MATH-656

Numerical linear algebra for Koopman and DMD

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Cursus	Sem.	Type
Mathematics		Opt.

Language of teaching	English
Credits	3
Session	
Exam	Project report
Workload	90h
Hours	**68**
Lecture	16
Project	52
Number of positions	

Frequency

Only this year

Remark

Spring semester

Summary

The Dynamic Mode Decomposition (DMD) has become a tool of trade in computational data driven analysis of complex dynamical systems. The DMD is deeply connected with the Koopman spectral analysis of nonlinear dynamical systems. This course will present recent results in this area.

Content

The Dynamic Mode Decomposition (DMD, introduced by P. Schmid) has become a tool of trade in computational data driven analysis of complex dynamical systems, e.g. fluid flows, where it can be used to decompose the flow field into component fluid structures, called DMD modes, that describe the evolution of the flow. The DMD is deeply connected with the Koopman spectral analysis of nonlinear dynamical systems, and it can be considered as a computational device in the Koopman analysis framework. Its exceptional performance motivated developments of several modifications that make the DMD an attractive method for analysis, model order reduction and numerical identification of nonlinear dynamical systems in data driven settings.

In this course, we will present recent results on the numerical aspects of the DMD/Koopman analysis. We show how the state of the art numerical linear algebra can be deployed to improve the numerical performances in the cases that are usually considered notoriously ill-conditioned. Further, we show how even in the data driven setting, we can work with residual bounds, which allows for practical error estimates for the computed modes.

The material is based on recent publications and it contains substantial practical components in form of software development and computational analysis of case study examples.

Note

The lectures will take place during 4 weeks (March 6 - April 11), with 4 hours of lectures/week.
The work on the (mini)projects will be carried out from end of March until end of April.

Keywords

dynamical systems, data driven analysis, model reduction, numerical linear algebra

Learning Prerequisites

Required courses

It is recommended that the participants have basic background in numerical analysis and dynamical systems. Programming skills (Matlab, Python or similar) are also required.

Learning Outcomes

By the end of the course, the student must be able to:

- Identify and understand the state-of-the-art in data driven analysis
- Apply DMD / Koopman operator analysis to complex dynamical systems

Resources

Bibliography

Lecture material and references will posted online in due time

Moodle Link

- https://go.epfl.ch/MATH-656