Trajectory World Models for Heterogeneous Environments

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Motivation: Heterogeneity inherent in sensor and actuator information

Motivation

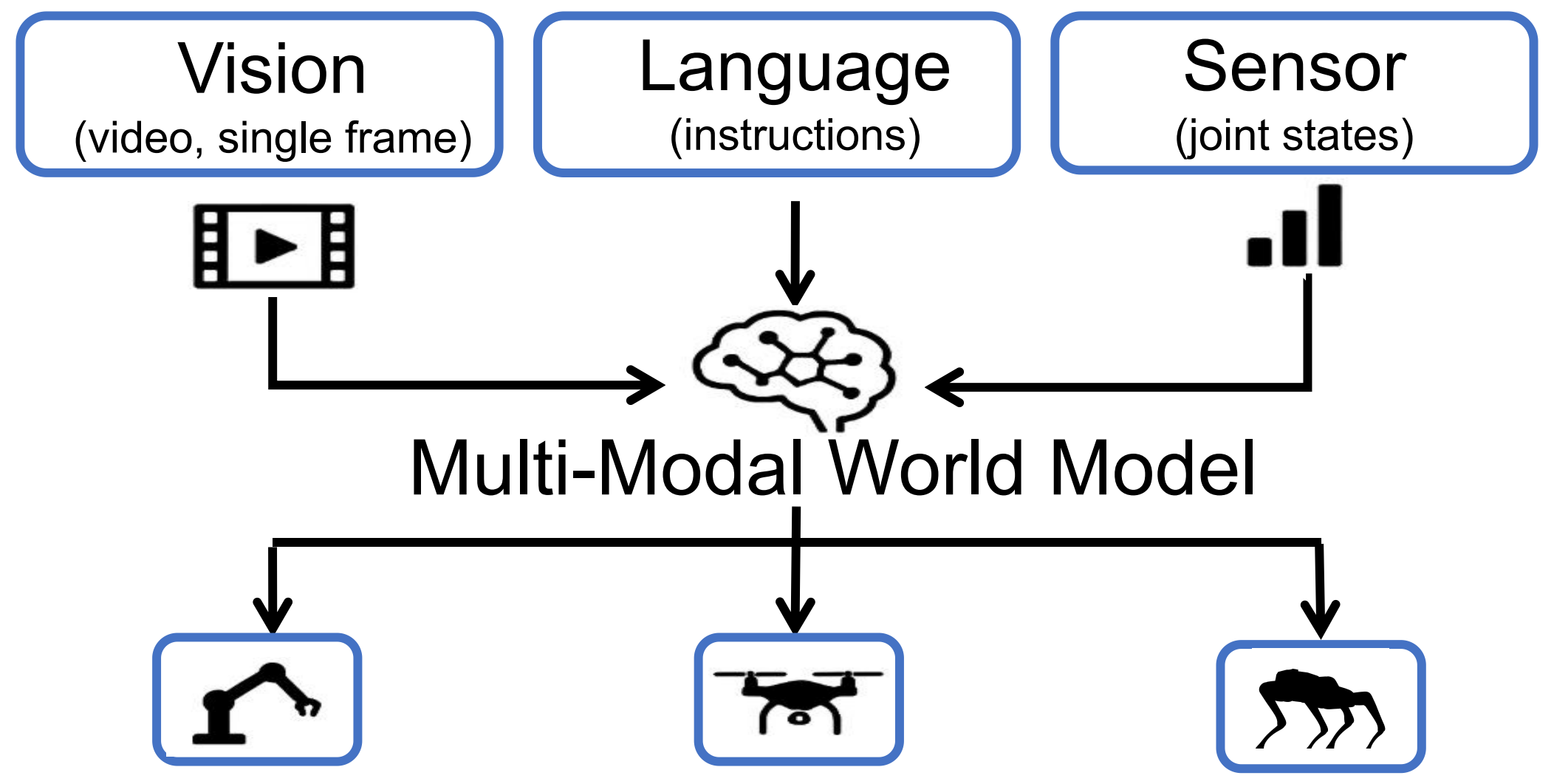
World models are all with videos or language?

No modality in world models should be left behind, including essential sensor information represented as low-dimensional vectors!

