

Development and validation of an automated MS reporting software

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Introduction

MR imaging is a mainstay of clinical management of Multiple Sclerosis (MS) patients. Reliable detection of (sub)clinical disease activity in MR imaging informs therapeutic management and thereby opens up therapeutic windows for clinicians.

Nonetheless, assessment of disease activity (evidenced by the occurrence of new inflammatory lesions in the brain) is time-consuming and error-prone task. We have already previously shown that longitudinal subtraction maps with their superior lesion-to-background contrast dramatically improve lesion detection (Eichinger et al., J. Neurol, 2017).

Purpose

To further facilitate assessment of MS follow-up examinations, we developed a tool for user-independent identification and classification of new or enlarged MS lesions in subtraction images over time.

Methods

To overcome the susceptibility of previous lesion detection approaches to artifacts and misregistrations, our software exploits multi-modal (FLAIR and T1) subtraction images based on cross-correlation driven non-linear deformable SyN transforms (using the ANTs registration toolkit). By analyzing both FLAIR- and T1-based subtractions, typical artifacts created at CSF-gray matter boundaries get canceled out.

To further improve subtraction performance, we developed a piece-wise linear intensity harmonization algorithm, which uses percentile information from the individual tissue classes (CSF, white matter, gray matter).

Lesion classification (periventricular, (juxta)cortical, subcortical, infratentorial) uses the SRI24 atlas which is adapted to the individual patient anatomy using ANTs Atropos, with the atlas template serving as an initialization prior.

Methods (continued)

To evaluate the performance of the software, we compared its performance in two cohorts from TU Munich (Philips 3T, 33 patients) and Tuebingen (Siemens 1.5 and 3T, 10 patients) against the clinical report.

Results

Files from both institutions could be run without problems or manual adjustment through our pipeline. On a desktop workstation, mean processing time was 15 – 20 minutes per case.

In the Munich cohort, the software correctly identified 151 / 164 lesions (92% accuracy), as opposed to a lesion detection accuracy of 72.5% for the clinical report (119 / 164 lesions).

In the second cohort from Tuebingen, 14 / 15 new or enlarged lesions were detected (93.3% accuracy). Intriguingly, the software also detected lesions previously overlooked (example in **Figure 1**, lower row).

The overall false positive rate was 19.5%, mostly easily identifiable artefacts close to the base of the skull. Classification accuracy was high (78.5%).

Along with the segmented and color-coded subtraction maps (right column in **Figure 1**), the software also returns a report with lesion volume (in total, per location and lesion).

