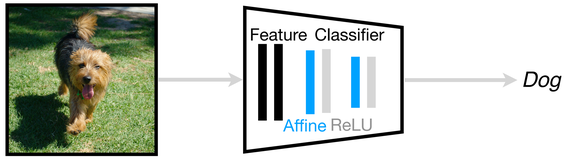
# PRISM: Polynomial Representations for Interaction-Structured Motor Control

Seung Hyun Lee  Stella X. Yu

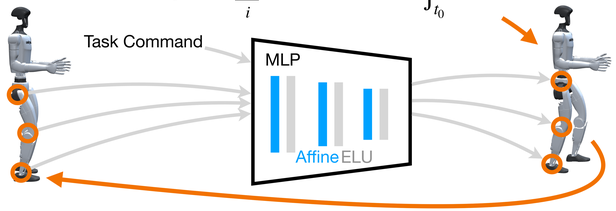
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## Arbitrary Image-to-Label Mapping via MLP



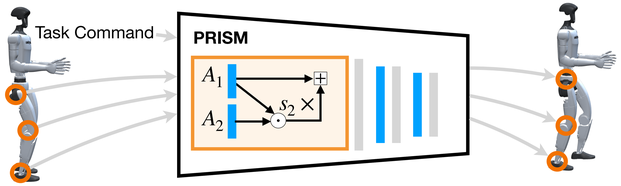

## Robot Policy Learning is Not Arbitrary Mapping

$$P_{\text{joint}} = \sum_i \tau_i \dot{q}_i \qquad W_{\text{contact}} = \int_{t_0}^{t_1} f_c^\top v_c \, dt$$




$$M(q)\ddot{q} + C(q,\dot{q})\dot{q} + g(q) = Q \qquad [C(q,\dot{q})\dot{q}]_i = \sum_{j,k} c_{ijk}(q)\dot{q}_j\dot{q}_k$$

## Robot Dynamics Control Objectives Use Products




$$A_k(x_t) = W_k x_t + b_k$$

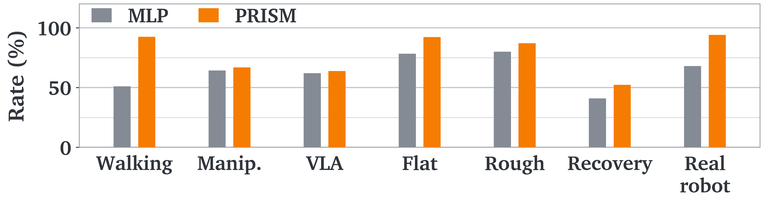
$$\text{MLP} = \text{PRISM}_{\{s_k=0,\forall k\}}$$

$$\psi_1(x_t) = A_1(x_t)$$

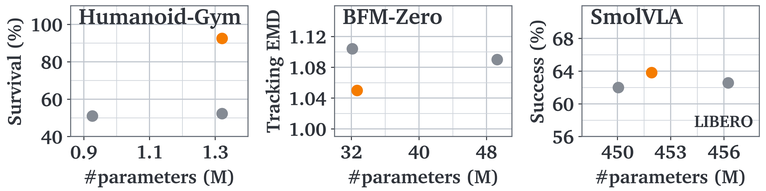
$$\psi_2(x_t) = A_1(x_t) + s_2\left(A_1(x_t) \odot A_2(x_t)\right)$$

$$\psi_k(x_t) = \psi_{k-1}(x_t) + s_k\left(\psi_{k-1}(x_t) \odot A_k(x_t)\right)$$

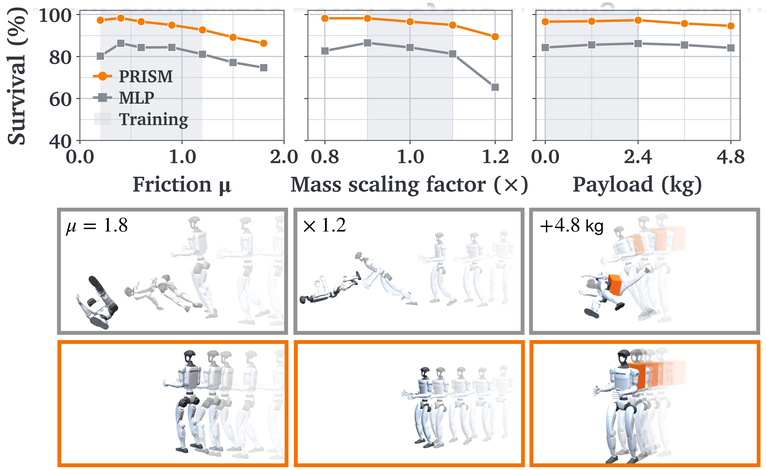
## PRISM Improves Robot Control and Generalization




## PRISM Gains Are Not Matched by Larger MLPs



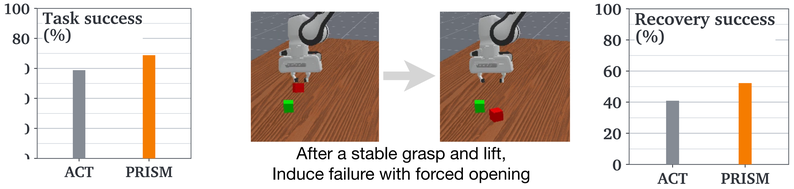

## PRISM Generalizes Better Beyond Training Conditions



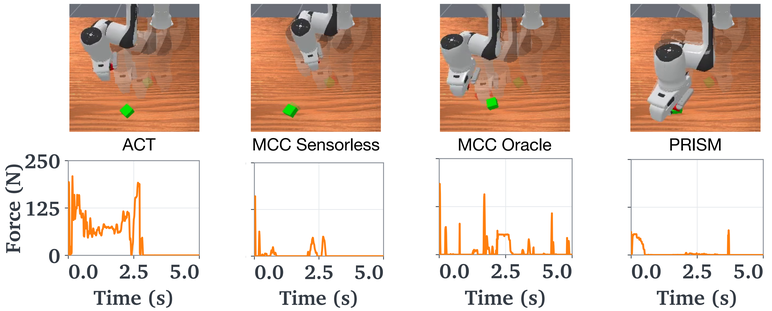

## PRISM Improves Real World Control of Tape Pickup




## PRISM Improves Recovery Success After Failures




## PRISM Automatically Achieves Sensorless Compliance




## Key Take-Aways

- ✓ PRISM learns multiplicative interactions rather than prescribes them.
- ✓ PRISM represents compactly by recursively adding bilinear terms.
- ✓ PRISM substantially outperforms standard MLPs, esp. on generalization.