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Presentation Abstract

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Abstract: Dimensionality reduction techniques such as PCA are a cornerstone of analyzing high dimensional data. PCA involves an eigenvalue decomposition of the data covariance matrix, which produces ranked orthogonal dimensions that can be used to linearly project the data to lower dimension. The covariance matrix is but one choice of summary matrix that can be used for linear projections. When the data are time series, the same decomposition can be used on a linear description of the dynamics (instead of the data covariance) to obtain a different projection. This 'dynamical PCA' produces projections representing the largest eigenvalues of the linear dynamical system. Linear dynamical systems capture scaling and rotational aspects of the data (and combining scalings/rotations yields familiar features such as shear, projection, reflection, etc.). Dynamical PCA makes no distinction between scaling and rotation, seeking only directions of largest and most consistent dynamical activity. However, in some settings, one may hypothesize the existence of certain types of dynamics, and thus an algorithm is desired that can verify those dynamics. For example, it is common for neural circuits to generate oscillations (or rotations), and we seek projections that best capture these fundamental aspects of the neural response. Here we introduce jPCA, which specifically extracts projections of largest rotational dynamics. Using skew-symmetric matrices, the jPCA algorithm is an extension of fitting a linear dynamical system. It has a unique, closed-form solution that can be quickly computed. Importantly, like PCA and dynamical PCA, jPCA produces simple projection vectors - orthogonal linear directions - and so the interpretation of jPCA is identical to PCA or any other linear projection of the data. We motivate and present details of the method, and we discuss its importance in extracting rotational structure from electrophysiological data recorded from primate motor cortex.

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