How can we pre-train a world model to extract shared knowledge from trajectories across heterogeneous environments?

Vision of the future

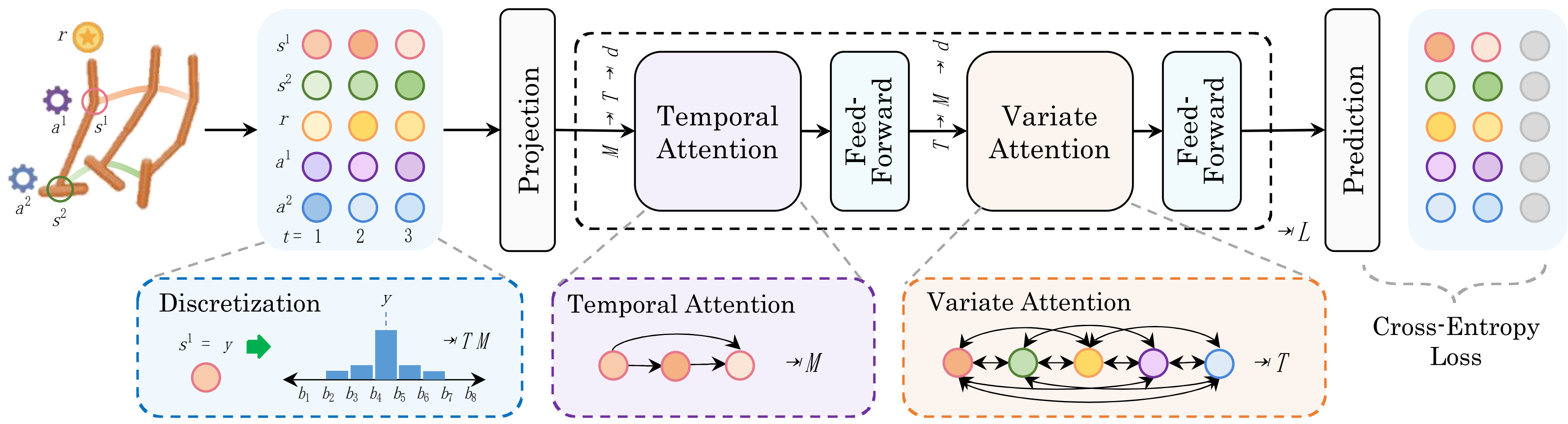
Towards multi-modal world models incorporating proprioceptive, visual and linguistical observations



Method: TrajWorld (Trajectory World Models)

Overview:

TrajWorld, designed for flexibility in handling divergent state and action definitions, is capable of flexibly handling varying sensor and actuator information and capturing environment dynamics in-context.



Intuition:

1. Rediscovering homogeneity in scalars.
2. Identifying environment through historical context.
3. Inductive bias for two-dimensional representations.

Interleaved temporal-variate attentions:

1. temporal attention

$$U^l_{1:T,j} = \mathrm{CausalAttention}(Z^{l-1}_{1:T,j}), \quad \forall j \in [M],$$

2. variate attention

$$V^l_{i,1:M} = \mathrm{Attention}(\hat{U}^l_{i,1:M}), \quad \forall i \in [T].$$

