Abstract: FastSurfer

A Fast and Accurate Deep Learning Based Neuroimaging Pipeline

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Traditional neuroimage analysis pipelines involve computationally intensive, time-consuming optimization steps, and thus, do not scale well to large cohort studies. With FastSurfer [1] we propose a fast deep-learning based alternative for the automated processing of structural human MRI brain scans, including surface reconstruction and cortical parcellation. FastSurfer consists of an advanced deep learning architecture (FastSurferCNN) used to segment a whole brain MRI into 95 classes in under 1 min, and a surface pipeline building upon this high-quality brain segmentation. FastSurferCNN incorporates local and global competition via competitive dense blocks and competitive skip pathways, as well as multi-slice information aggregation that specifically tailor network performance towards accurate recognition of both cortical and sub-cortical structures. We demonstrate the superior performance of FastSurferCNN across five different datasets where it consistently outperforms existing deep learning approaches in terms of accuracy by a margin. Further, we perform fast cortical surface reconstruction and thickness analysis by introducing a spectral spherical embedding and by directly mapping the cortical labels from the image to the surface. Precisely, we use the eigenfunctions of the Laplace-Beltrami operator to parametrize the surface smoothly and quickly generate the final spherical map by scaling the 3D spectral embedding vector to unit length. For sustainability of the pipeline we perform extensive validation of FastSurfer: we measure generalizability to different scanners, disease states, as well as an unseen acquisition sequence, demonstrate increased test-retest reliability, and increased sensitivity to disease effects relative to traditional FreeSurfer. In total, we provide a reliable full FreeSurfer alternative for volumetric analysis (within 1 minute) and surface-based thickness analysis (within only around 1h + optionally 30 min for group registration).

References

1. Henschel L, Conjeti S, Estrada S, et al. FastSurfer – a fast and accurate deep learning based neuroimaging pipeline. CoRR. 2019;abs/1910.03866.