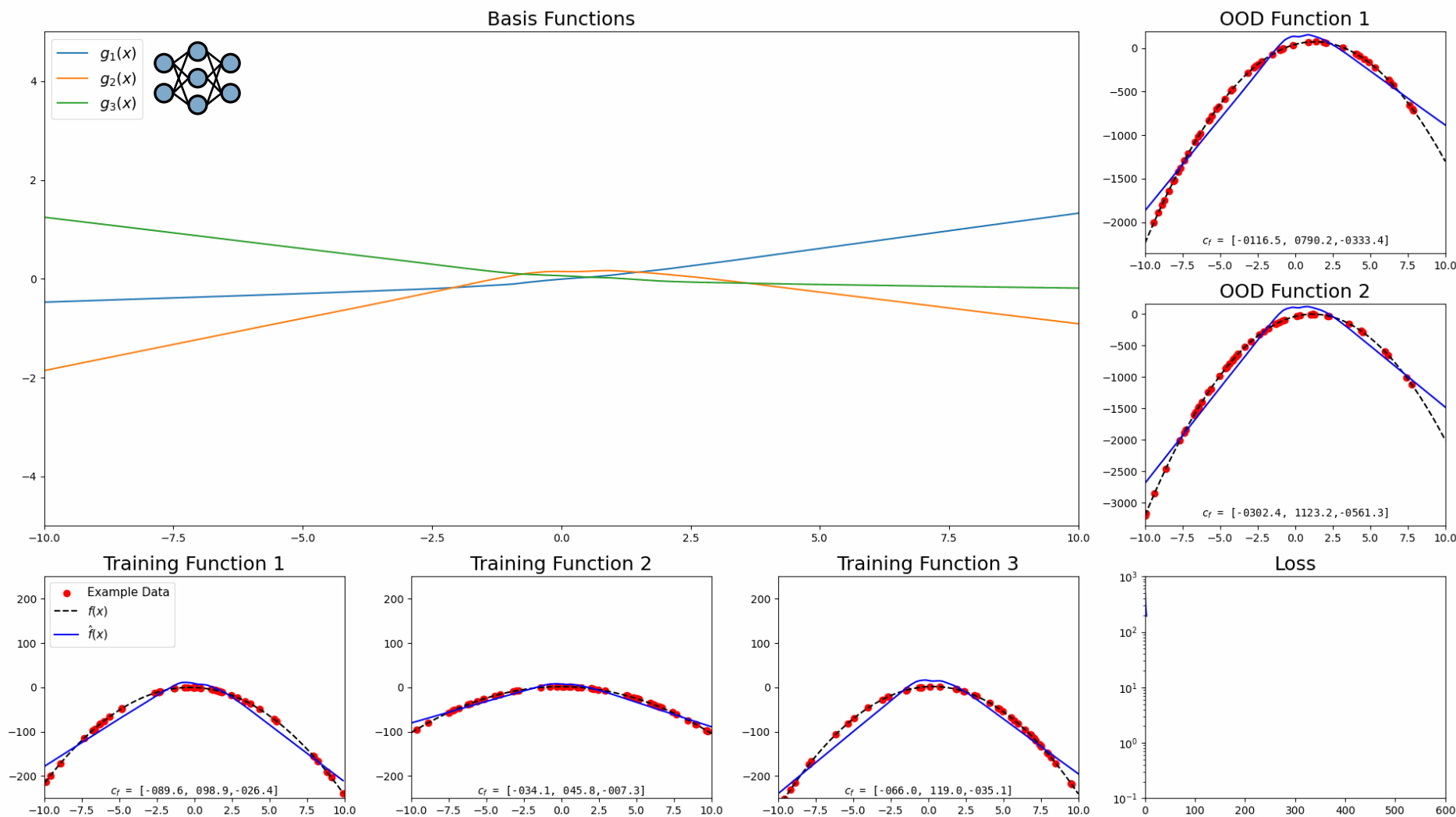


Zero-Shot Transfer of Neural ODEs

TYLER INGE BRAND, ADAM J. THORPE, UFUK TOPCU

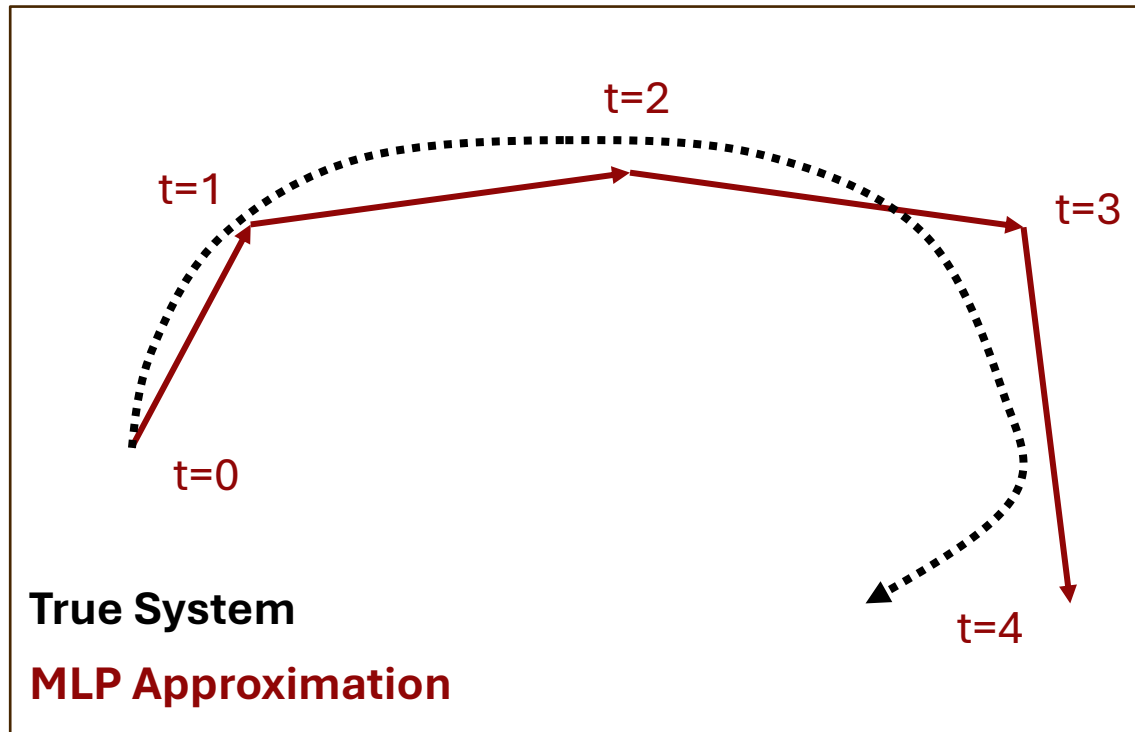
Function Encoders: A visualization



