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Background

Next-generation high-precision positioning systems are designed lightweight to enable an increase of product throughput. Generally, lightweight systems exhibit flexible dynamical behavior in relevant frequency ranges, corresponding to structural deformations upon acceleration. As these are typically not aligned with the motion degrees-of-freedom, the dynamical system behavior is intrinsically multivariable. As a consequence, multivariable control is an essential instrument to achieve the limits of performance. A systematic design procedure for such controllers is model-based.

Robust-control-relevant model sets

Any physical system is too complex to be represented exactly by a mathematical model. Potentially, inevitable discrepancies between model and reality may lead to a dramatic deterioration of performance when implementing a designed controller on the true system, [1]. Hence, it is imperative to account for model imperfections explicitly through the design of a robust controller. While it is essential to cover true system behavior by the model set, achieving performance enhancements through robust control demands for a limitation of uncertainty whenever possible. In particular, explicit compensation of performance-hampering flexible behavior requires an accurate, *certain* description of the corresponding resonance phenomena of the system. Robust-control-relevant identification, [2], provides model sets in which system artifacts that need to be compensated for in order to achieve high-performance are described with large fidelity.

Fast, reliable identification of a nominal model

Control-relevant nominal modeling is at the heart of tight modeling for robust control. Essentially, the same performance weights used for robust control design are incorporated in the identification problem, hereby focussing modeling effort on control-relevant system artifacts. However, by doing so, the identification problem can become notoriously ill-conditioned, see [2]. This problem may be resolved effectively by constructing an orthonormal polynomial basis with respect to the *weighted* discrete inner product that underlays the identification problem. A numerically reliable algorithm for the construction of such a basis is proposed in [3]. However, in case of real-rational approximation, this algorithm turns out to be computationally intensive, since part of the presumed structure of the problem is lost. A possible alternative for faster construction of an orthonormal basis is provided by the Stieltjes-procedure, which exploits knowledge on fundamental three-term-recurrence relations between successive basis polynomials; see also, *e.g.*, [4].

Model order selection for robust control

Specification of the desired complexity of models is an integral part of any parametric system identification procedure. In modeling for robust control, however, order selection is particularly difficult, since the allowed complexity needs to be distributed over the nominal model and the uncertainty description. By increasing the complexity of the nominal model, more and more true system artifacts can be described accurately. Consequently, a smaller uncertainty set suffices to encompass true system behavior by the model set. However, refinement of the nominal model is meaningless if a very rigorous uncertainty description is made subsequently. Therefore, in modeling for robust control, order selection of the nominal model and the uncertainty model cannot be perceived as individual steps. A new order selection paradigm is presented in [5], which yields model sets of limited complexity that describe performance-hampering system artifacts with high fidelity indeed, see Fig. 1.

References

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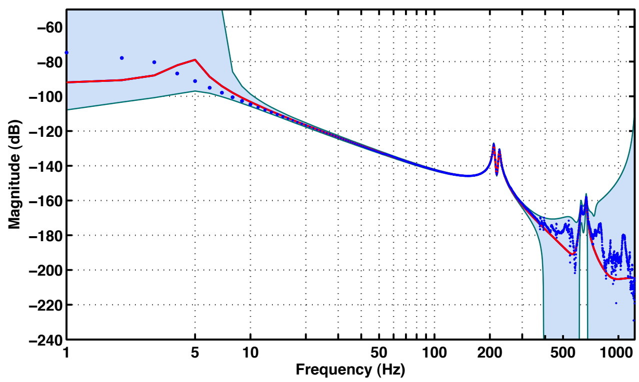

Figure 1: Bode magnitude plot of the identified FRF (dotted), control-relevant nominal model (solid, order 11), and validation-based candidate plant set (shaded, order 10).