What's the Move? Hybrid Imitation Learning via Salient Points

Priya Sundaresan^{*1}, Hengyuan Hu^{*1}, Quan Vuong ², Jeannette Bohg ¹, Dorsa Sadigh ¹

*Equal contribution ¹Stanford University, ²Physical Intelligence



How can we learn sample-efficient IL policies that generalize spatially for complex tasks?

Prior Work

Dense Policies

Actions on a *per-timestep* basis.



[1, 2, 3]

Hybrid Policies Multiple action modes.



Waypoint Policies

Actions predicted *sparsely* as poses.



^[1] Chi, Cheng, et al. "Diffusion policy: Visuomotor policy learning via action diffusion." *IJRR*, 2023.

^[2] Zhao, Tony Z., et al. "Learning fine-grained bimanual manipulation with low-cost hardware." RSS, 2023.

^[3] Ze, Yanjie, et al. "3d diffusion policy." *arXiv preprint arXiv:2403.03954* (2024).

^[4] Shridhar, Mohit, Lucas Manuelli, and Dieter Fox. "Perceiver-actor: A multi-task transformer for robotic manipulation." *CoRL*, 2023.

^[5] Goyal, Ankit, et al. "Rvt: Robotic view transformer for 3d object manipulation." CoRL, 2023.

^[6] Belkhale, Suneel, Yuchen Cui, and Dorsa Sadigh. "Hydra: Hybrid robot actions for imitation learning." CoRL, 2023.

Key Insight

• Different **input modalities** & **action spaces** are suited to different task phases:

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Point Clouds + Waypoints → Long-Range Movements

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• Different **input modalities** & **action spaces** are suited to different task phases:

Point Clouds + Waypoints → Long-Range Movements Wrist Images + Dense Actions → Precise Movements

These mode switches typically occur around task-relevant salient points which can be learned.

SPHINX

Salient-Point based Hybrid Imitation and eXecution

SPHINX Data Collection Interface

Record Waypoint

End Demo

[Translation] Key: Shift



SPHINX Data Collection



place train on bridge

grasp and tilt bridge

SPHINX







Classify salient (task-relevant) **point**, predict waypoint as a relative offset to that point





SPHINX: Dense Policy

Diffusion Policy which outputs dense actions + mode.



SPHINX



Experiments: Waypoint-Only Tasks





Experiments: Waypoint-Only Tasks



DP 🔤 3D DP 📁 Vanilla Waypoint 📁 Vanilla Waypoint + Aux. Salient Pts.

Experiments: Waypoint-Only Tasks

DP



🗰 3D DP 🛛 🖿 Vanilla Waypoint 📁 Vanilla Waypoint + Aux. Salient Pts. 📁 SPHINX

Experiments: Hybrid Tasks Diffusion Policy





Experiments: Hybrid Tasks



SPHINX Results: Precise, Long-Horizon Tasks



SPHINX Results: Visual Generalization



Visual Distractors

Novel Viewpoint

Raised Drawer Height

SPHINX Results: Novel Execution Speeds



SPHINX Vanilla Controller

SPHINX 2x Sped Up Controller

SPHINX Results: Spatial Generalization



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