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NRI: EAGER:
Teaching Aerial Robots to Perch Like a Bat via AI-Guided Design and Control

NSF-NRI #1944964

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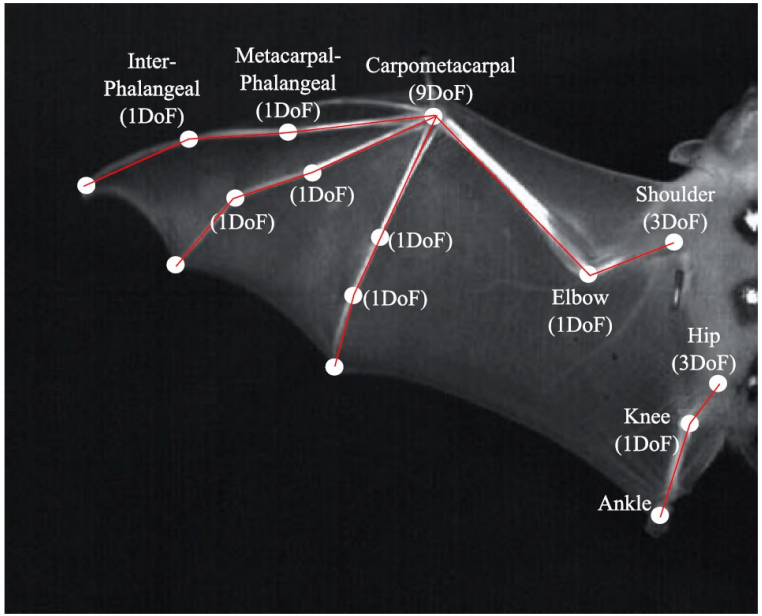
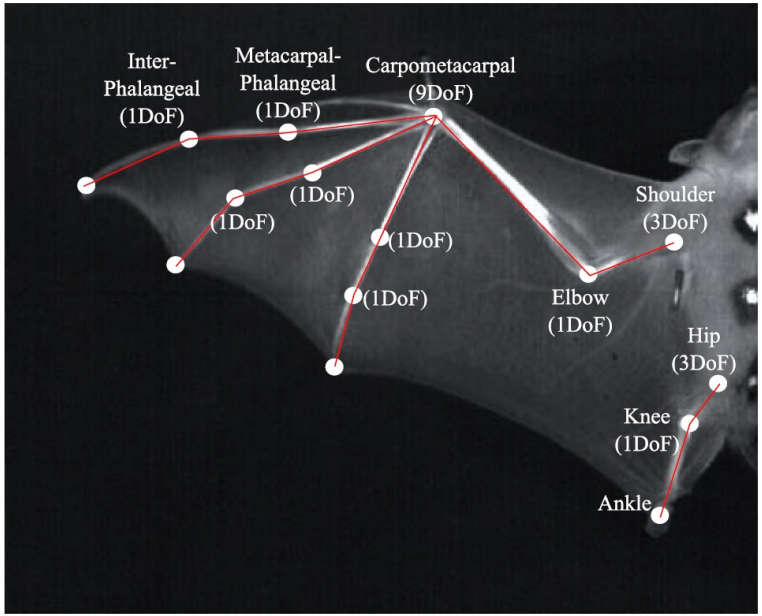
Bat as An Inspiration for Aerial Robots Design

- Objective: AI-guided analysis and modeling of bat's various flight maneuvers



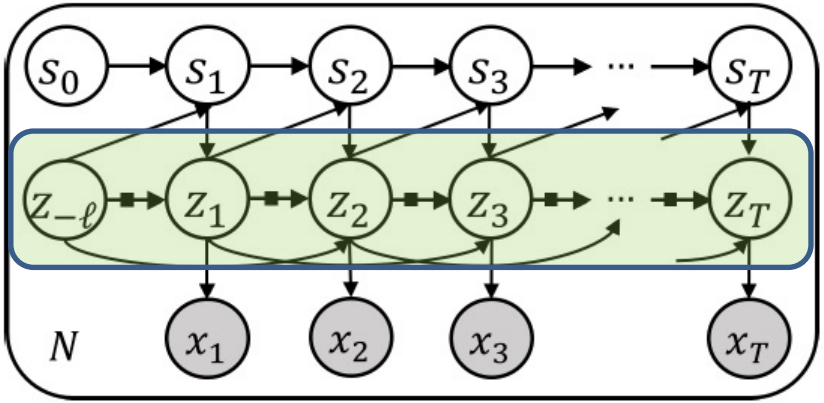
Modeling Dynamical Motions of A Bat Flight

- We model time evolution of motion data in a nonlinear switching dynamical system to:
  - provide a collection of interpretable states abstracted from the process dynamics, and
  - unravel recurring patterns in the data to perform robust short- and long-term predictions in a complex multimodal setting.



