“Modifications of the FDR Procedure for FMRI Data”

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The False Discovery Rate (FDR) criterion has been proposed for use in multiple-comparisons testing problems (Benjamini and Hochberg, 1995). A multiple testing procedure uses the FDR criterion if the procedure controls the expected proportion of false positives that are identified as active. Functional Magnetic Resonance Imaging (FMRI) are used to create images of a subject's brain which show changes in blood oxygenation that can occur because of regional brain activation. The aim of many FMRI experiments is to locate regions of the brain that are activated by a specific task.

This talk will propose procedures that apply the FDR criterion for analyzing FMRI data which is used for such brain mapping. FMRI images are both strongly spatially correlated and contain a large number of hypotheses to be tested. Numerous procedures have been suggested for solving this multiple-comparisons problem. We propose using the Enhanced FDR (EFDR) method of Shen at al. (2002) and a new Adaptive FDR (AFDR) method. Both methods transform the map of dependent test statistics to the wavelet domain and test the activation hypotheses in this space. The wavelet representation of the spatial image has simpler statistical properties than those of the original image. The distinctive wavelet coefficients of a deterministic signal are typically clustered, both within each scale and across different scales in the wavelet domain, while the corresponding wavelet coefficients of correlated noise are approximately uncorrelated. The EFDR procedure optimally reduces the number of hypotheses being tested using a criterion based on generalized degrees of freedom (Ye, 1998). The AFDR method thresholds the wavelet coefficients using an adaptive threshold which is adjusted by the estimated number of true, activatived hypotheses. Transforming the non-zero wavelet coefficients back via the inverse discrete-wavelet transformation produces a final image that indicates presence of a signal and also gives an idea about its location and magnitude.

These procedures are calibrated empirically using null data collected from three subjects using 1.5-T GE Signa MRI scanner with a standard head coil taken over 200 successive, equally spaced time points. All images were obtained under a baseline rest condition with no time-locked experimental stimuli or tasks. The power of the procedures are compared with several proposals in the literature using artificial-activation data sets, consisting of empirical noise, as determined above, plus a known signal component.

References

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