Pre-training & Finetuning

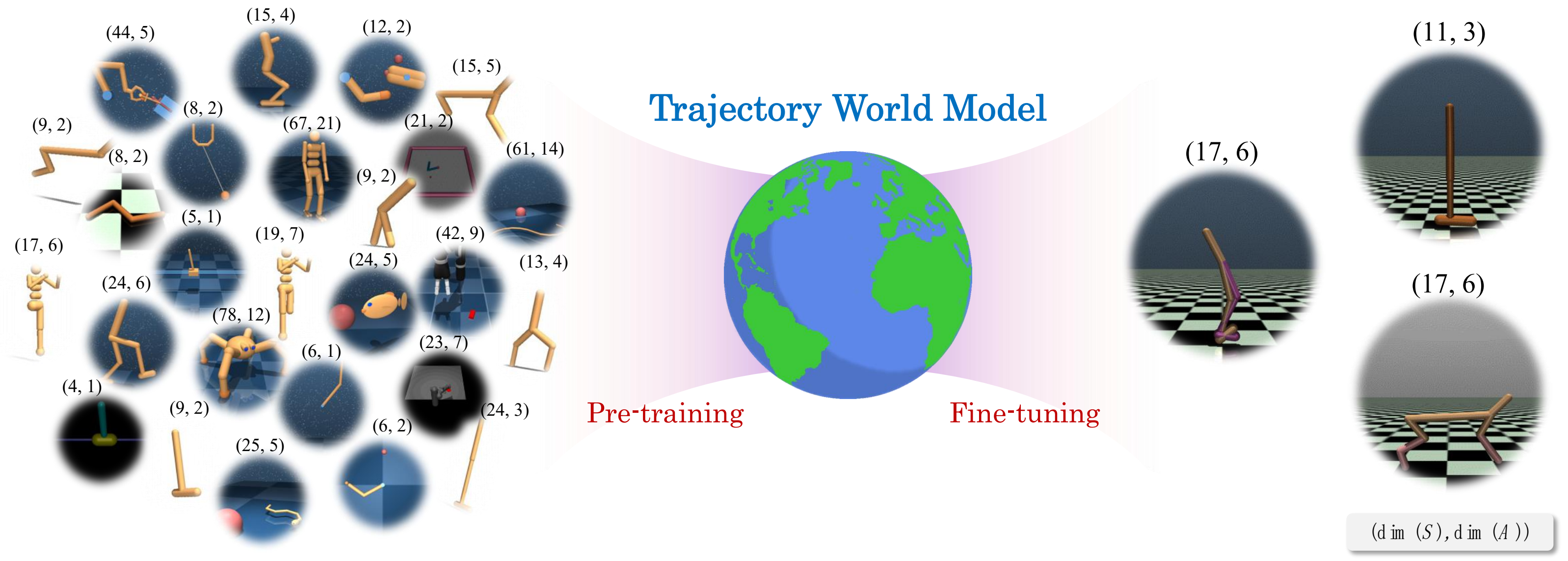
80 Unique Envs

719M Environment Steps

1.4M Episodes

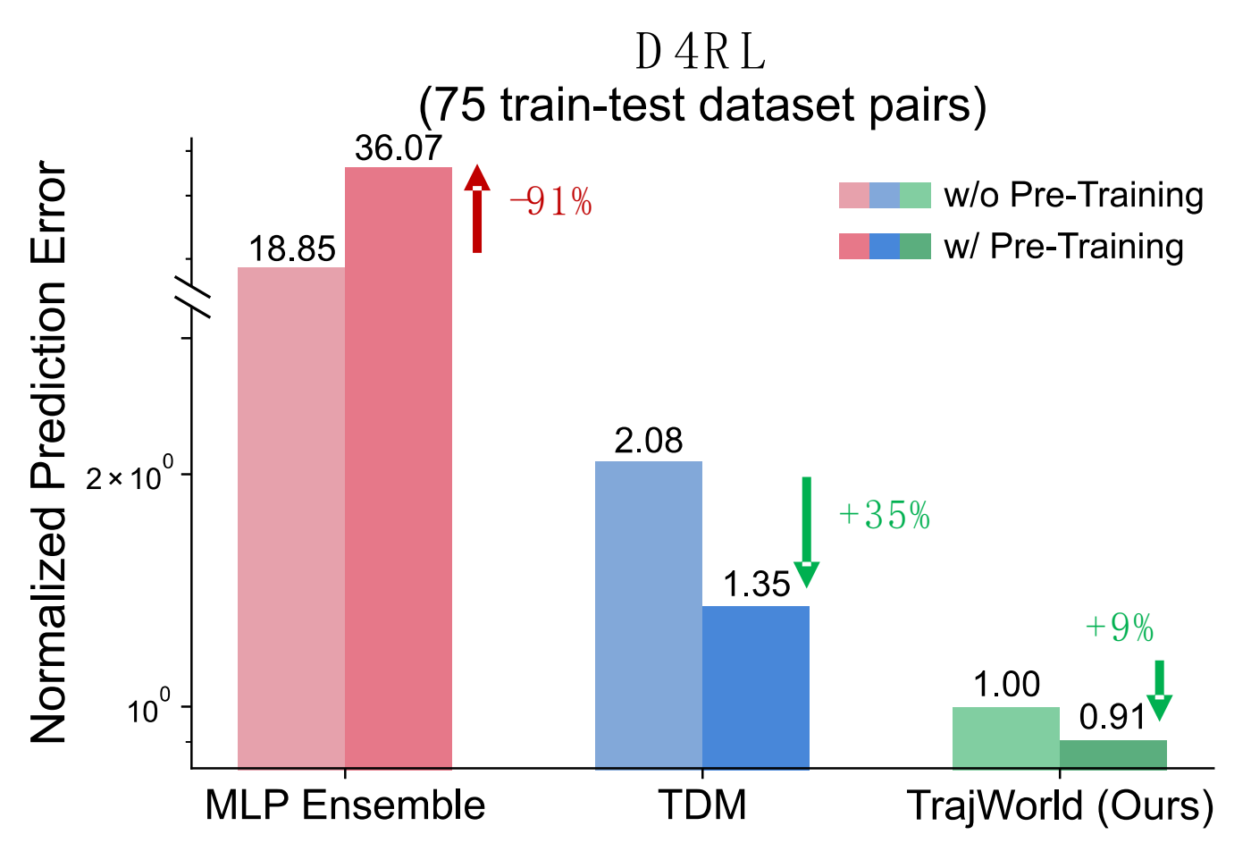
merge five atasets with different characteristics self-collection

