Robust regression for large-scale neuroimaging studies

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The multi-subject brain imaging datasets used in neuroimaging group studies have a complex statistical structure, including local and long range correlations, non-stationarity of the statistical properties and the presence of artifacts. While small-sample size studies can hardly be proved to deviate from standard hypotheses (such as the normality of the residuals) due to the low degrees of freedom of the statistical model, large-scale studies (e.g. on more than 100 subjects) give a different picture and encourage the practitioner to use finer models to perform statistical inference. In this work, we demonstrate the benefits of robust regression as a tool for analyzing large neuroimaging cohorts. Our first contribution is to validate the use an analytic test based on robust parameters estimates; this procedure makes it possible to forgo permutation testing and thus to perform whole brain analysis in a reasonable time. Then we demonstrate that robust regression yields sensitivity improvements in two real data examples on 392 and 1502 subjects. We finally show that robust regression can be combined with more complex analysis techniques to improve whole-brain tests sensitivity.

Keywords: Large cohorts; neuroimaging genetics; outliers; robust regression; fMRI.