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Fully automated longitudinal segmentation of new or enlarging Multiple Sclerosis (MS) lesions using 3D convolution neural networks

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Introduction and Purpose

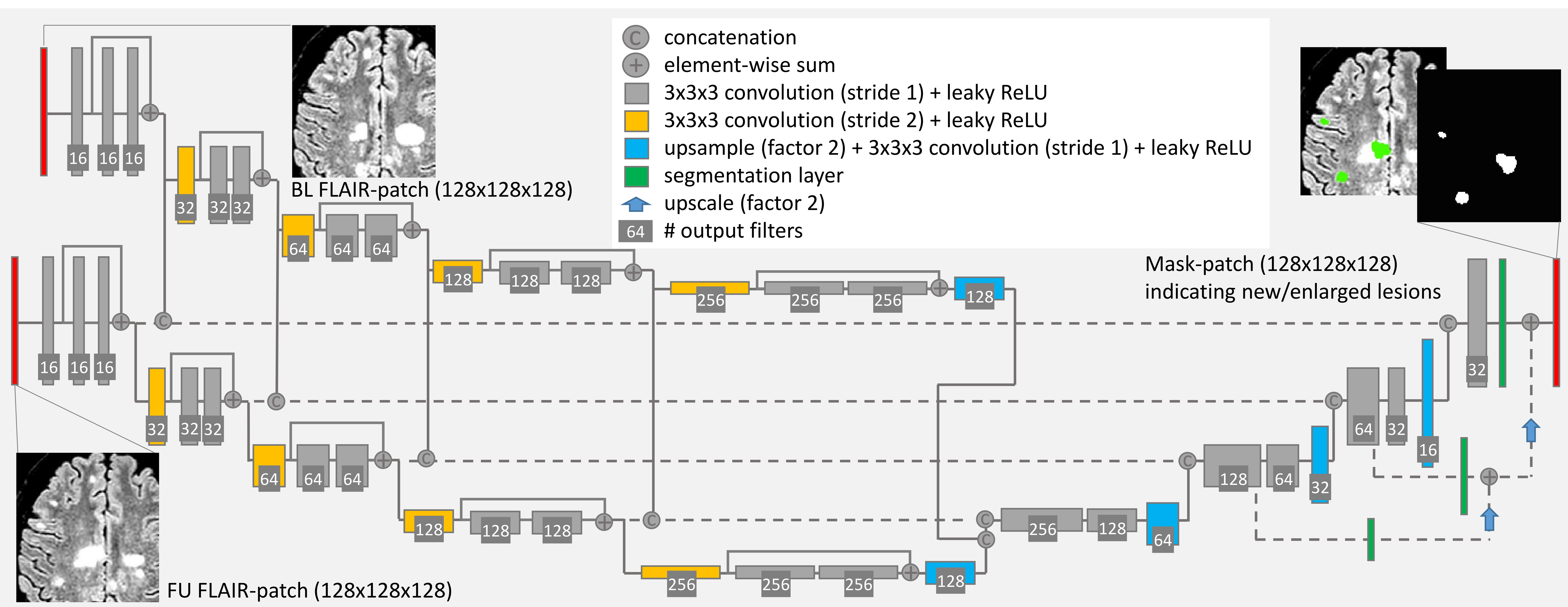
- Quantification of new and enlarging Multiple Sclerosis (MS) lesions (lesion activity) from follow-up MRI scans is an important surrogate of clinical disease activity
- Manual assessment is time consuming, **inter-rater variability is high** (Egger et al., 2017), and only few fully automated methods are available so far
- **Deep-learning** methods like convolutional neural networks (CNN) **show promising results** for lesion segmentation (Danelakis et al., 2018)

Methods

- 3D-CNN with an encoder-decoder (**U-Net-like**) architecture
- **Input: 2 FLAIR images** – baseline (BL) and follow-up (FU)
- **Output: 3D mask** indicating **new or enlarged lesions**
- **Pretrained** on **1809 single time point** routine data
- **Trained** on **587 BL-FU pairs** from clinical routine

Evaluation data:

