Physical Plausibility-Aware Trajectory Prediction via Locomotion Embodiment

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CVPR Nashville JUNE 11-15, 2025

Intro: Human Trajectory Prediction (HTP)

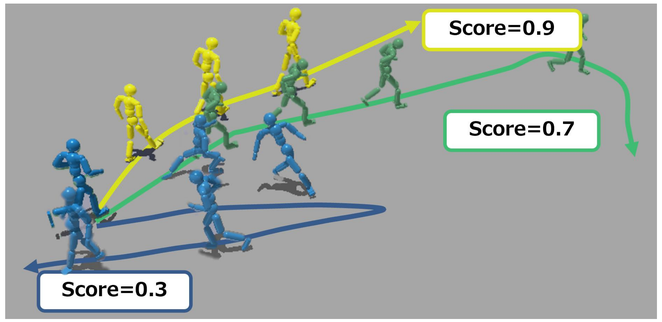
- Predicts future trajectories from past observations
- Recent work [1] incorporates human poses, but…

☹ **Even SoTA predicts implausible trajectories**

Idea: Locomotion Embodiment

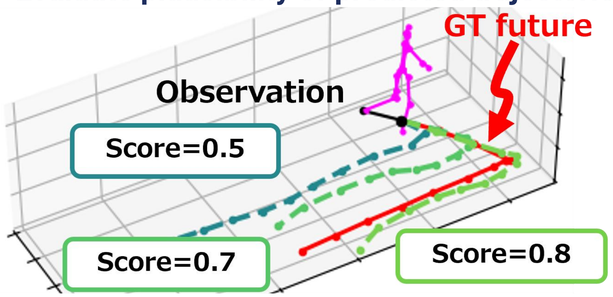
- Locomotion generation [2] in a physics simulator