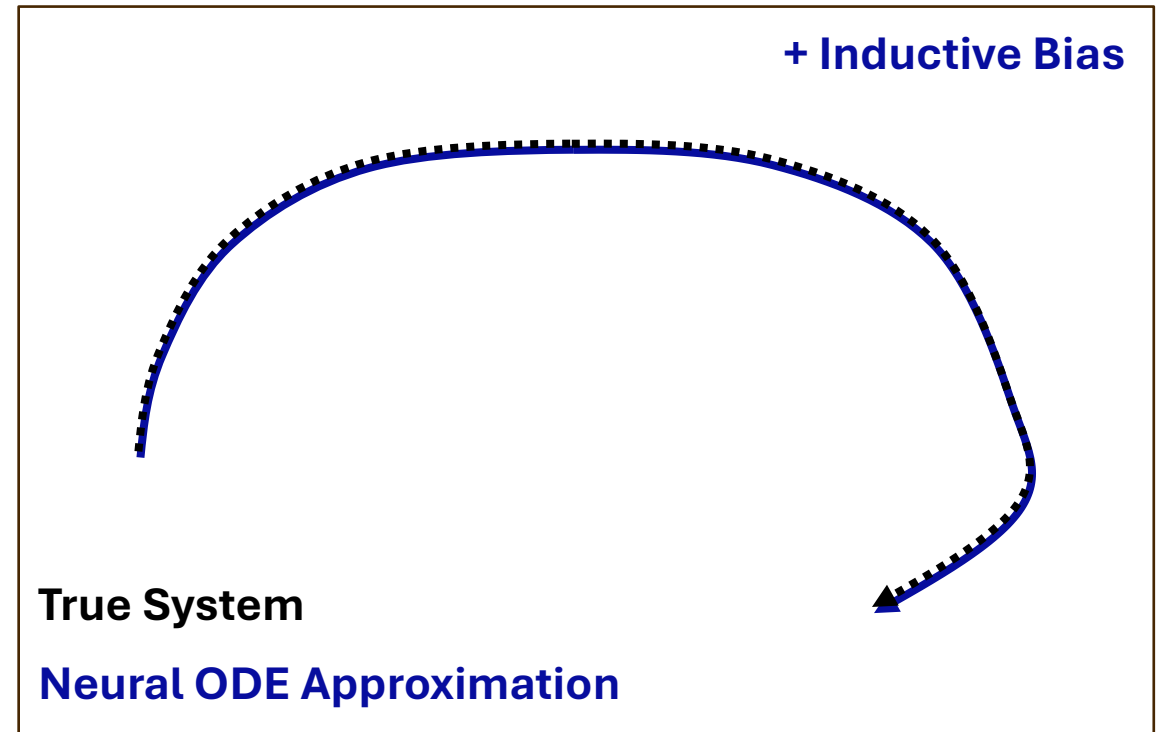
Improving Accuracy with Neural ODEs

$$x_{t+1} = f_{\theta}(x_t, u_t)$$

$$x(t_f) - x(t_0) = \int_{t_0}^{t_f} f_{\theta}(x(t), u(t)) dt$$

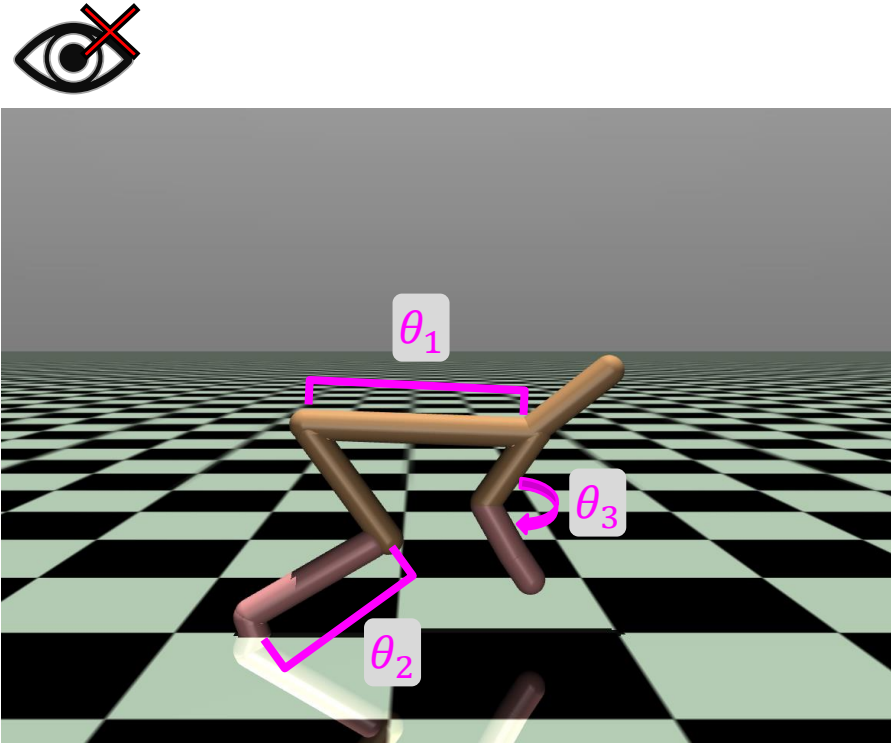


Modeling a dynamical system with a MLP predicts the state *only* at discrete time points.



Modeling a dynamical system with a neural ODE predicts the state at *all* time points.