Our Proposed Deep Switching Autoregressive Factorization (DSARF) Model

$$X_n \sim \text{Norm}(L_\theta[Z_n],\, \sigma^X I),$$
$$Z_n \sim p_\theta(Z_n \,|\, \mathcal{S}_n),$$
$$\mathcal{S}_n \sim p_\theta(\mathcal{S}),$$



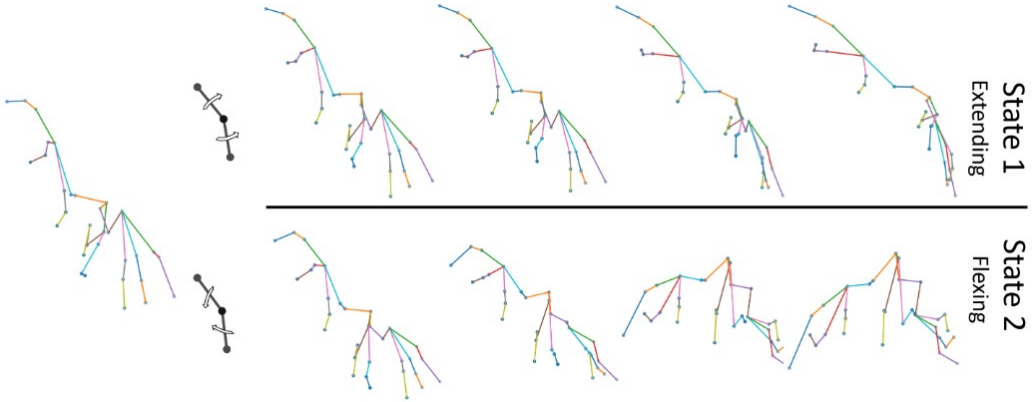
Discrete Markovian Prior $p_\theta(\mathcal{S})$

$$p_\theta(s_t | s_{t-1} = s, z_{t-1}) = \text{Cat}\left(\sigma\left(\mathbf{\Phi}_\theta^s\, z_{t-1}\right)\right),$$

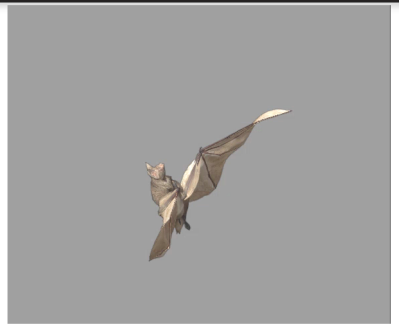
Deep Switching VAR Prior $p_\theta(Z_n|\mathcal{S}_n)$

$$p_\theta(z_t | z_{t-\ell}, s_t = s) = \text{Norm}\Big(\mu_\theta^s(z_{t-\ell}), \sigma_\theta^s(z_{t-\ell})\Big),$$

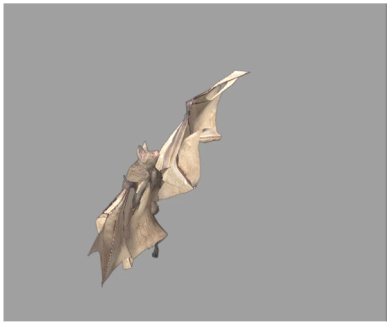
Bat Flight



Predicted Dynamical Trajectories for Each State



Extending



Flexing

Rendered in Blender

Broader Impact

- Our research objective will simplify the engineering procedure to design bio-inspired aerial co-robots that closely mimic the flight behavior of a target animal,
  - ***therefore is directly towards lowering the barriers for understanding fundamentals regarding closed-loop control and design of bio- inspired multimodal co-robots.***