environment + distribution diversity

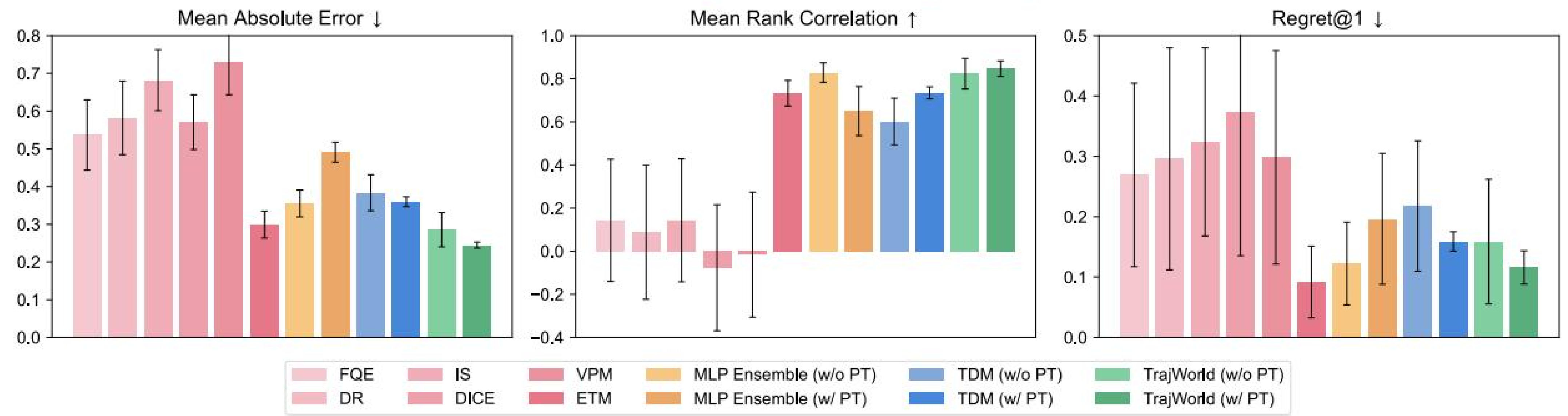


Experiments

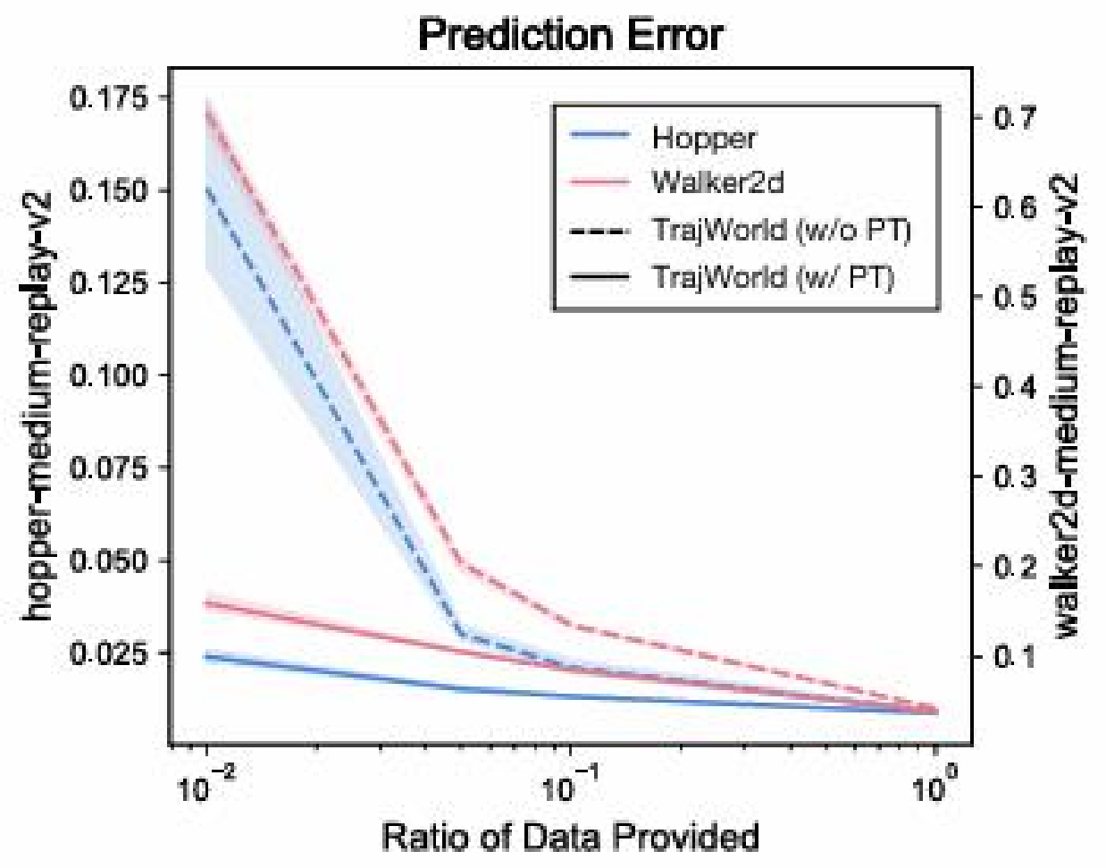