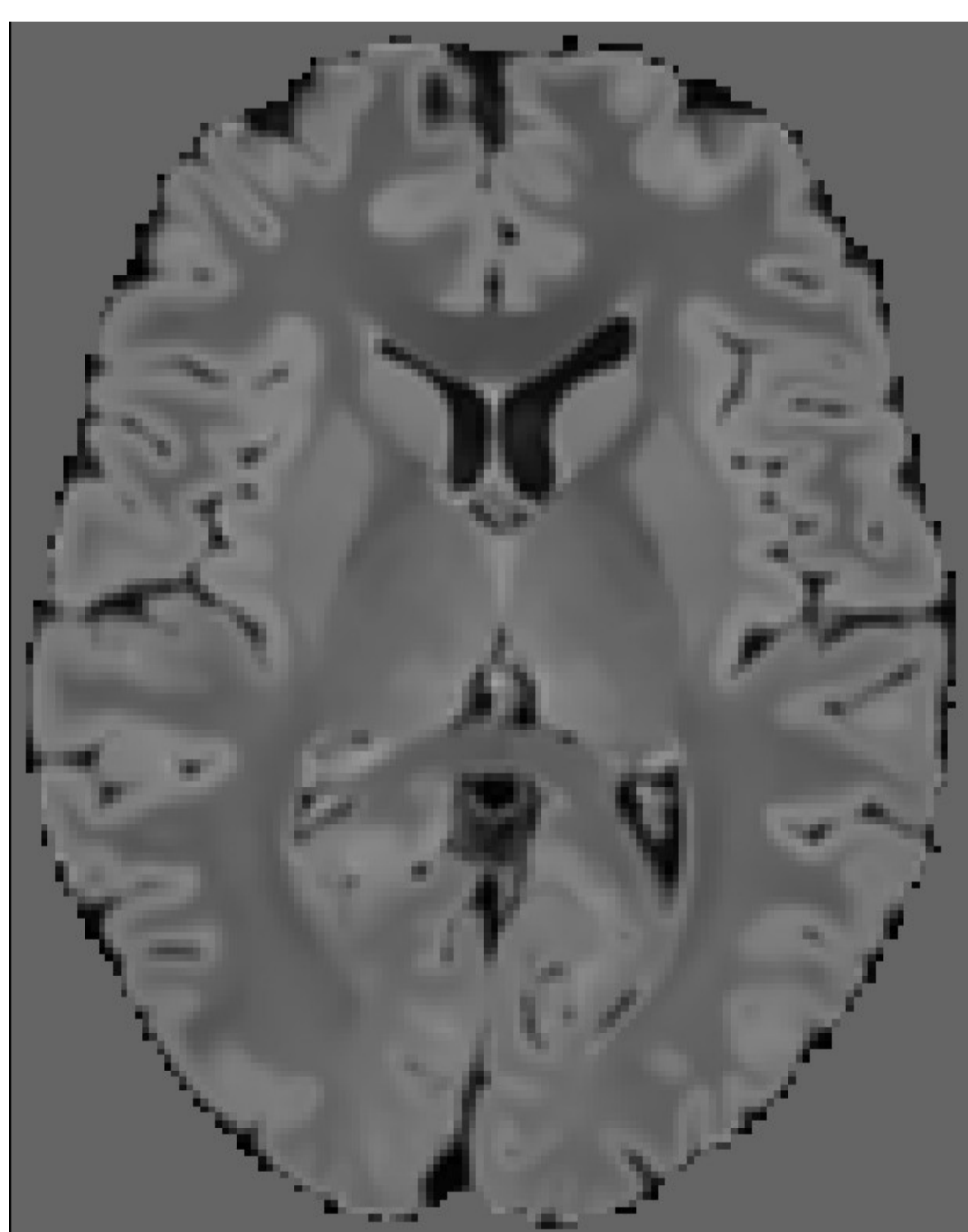
Conclusion & Outlook

In a multicenter setting across different MR scanners, our software consistently displays a very high detection and classification accuracy of new/enlarged MS lesions, highlighting