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Do multiple sclerosis lesions affect automatic brain structure segmentation?

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Background: In multiple sclerosis (MS) and in other neurodegenerative diseases, it has been demonstrated that grey matter atrophy is relevant to disease progression. For this reason, automatic brain structure segmentation algorithms have been proposed. However, the effect of MS lesions on their performance has not been deeply evaluated.
Aim: To analyse the effect of focal lesions on three well-known automatic brain structure segmentation methods (FreeSurfer, FIRST and majority voting) when segmenting the deep grey matter structures (thalamus, caudate, putamen, pallidum, hippocampus, amygdala, and nucleus accumbens) and the brainstem.
Methods: We analyse how lesions affect the performance of each method based on structure and lesion location. To perform a quantitative analysis, 2174 MS lesions were simulated on four healthy subjects (controls) from two public databases with brain structure ground truth (IBSR18 and MICCAI12), obtaining a total of 100 synthetic MS patient images. The Dice similarity coefficient (DSC) differences and the volume differences between the healthy controls and the simulated MS patients were calculated for the deep grey matter structures and the brainstem. Statistical tests were applied to prove significant differences in the robustness of the three methods for each analysed structure.
Results: We observed that the three strategies were affected when MS lesions were present. The obtained results shows that FreeSurfer (with mean DSC differences ranging from -0.11±0.54 to 9.65±9.87) is the most affected method by the presence of lesions whereas FIRST (differences from -2.40±5.54 to 0.44±0.94) is the most robust against lesions. The lesion location is not important for the global strategies such as FreeSurfer or majority voting, where structure segmentation is affected wherever the lesions exist. On the other hand, FIRST is more affected when the lesions are overlaid or close to the structure of analysis. The most affected structure by the presence of lesions was the accumbens (from -1.12±2.53 to 9.65±9.87), whereas the structures that showed less variation include the thalamus (from -0.48±1.08 to 0.74±0.89) and the brainstem (from -0.20±0.38 to 1.03±1.31).
Conclusion: The three segmentation methods were affected by the presence of MS lesions, which demonstrates that there exists a problem in the automatic segmentation of the deep grey matter structures that has to be taken into account when using them as a tool to measure the disease progression.

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