Automatic lesion detection in white and grey matter using T1-weighted and FLAIR images

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Background: Some studies have reported the detection of cortical lesions in multiple sclerosis by manual thresholding of 3D FLAIR and 3D T1-weighted images. They then apply visual detection and use histopathology as a gold standard for clasification[1]. This method requires intense human intervention because cortical lesions are usually very small and numerous. We apply artificial vision techniques to the problem, combining the result with standard techniques for segmentation, in order to automate lesion detection and quantification.

Methods: Cortical lesions were identified and classified on 3D FLAIR and 3D T1-weighted 3T MR images. Brains were segmented using Statistical Parametric Mapping (SPM version 8). The rest of the software was developed in C++ based on the Insight Segmentation and Registration Toolkit (ITK)[2] and the 3D Slicer3[3] platform. The essence of the algorithm is extracting regions that present simultaneous hyperintensities in the FLAIR image and hypointensities in the T1 image (Figure 1). Classical tissue segmentation methods fail in these cases, in particular when the lesions on the T1 images present an intensity similar to gray matter.
To label the lesions, we compute morphological local minima in T1 and local maxima in FLAIR. We consider as lesion only those regions that appear as minima and maxima simultaneously. Finally, to remove residual voxels, we keep only those objects that are at least 3 mm in size in one of the three axes. To evaluate the software, we performed a study involving fifteen MS patients and twenty controls.

Results: We have developed a technique that can obtain the volume of brain lesions with no human intervention. The software can be used inside the 3D Slicer Platform[3] with a graphical interface, or can be directly executed in command line. Figure 2 shows the different lesional load distributions for each group and tissue .Table 1 shows p values after applying a t-test with bonferroni correction, for the difference in lesional load for gray and white matter and total lesional load. The results were normalized with respect to the volumes of gray and white matter and the total sum of both.

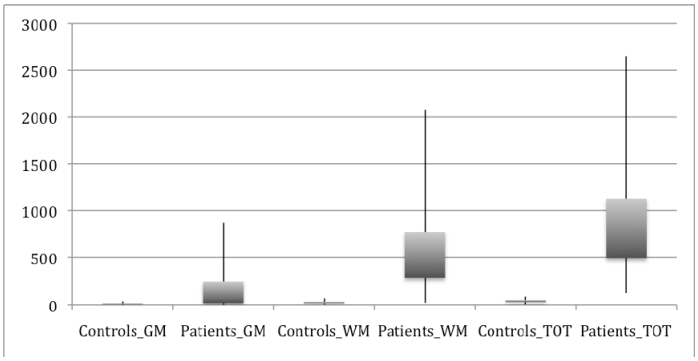

Figure **1**: Lesional load in mm3 in gray matter, white matter, and both.

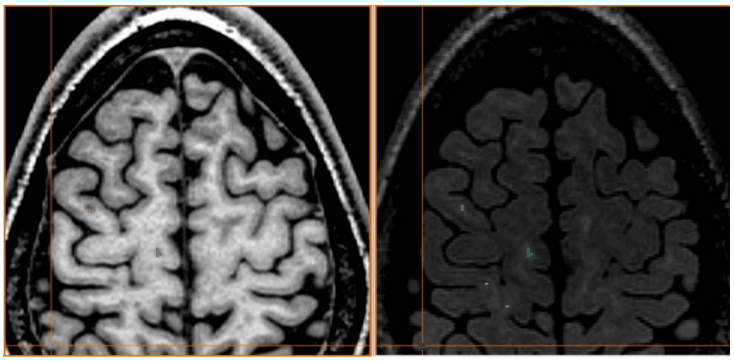

Figure **2:** T1-weighted and FLAIR 3T MR showing GM and WM lesions.

GM	WM	Total	GM_normalised	WM_ normalised	Total_ normalised
p<0,00004	p<0,000007	p<0,000003	p<0,00005	p<0,000003	p<0,000002

Table 1: p values of t-test with Bonferroni correction of lesion volume detected on Controls and Patients in GM, WM and both. Without and with partial volume correction.

Discussion: We have developed and automatic tool for detecting and classifying lesions in Multiple Sclerosis. The software is available as a plug-in for 3D Slicer. In some controls, there are still some lesions detected, some of them due to the noise present in the image. But the system has allowed to classify all patients and controls in a study on 36 subjects. We are working on including new “a priori” information to refine the procedure in order to improve the sensibility and specificity, with the aim of using it as a staging biomarker.

Biography:

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[2] L. Ibanez, W. Schroeder, L. Ng, and J. Cates, *The ITK Software Guide*. Kitware, Inc. ISBN 1-930934-15-7, 2nd. edition, 2005.

[3] Pieper S, Halle M, Kikinis R (2004) 3D Slicer. in IEEE International Symposium on Biomedical Imaging: Macro to Nano.