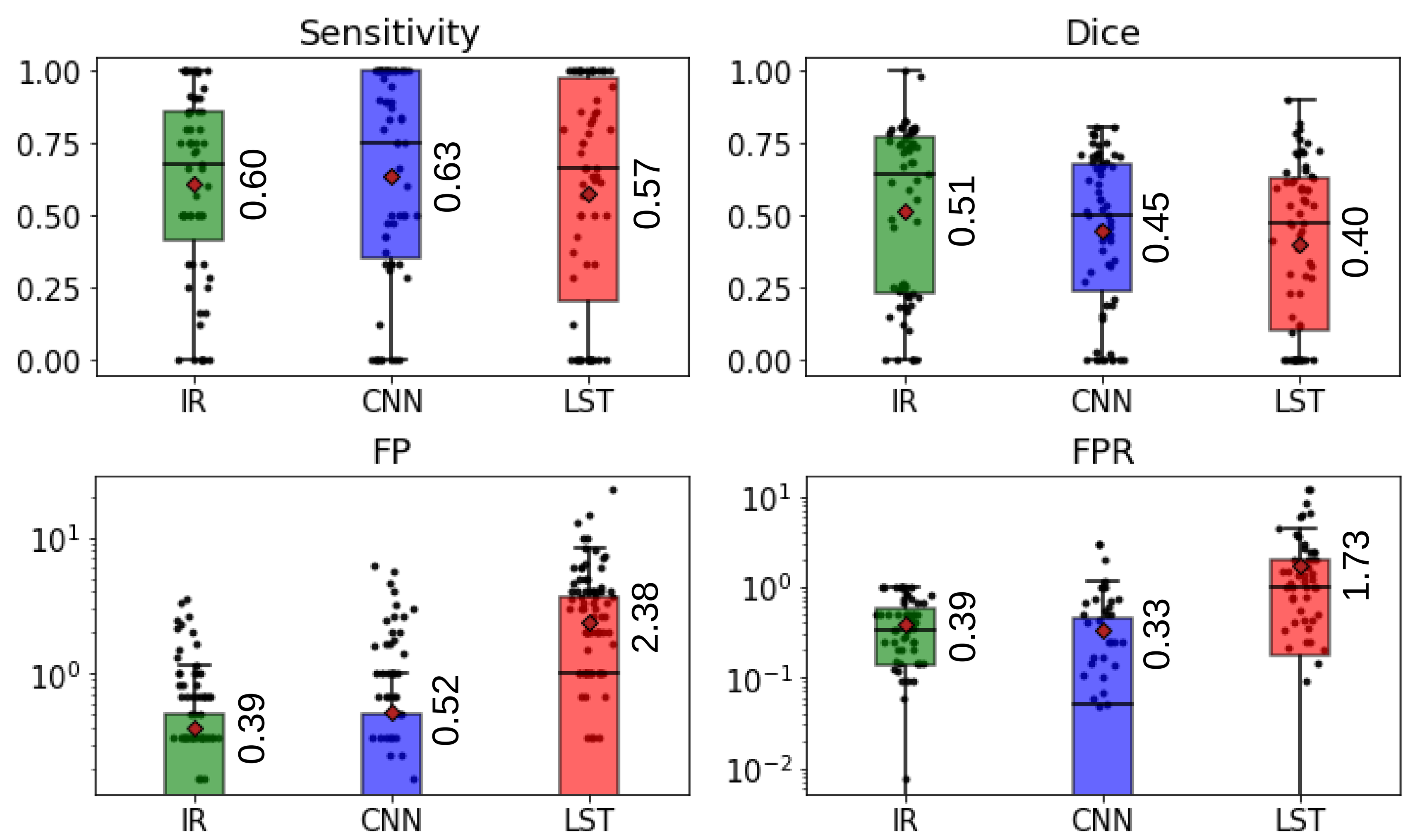
- 89 data (BL,FU), 3T Philips Ingenia, University Hospital of Zurich, Switzerland; age: 36.76 ($\pm$ 8.67); follow-up time: 2.21 ($\pm$ 1.09) years
- 27 data (BL,FU), 1.5T Siemens Avanto; Multiple Sclerosis Centre of the University Hospital Zurich, Switzerland; age: 38.92 ($\pm$ 10.49); follow-up time: 5.93 ($\pm$ 0.56) years



- **2-3 independent ground-truth** segmentations available
- Compared to lesion segmentation toolbox (LST) (Schmidt et al., 2019, http://www.applied-statistics.de/lst.htm)

Results

- Lesion masks were compared between raters (inter-rater, IR) as well as to the results provided by the CNN and the compared LST method
- **Performance measures:** mean lesion-wise sensitivity, dice coefficients, lesion-wise number of false positives (FP) and false positive rate (FPR)



Conclusion

- **Low inter-rater performance** signifies the **complexity and uncertainty of identifying new and enlarging lesions**
- Automated CNN-based approach can **quickly (<1 min)** provide an **independent and deterministic assessment** of lesions from BL and FU scans to support diagnosis and **potentially mitigate inter-rater variability**
- **Outperforms non-deep learning method (LST)**

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