Site effects removing and signal enhancement using dual-projection based ICA model

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Abstract

Combining magnetic resonance imaging (MRI) data from multi-site studies is a popular approach for constructing larger datasets to greatly enhance the reliability and reproducibility of neuroscience research. However, the scanner/site variability is a significant confound that complicates the interpretation of the results, so effective and complete removal of the scanner/site variability is necessary to realize the full advantages of pooling multi-site datasets. Independent component analysis (ICA) and general linear model (GLM) based harmonization methods are the two primary methods used to eliminate scanner/site-related effects. Unfortunately, there are challenges with both ICA-based and GLM-based harmonization methods to remove site effects completely when the signals of interest and scanner/site-related variables are correlated, which may occur in neuroscience studies. In this study, we propose an effective and powerful harmonization strategy that implements dual-projection (DP) theory based on ICA to remove the scanner/site-related effects more completely. This method can separate the signal effects correlated with site variables from the identified site-related effects for removal without losing signals of interest. Both simulations and vivo structural MRI datasets, including a dataset from Autism Brain Imaging Data Exchange II and a traveling subject dataset from the Strategic Research Program for Brain Sciences, were used to test the performance of DP-based ICA harmonization method. Results show that DP-based ICA harmonization has superior performance for removing site effects and enhancing the sensitivity to detect signal of interest as compared with GLM-based and conventional ICA harmonization methods.

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