👉 **Cannot follow implausible trajectories!**



- Learn physics simulation-based plausibility score

👉 **Evaluate plausibility of predicted trajectories!**

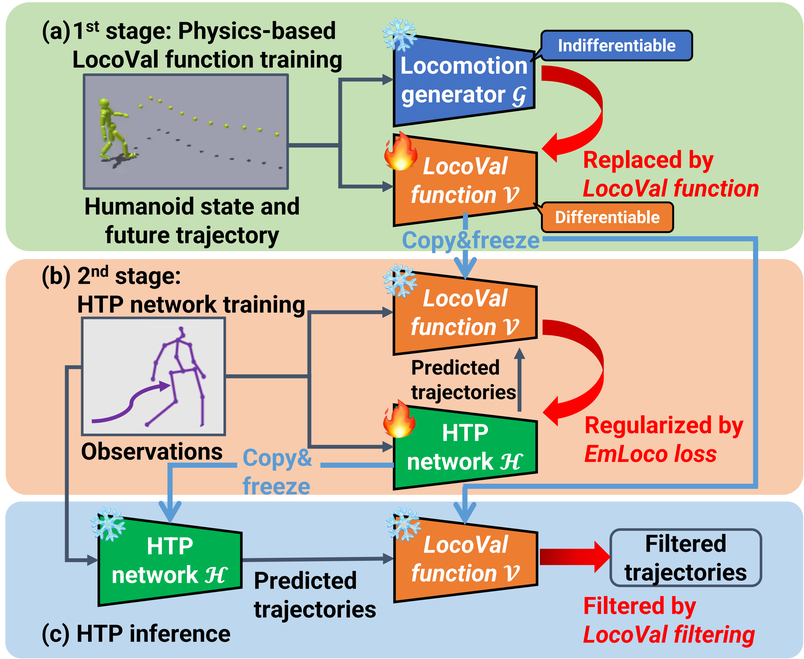


Proposed Method: Physical Plausibility-aware HTP

(a) ***LocoVal function*** estimates returns of locomotion generation

(b) ***EmLoco loss*** promotes plausible HTP through *LocoVal function*

(c) ***LocoVal filtering*** of implausible predictions using *LocoVal function*



✅ **No need for physics simulation at training and inference**

✅ **Plausibility-aware supervision of multi-head predictions**

✅ **Plug-and-play filtering with pretrained HTP networks**

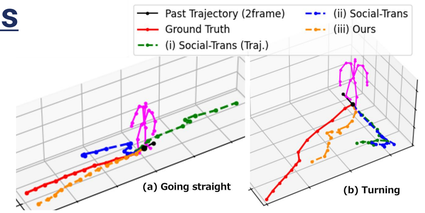
Results

HTP Training with EmLoco Loss

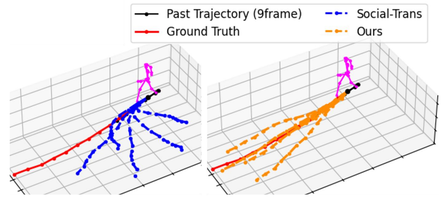
😄 **EmLoco loss stably enhances HTP performance**

Method	JTA ADE	JTA FDE	JRDB ADE	JRDB FDE
Social-GAN-det	1.66	3.76	0.50	0.99
Transformer	1.56	3.54	0.56	1.10
Vanilla-LSTM	1.44	3.25	0.42	0.83
Occupancy-LSTM	1.41	3.15	0.43	0.85
Directional-LSTM	1.37	3.06	0.45	0.87
Dir-social-LSTM	1.23	2.59	0.48	0.95
Social-LSTM	1.21	2.54	0.47	0.95
Autobots	1.20	2.70	0.39	0.80
Trajectron++	1.18	2.53	0.40	0.78
EqMotion [3]	1.13	2.39	0.40	0.77
Social-Trans [1]	**1.11**	**2.26**	**0.40**	**0.76**
Ours	**0.97**	**1.91**	**0.37**	**0.72**

Deterministic HTP with complete past observations



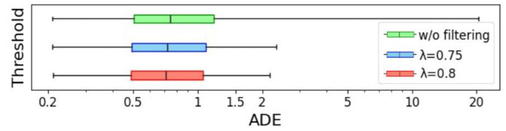
HTP with momentary observations

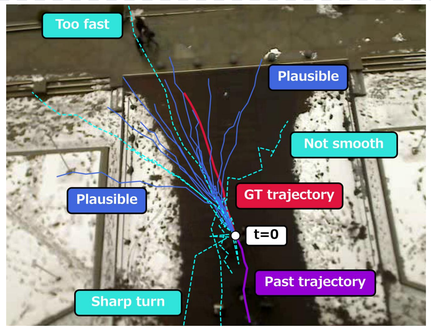


HTP with multi-head predictions

Zero-shot LocoVal Filtering

😄 **LocoVal filter can reject implausible trajectories, while preserving accuracy and diversity**





Method	ETH ADE	ETH FDE	HOTEL ADE	HOTEL FDE	UNIV ADE	UNIV FDE	ZARA1 ADE	ZARA1 FDE	ZARA2 ADE	ZARA2 FDE	Mean ADE	Mean FDE
Pretrained EqMotion [3]	2.18	4.63	0.64	1.31	1.30	2.81	0.82	1.84	0.65	1.47	1.12	2.41
Ours (w/ LocoVal filter)	**1.41**	**2.88**	**0.61**	**1.26**	**0.93**	**2.04**	**0.80**	**1.80**	**0.64**	**1.45**	**0.88**	**1.89**
Rejected trajectories	8.89	19.72	2.69	5.53	4.33	9.18	1.70	3.67	2.21	4.72	3.96	8.56

Key Take-away:

Trajectory evaluation as locomotion leads plausible & accurate predictions

References and link

[1] S. Saadatnejad *et al.*, "Social-Transmotion", ICLR2024.
[2] D. Rempe *et al.*, "Trace and Pace", CVPR2023.
[3] C. Xu *et al.*, "EqMotion", CVPR2023.

- Code available on GitHub
- Paper released on arXiv

SCAN ME 👉