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Assessing the usability of synthetic images to improve the detection of new T2 lesions

L. Valencia[1], S. Valverde[2], A. Clèrigues[1], A. Oliver[1], J.F. Corral[3], A. Rovira[3], X. Lladó[1]

[1]University of Girona, Vicorob Institute, Girona, Spain, [2]Tensormedical, Girona, Spain, [3]Vall d'Hebron University Hospital, Section of Neuroradiology and Magnetic Resonance Unit, Department of Radiology, Barcelona, Spain

Introduction: Detection of new T2 lesions on brain Magnetic Resonance Imaging (MRI) is considered the best imaging biomarker for monitoring and predicting treatment response in multiple sclerosis (MS). Recently, deep learning tools have been proposed for this purpose, however, most of them require the use of multiple MRI sequences (i.e. T1-w, T2-FLAIR, PD-w or T2-w).

Objective: To study the impact of using synthetic T1-w images generated from a T2-FLAIR sequence into a state-of-the-art deep learning tool that quantifies new T2 lesions (Salem et al. 2020).

Materials and Methods: The data was composed of 135 MS patients scanned on the same 3T magnet following a standardized protocol composed of 3D-FLAIR and 3D-MPRAGE sequences. Each patient underwent two MRI scans, with a mean interval between time-points of 12 months [3-27 months]. 73 subjects (54%) had new T2 lesions on the follow-up scans (active patients). A 3D conditional Generative Adversarial Network was first trained to synthesize T1-w images from T2-FLAIR images using a subset of 100 subjects (62 without and 38 with new T2 lesions). These 38 subjects were then also used to train a 3D convolutional neural network model to detect new T2 lesions. Finally, the remaining 35 active subjects were used for testing. Three different models were trained and studied: 1) using both the original FLAIR and T1-w images (baseline), 2) using only the FLAIR image (flair-only), and 3) using FLAIR and its synthesized T1-w image (synthetic).

Results: A trained neuroradiologist identified 114 new T2 lesions on the testing set. The baseline model correctly identified 80 lesions (TPF=70%), misclassified 17 (FPF=18%) and missed 34 (FNF=30%). The flair-only model correctly identified 70 lesions (TPF=61%), misclassified 16 (FPF=18%) and missed 44 (FNF=39%). Finally, the synthetic model correctly classified 83 lesions (TPF=73%), misclassified 22 (FPF=21%) and missed 31 (FNF=27%).

Conclusions: Our results show that incorporating T1-w images help to increase the sensitivity of the model. Moreover, on the available data, our results suggest that the synthesized version of the T1-w image had a similar effect on the performance of the lesion detection model. These results are relevant, and show that synthetic T1-w images may be used to reduce the number of sequences required to monitor the evolution of the disease in clinical practice, reducing scanning time and derived costs for the center.

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