A pipeline approach with spatial information for segmenting multiple sclerosis lesions on brain magnetic resonance imaging

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Background: Conventional magnetic resonance imaging (MRI) techniques are highly sensitive to detect multiple sclerosis (MS) plaques, enabling a quantitative assessment of inflammatory activity and lesion load. In quantitative analyses of focal lesions, manual or semi-automated segmentations have been widely used to compute the total number of lesions and the total lesion volume. These techniques, however, are both challenging and time-consuming, being also prone to intra-observer and inter-observer variability.
Aim: To develop an automated approach to segment brain tissues and MS lesions from brain MRI images. The goal is to reduce the user interaction and to provide an objective tool that eliminates the inter- and intra-observer variability.
Methods: Based on the recent methods developed by Souplet et al. and de Boer et al., we propose a novel pipeline which includes the following steps: bias correction, skull stripping, atlas registration, tissue classification, and lesion segmentation. After the initial pre-processing steps, a MRI scan is automatically segmented into 4 classes: white matter (WM), grey matter (GM), cerebrospinal fluid (CSF) and partial volume. An expectation maximisation method which fits a multivariate Gaussian mixture model to T1-w, T2-w and PD-w images is used for this purpose. Based on the obtained tissue masks and using the estimated GM mean and variance, we apply an intensity threshold to the FLAIR image, which provides the lesion segmentation. With the aim of improving this initial result, spatial information coming from the neighbouring tissue labels is used to refine the final lesion segmentation.
Results: The experimental evaluation was performed using real data sets of 1.5T and the corresponding ground truth annotations provided by expert radiologists. The following values were obtained: 64% of true positive (TP) fraction, 80% of false positive (FP) fraction, and an average surface distance of 7.89 mm. The results of our approach were quantitatively compared to our implementations of the works of Souplet et al. and de Boer et al., obtaining higher TP and lower FP values.
Conclusion: Promising MS lesion segmentation results have been obtained in terms of TP. However, the high number of FP which is still a well-known problem of all the automated MS lesion segmentation approaches has to be improved in order to use them for the standard clinical practice. Our future work will focus on tackling this issue.

Authors have nothing to disclose