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Strategies for automated segmentation of multiple sclerosis lesions on brain magnetic resonance imaging

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Background: The development of fully automated segmentation methods for assessing lesion volume in multiple sclerosis (MS), which can segment large amounts of MRI data and do not suffer from intra- and inter-observer variability, has become an active research field.

Aim: To analyze the different automated methods described for segmentation of MS lesions on brain MRI.

Methods: We analyzed 33 different automated MS lesion segmentation approaches with the aim of pointing out their strengths and weaknesses.

Results: The different methods can be divided in supervised and unsupervised strategies. The majority of the automated segmentation approaches belong to the former group, which can be subdivided between atlas-based approaches (12 methods), that require a registration between the patient and a template, and those based on training a classifier with features extracted from manual segmentations (12 methods). In the unsupervised group we distinguish between approaches based on segmenting the tissues for obtaining the lesions (5 methods), and those based on using only the lesion properties for the segmentation (4 methods). Analyzing the qualitative and quantitative comparison of the works we observed the following trends. When evaluating the methods with the synthetic data from the BrainWeb, the best results with a Dice coefficient (DSC) value of 0.87 were obtained by an unsupervised approach based on performing tissue and lesion segmentation. However, when evaluating the same approach using 7 real volumes from the McConnell Brain Imaging Centre the mean DSC dropped to 0.55. When evaluating the approaches on real data, the highest mean DSC (using 23 real volumes) was 0.78. This approach was a supervised strategy based on learning classifiers from manual segmentations. In particular, this approach segments CSF and T2 lesions using a Parzen windows classifier, while segments white and gray matter using the PD and T2 images and a parametric method. Analyzing all the methods, we noticed that the best performances in terms of DSC and also sensitivity were obtained by atlas-based supervised strategies.

Conclusion: Automated segmentation of different MS lesion types in MRI is a challenging task due to the heterogeneous intensity values across the different MRI images (enhancing lesions, black holes, and hyperintense lesions). Despite the recent progress made, there is not a single automated lesion segmentation approach robust enough to emerge as a standard for clinical practice.