Transition Prediction



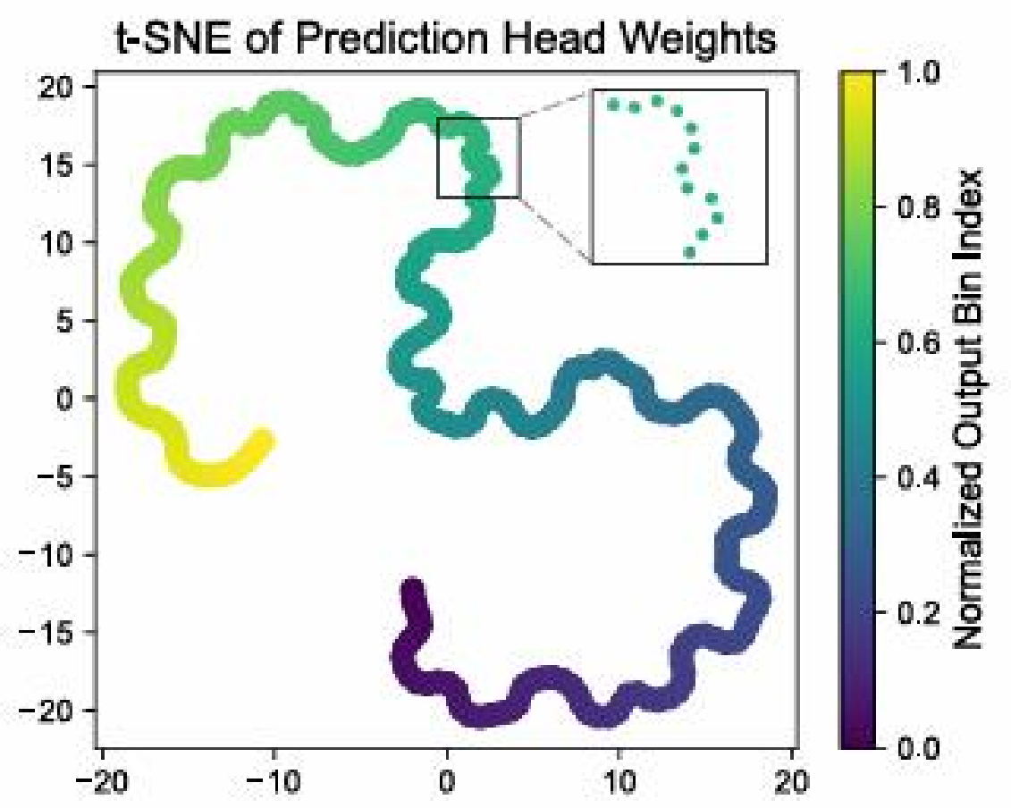
Off-Policy Evaluation (OPE)