the future potential of computer-assisted imaging.

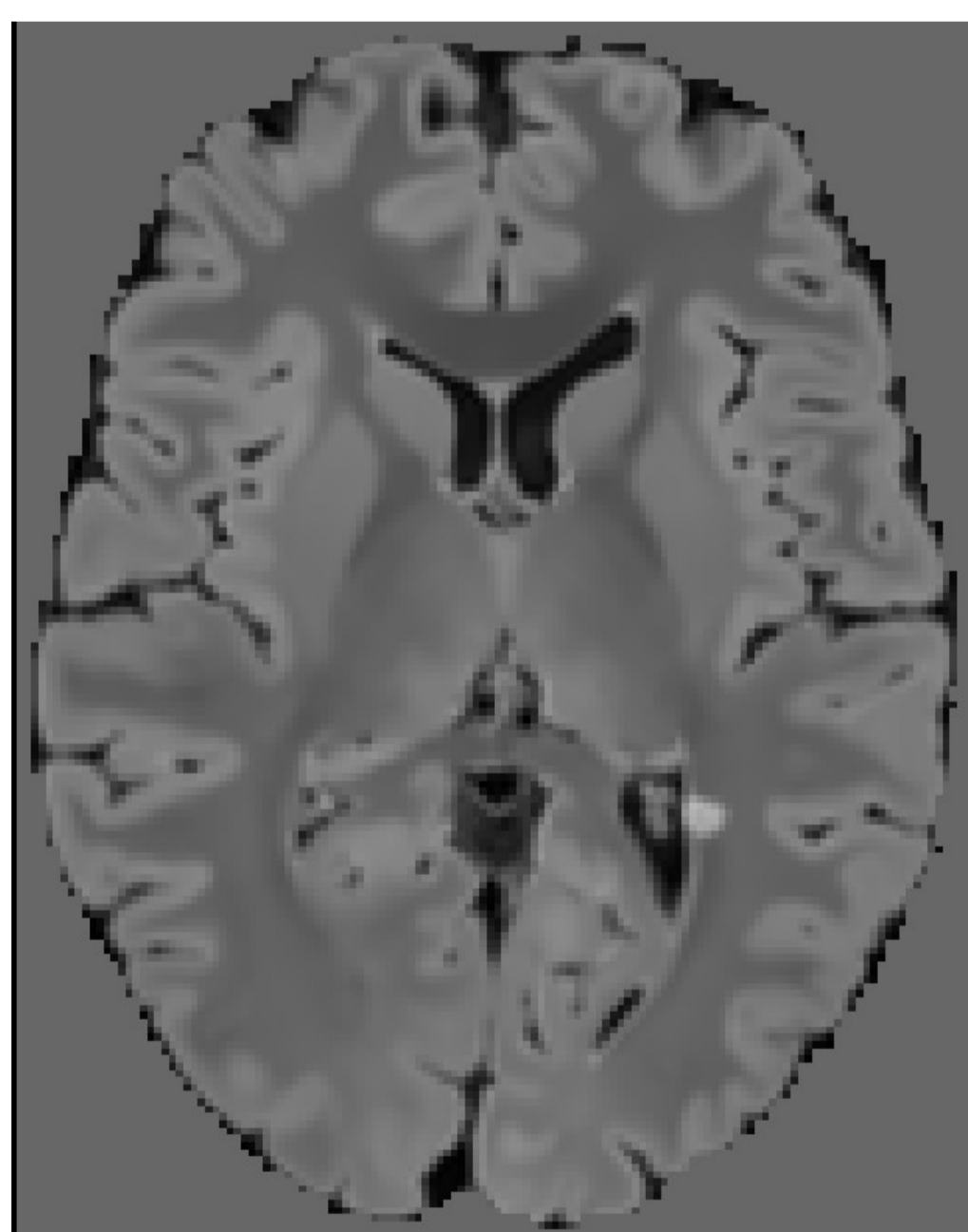
To further lessen the false-positive rate, we are currently developing an additional filter using a shape- and location-driven random forest classifier.

