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Ball Trajectory Inference from Multi-Agent Sports Contexts Using Set Transformer and Hierarchical Bi-LSTM

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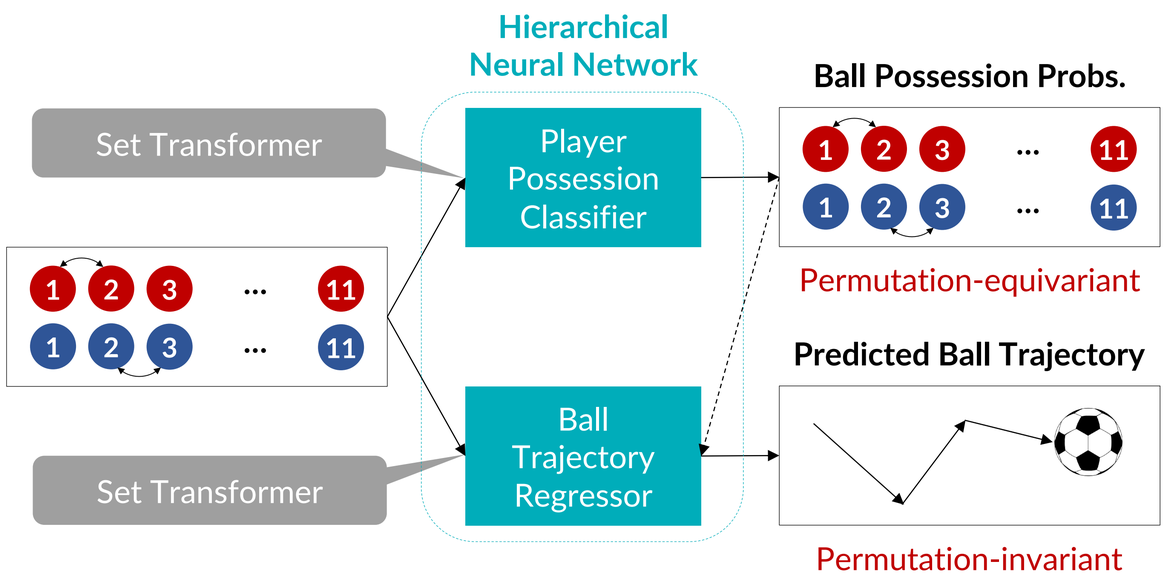
Introduction

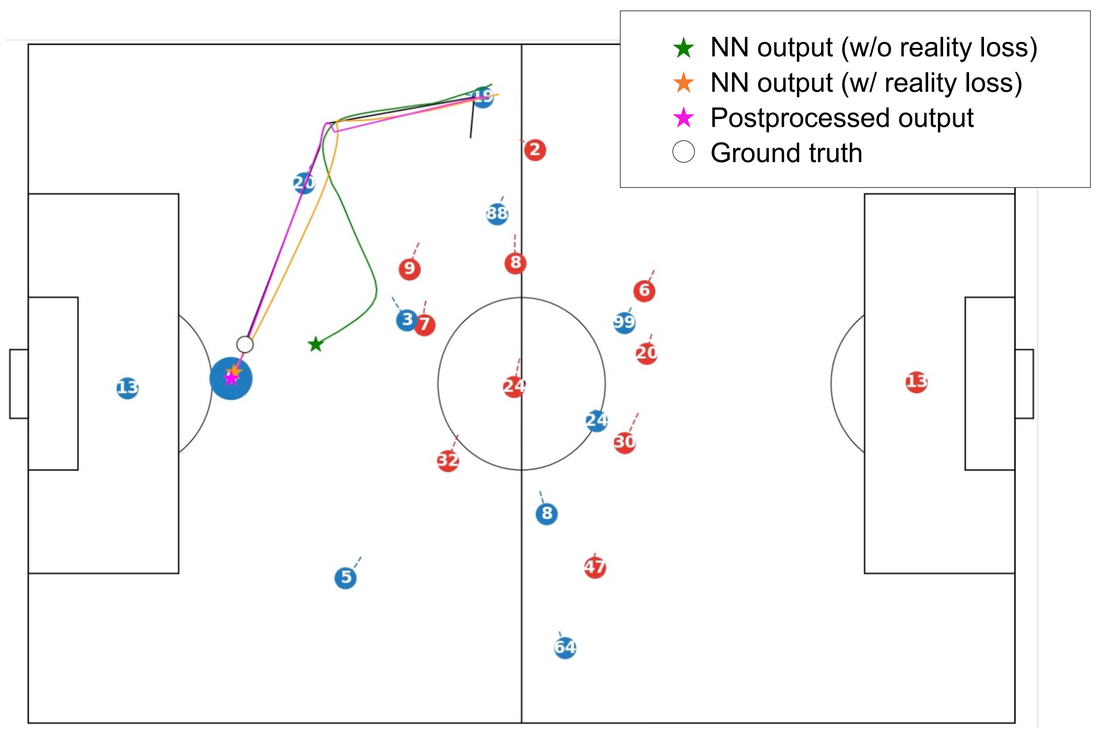
- Accurate acquisition of trajectory data is crucial in sports analytics.
- However, it is very challenging to reliably track a tiny ball on a wide pitch due to occlusion and confusing objects.
- Thus, in practice, data providers suffer from the expensive installment of multiple cameras or a lot of manual work to correct the detection results.
- This paper proposes a framework that **infers the ball trajectory from player trajectories in sports matches** as a cost-efficient alternative to ball tracking.

