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A Kernel-Based Approach to Predicting Arm Motion from MI Activity

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Development of a brain-machine interface for control of a prosthetic arm requires an accurate and robust translation of the activation of a small subset of cells into a specification of motion for the prosthetic device. A common approach is to first construct a feature vector that describes the activation of some N cells over a history of M time bins. Next, given a set of observations of cell activity and actual arm movements, a linear model is computed over this feature set that predicts the subsequent motion of the arm (e.g., using a gradient descent or pseudo-inverse approach). These linear models have been shown to perform reasonably well in predicting the motion of the arm (e.g., Reina et al., 2001; Surruya et al., 2003). By their nature, linear models treat the contribution of each cell to the prediction process independently of the other cells. However, it is possible that critical information is encoded in the co-occurrence of sets of spikes across two or more cells.

Kernel regression methods explicitly allow for the introduction of nonlinearities into the prediction process (Scholkopf and Smola, 2002). A large set of nonlinear features is computed over the cell activation patterns; it is over this transformed feature set that a linear function is then constructed for the purposes of arm motion prediction. This nonlinear feature set increases the representational power of the full model. In particular, *polynomial kernels* compute a set of features that capture the activation of several specific cells at particular times. For example, an individual feature can encode the conjunction of the firing of cell A at time t and that of cell B at time t-50ms.

In this poster, we compare linear models with a kernel-based approach in terms of their ability to predict both Cartesian hand position, as well as shoulder and elbow torque, in the context of a random-walk reaching task. Model performance is compared using a *fraction of variance accounted for* (fvaf) measure, enabling performance comparisons across the different predicted variables. We employ a 20-fold cross-validation experimental approach in which the same data set is divided 20 different times into separate training and test sets (in particular, for a given model, performance is measured using a data set that is independent of the training set). The experimental results are as follows: 1. Polynomial kernels of degree two outperform a purely linear model by 3.7% to 9%. This difference is significant according to a paired t-test ($p < .0004$). 2. With a reduction in training set size (to 56% of the original), the kernel-based method still outperforms the linear model based on the

full training set ($p < .03$).

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