Project Description: Computation of Norms for Large-Scale Dynamical Systems

October 16, 2012

During the design process of technical devices, often mathematical models are set up in order to simulate, optimize and control the behavior of the devices. Usually these models are described by differential or differential algebraic equations. In this project we consider the class of linear time-invariant differential-algebraic equations of the form

$$E\dot{x}(t) = Ax(t) + Bu(t), \quad y(t) = Cx(t) + Du(t).$$

Here, E, $A \in \mathbb{R}^{n \times n}$, $B \in \mathbb{R}^{n \times m}$, $C \in \mathbb{R}^{p \times n}$, $D \in \mathbb{R}^{p \times m}$, $x(t) \in \mathbb{R}^n$ describes the state of the system, whereas $u(t) \in \mathbb{R}^m$ is a control input signal and $y(t) \in \mathbb{R}^p$ is an output signal (obtained, e.g., by measurements). Additionally, the matrix E might be singular which means that there are hidden algebraic constraints in the dynamics of the system.

System norms are powerful tools to quantify the influence of the inputs on the outputs and to measure the "size" of a dynamical system. This project will be devoted to computation of such a norm (the $\mathcal{H}_\infty$-norm) for large-scale systems, i.e., n is a large number. An algorithm to solve this task is based on the computation of certain eigenvalues of large structured matrix pencils. There exists a recent algorithm that can efficiently compute the eigenvalues of such a matrix pencil close to a prespecified complex number (shift). The key point is to find **all** desired eigenvalues by choosing the shifts in a smart way.

Your task will be to implement and test the algorithm for the norm computation in MATLAB. The focus will be on implementing the shift selection strategy and to tune certain design parameters of the algorithm. Furthermore you should compare your results with a different method recently developed at our institute.

The internship will take place in the "Computational Methods in Systems and Control Theory" group at the Max Planck Institute for Dynamics of Complex Technical Systems in Magdeburg. Our group has a strong background in systems theory, numerical linear algebra and model reduction with applications in engineering sciences. The working environment is quite international due to the high amount of scientists from abroad. Many other research institutions such as the Otto-von-Guericke University or the Fraunhofer Institute for Factory Operation and Automation are very close to the institute.

Magdeburg is a medium-size city with about 230.000 inhabitants. It is the capital of the federal state of Saxony-Anhalt and therefore offers lots of possibilities to enjoy free-time and cultural life. There are also many opportunities for day-trips, for instance to the Harz Mountains or Berlin which can be reached by train within two hours.

Contact Info:

Matthias Voigt
Max Planck Institute for Dynamics of Complex Technical Systems
Sandtorstraße 1
39106 Magdeburg
Germany

Phone: +49 391 6110 464
E-Mail: voigtm@mpi-magdeburg.mpg.de