2] A. Lye, A. Cicirello, and E. Patelli, 'Sampling methods for solving Bayesian model updating problems: A tutorial', *Mechanical Systems and Signal Processing*, vol. 159, p. 107760, Oct. 2021, doi: 10.1016/j.ymssp.2021.107760.