MULTI-LABEL SEGMENTATION OF BRAIN WHITE MATTER STRUCTURES USING DEEP LEARNING TECHNIQUES

Bramyah S. [1,*]

[1] Department of Physical Science, Faculty of Applied Science, University of Vavuniya, Sri Lanka.
[*] Corresponding author email: bramyasinthathurai@gmail.com

Abstract: Accurate segmentation of brain white matter structures is fundamental for understanding anatomical connections that provide insights into brain structure and function. Diffusion-weighted MRI (DWMRI) is a unique in vivo imaging technique that enables the visualization of the three-dimensional architecture in the human brain. While numerous methods have been proposed in the literature, the complexity of white matter anatomy and the spatial resolution of DWMRI can result in multiple fiber bundles passing through a single voxel. The primary aim of this study is to develop an efficient model for segmenting 13 different brain white matter structures and assigning one or more anatomical labels of white matter bundles to each voxel. To achieve this goal, we propose a new deep learning model based on the U-Net architecture. Our method employs a dataset comprising DWMRI images from 20 neonatal subjects, each accompanied by corresponding binary masks for the 13 white matter structures. The DWMRI images undergo standard preprocessing steps and diffusion tensor computations, and finally, we compute fractional anisotropy (FA) images (4000 two-dimensional images) to enhance white matter contrast, which serves as input for our model. Our segmentation pipeline entails training individual U-Net models for each white matter tract and optimizing their performance based on the Dice coefficient. Once the models are trained, we employ them to generate predicted masks for the FA images in the test set. This process is repeated for all 13 white matter tracts, ensuring accurate segmentation. The final multi-label segmentation is generated based on the resultant masks. Our results demonstrate an impressive average Dice coefficient of 90% across all 13 white matter tracts, highlighting the effectiveness of our approach. Our research contributes to the advancement of neuroimaging analysis by offering a reliable and precise method for multi-label segmentation of brain white matter structures.

Keywords: Fractional anisotropy, Multi-label segmentation, U-Net architecture, White matter structure