Automatic measurement of periventricular halo in an elderly cohort

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SUMMARY

One particular feature of an ageing brain is the increased presence of white matter hyperintensities. These can be clearly visualised with a T2 weighted MR image which a radiologist would then manually grade using visual scoring methods. However, these methods are prone to inter and intra observer variability. In this study, an automated technique has been developed for measurement and localisation of the periventricular white matter lesion load into frontal and occipital areas. This involved developing computer software to perform image registration and segmentation using state of the art image analysis libraries. We found that automatic periventricular halo measurement correlate with respiratory function in an elderly cohort.

INTRODUCTION

Ageing is associated with mental ability (cognitive) decline (Raz, 2000) and also the presence of white matter changes (hyperintensities (WMH)) on T2 weighted (T2W) brain magnetic resonance images (MR images) (Yue, 1997).

WMH are usually divided on visual assessment scales, such as the Scheltens' scale (Scheltens, 1993) into subcortical and deep punctuate WMH, which appear as discrete areas of brightness on T2W images, and periventricular white matter hyperintensities (PVWMH), which appear as a smooth band or halo around the lateral ventricles (Figure 1). It has been suggested that PVWMH scored semi quantitatively correlate with health measure (Murray, 2005) particularly reduced in respiratory function (Forced Expiratory Volume in 1 second (FEV_1), Forced Vital Capacity (FVC) and Peak Expiratory Flow Rate (PEFR)). However, visual assessment scales are labour intensive, prone to observer variability and subject to ceiling effects (van Straaten, 2006).

We hypothesise that automatic methods of PVWMH volume measurement provide more informative measurements than visual scoring. Therefore, we have developed a voxel based method for PVWMH volume measurement. Here we compare this method with Scheltens' scores in 241 participants of the 1936 Aberdeen Birth Cohort at age 68 and correlate voxel based measures with respiratory function.

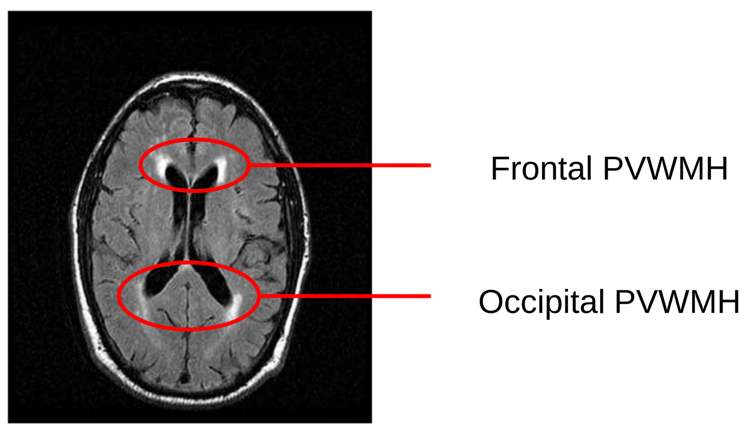
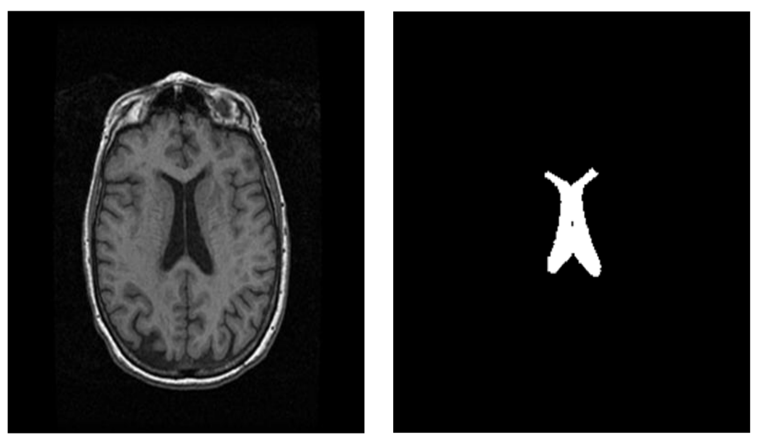
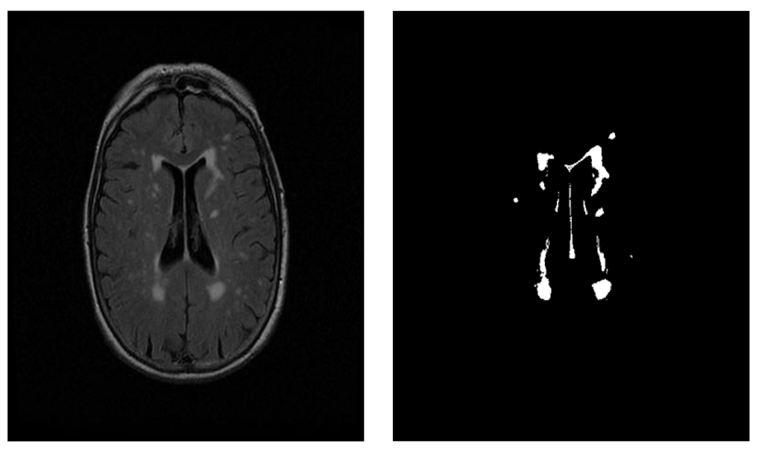


