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Extracting the brain in axial MRI images with an adaptive segmentation technique

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Background: Automatic brain magnetic resonance image (MRI) analyses require a pre-processing step where the brain is separated from other tissues and structures of the head. This step aids the automatic tissue segmentation among grey matter (GM), white matter (WM) and cerebrospinal fluid (CSF), which is used for radiologists in multiple sclerosis clinical analyses.

Aim: To develop an adaptive brain segmentation method that improves the current state-of-the-art techniques. The novelty relies on taking benefits from complementary information provided by T1-weighted (T1w) and T2-weighted (T2w) images.

Methods: Given that the orientation and resolution is a crucial factor in MRI processing, we have proposed a segmentation method which deals with axial oriented images that can be also of low resolution. The algorithm divides the brain into three zones (superior, inferior and central) to adapt itself to changes in intensity distributions. Besides, we combine the use of T1w and T2w images to provide more accurate boundaries especially in CSF regions, which are represented with low intensity in T1w and a high intensity in T2w. The segmentation process is divided into three steps: 1) determine a region of interest from which the segmentation is initialised (the starting point corresponds to the central slice); 2) 2D slice region growing segmentation towards the inferior/superior part of the brain; and 3) combine the obtained T1w and T2w masks and fill in possible holes.

Results: Three databases of very different nature were used. 10 synthetic cases from the BrainWeb, 20 public cases (10 normal brains and 10 brains of schizophrenic patients) acquired with a 3T GE MRI scanner and 10 multiple sclerosis patients acquired with a 1.5T GE scanner. The experimental evaluation was performed qualitatively and quantitatively using the Dice Similarity Coefficient (DSC) which indicates the amount of area overlap between each segmented mask compared to its ground truth. We compared our approach with three well-known available tools, Brain Extraction Tool (BET), Brain Surface Extractor (BSE) and Statistical Parametric Mapping (SPM). The mean DSC for our proposal was 0.965±0.013, outperforming significantly the performance of the other algorithms: 0.936±0.015 for BET, 0.907±0.021 for BSE, and 0.922±0.021 for SPM.
Conclusion: Our adaptive brain segmentation obtained satisfactory skull stripping results when dealing with axial MRI images acquired both at 1.5T or 3T.

Nothing to disclose