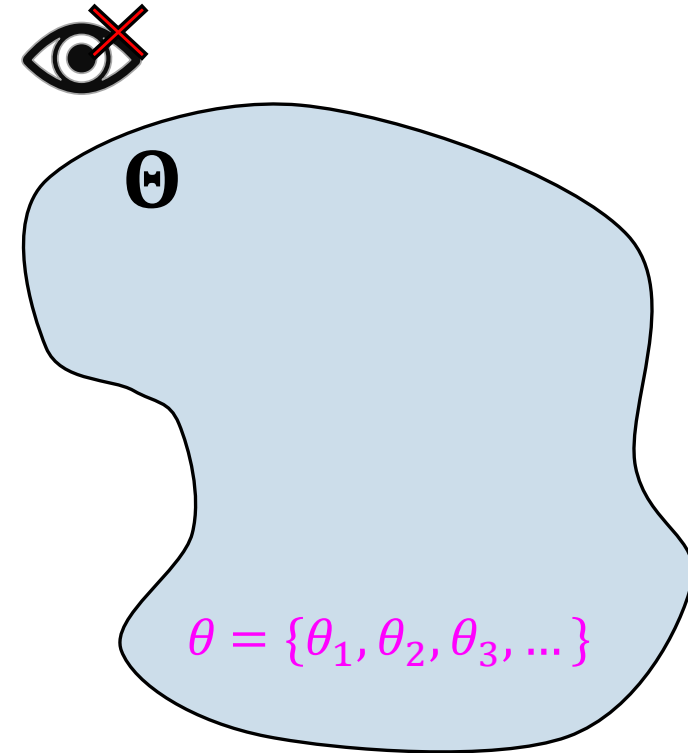
Hidden-Parameter Dynamics Prediction



Segment lengths, control authority, and friction are varied every episode.

Transition dynamics depend on θ , e.g.

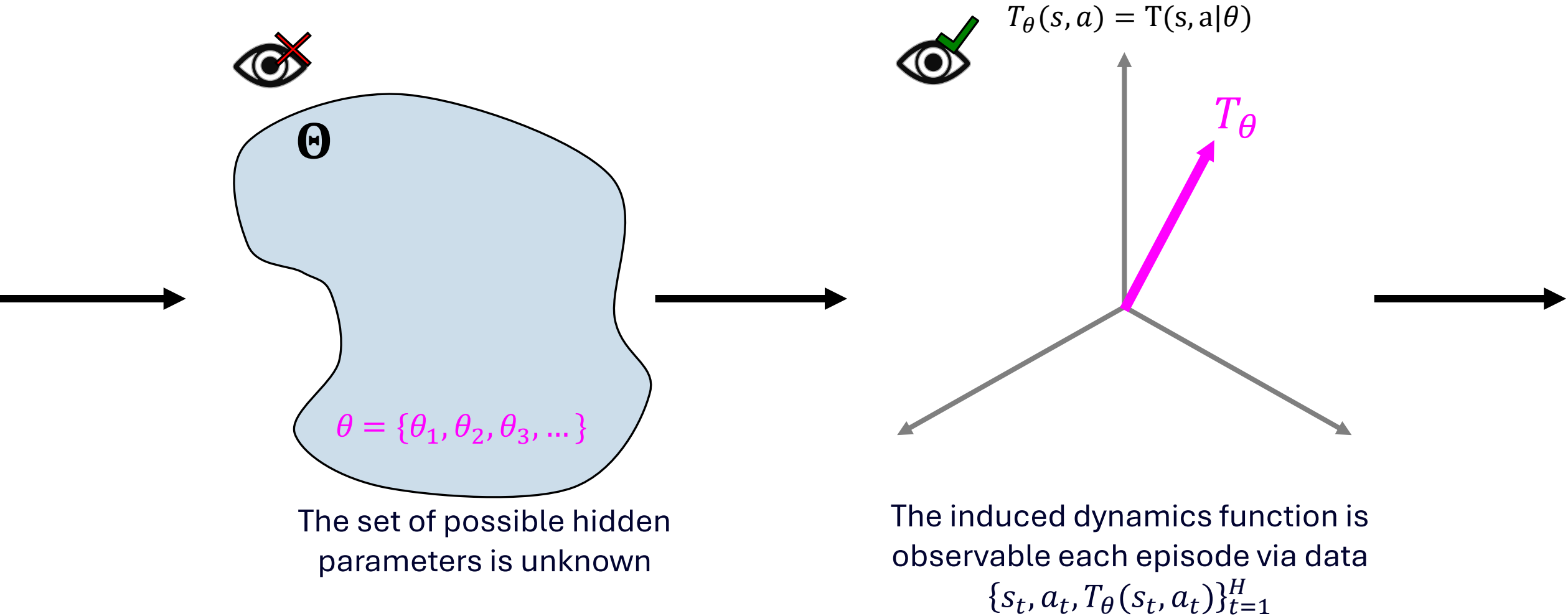
$$s_{t+1} = T(s_t, a_t | \theta)$$



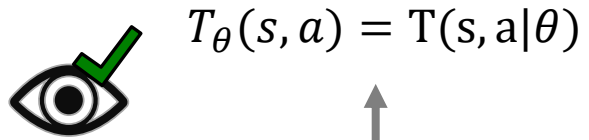
The set of possible hidden parameters is unknown



