ABSTRACT

Pre-surgical mapping has become a crucial tool in the preparation and planning for brain tumor resection since the development of widely available non-invasive imaging technologies like functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG). Strategies for dealing with single-subject analysis are key to overcome issues surrounding individual variability and inter-rater reliability. In this thesis, a receiver-operating-characteristic reliability (ROC-r) framework for evaluating and optimizing the reliability of pre-surgical mapping is developed and implemented in a variety of applications. ROC-r allows for fully automated, yet individualized processing of single-subject data, directly addressing both the issues of individual variability and inter-rater reliability for fMRI and MEG.

A series of four manuscripts form the foundation of this thesis. The first, “Thresholds in fMRI studies: Reliable for single subjects?” shows the impact of individual variability on the reliability of fMRI activation maps, and demonstrates the use of ROC-r for evaluating reliability and selecting activation thresholds. The second paper, “Fully automated quality assurance and localization of volumetric MEG for pre-surgical mapping”, establishes the use of ROC-r for quality assurance and automated localization in MEG. The third study, “Improving fMRI reliability in pre-surgical mapping for brain tumors”, shows the primary clinical application of ROC-r in pre-surgical mapping. This paper demonstrates that although patient data is less reliable than controls, this can be compensated for by optimization of pre-processing pipelines. Furthermore, this manuscript compared the fMRI results to cortical stimulation mapping, showing that more reliable datasets were better at identifying critical eloquent brain regions. In the fourth and final manuscript, “A unified framework to optimize fMRI and MEG processing for push-button pre-surgical mapping”, we explicitly evaluate ROC-r as a unified framework for push-button individualized analysis of fMRI and MEG data.

Overall, this thesis demonstrates that ROC-r enhances the reliability of pre-surgical mapping by both fMRI and MEG, by providing quantitative measures for selecting reliable pre-processing pipelines, and determining data-driven thresholds for localizing reliable activation foci. The ROC-r method improves pre-surgical mapping capabilities by introducing clinically relevant quality assurance parameters and facilitating push-button production of reliable activation maps.