

AUTOMATED SEGMENTATION OF CORPUS CALLOSUM IN BRAIN MR IMAGES IN ALZHEIMER'S CONDITIONS USING IMPROVED UNET++ MODEL

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ABSTRACT

The Corpus Callosum (CC) is a large white matter bundle that connects the left and right cerebral hemispheres of the human brain. It is susceptible to atrophy as Alzheimer's disease progresses. The robust segmentation of CC allows quantitative investigation of its structural changes. However, deep learning-based CC segmentation is less explored. In this work, an improved UNet model is proposed for CC segmentation from two-dimensional T1-weighted mid-sagittal brain MRI. For this, mid-sagittal scans (n = 184) from the publicly available Open Access Series of Imaging Studies (OASIS) brain MRI database are used. The images are fed to an improved UNet++ network. The architecture contains a fully convolutional network with two paths, contracting and extracting, that are connected in a U-shape to automatically extract spatial information. Leave one out Cross-Validation (LooCV) method is used to evaluate the robustness of the proposed method. Results show that the proposed approach is able to segment CC from MR images. The proposed method yields the Dice score of 98.43%, and Jaccard index of 98.53%. The improved UNet++ model obtained the highest sensitivity of 99.21% for AD conditions. Further, the performance of the proposed model has been validated against the state-of-the-art methods. Thus, the proposed approach could be useful for the segmentation of MR images in clinical condition.

Keywords: Corpus Callosum, Magnetic Resonance Imaging, Alzheimer's disease, Segmentation, UNet, UNet++, Leave one out Cross-Validation.

INTRODUCTION

The corpus callosum (CC) is a huge bundle of myelinated fibers that connects the two cerebral hemispheres. CC is the major white matter channel between the cerebral hemispheres that supports the transfer of visual, auditory, and somatosensory information [1]. A previous imaging study has shown that the degeneration of white matter is associated with aging and it is more pronounced in Alzheimer's Disease (AD).

Structural magnetic resonance imaging (MRI) techniques have facilitated the visualization of the size and shape of the corpus callosum non-invasively. Study of CC in the mid-sagittal plane (MSP) of MRI plays a vital role in the diagnosis of Alzheimer's disease as the diseases change the shape and size of CC [2]. Segmentation of CC is required to conduct quantitative and qualitative visualization of the structure in order to fully analyze it [3]. The goal of segmentation is to separate the region of interest from the rest of the image but the task of segmentation of CC comes as a critical challenge in the field of medical image processing [4]. Hence, it is needed to develop an automatic, robust, and effective technique for segmentation [5]. Park et al. suggested a unique Bayesian inference for CC segmentation in the mid-sagittal that comprised sparse representation and multi-atlas voting [6] but it requires domain knowledge for selecting features to be extracted. Some automated segmentation methods were also studied. Other deep learning-based models like CE-Net, MultiRes-