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Mixture of trajectory models for neural decoding of goal - directed movements

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Probabilistic techniques have been fruitfully applied to decoding physical parameters, such as arm trajectories or the position of a freely-foraging rat, from neural data. Current trajectory models assume little or no knowledge about the direction or form of movement, but rather provide only a basic smoothness constraint on the decoded trajectory. When trajectories are goal-directed however, we can define stronger models that reflect the typical kinematics of movement, as well as the discrete set of goal locations. We present a mixture of trajectory models (MTM) framework that can be used with many current probabilistic decoding techniques, including the Bayes' Filter (Brown et al. 1998), particle filters, and Kalman filter variants. The idea is to train a separate trajectory model for each goal location. A decoded trajectory is then obtained by weighting the estimate of each model by the likelihood that the observed spike trains were generated by this model. We apply this framework to decoding arm trajectories in a center-out delayed reach task. Neural activity was recorded using a 96-electrode array in pre-motor cortex of a rhesus macaque. The weight of each trajectory model, which is updated at 10 ms time steps, is determined by the peri-movement neural activity observed up to the current time. We found that a MTM gives 40% lower root-mean-square position error than a single trajectory model that knows little about the direction or form of the actual movements. Using delay period neural activity to define a prior over the goal locations further improves decode performance. The MTM framework also preserves the real-time properties of its constituent estimators and can be used for prosthetic applications.

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