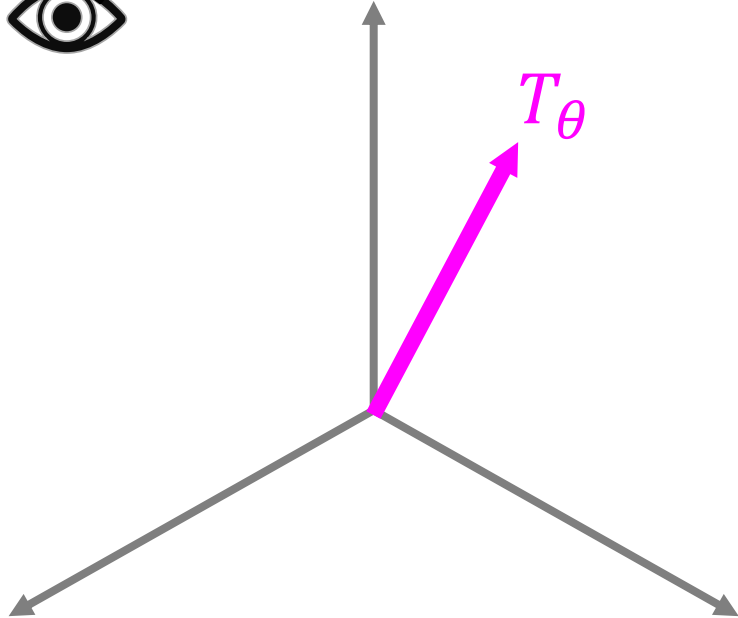
Hidden-Parameter Dynamics Prediction



Hidden-Parameter Dynamics Prediction



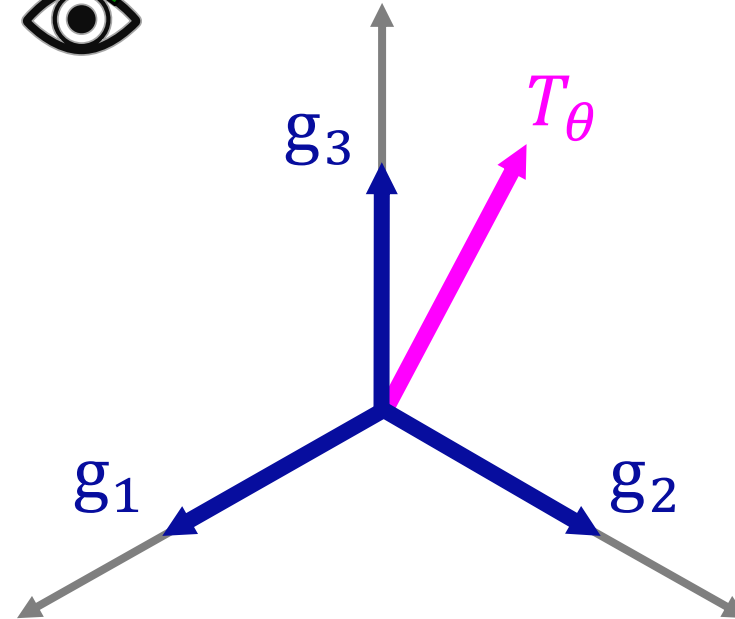
$$T_{\theta}(s, a) = T(s, a | \theta)$$



The induced dynamics function is observable each episode via data $\{s_t, a_t, T_{\theta}(s_t, a_t)\}_{t=1}^H$



