Large-scale and infinite dimensional dynamical model approximation

Soutenance de thèse - Igor Pontes Duff Pereira

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Abstract

In the engineering area (e.g. aerospace, automotive, biology, circuits), dynamical systems are the basic framework used for modeling, controlling and analyzing a large variety of systems and phenomena. Due to the increasing use of dedicated computer-based modeling design software, numerical simulation turns to be more and more used to simulate a complex system or phenomenon and shorten both development time and cost. However, the need of an enhanced model accuracy inevitably leads to an increasing number of variables and resources to manage at the price of a high numerical cost. This counterpart is the justification for model reduction.For linear time-invariant systems, several model reduction approaches have been effectively developed since the 60's. Among these, interpolation-based methods stand out due to their flexibility and low computational cost, making them a predestined candidate in the reduction of truly large-scale systems. Recent advances demonstrate ways to find reduction parameters that locally minimize the H2 norm of the mismatch error.

In general, a reduced-order approximation is considered to be a finite dimensional model. This representation is quite general and a wide range of linear dynamical systems can be converted in this form, at least in principle. However, in some cases, it may be more relevant to find reduced-order models having some more complex structures. As an example, some transport phenomena systems have their Hankel singular values which decay very slowly and are not easily approximated by a finite dimensional model. In addition, for some applications, it is valuable to have a structured reduced-order model which reproduces the physical behaviors. That is why, in this thesis, reduced-order models having delay structures have been more specifically considered.

This work has focused, on the one hand, in developing new model reduction techniques for reduced order models having delay structures, and, on the other hand, in finding new applications of model approximation. The major contribution of this thesis covers approximation topics and includes several contributions to the area of model reduction. A special attention was given to the H2 optimal model approximation problem for delayed structured models. For this purpose, some new theoretical and methodological results were derived and successfully applied to both academic and industrial benchmarks. In addition, the last part of this manuscript is dedicated to the analysis of time-delayed systems stability using interpolatory methods. Some theoretical statements as well as an heuristic are developed enabling to estimate in a fast and accurate way the stability charts of those systems.

Mots clés : Model reduction, numerical analysis, time-delay systems