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Abstract Title: Identification of paramagnetic rim lesions using conventional MRI - a deep learning approach

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Introduction:

To date, the detection of paramagnetic rim lesions (PRLs) in multiple sclerosis (MS) is based on susceptibility-based MRI sequences, which are not widely implemented in clinical routine. In this work, we exploit a deep learning approach to segment white matter lesions (WML) based on conventional MRI data (FLAIR and T1-

weighted images) and then employ saliency maps (SMs) - which are usually generated to understand which parts of a model's input have the highest impact on classification - to characterise PRLs.

Objectives/Aims:
To expose significant differences between PRLs and WML in MS using conventional MRI. Exploiting the potential of these findings to classify PRLs.

Methods:
FLAIR and MPRAGE were collected in 650 MS patients (age: 45.7±12.3, EDSS median: 2.5 [0-9]) and used to train a U-Net network to segment WML. This model was then tested on an independent set of 20 MS patients presenting PRLs. In both datasets, WML masks were annotated by three expert clinicians, while PRLs in the test set were marked by a neurologist.

With respect to both input modalities, we generated a local SM for each lesion (SmoothGrad), using WML masks as footprint. Confluent lesions were excluded from the study, leading to 47 PRLs and 598 WML. Positive and negative contributions in a SM respectively represent voxels whose increase in intensity would suggest and reject the presence of a lesion. Separating positive and negative values, we observed and reported their distributions across PRLs and WML.

Lastly, we explored the classification of PRLs and WML by setting a threshold at the 90th percentile of positive contributions with respect to (w.r.t.) FLAIR.

Results:
On the test set we achieved a normalised Dice score of 0.75. Lower intensity areas in PRLs were not correctly predicted: in SMs they showed lower attention, indicating that the model focuses on hyperintensities. SMs computed w.r.t. FLAIR showed consistently higher values than MPRAGE, i.e., FLAIR features were more relevant. The distribution of positive values in SMs w.r.t. FLAIR for PRLs and WML was different (Mann-Whitney U test, $p<0.0001$). The true positive rate of PRLs and WML was around 70%.

Conclusion:
Our investigation supports the feasibility of generating saliency maps to expose and exploit features of PRLs for lesion classification based on conventional MRI sequences.

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