AUTOMATIC WHITE MATTER HYPERINTENSITY SEGMENTATION USING FLAIR MRI: THE MS LESION SEGMENTATION CHALLENGE

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ABSTRACT

We present a fully automatic algorithm developed for the segmentation of white matter hyperintensity lesions. The longitudinal test data which is made available to participants of the ISBI 2015 Longitudinal Multiple Sclerosis Lesion Segmentation Challenge, consists of MRIs of 5 patients along with manual segmentations of two experts. Our method involved intensity thresholding and the so called 3D voxel connectivity analysis. We train a simple model that is optimized by searching for the maximum obtainable dice score.

Index Terms— segmentation, white matter hyperintensity, thresholding, histogram analysis, full width at half maximum, voxel connectivity

1. INTRODUCTION

It is well known that the increased T2 relaxation time of WMH regions is as a result of a wide range of pathological processes including edema, inflammation, demyelination, axonal loss and gliosis [1]. White matter hyperintensity is the bright signal observed in FLAIR MRIs of subjects with vascular dementia, Alzheimers disease (AD) as well as in multiple sclerosis (MS) patients [2, 3, 4].

Several automated WMH segmentation methods have been proposed in the literature, some of which employ combined usage of multiple contrasts (T2-, T1-, and sometimes proton density-weighted (PD) images) for the purpose of obtaining an accurate segmentation result [5, 6]. However, the use of FLAIR images makes the segmentation task fairly easy since there is an increased contrast between WMH and other brain tissues. A known issue that arises from thresholding FLAIR images for the purpose of white matter hyperintensity segmentation is the abundance of false positives (FP) [6]. To curb the problem, several methods have been used: for example, in [7] and [8], seed voxels with very high signal intensities on FLAIR and PD/T2-weighted images are identified and used as input to a fuzzy-connectivity algorithm which assesses the degree of fuzzy affinity between spatially connected elements but this methods still requires the use of multiple contrasts. Our proposed algorithm aims to achieve MS lesion segmentation by use of FLAIR images only.

2. METHODOLOGY

2.1. Intensity Thresholding

We begin by mapping the intensities of every training image to those of a reference image which in this case is the first image of training01 subject; we then compute the histogram of the whole brain foreground voxels from the FLAIR image and assume that the peak is that of a normal distribution so that its 7 dB drop is more than twice its Full Width at Half Maximum (FWHM). The intensity of this I_{7dB} point is guaranteed to be amongst the highest intensity values of the image. With this value as a minimum threshold for WMH, we define the threshold as:

$$T = I_{peak}(1 - w) + I_{7dB} \qquad (1)$$

where w is a weight value to be determined. In Figure 1, the voxels that fall to the right of the global peak are segmented as those belonging to lesions. For a more detailed description and an evaluation of the method, refer to [9].

2.2. 3D Connectivity Analysis & Corpus Callosum Delineation

The 3D connectivity analysis in brief involves the examination of every detected voxel for the degree of connectivity with its neighboring voxels. This step translates to analysing the volumetric significance of every detected lesion. Lesions that are deemed insignificant are assumed to be false positives and are therefore ignored during the segmentation. A parameter that needs to be optimized during training is the minimum volume of lesions. Refer to Figure 2 where the false positive minimization effect of the 3D connectivity analysis is depicted.

Additional steps were required to get rid of false positives that appear on the corpus callosum. We employ a RANSAC
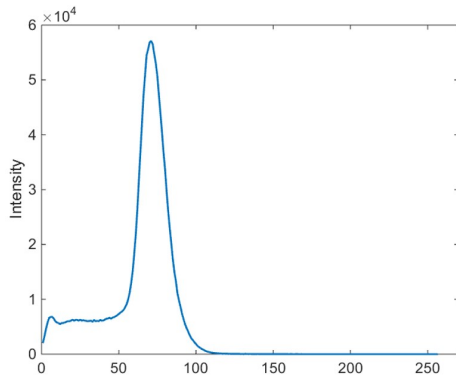
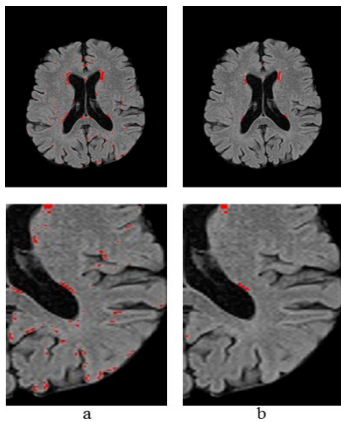**Fig. 1**. The 3D histogram of foreground voxels

a   b

Fig. 2. The effect of the 3D connectivity analysis. Figures a & b depict the before and after effects respectively

based approach [10] to detect the interhemispheric fissure which coincides with the corpus callosum when the image is viewed axially.

2.3. Training & Testing

We train a two parameter model by performing a grid search for the parameters that maximize the dice score. The optimization is carried out for each mask as well as for the union of the two masks. Testing would require mapping the intensities of the new data to those of the reference image then applying the method described previously.

3. REFERENCES

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