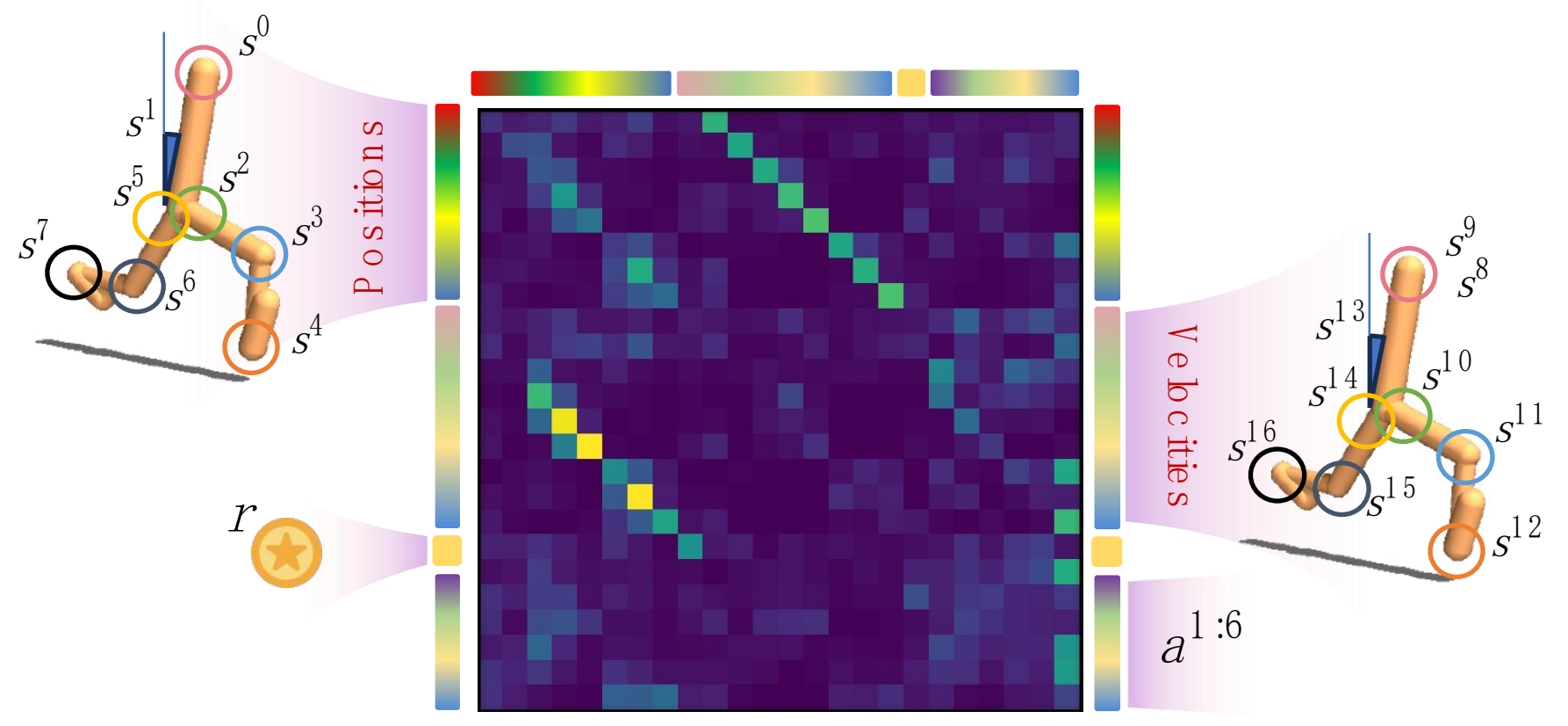
Few-shot adaptation



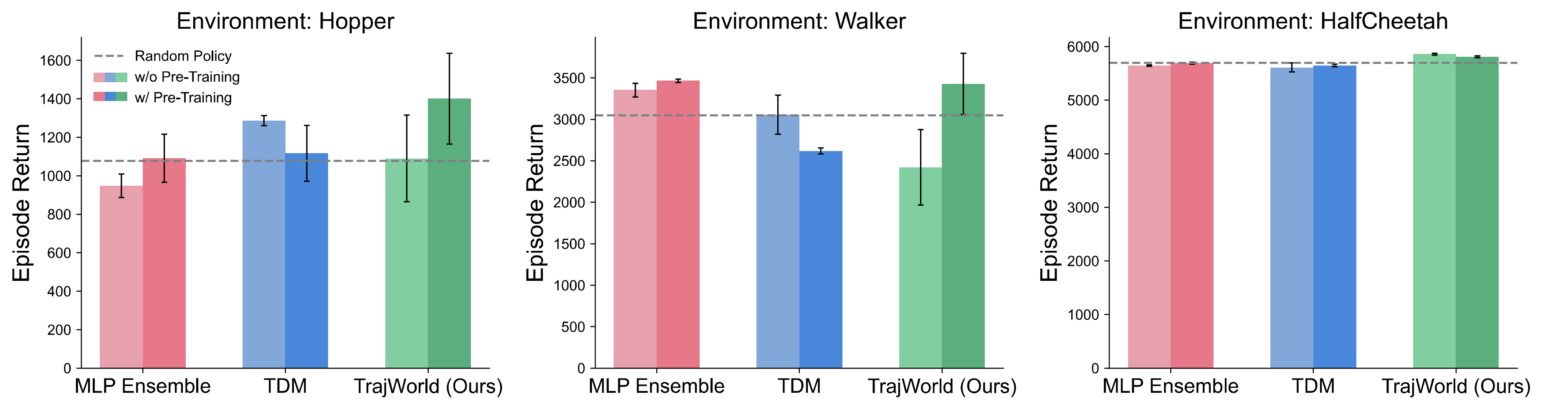
Discretization



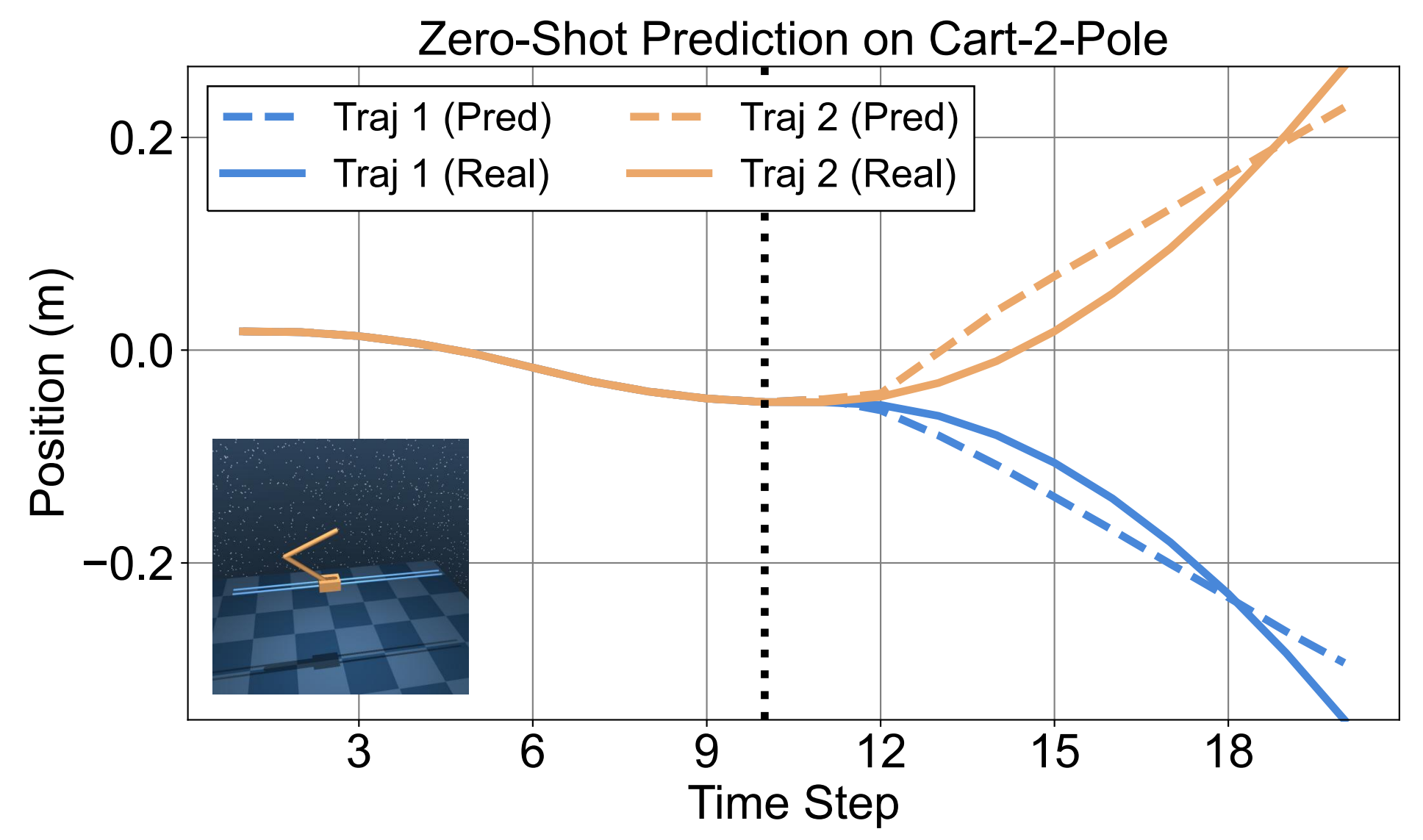