In addition, we aim to make the report configurable as to serve as a template for automated structured reporting of MS examinations.

Baseline



Follow-Up



Subtraction

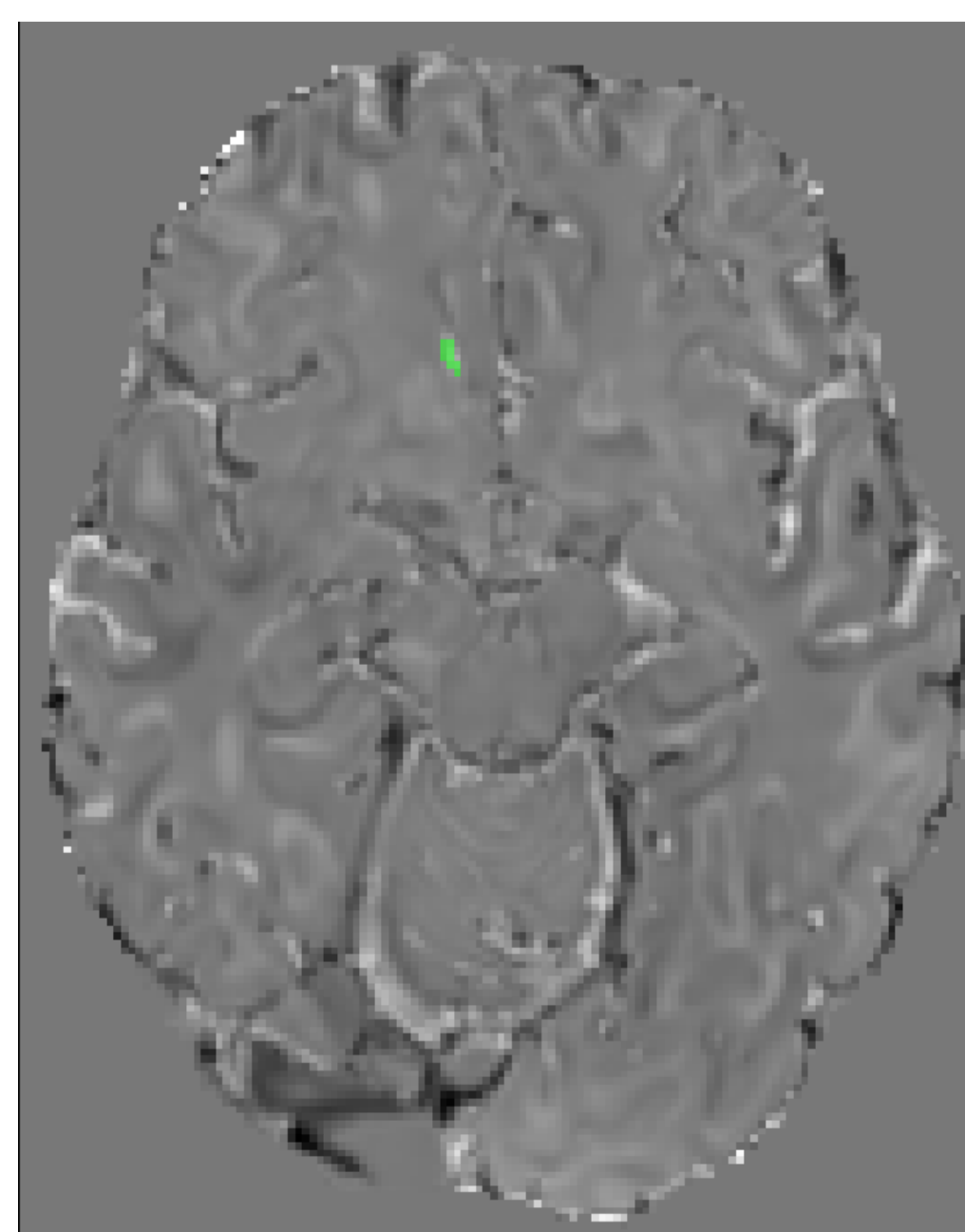
