Master Thesis Proposal

• Title

Test-based modelling of industrial systems and their applicability to time-domain simulations

• Objective

- Develop a robust and optimal procedure to derive experimental modal models and convert them into state space representation to be used in time domain hybrid simulations
- Validate the proposed approach on simple structures
- Verify applicability of the proposed approach on full vehicle models using the siemens Simrod demonstrator as an example

• Subject

The possibility to reliably derive experimental data-driven models is extremely useful in industry, as it allows simulating very quickly the system response without the need of immediately building complex models, which will still be required at a later stage for more accurate investigations. Compared to other data-driven system identification techniques, such as State Space modelling, modal analysis aims at creating a physical representation of the system by describing it in terms of its modal parameters (i.e., resonance frequencies, damping ratios, mode shapes, and participation factors). However, while classical system identification methods allow to directly derive an input/output representation that can be used for simulations or estimations, modal models necessitate of some additional steps to be used in these calculations. Several methods currently exist to convert modal models into input/output models, but, when starting from experimental data, the process is not straightforward. For instance, when selecting the poles of the system in the stabilization diagram, users have to be careful of only including physical poles and avoid overmodelling, as this would normally lead to stability issues after converting the modal model into state-space representation. Recently, the MLMM (Maximum Likelihood estimation of a Modal Model) estimator has been developed, which further optimizes an estimated modal model considering, in the optimization process, some physically motivated constraints that ensure the stability of the estimated modal model.

• Tasks description

- Taking advantage of the current properties and implementation of the MLMM estimator, additional constraints could be added in the optimization process to ensure only physical poles are retained and the conversion to State Space or other input/output models can be performed without stability issues.

- As the Lower and Upper Residual terms, which are normally used to model the effects of the out-of-bend modes, are typically not compatible with the conversion to input/output models, extensions to the current formulation of those terms are required to ensure the residuals are converted to Lower and Upper modes. These modes will be then included in the optimization process of MLMM as well to ensure an optimal fit of the model to the measured data.
- Converting the MLMM modal model into a state-space (SS) representation and validating the obtained SS model
- Comparison with the direct subspace identification.

- **Type of work**

30% literature review/theory, 40% development of the techniques & Matlab inplementation & Validations, 30% experimental work .

- **Requirements**
  - Background in mechanical vibration and theory of system dynamics
  - Experience with matlab

- **Additional Remarks**

In collaboration with Siemens Industry Software.