CIBM Center for Biomedical Imaging

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MSxplain: towards integration of deep learning into diagnosis and treatment planning for multiple sclerosis

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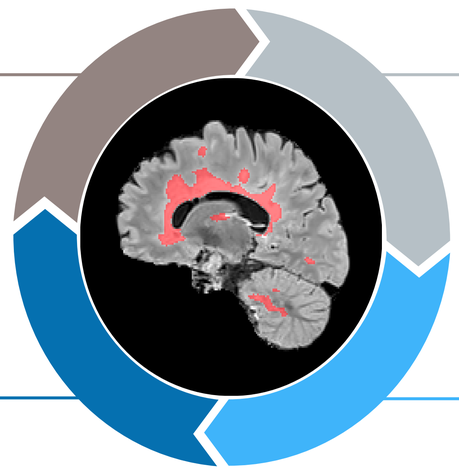
PROJECT OVERVIEW

MSxplain aims at developing **Explainable and Reliable AI**[1,2] tools in application to automatic methods of **multiple sclerosis followup**, and testing them in the **clinical setting**

Explainability
Insight on internal actions and/or features of a deep learning model.

Interpretability
Links a deep learning model to the human observer knowledge.



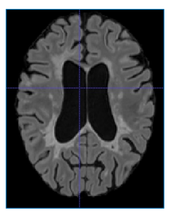
Uncertainty
Quantification of the reliability of model predictions.

Integration
Trustworthy and transparent decision support for patient assessment.

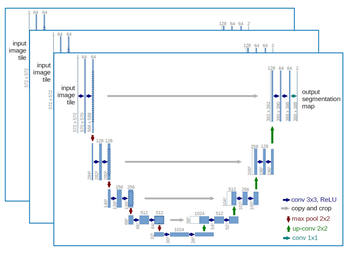
YEAR 2022: UNCERTAINTY QUANTIFICATION

Uncertainty quantification with deep ensembles[3] **for WM lesion segmentation** as a proxy for the deep learning **model reliability**

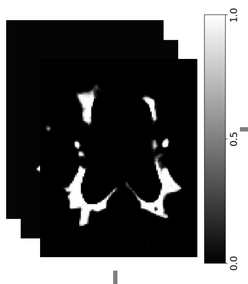
3D FLAIR scan



Ensemble of 3D U-Net models with different seed initialisations

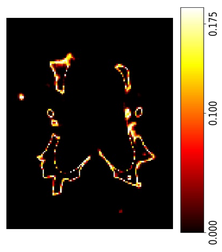


Predicted probability maps



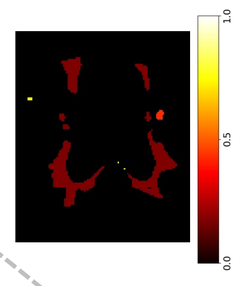
Disagreement in voxel predictions between ensemble members

Voxel-scale uncertainty map[4,5]



Disagreement in structural lesion predictions between ensemble members

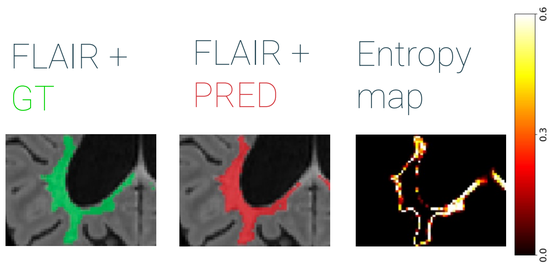
Lesion-scale uncertainty map[5,6]



EXAMPLES OF UNCERTAINTY MAP USAGE

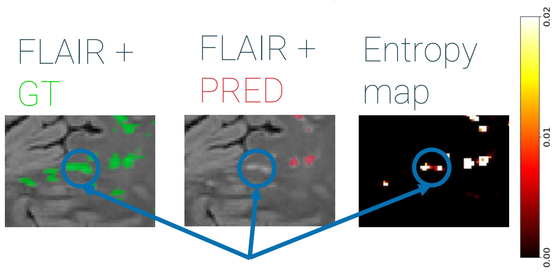
Voxel-scale maps

Correction of lesion delineation



Borders of lesions are the regions of higher voxel-scale uncertainty

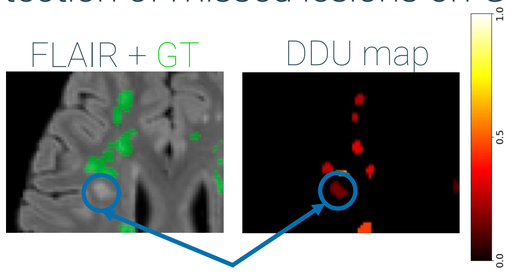
Detection of false negative lesions



WM lesion not detected by the model, but having non-zero voxel-scale uncertainty

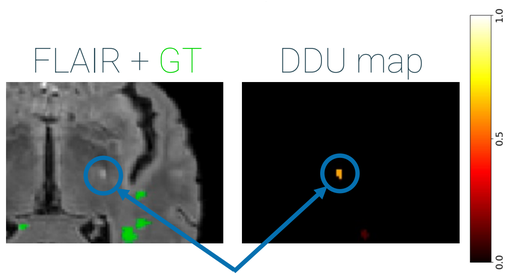
Lesion-scale maps

Detection of missed lesions on GT



WM hyperintensity absent on GT, but present in predictions + has low lesion-scale uncertainty

Detection of false positive lesions



WM hyperintensity absent on GT, but present in predictions + has high lesion-scale uncertainty

Proposed lesion-scale uncertainty measure
Detection disagreement uncertainty[6] (DDU)

$$\mathrm{DDU} = 1 - \frac{1}{K}\sum_{k=1}^{K} \mathrm{IoU}(\Omega, \Omega_k)$$

Notations: Ω - lesion region predicted by an ensemble of models, Ω_k - region of the same lesion predicted by the kth model in ensemble ($k = 1,2,...,K$), *i.e.* a connected component on the kth model predicted binary mask with the maximum intersection over union (IoU) with Ω.

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References:
[1] W Samek et al., ITU Journal (2017)
[2] M Graziani et al., Comput. Biol. Med. (2020)
[3] A Malinin, PhD Thesis (2019)
[4] T Nair et al., Med. Image Anal. (2020)
[5] Shifts Challenge 2.0 (2022)
[6] N Molchanova et al., arXiv (2022)