Attention Analysis



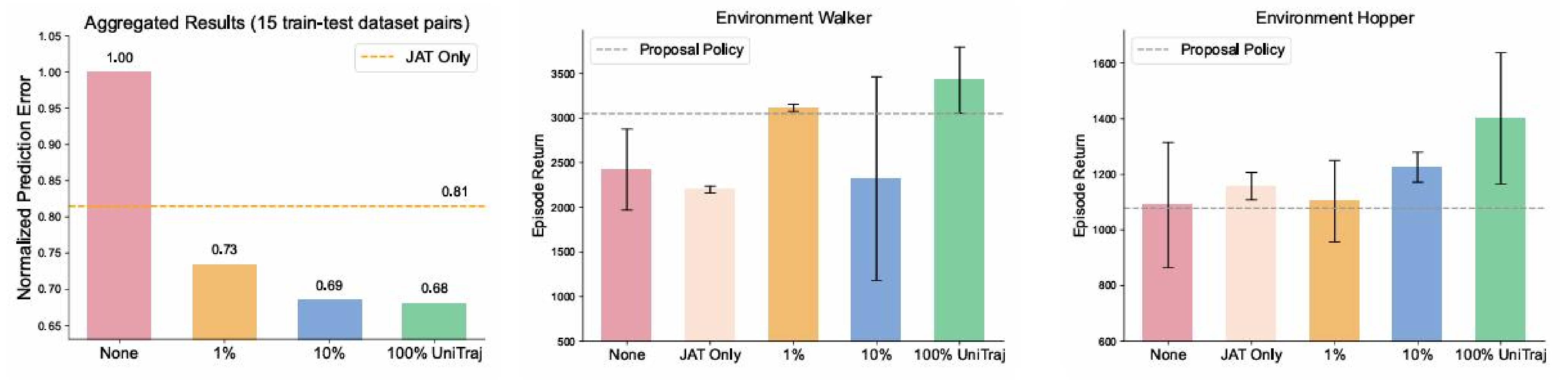
Model Predictive Control (MPC)



Zero-Shot Transfer



Scaling Trend



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Code: https://github.com/thuml/TrajWorld

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