Welcome to instats

The Session Will Begin Shortly

(At the top of the hour, Eastern USA time)

1

START

2

Nonlinear Time Series Analysis, Part II: Modeling and Phenomenology

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3

Seminar Outline

- Day 1
  - Session 1 – Overview of Phenomenology
  - Session 2 – Dynamical Systems Analysis
- Day 2
  - Session 3 – Sparse Identification of Nonlinear Dynamics
  - **Session 4 – Dynamic Mode Decomposition**
- Day 3
  - Session 5 – Hidden Markov Models
  - Session 6 – Machine Learning Approaches
- Day 4
  - Session 7 – Putting it All Together: Lorenz
  - Session 8 – Putting it All Together: Infectious Diseases

4

Dynamic Mode Decomposition (DMD)

- DMD
  - Identifies linear dynamics (modes) from high-dimensional data
  - Purely data-driven
  - Computationally and conceptually not-too-hard
  - Foundation for Hankel, Koopman, etc.
- However
  - Limited to linear modes
  - Noise sensitivity
  - Generally requires long data sequences

5

Dynamic Mode Decomposition (DMD)

- Measurements
  - x1, x2, x3…xm+1
  - t1, t2, t3…tm+1
- Constraints
  - Equally spaced times
  - No missingness

6

Dynamic Mode Decomposition (DMD)

- Make 2 matrices from the data
- $X = [x_1 \;\; x_2 \;\; \ldots \;\; x_m]$
- $X' = [x_2 \;\; x_3 \;\; \ldots \;\; x_{m+1}]$
- DMD equation
- $X' = AX$
- In general, can't find eigenvectors and eigenvalues of A
  - But we can approximate them
  - Especially for large *m*

7

Modes

- Redux from Part I of series

8

Sample Matrix Creation

- One dimensional example (simple oscillator, with very slow decay)
- Then do a string to show many different modes and how to work with them

9

Eigenvalues and Eigenvectors

- Here we can exactly solve the equations (I think!)

10

Reconstruction from Modes

11

DMD v. SINDy

- DMD: Modes
  - Most modes decay to zero long-term
  - Response to external perturbations given by modes
- SINDy: Equations
  - Trajectories and *fixed points*
  - Doesn't tell us much about perturbations

12

An Intriguing Finding

- Ricca & Green (in preparation)
- Long-term behavior prediction
  - 30-day EMA
  - 6-month follow up
  - Latent SINDY classes > GMM classes > DMD classes
- Don't make too much of this
  - There are reasons we haven't submitted this for publication yet

13

HAVOK Analysis

- *Hankel Alternative View Of Koopman*
  - Specific approach to DMD
- Moulder et al. (2023)
  - ECG Behavior during a *go/no-go* task

14

Tangentially Related Tools

- Burstiness *(package:ndstools)*
  - System memory as a measure of *self-organization*
- Autoregression (*package:forecast)*
  - Includes ARIMA, network psychometrics, etc.
  - Different estimation method than DMD, but same delay setup
- Orbital decomposition *(package:ndstools)*
  - Mesoscale pattern identification
- Detrended fractal analysis *(package:DFA)*
  - Long-range correlation structure

15

Questions

16

STOP

17

Next session @ UTC 1900

18