ABSTRACT

Magnetic resonance imaging (MRI) is a noninvasive technique offering high resolution brain image, which is useful for brain morphometry investigation. The common approach to investigate sMRI data is to separate the image into regions of interest (ROI) and compute volume differences between groups in anatomically defined regions. More recently, investigators have begun using voxel-based morphometry (VBM) to automatically identify group differences in voxels throughout the whole brain images via a statistical map. As an univariate method, VBM does not utilize any information about the relationships among voxels. In contrast, a multivariate, data-driven approach can provide a way to pool information across different voxels as well as identify unpredicted patterns.

In this dissertation, we present a framework, called source based morphometry (SBM), for understanding and studying the application of independent component analysis (ICA) to sMRI data. We first introduce SBM to extract structural brain networks from sMRI images in gray or white matter separately. This multivariate method considers cross-voxel information and estimates “sources” which comprises several regions together exhibiting group differences. Both simulation and application to real sMRI data collected from schizophrenia patients and healthy controls are used to evaluate the method and demonstrate its promise. Next, an extension of SBM, joint SBM (jSBM), is presented, which aims at detecting linked gray and white matter networks presenting intersubject covariance. We also introduce new sMRI features, structural phase and magnitude images, which can be utilized in the SBM framework and emphasize the interrelationship between gray and white matter. Finally, we present constrained SBM,
which incorporates prior information to improve structural network detection. We show an application in which the structural network associated with the functional default mode network is identified using constrained SBM. In summary, we provide several significant advances for the application of ICA to sMRI that are very promising and may help to increase our understanding of brain structure in health and disease.