Figure 1: Frontal and occipital PVWMH



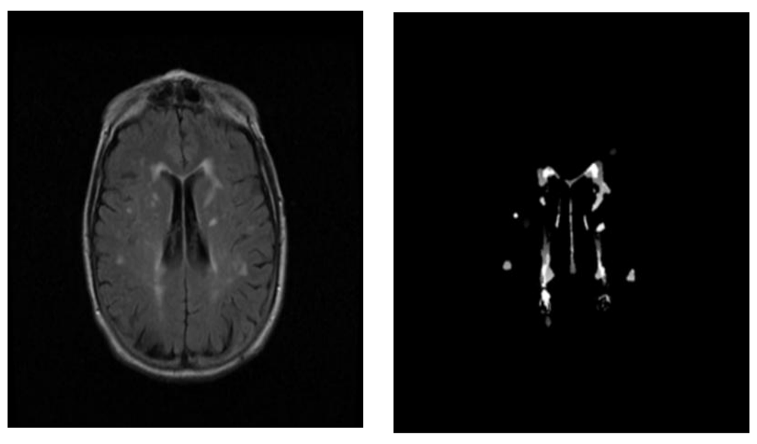
(a) T1W (b) Lateral ventricle

Figure 2: Segmented lateral ventricle from T1W using FIRST



(a) FLAIR (b) WMH

Figure 3: Segmented WMH from FLAIR image using fuzzy connectedness algorithm



(a) Resliced FLAIR (b) Resliced WMH

Figure 4: Registered FLAIR and WMH

METHODS

The lateral ventricles were segmented with the FSL tool FIRST (Patenaude, 2007) using the T1 weighted (T1W) images (Figure 2). WMH were segmented from fluid attenuated inversion recovery (FLAIR) images using a fuzzy connectedness algorithm (Wu, 2006) (Figure 3). FLAIR images were registered to the T1W and the transforms applied to the segmented WMH images (Figure 4).

A region growing technique was used to identify areas in which WMH were located adjacent to the segmented lateral ventricles. The PVWMH finally were classified into frontal and occipital horn based on their location from centre of gravity (Figure 5).

The obtained PVWMH volume were then compared with visual score of PVWMH which were performed by trained observers. Respiratory function was estimated by using the highest value recorded during three attempts after one practice session with a spirometer.

RESULTS

PVWMH volume correlates with local Scheltens' scores (Scheltens, 1993) for frontal and occipital horns (p<0.05) with r values for frontal and occipital were 0.301 and 0.184 respectively.

We found that FEV_1, FVC and PEFR were significantly correlated (p<0.05) with automated measurement of PVWMH in occipital horn (with r values -0.139, -0.142 and -0.156 respectively) but not with occipital Scheltens' score.

DISCUSSION

We have shown that automatic PVWMH measurements correlate with measures of respiratory function in an elderly cohort.

Better ventricular segmentation may improve our results further.

FUTURE WORK

1. Comparison between FSL and FreeSurfer for segmentation of lateral ventricle.
2. Investigate the effect of different segmentation tools on total lesion load of PVWMH.
3. Investigate the suitable technique on how to localise the PVWMH into frontal and occipital horns.