$$T_{\theta}(s, a) = T(s, a | \theta)$$

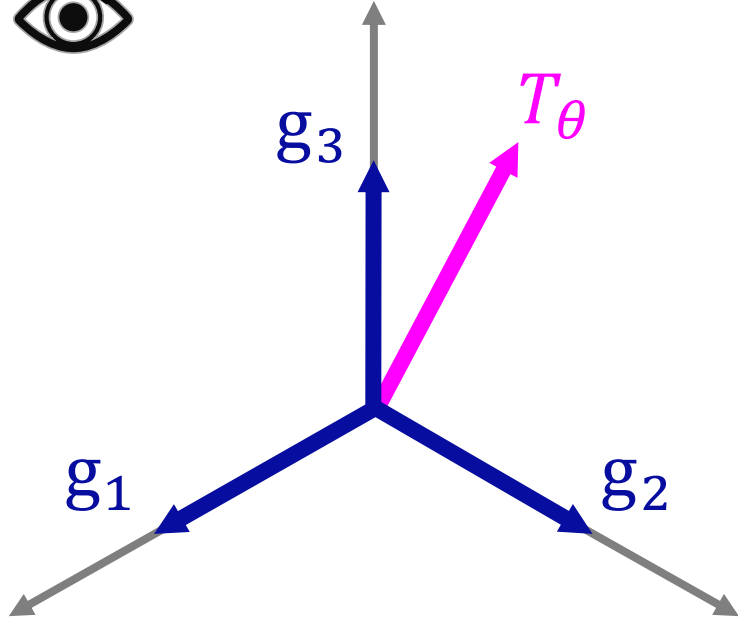


Given data over many episodes, we can learn basis functions over the space of induced dynamics, where $g_i: S \times A \rightarrow S$

Hidden-Parameter Dynamics Prediction



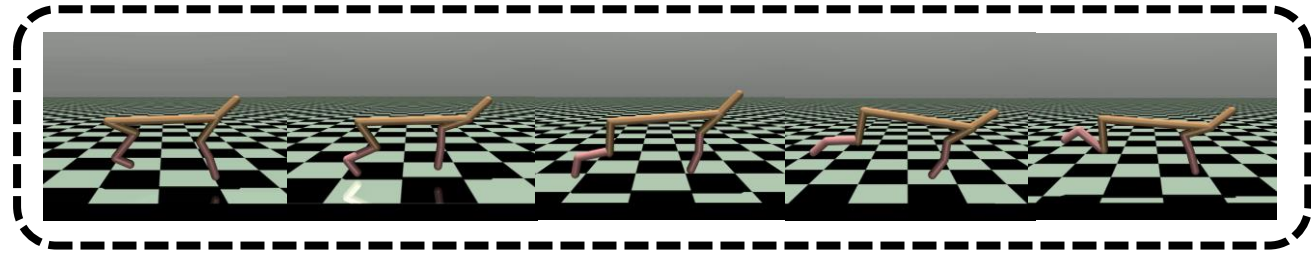
$$T_{\theta}(s, a) = T(s, a|\theta)$$



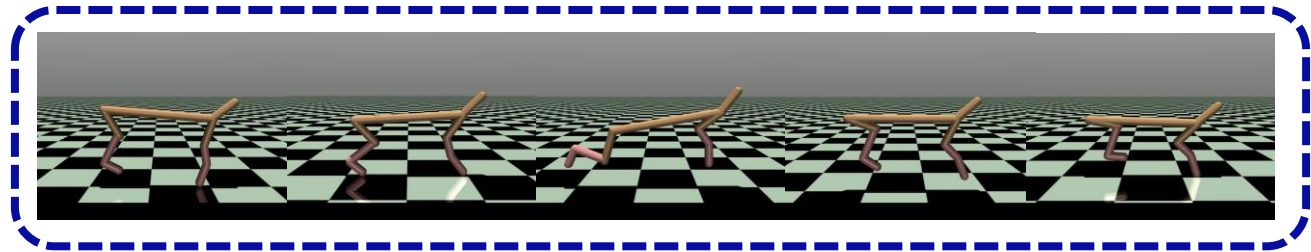
Given data over many episodes,
we can learn basis functions over
the space of induced dynamics,
where $g_i: S \times A \rightarrow S$



Small, online dataset

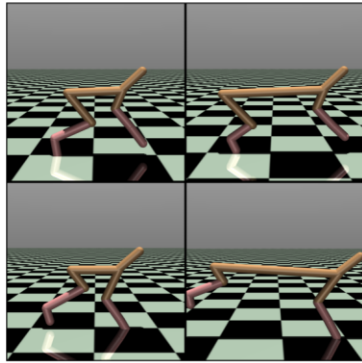


Future states of the episode

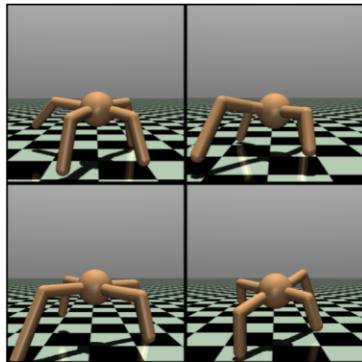


Once we have learned basis
functions, can we predict
dynamics after collecting a small
amount of online data?

