Parametric Linearization of Nonlinear Dynamical Systems Subject to Periodic Inputs

Giovanni Conni[1], *Karl Meerbergen*[2], *Frank Naets*[3]

[1] *Computer Science Dpt., KU Leuven, Belgium*
E-mail: giovanni.conni@kueuven.be
[2] *Computer Science Dpt., KU Leuven, Belgium*
E-mail: karl.meerbergen@kuleuven.be
[3] *Mechanical Engineering Dpt., KU Leuven, Belgium*
E-mail: frank.naets@kuleuven.be

Abstract

Mathematical models of dynamical systems have seen a gradual increase both in size and complexity, and together with these the necessity of computational power. Moreover, these models are often nonlinear, which makes them more computationally expensive and limits their real-world applications. To allow for faster simulations, Model Order Reduction (MOR) techniques in the frequency and in the time domain have been developed.
In the frequency domain, these methods are usually related to the Volterra series [1]. This is an extension of the transfer function to nonlinear system, where the input-output relationship is expanded through an infinite series of so called Volterra kernels. The Volterra series is a powerful tool for the analysis of nonlinear systems, but its application can be complicated: research is still ongoing regarding convergence conditions, and the identification of the kernels is not straightforward.
On the other hand, the interest for time-domain MOR methods is raising, due to their data-driven nature. We have developed a variant of the AAA MOR method [2], called tLS-AAA, which employs time domain data to generate a linear Reduced Order Model (ROM). This reduction method regards the system as a black box and does not require any information on the input to generate the ROM. tLS-AAA approximates the input-output relationship of the nonlinear system, and it can be related to the Volterra series. By exploiting this equivalence, tLS-AAA can be modified to generate a parametric linear ROM which approximates the system output for periodic input functions. Moreover, other techniques which employ the Volterra series in the context of condition monitoring and system analysis can be redefined for the tLS-AAA method in an efficient way.

Acknowledgements: This research is partly founded by internal KU Leuven funds as part of the C2 project 3E190371.