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Session PSTR512 - Software Tools: Behavior

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PSTR512.04 / XX35 - Lightning Pose: improved animal pose estimation via semi-supervised learning, Bayesian ensembling, and cloud-native open source tools

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Abstract

Pose estimation algorithms are shedding new light on animal behavior and intelligence. Most existing models are only trained with labeled frames (supervised learning). Although effective in many cases, the fully supervised approach requires extensive image labeling, struggles to generalize to new videos, and produces noisy outputs that hinder downstream analyses. We address each of these limitations with a semi-supervised approach that leverages the spatiotemporal statistics of unlabeled videos in two different ways. First, we introduce unsupervised training objectives that penalize the network whenever its predictions violate smoothness of physical motion, multiple-view geometry, or depart from a low-dimensional subspace of plausible body configurations. Second, we design a new network architecture that predicts pose for a given frame using temporal context from surrounding unlabeled frames. These context frames help resolve brief occlusions or ambiguities between nearby and similar-looking body parts. The resulting pose estimation networks achieve better performance with fewer labels, generalize better to unseen videos, and provide smoother and more reliable pose trajectories for downstream analysis; for example, these improved pose trajectories exhibit stronger correlations with neural activity. We also propose a Bayesian post-processing approach based on deep ensembling and Kalman smoothing that further improves tracking accuracy and robustness. We demonstrate our results on a range of datasets, including head-fixed mice running on a treadmill, freely swimming fish, and head-fixed mice data from

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the International Brain Lab. In addition, we release a deep learning package that adheres to industry best practices, supporting easy model development and accelerated training and prediction. Our package is accompanied by a cloud application that allows users to annotate data, train networks, and predict new videos at scale, directly from the browser.