Abstract Title: A Deep Learning Algorithm for Multi-Modal Multiple Sclerosis Lesion Segmentation

Abstract Short Title: Deep-Learning for MS Lesion Segmentation

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CSG, DI and AC are employees of Therapanacea.

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Introduction:

Multiple sclerosis (MS) lesions can be detected as white matter hyperintensities (WMHs) on T2-w and FLAIR MRI. Segmentation of such lesions is necessary for many MRI-based measurements supporting the assessment of MS patients.

Objectives:

To develop an algorithm to automatically delineate WMHs from any combination of MRI modalities across (pre-contrast) T1-w, T2-w, and FLAIR MRI.

Methods:

A multi-modal convolutional neural network for MS lesion segmentation was designed by adapting the self-configuring nnU-Net framework. A fully learnable fusion operator integrates information across MRI modalities into the latent space, from which a WMH segmentation map could be predicted via decoding.

Brain FLAIR, (pre-contrast) T1-w and T2-w MRIs from the ADVANCE (NCT00906399; n=1512, with relapsing-remitting MS [RRMS]) and ASCEND (NCT01416181; n=886, with secondary

progressive MS) trials were used for model training. Ground truth WMH masks were obtained via a semi-automatic method. Our model was independently validated on scans from the DECIDE (NCT01064401; n=1841, with RRMS) and EXTEND (NCT01797965; n=1501, extension from DECIDE) trials, by comparing predicted WMH masks against ground truth masks via the Dice coefficient.

Results:

Our model achieved 0.703 Dice score when combining FLAIR, T1-w and T2-w MRI, which was maintained when T1-w was excluded. Dice score when FLAIR and T2-w were excluded were 0.694 and 0.683, respectively. In the single-modality setting, our model achieved Dice scores of 0.635, 0.652 and 0.686, with T1-w, FLAIR and T2-w MRI, respectively. The predicted total MS lesion volume was strongly correlated with the ground truth volume ($r > 0.92$).

Conclusions:

Our deep-learning algorithm can provide automatic delineation of MS lesions from any combination of conventional MRI modalities and can be used for the quantification of MS lesion load across different clinical sites and scanners.

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