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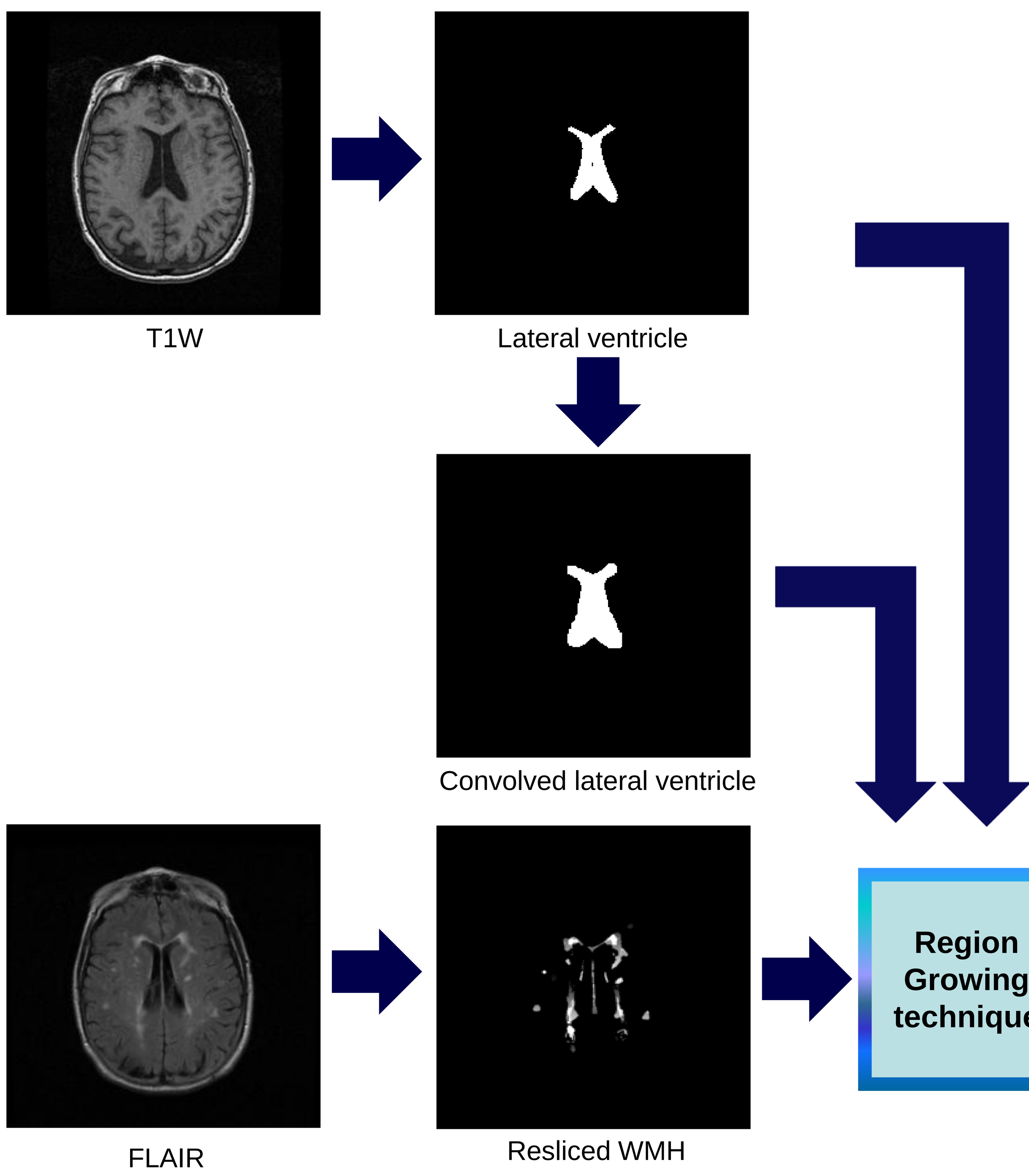

Table 1: Local Scheltens' score of PVWMH

Score	Characteristics
0	Normal
1	Pencil thin lining
2	Smooth halo
3	Large confluent

$$m_{00} = \sum_i \sum_j a_{ij} \qquad i_c = \frac{m_{10}}{m_{00}}$$

$$m_{10} = \sum_i \sum_j i a_{ij} \qquad j_c = \frac{m_{01}}{m_{00}}$$

$$m_{01} = \sum_i \sum_j j a_{ij}$$

Note:
a_{ij} is the voxel intensity,
i and *j* are the pixel coordinates
m_{00}, m_{01}, m_{10} are moments
i_c , j_c are x, y coordinates of centre of gravity

Calculation of centre of gravity

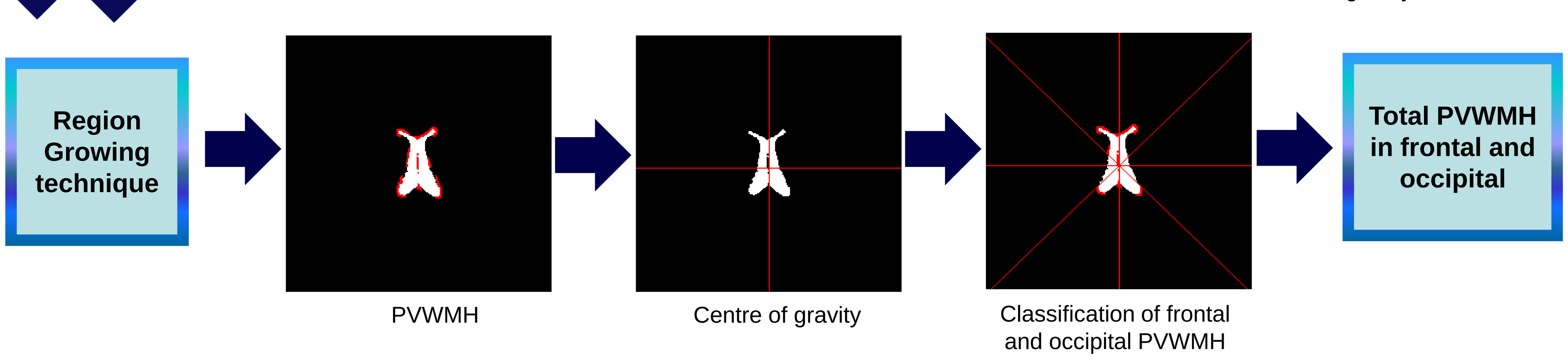

Figure 5: Measurement process of PVWMH into frontal and occipital horns