P428

A pipeline for detecting new multiple sclerosis lesions on longitudinal brain magnetic resonance imaging

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Background: The presence of new T2 lesions in follow-up MRI scans is an accepted biomarker to evaluate treatment efficacy in MS. However, this task is commonly applied visually or semi-automatically and is prone to inter- and intra-observer errors as well as labour intensive. Automatic tools for new T2 lesion detection would therefore be highly desirable.
Aim: To develop and test in a relevant clinical cohort an automated approach to detect new T2 MS lesions from serial brain MRI images.
Materials and methods: The study sample is made up of 36 patients with a clinically isolated syndrome (CIS), selected according to the presence of new T2 lesions in follow-up MRI scans. In this sample, new T2 lesion volume range was 12.53 to 7563.08 mm^3 and new lesions mean was 5. All patients were scanned with a 3T magnet at two different time points: the first within 3 months and the second 12 months after the onset of symptoms. Each MR scan includes transverse T2-FLAIR, PD-w, T2-w and T1-w images. A new pipeline introducing a novel post-processing approach based on deformation fields computed using Demons non-rigid registration was compared to a ground truth of visual semiautomatic annotations of new T2 lesions provided by expert neuroradiologists. This new approach studies the deformation between timepoints to determine changes in lesions. The automated pipeline includes several steps: common MRI pre-processing, co-registration between the baseline and follow-up images, automatic computation of a threshold on the white matter region of the 3D subtraction and a final post-processing step that combines the individual lesion masks for each image and applies rules based on intensity, lesion size and deformation fields to reduce the number of false positives. Concordance measures were applied.
Results: Using the T2-FLAIR image to detect new lesions we obtained: 70.93% of true positive (TP) fraction and 17.80% of false positive (FP) fraction, with a mean true positive detection of 3 new lesions and a Dice similarity coefficient (DSC) of 0.68. Using the PD-w and T2-w images the TP fraction and FP fraction increased to 71.67% and 37.68%, respectively with a decrease in the DSC to 0.62.
Conclusion: Our novel approach provides a low rate of FP and a high rate of TP with acceptable DSC and looks promising for further validation in other clinically relevant samples.

Disclosure

Mariano Cabezas has nothing to disclose.
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Xavier Lladó has nothing to disclose.
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Alex Rovira serves on scientific advisory boards for Biogen Idec, Novartis, Genzyme, and OLEA Medical, and has received speaker honoraria from Bayer, Genzyme, Sanofi-Aventis, Bracco, Merck-Serono, Teva Pharmaceutical Industries Ltd, OLEA Medical, Stendhal, Novartis and Biogen Idec.