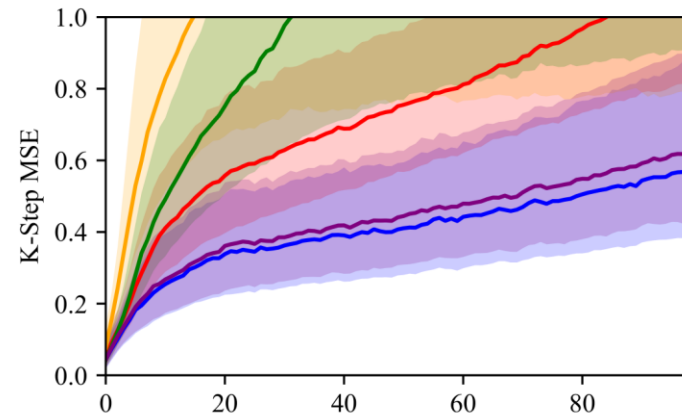
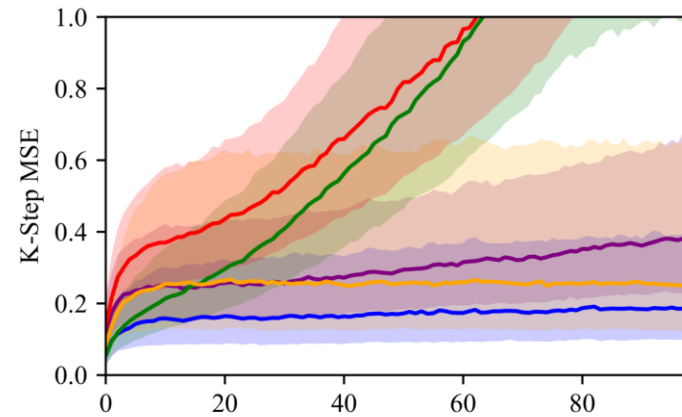
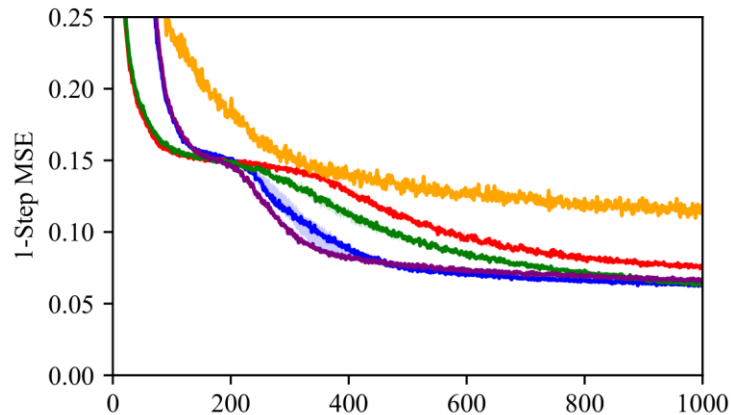
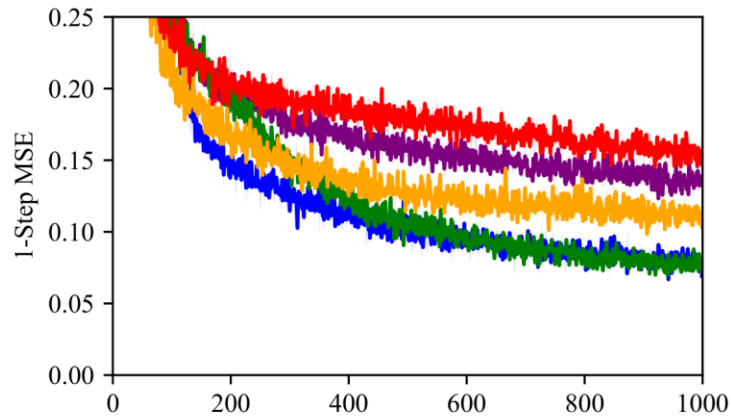
Hidden-Parameter Dynamics Prediction w/ Neural ODEs



