Optimizing Machine Learning Algorithms for Multiclass Neuroimaging Segmentation

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In recent years, analysis of cerebral structures using whole-brain quantitative neuroimaging has been widely recognized for its ability to provide deep insights on neurological disease. Quantifying morphological and volumetric changes in MRI holds vast potential to revolutionize diagnostics for neurological pathologies like multiple sclerosis, epilepsy, dementia, glioblastoma, and traumatic brain injury. The segmentation of 3D MRI for gray-matter, white-matter, cerebrospinal fluid, lesions, and key neural structures can thus provide crucial diagnostic information to neurologists. Although manual or semi-automatic quantification by radiologists have been the historical norm, they have proven too time-consuming for widespread clinical implementation. Working with a dataset of 30 scans, this study tested the efficacies of various machine learning approaches in performing whole-brain multi-tissue quantification through classifier segmentation. Utilizing an approach focused on optimizing the feature "stack" of processed variations of input images used in training, experimentation showed that a combination of gaussian blur subtraction, laplacian smoothing, minimums-based sampling, and structure tensors yielded a stack which—when paired with normalization preprocessing and an optimized random forest algorithm—yielded near 98% accuracy in quantifying every tissue visible in FLAIR MRI. Although limited by hardware constraints and data availability, the study’s novel understanding of the relationship between gaussian differences and minimums-based voxel sampling proved—when implemented—to yield increased effectiveness in distinguishing between brain matter despite contrast irregularities—providing a framework for future brain quantification algorithm development.

Awards Won: