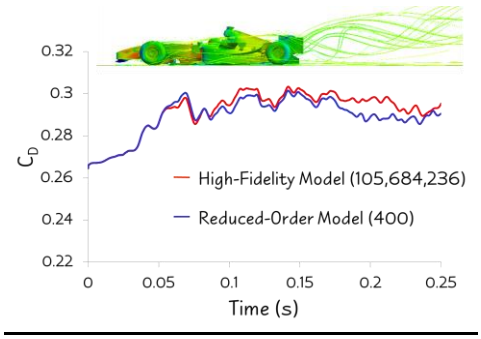
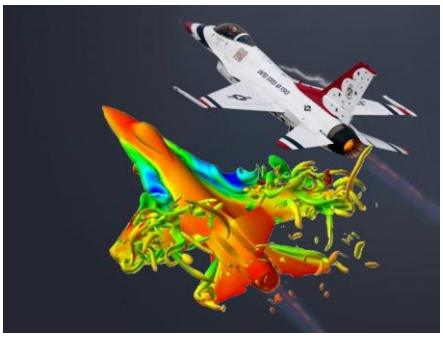
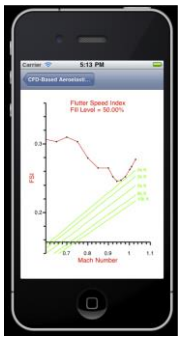
Stanford ENGINEERING
Aeronautics & Astronautics

AA216/CME345: Projection-Based Model Order Reduction

Schedule: Autumn 24, M-W-F (2 of 3) 1:30 pm – 2:50 pm **Units:** 3
Venue : Mitchell Earth Sciences B67







Course Description

Projection-based model order reduction (PMOR) is an important pillar of physics-based machine learning. It has rapidly become critical for computational-based design and optimization, statistical analysis, embedded computing, and real-time optimal control; and indispensable for scenarios where real-time, physics-based numerical simulation responses are desired. This course presents the basic mathematical theory for PMOR. It is intended primarily for graduate students interested in computational sciences and engineering. The course material outlined below is complemented by a balanced set of theoretical, algorithmic, and computer programming assignments.

Course Outline

Parametric modeling and simulation - Why model order reduction? – Parameterized differential equations – Projection-based model order reduction – Error analysis – Proper orthogonal decomposition (POD) and connection with singular value decomposition (SVD) – Linear dynamical systems – Balanced truncation methods – Moment matching methods based on Krylov subspaces – Nonlinear dynamical systems – Local parametric database approaches – Nonlinear approximation methods and connection with deep learning – the least-squares Petrov-Galerkin method – Hyperreduction.

Instructor

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Teaching Assistant

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Office Hours: Tu, 3:00 pm – 4:30 pm and F, 10:30am – 12:00 pm, Durand 224

Prerequisites

- Solid foundations in numerical linear algebra (CME 200 or equivalent)
- Basic numerical methods for ODEs (CME 206 or equivalent)

Textbook

- Approximation of Large Scale Dynamical Systems, A.C. Antoulas, SIAM 2005
- Lecture notes and reading materials provided by instructor

Homeworks

- Assigned in general on a weekly basis
- Subject to the Stanford Honor Code (no attempt to find and no consultation of any published solutions; collaboration with other students taking the course is allowed as long as it is limited to discussing the statement of the problem and how to proceed about solving it – everything else is an individual task)

Examination

- Take Home Final Project: 1- or 2-page proposal will be due on or before November 8, 2024; and final version of the proposal will be approved on or before November 15, 2024
- Subject to the Stanford Honor Code (no attempt to find and no consultation of any published solutions; no assistance from anyone/anything)

Course Grade

- Based 65% on the grades for the homework assignments
- Based 35% on the grade for the Take Home Final Project
- In fairness to all and in order to enable a timely posting of the solutions and course grade: Homework assignments will be due on time or will not be graded; Take Home Final Project will be due on December 11, 2024, or will not be graded

Students with Documented Disabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Student Disability Resource Center (SDRC) located within the Office of Accessible Education (OAE). SDRC staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the SDRC as soon as possible since timely notice is needed to coordinate accommodations. The OAE is located at 563 Salvatierra Walk (phone: 723-1066).