

Manifold Learning for Data-Driven Dynamical System Modeling

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What is it?

- A camera records dynamical systems in motion



Simple Pendulum



Spring Pendulum



Coupled Pendulum

- We model the underlying nonlinear dynamics solely from observations
 - No prior knowledge and no assumptions about the model
- **No image processing is used**

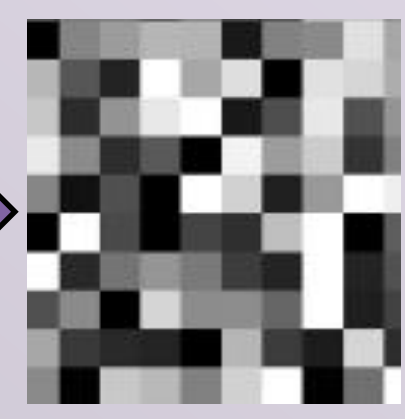
How is it done?

- Based on a recent PNAS paper (Yair, et al., 2017)
- Each frame is embedded in a low-dimensional space using:
 - **Diffusion Maps** (Coifman & Lafon, 2006)
 - **Input:** High-dimensional and nonlinear observation function
 - **Output:** Meaningful low-dimensional representation
- We use random scrambling of each frame to show that no image processing tools are used

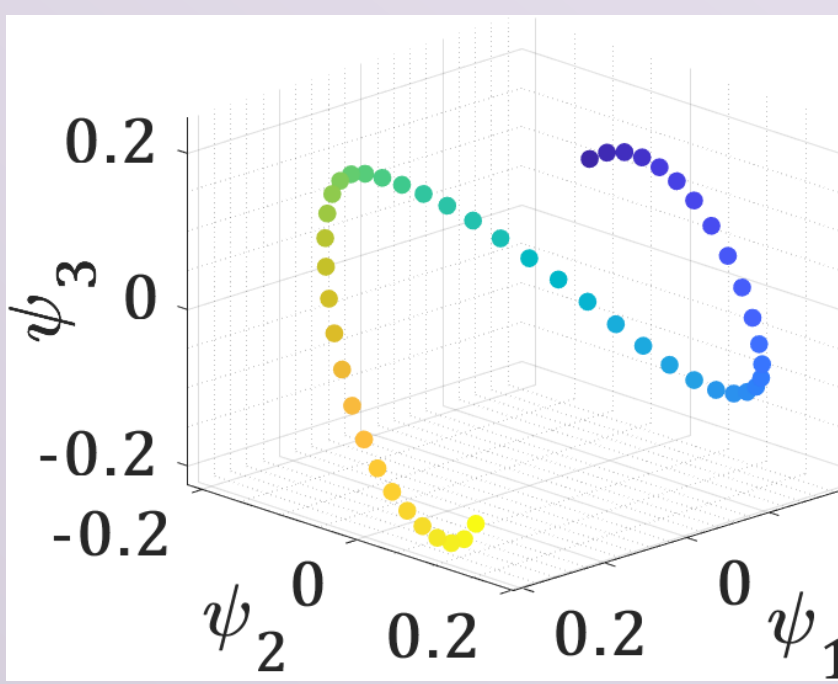
Offline



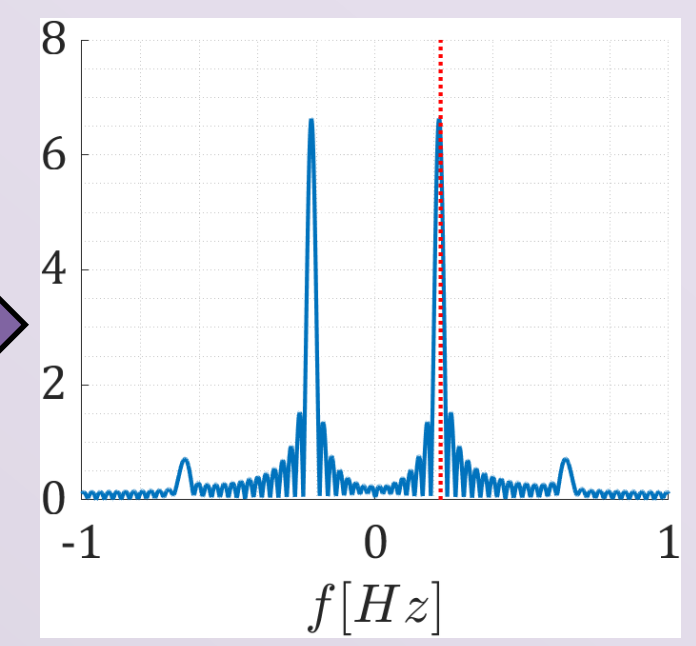
Input Video



Scrambling
(of each frame)



Diffusion Maps

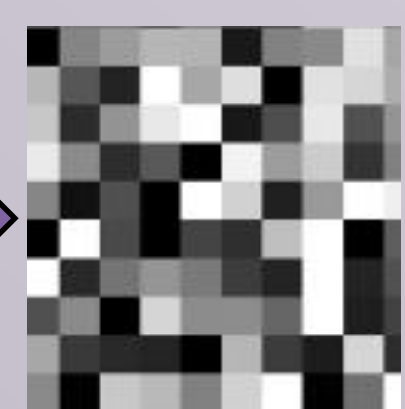


Frequency Extraction
(from Fourier transform of
first eigenvector)

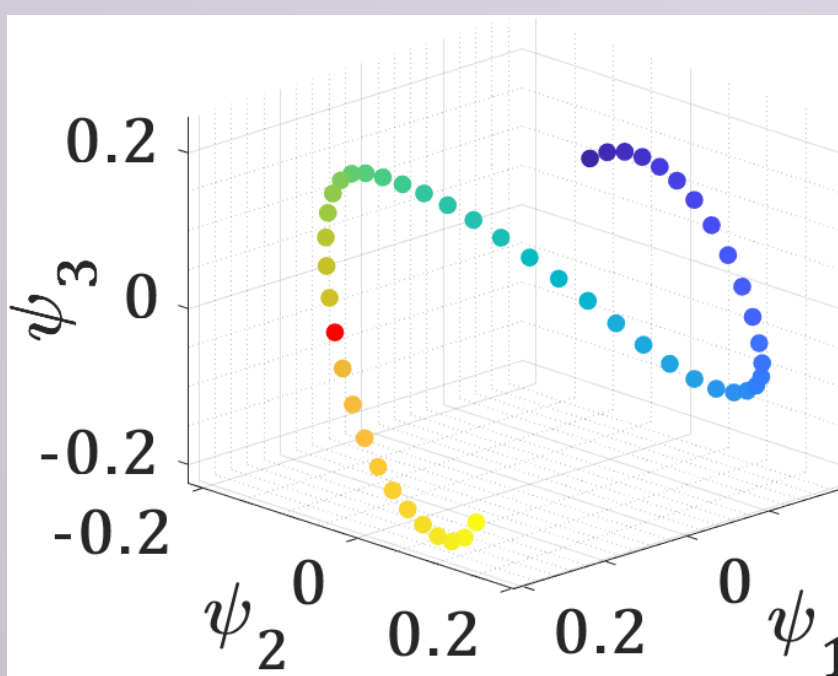
Online



New Video Frame



Scrambling



Out-of-sample Extension

Phase
Extraction

Prior
Knowledge:
Pendulum

Output Animation