Technische Universität Braunschweig

Institut für Strömungsmechanik

Masterarbeit Nr. 486
for Mr. Javed Butt
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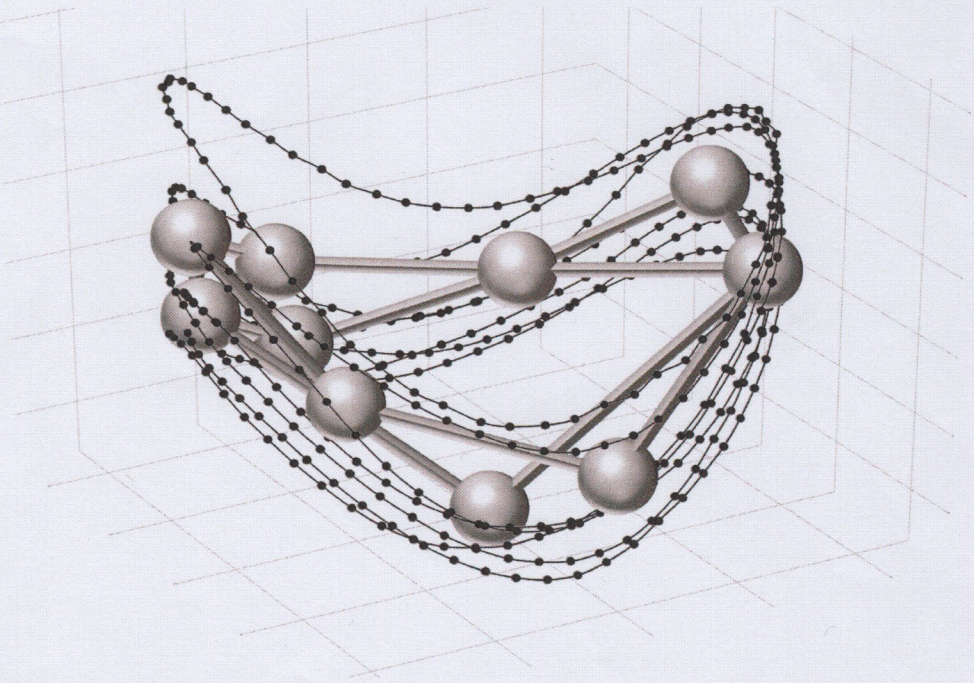
Flow predictions using control-oriented cluster-based network modeling

1. Introduction

Cluster-based network modeling (CNM) is a universal method for data-driven modeling of complex non-linear dynamics from time-resolved snapshot data. Complex nonlinear dynamics govern many fields of science and engineering. CNM describes short- and long-term behavior and is fully automatable as it does not rely on application-specific knowledge. This automatable universal data-driven representation of complex nonlinear dynamics complements and expands network science. A first-attempt to generalize CNM to include control effects was attempted by Fernex et al. However, that approach is neither robust nor accurate. It is also complicated to implement.

The proposed Masterarbeit's investigates a new approach to control-oriented cluster-based network modeling. The proposed approach shall directly identify the new clusters position as well as their transition properties directly based on machine learning predictions. The method shall be evaluated on the Lorenz system before being deployed to predict the flow full state around an airfoil.



2. Tasks

To achieve the above-stated objectives, the following points should be addressed:

1. Literature review
2. Further refine the CNMc algorithm on the Lorenz system
    a. Employ a different NMF algorithm to handle larger datasets
    b. Test two approaches with
        i. Cluster locations modeled and transition properties interpolated
        ii. Both cluster locations and transition properties modeled
    c. Test CNMc with various number of clusters and time delay embeddings
3. Apply CNMC on airfoil database
    a. Analyze the airfoils aerodynamic characteristics
    b. Apply CNMc
        i. on integrated coefficients: Cl, Cd
        ii. [Optional] on the POD-reduced state
    c. Validate CNMc on multiple airfoil geometries
4. Reporting of the results

3. Reporting of the results

The results of the work are to be detailed and discussed in a clearly structured report with a concise text and clear images and charts.

Javed Butt

Dr. Richard Semaan
(Advisor)

Duration: 6 months
Start: 29.10.2021
End: 29.04.2022

Prof. Dr.-Ing Rolf Radespiel
(Examiner)