

## **Model Reduction for Dynamical Systems**

Within the general concept of surrogate modeling, model reduction has been recognized as an efficient tool for fast simulation of large-scale systems arising from numerical discretization of mathematical models for various engineering applications. It is developed from well-established mathematical theories, robust numerical algorithms, and is nowadays aided by machine learning to tackle more complex problems. This lecture will start with basic mathematical theories and numerical algorithms used in model reduction, and will continue to introduce state-of-the-art physics (model)-based model reduction methods applicable to problems ranging from simple to complex ones. Data-driven and non-intrusive model reduction methods, such as dynamic mode decomposition, proper orthogonal decomposition combined with neural networks, will be introduced in the end. During the lecture, the students are encouraged to interrupt and ask questions.

There are exercise courses associated with this lecture. During the exercise courses, the student are free to ask questions about the lecture as well as the exercises. The exercises include exercises on theoretical aspects and practical ones for which the students will have access to the data of some benchmark examples (e.g., transmission lines, viscous Burgers' equation, inviscid Burgers' equation, etc.) from engineering applications and will be able to test the learned methods and algorithms on those examples. We will present the performance of some methods on selected examples showing their accuracy and efficiency during the exercise courses.

### **Exam:**

The exam is oral. The examination appointment can be made upon sending an email to the lecturer.

### **Target students and more:**

Senior Bachelor's students, Master's students, in mathematics, computational science, computational engineering, modelling and simulation, and related. Basic knowledge of *numerical* linear algebra, ordinary differential equations (ODEs), numerical methods for solving ODEs, and experience in using MATLAB, will make the course learning much easier. Upon request, master's theses on model reduction with applications in engineering problems may be assigned after taking the lecture. Promising results of the master theses will be considered for publication submission under the guidance of the lecturer.