MCMxxxVI (1936): A new versatile automatic technique for brain lesion segmentation and volume analysis

M. V. Hernandez[1], M. E. Bastin[2], and J. M. Wardlaw[1]
[1]Clinical Neurosciences, University of Edinburgh, Edinburgh, United Kingdom, [2]Medical Physics, University of Edinburgh, Edinburgh, United Kingdom

Purpose: Brain microbleeds (BMBs) are hemosiderin deposits (HDs) [1] around abnormal small cerebral arterioles associated with increased risk of stroke, cognitive impairment, amyloid angiopathy and dementia, and may influence the treatment of stroke [2]. White matter lesions (WMLs) are damaged white matter tissue areas important for predicting stroke risk, dementia, other neurodegenerative diseases and have a direct effect on cognitive ability. Due to the importance of the segmentation and quantification of normal appearing brain tissue volumes along with these types of anomalies several different approaches have been made, but with limited success. The semi-automated methods that currently exist have low or variable accuracy for normal/abnormal tissue discrimination, some of them introduce systematic bias in the presence of increasing WMLs or atrophy, and in general their results have low repeatability [3]. Despite WMLs and iron deposits being common findings in scans of older people, most conventional automatic segmentation methods do not segment WMLs accurately and include HDs as normal white or grey matter. We have developed an alternative approach for segmenting brain tissues automatically to distinguish these anomalies.

Subjects and Methods: We used structural MRI data from 250 healthy volunteers of the Lothian Birth Cohort 1936 scanned at the age of 71-72 years with a 1.5T GE Echospeed MR scanner as part of the Disconnected Mind Project [4]. The imaging data were processed using Analyze 8.1 (Mayo Clinic) and software modules written in MATLAB.

The principle of our method is the data fusion of two or more types of structural images registered and modulated in frequency to two non-contiguous spectral bands of the visible spectrum, that is from approximately 380 to 750 nm. We use T2*- and FLAIR-weighted axial images (Figure 1) for differentiating WMLs, BMBs and HDs in general, as well as CSF. The combination of T1- and T2-weighted contrast was used for extracting CSF and normal appearing white matter (WM). The grey matter volume was determined by subtracting the WMLs, the CSF and the WM volumes from the total brain volume. The Minimum Variance Quantization (MVQ) method allows us to quantify the volumes of the tissues visually segmented.

Results: We compared the results of this technique to the 'gold standard' measurement obtained by an experienced image analyst (MVH) who manually outlined the lesions using thresholding in the FLAIR images. The overall process was evaluated by an experienced neuroradiologist (JMW). A sample of the results is shown in Figures 2 to 4.

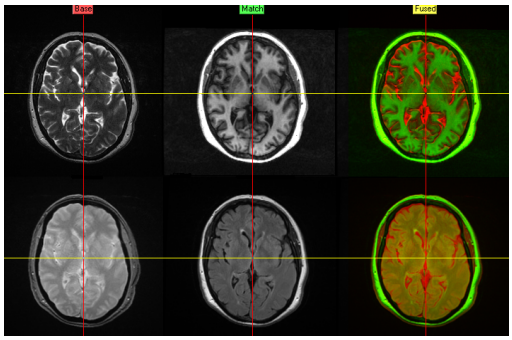

Figure 1: Fusion and modulation in red/green of T2 and T1 (upper row), and T2* and FLAIR images (bottom row).

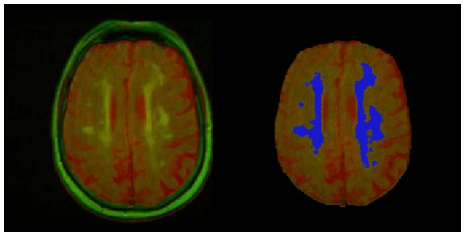

Figure 2: WMLs segmentation (right) from fused T2*/FLAIR images (left); note the immunity to motion artifacts.

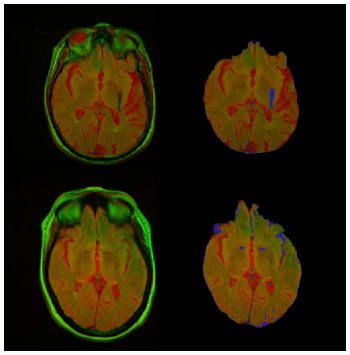

Figure 3: HDs and an old hemorrhage segmented (right) from fused T2*/FLAIR images (left).

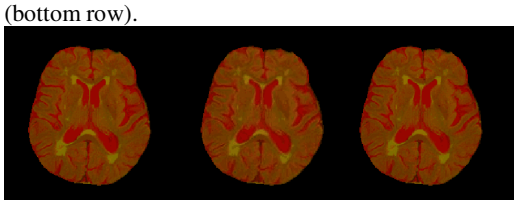

Figure 4: Robustness of the technique applicable to images in different formats. These results are promising for applications in teleradiology. From left to right: tiff (193 kb), jpeg (8kb) and bmp (193 kb) segmented images.

Both the intra-observer reliability and intra-class correlation coefficient for WMLs segmentation was 0.99, with a similarity index of 0.9. HDs and BMBs are all detected. This method also highlights the high-iron content areas like small vessels. For this reason, a post-processing step that discriminates between the types of high-iron content areas segmented is needed.

Conclusions: These data suggest that the Multispectral Coloring Modulation and Variance Identification (MCMxxxVI) technique is fast, accurate, observer independent and increases the reliability and repeatability of WML, BMBs and HDs volume measurements. Further testing in a wider range of subjects is now required.

Acknowledgements: This work is funded by Help the Aged and the UK Medical Research Council as part of the Disconnected Mind Project: LBC1936. The imaging was performed in the SFC Brain Imaging Research Centre (www/sbirc.ac.uk). The image format conversion tools were written by Dr. Paul Armitage.

References: [1.] Tatsumi, S. *et al*. Cerebrovasc Dis 2008;26:142-146. [2.] Cordonnier, C. *et al*. Brain 2007;130:1988-2003. [3.] Frisoni, GB. *et al*. Neurology 2007;3:620-627. [4.] Deary, IJ. *et al*. BMC Geriatr 2007;7:28.