Nonparametric Parts Modeling with Lie Group Dynamics and the Joint Posterior Tracker

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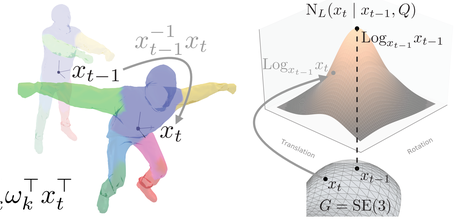
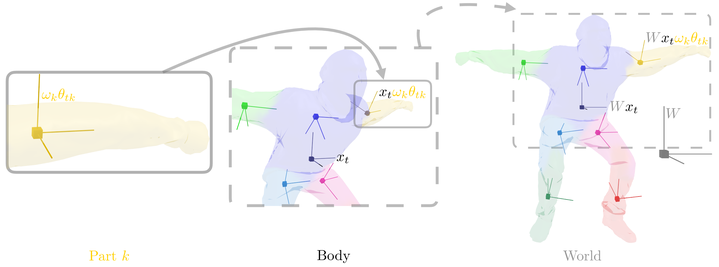
Nonparametric Parts Model (NPP)

➢ Learn a parts model by observing an object in motion (2D, 2.5D, 3D).

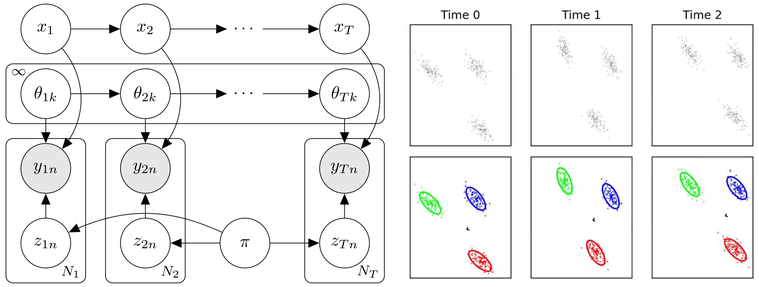
Nonlinear Lie group dynamics with state-dependent observation noise

$$x_t \sim \mathrm{N_L}\left(x_{t-1}, Q\right)$$
$$\theta_{tk} \sim \mathrm{N_L}\left(\theta_{(t-1)k}, S_k\right)$$
$$\tilde{y}_{tn} \sim \mathrm{N}(\mu_{tk}, \Sigma_{tk})$$
$$\mu_{tk} = x_t \omega_k \theta_{tk} \tilde{0}_{\mathbb{R}}$$
$$\Sigma_{tk} = x_t \omega_k \theta_{tk} \tilde{E}_k \theta_{tk}^\top \omega_k^\top x_t^\top$$





Dirichlet Process for unknown number of rotating, translating parts.

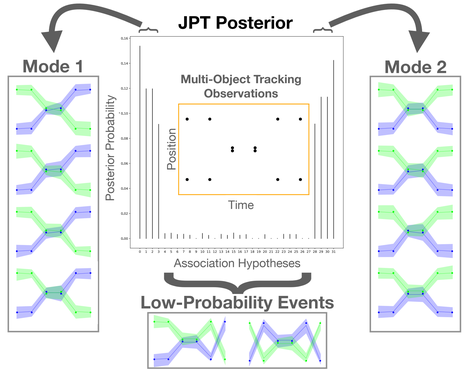


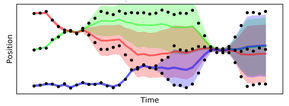
Nonparametric Object and Parts Modeling with Lie Group Dynamics, Hayden et al. CVPR '20

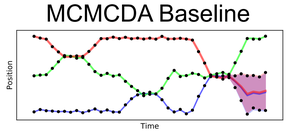
Joint Posterior Tracker (JPT)

➢ Multi-object tracking with uncertainty quantification and error recovery.

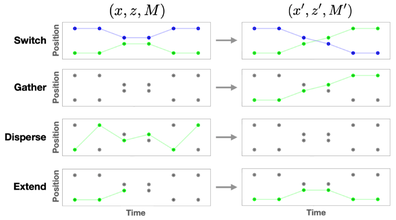
Discovers and explicitly represents tracking ambiguities





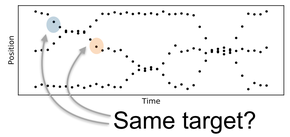


Generative model with MCMC inference and no gating heuristics



$$p(x, z, M \mid y) \propto$$
$$p(y \mid x, z) \quad \text{Likelihood}$$
$$p(z \mid M) \quad \text{Associations}$$
$$p(x \mid z) \quad \text{Trajectories}$$
$$p(M) \quad \text{Events}$$

Error recovery using Bayesian Experiment Design



For each round l = 1, 2, …

$$d_l = \arg\max_d I_d\left(a_l; x \mid y, D\right)$$

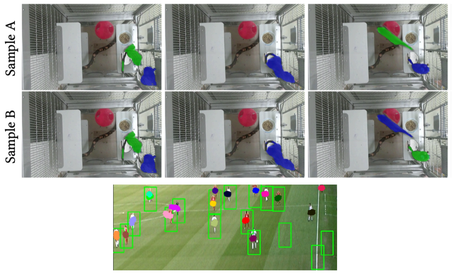
$$\mathbb{E}\left[\log \frac{p_d(a_l, x \mid y, D)}{p_d(a_l \mid y, D) p_d(x \mid y, D)}\right]$$

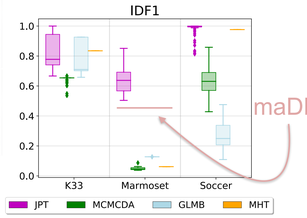
Efficient Data Association and Uncertainty Quantification for Multi-Object Tracking, Hayden et al. arXiv '20

Results

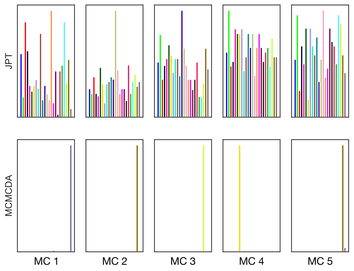
NPP Unsupervised Part Segmentation and Synthesis

JPT Multi-Object Tracking Performance





JPT Uncertainty Quantification



JPT Error Recovery