

# **AA216/CME345: PROJECTION-BASED MODEL ORDER REDUCTION**

## **1. Introduction**

- 1.1 Physics-based modeling and simulation: CPU cost
- 1.2 What is model reduction?
- 1.3 How is it done today?
- 1.4 When does it pay off?
- 1.5 Examples

## **2. Parameterized Partial Differential Equations**

- 2.1 Initial boundary value problems
- 2.2 Parameters of interest
- 2.3 Untypical parameters of interest
- 2.4 Semi-discretization processes and dynamical systems
- 2.5 Case for model reduction
- 2.6 Subspace approximation

## **3. Projection-Based Model Order Reduction (PMOR)**

- 3.1 Solution approximation
- 3.2 Orthogonal and oblique projections
- 3.3 Galerkin and Petrov-Galerkin projections
- 3.4 Equivalent high-dimensional model
- 3.5 Error analysis
- 3.6 Preservation of model stability

## **4. Proper Orthogonal Decomposition (POD)**

- 4.1 Time-continuous formulation
- 4.2 Method of snapshots for a single parametric configuration
- 4.3 POD method in the frequency domain
- 4.4 Connection with SVD
- 4.5 Error analysis
- 4.6 Extension to multi-parameter configurations
- 4.7 Applications

## **5. Linear Dynamical Systems**

- 5.1 External description
- 5.2 Internal description
- 5.3 Exact solution
- 5.4 Congruence transformation
- 5.5 Stability

## **6. Balanced Truncation**

- 6.1 Reachability and observability
- 6.2 Balancing
- 6.3 Balanced truncation method

- 6.4 Error analysis
- 6.5 Stability analysis
- 6.6 Computational complexity
- 6.7 Comparison with the POD method
- 6.8 Application
- 6.9 Balanced POD method (BPOD)

## **7. Moment Matching**

- 7.1 Moments of a function
- 7.2 Moment matching method
- 7.3 Krylov-based moment matching methods
- 7.4 Comparison with POD and BPOD in the frequency domain
- 7.5 Applications

## **8. Local Parametric Approaches**

- 8.1 Parameterized systems
- 8.2 Concept of a database of local reduced-order bases
- 8.3 Concept of a database of local linear projection-based reduced-order models (PROMs)

## **9. Hyperreduction of Projection-Based Reduced-Order Models**

- 9.1 Nested approximations
- 9.2 Hyperreduction methods

## **10. Nonlinear Projection-Based Model Order Reduction**

- 10.1 PMOR at the discrete level
- 10.2 Least-squares Petrov-Galerkin method
- 10.3 Barrier to PMOR
- 10.4 Piecewise linear or affine approximation method
- 10.5 Quadratic approximation method
- 10.6 Arbitrarily nonlinear approximation method using deep learning

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