Notable Points

- **Permutation-invariant and equivariant representations** of a multi-agent sports context using Set Transformers (Lee et al., 2019).
- **Hierarchical neural network** that first predicts the ball possessor at each time-step and then predicts the ball trajectory conditioned on it.



- **Reality loss** to improve the naturalness of predicted ball trajectories by enforcing the ball to change its direction only when there is a player nearby.
- **Rule-based postprocessing** to fine-tune the model output to a fully constrained trajectory that either moves with the ball possessor or is linearly transferred from one player to another in a straight line.



Practical Applications

- **Ball trajectory imputation:** When fragmentary ball trajectories are given, predict the ball trajectories for the remaining unobservable frames.

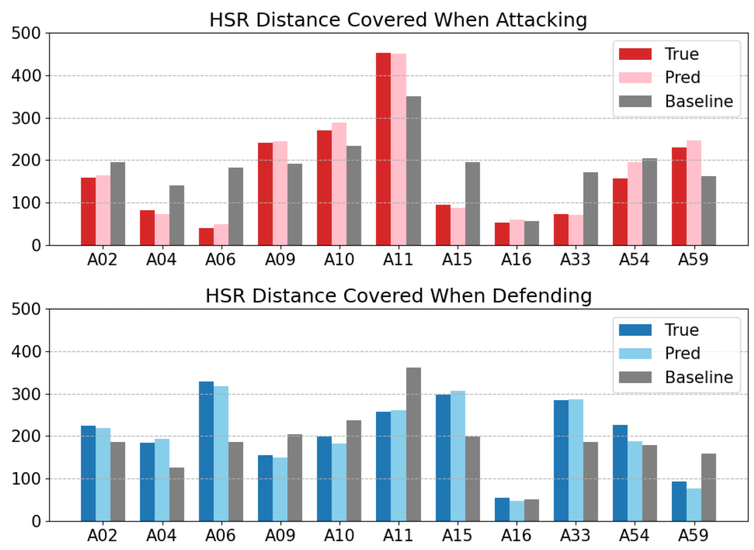
Step	Masking	PE	RL	PPA	TPA
Before PP	100 %	5.3536	0.3573	61.91 %	83.96 %
	95 %	3.0018	0.3911	79.51 %	91.54 %
	90 %	2.0939	0.4220	87.11 %	95.04 %
	80 %	1.3052	0.5059	93.13 %	97.41 %
After PP	100 %	5.1440	0.0031	57.29 %	81.06 %
	95 %	3.7990	0.0056	78.71 %	90.73 %
	90 %	2.5913	0.0046	85.92 %	94.50 %
	80 %	1.4137	0.0038	91.25 %	96.67 %

- **Semi-automated pass annotation:** Detect passes and intercepts from predicted ball trajectory.

Masking	Pass	Passer	Receiver	#. Passes	#. Receives
100 %	0.3877	0.6039	0.5707	0.7935	0.8150
95 %	0.5972	0.7265	0.7199	0.9031	0.9493
90 %	0.7428	0.8315	0.8208	0.9347	0.9717
80 %	0.8693	0.9149	0.8991	0.9331	0.9746

- **Automated zoom-in for match broadcasting:** Decide the “region of interest” at each frame in a panoramic match video based on the predicted ball locations and generate a dynamic zoomed-in video using this ROI information.

- **Approximating possession-wise running performance metrics:** Predict which team is attacking at each frame from players’ ball possession probabilities and separately calculate RP metrics (e.g., total running distance, high-speed running distance) in attacking/defending situations.



Overview of the Framework