Towards Multiple Sclerosis Assessment through Advanced MRI Biomarkers and Artificial Intelligence

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\textbf{BACKGROUND}

- Approximately 2.3 million people worldwide live with Multiple Sclerosis (MS).\textsuperscript{1}
- Autoimmune inflammatory disease of the central nervous system affecting myelin sheath damaging it and the nerves, degrading or interrupting the information flow.
- Degenerative disease, increased patient disability through time, without cureation.

- MS lesion assessment in-vivo with MRI.
- During clinical practice, monitoring White Matter Lesions (WML).
- Advanced MRI sequences allow the discovery of more informative biomarkers for research: Cortical Lesions (CL), Parametric Rims (PRL) and Central Veins Sings (CVS).\textsuperscript{2}

\textbf{AIMS}

- Automated segmentation and/or detection of advanced biomarkers aligned with the MSxplain project goals:
  - Improve the automation model’s generalization capabilities by identifying existence bias.
  - Increase confidence in the clinical decision-making process through new interpretability and explainability strategies.
  - Extract measures of MS progression modelling the possible cause and effects relations underlying the disease’s biological mechanisms.

\textbf{PROJECTS}

- **CL Segmentation**
  - CL are present in all MS phenotypes and can be detected at early stages.
  - 3D-UNET:\textsuperscript{3}
    - Experiment: Train = 54
    - Test = 35
    - Results:
      - Dice = 0.60\textsuperscript{39}
      - True Positive Rate\textsubscript{\textdagger} = 0.71\textsuperscript{0.16-0.48}
      - False Positive Rate\textsubscript{\textdagger} = 0.27\textsuperscript{0.13}

- **PRL Detection**
  - PRL biomarker for progression. PRL burden correlates with MS aggressiveness.
  - RIMNet\textsuperscript{1}
    - Allows to differentiate selected patches.
    - Experiment:
      - Rim+ = 462 patches
      - Rim- = 4857 patches
    - Results:
      - Phase input→AUC = 0.913
      - Phase+Flair→AUC = 0.943

- **Uncertainty Estimation**
  - Extended from our work in WML segmentation\textsuperscript{2} (Check @NM poster!)
  - Deep Causal Models
    - To deal with Domain Adaptation issues and improve explainability\textsuperscript{2}.

- **Fully automated PRL detection**
  - SSD model learning is based on cheaper annotations, lesions localization, than Retina UNet\textsuperscript{3}.


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\textsuperscript{\textdagger}https://wp.unil.ch/mial/research/projects/msxplain/