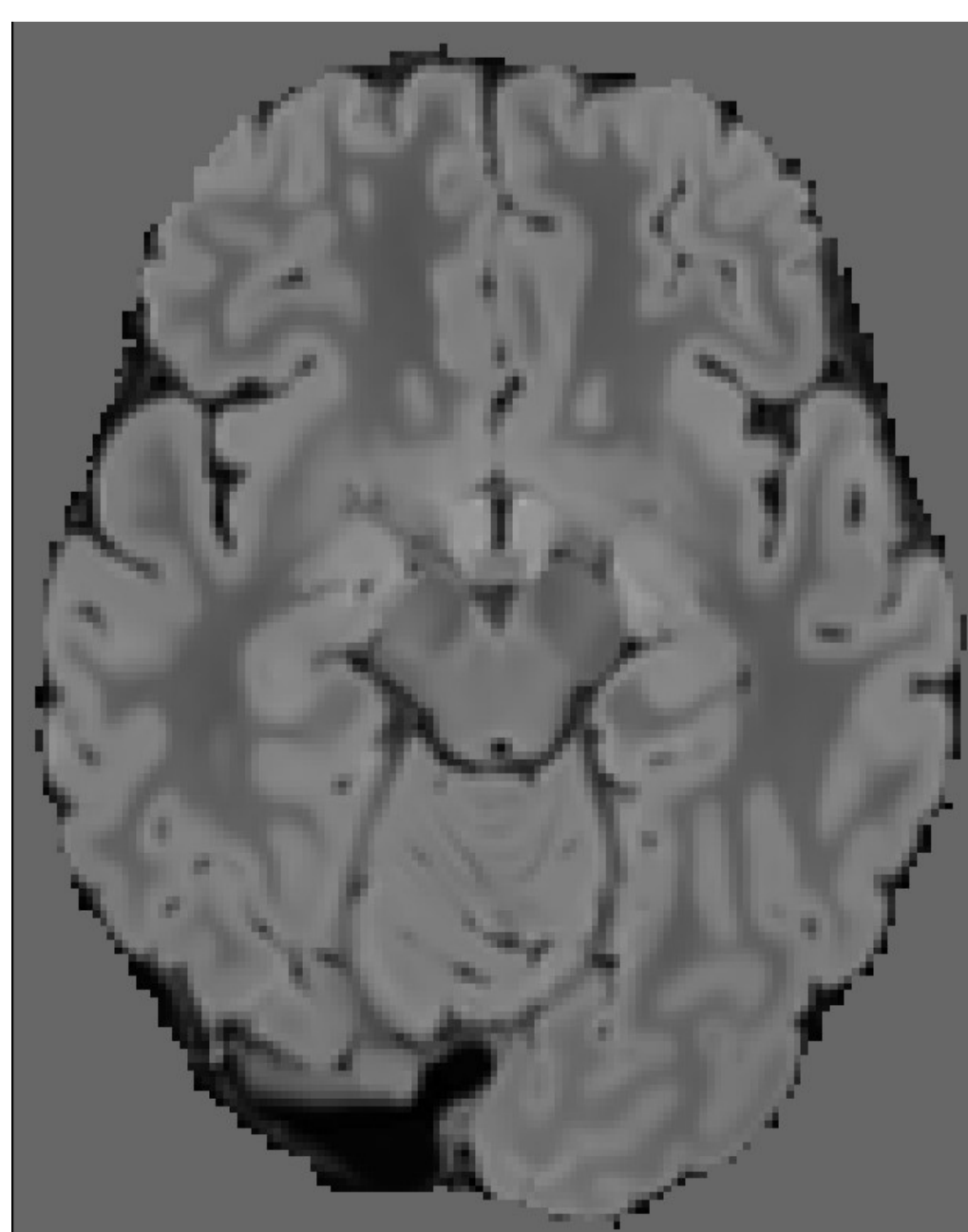
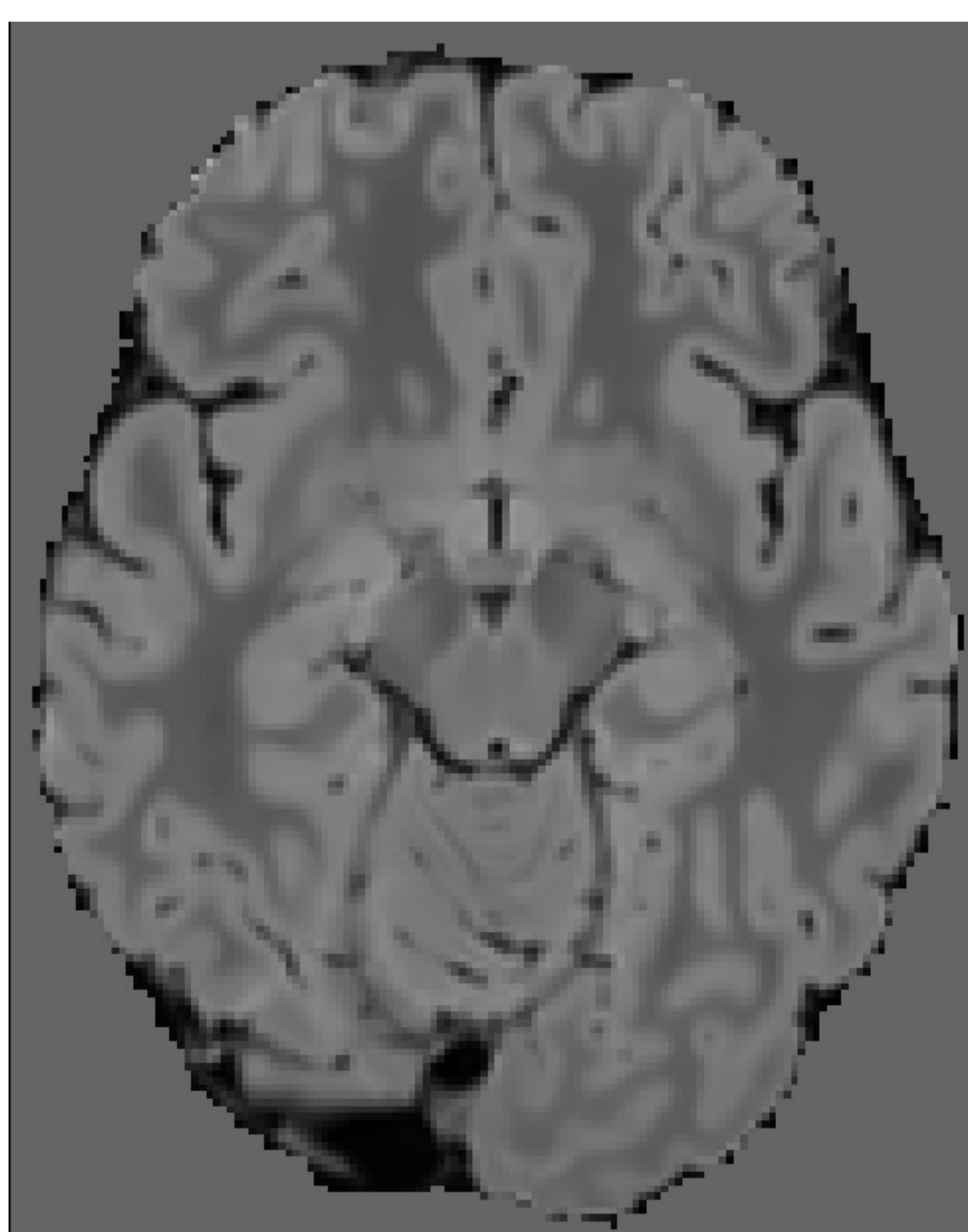
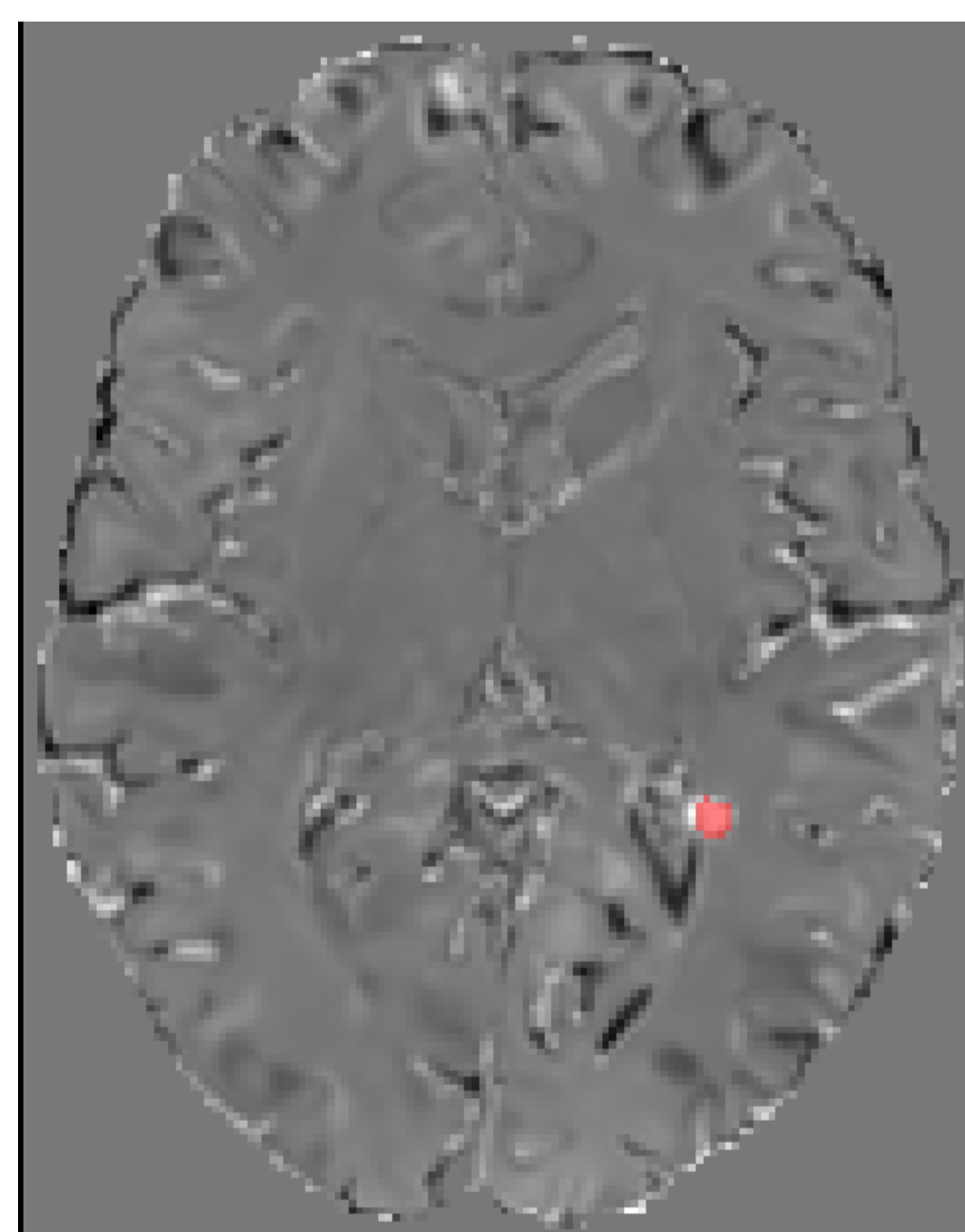


Figure 1: Examples of two lesions identified by the software, and the location-based color-coding. Top row, a left periventricular lesion (red). Bottom row, a right (juxta)cortical lesion (green). The latter lesion was overlooked by two radiologists, but could be verified as a true new lesion.