Half Cheetah



Ant

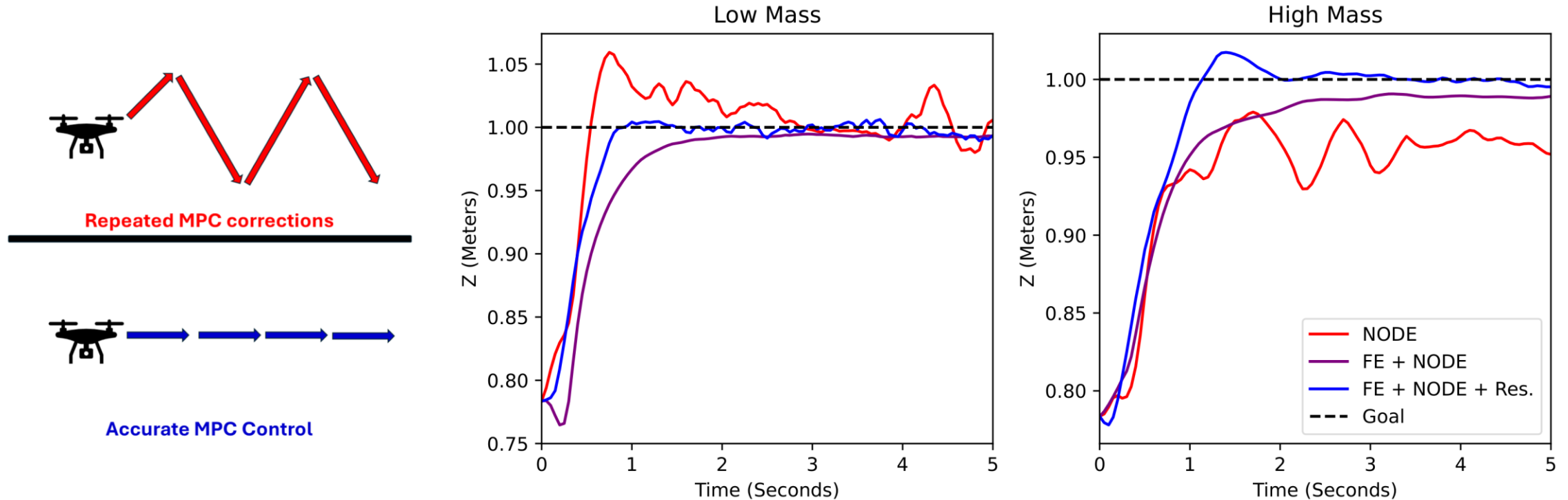


K-Step
lookahead is
significantly
improved

Takeaway:
Function encoders
inherit the inductive
biases of their basis
functions

— NODE — FE + Res. — FE + NODE — FE + NODE + Res. — Oracle

The Impact on Downstream Controllers

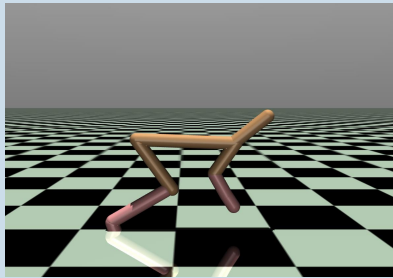


Example: A quadrotor carrying a package, where the weight of the package is a hidden parameter. The controller is using a learned model for model predictive control (MPC).

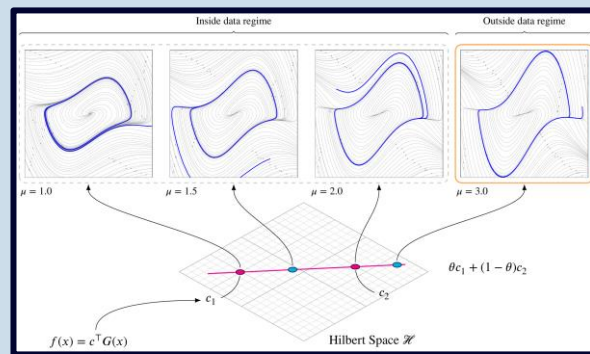
Learned Basis Functions and Transfer

Online Prediction

Dynamics Prediction

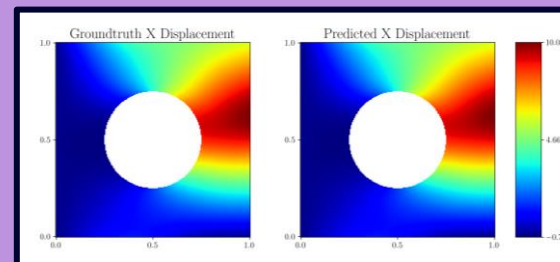
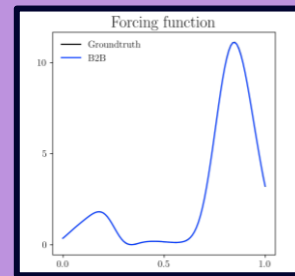


Neural ODEs



Context Representation

Operator Learning



Multi-Task RL



Multi-Agent RL

