Extending the General Linear Model for analyzing fMRI data to a constrained Multivariate Regression Model

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Local canonical correlation analysis (CCA) is a multivariate method that simultaneously analyzes the timecourses of a group of neighboring voxels and has been demonstrated to be more sensitive than the conventional univariate general linear model approach. However, unlike the general linear model, an arbitrary linear contrast of the temporal regressors has not been so far incorporated in the CCA formalism. To address the first problem, a multivariate regression model is presented which is a direct extension of univariate general linear model. Mathematically, multivariate regression model (MRM) is equivalent to CCA, but easier to interpret since the framework is similar to general linear model. Arbitrary contrasts can be used in the MRM approach including multivariate contrasts. With multivariate contrasts, it is also possible to test for significance of contrasts on regression coefficients as well as contrasts on voxels. The test for contrasts on voxels is not possible in the univariate framework. Furthermore, a constrained version of MRM is introduced which not only has more sensitivity than univariate general linear model, but also corrects for the potential loss of specificity due to over-fitting in the multivariate model. Quantitative results from simulated and pseudo-real data as well as qualitative results from real data show that constrained MRM can detect activations more accurately for noisy functional MRI (fMRI) data without losing specificity.

Keywords: fMRI data analysis; multivariate regression; constrained canonical correlation analysis; CCA.