An Automatic Tissue Segmentation Approach using Multispectral MRI Analysis for White Matter Lesions and Brain Volume Analysis

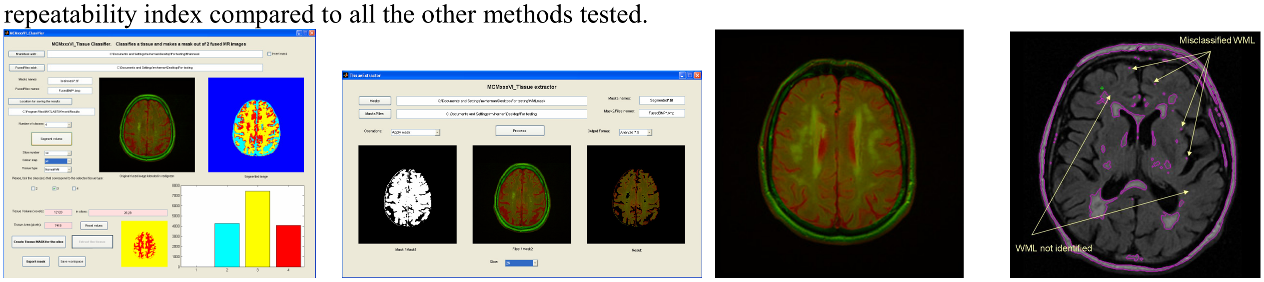
Maria del C. Valdes Hernandez[a], Karen Ferguson[a], Mark Bastin[b] and Joanna M. Wardlaw[a]

[a]Department of Clinical Neurosciences, [b]Medical Physics, University of Edinburgh. School of Clinical and Molecular Sciences. Western General Hospital. Crewe Road. Edinburgh, EH4 2XU.

Introduction: Due to the importance of the segmentation and quantification of brain tissue volumes in older subjects including abnormalities like white matter lesions for predicting future stroke risk and dementia, several approaches have been made but with limited success. The current semi-automated methods have low or variable accuracy for normal/ abnormal tissue discrimination, some of them introduce systematic bias in the presence of increasing white matter lesions (WML) or atrophy, in general they have low repeatability, and most conventional automatic segmentation methods classify them as normal white or gray matter. Following an extensive literature review on approaches for segmenting white matter lesions, we compared the existing automatic multispectral classifiers, semi-automatic approaches (as described in over 30 major previous studies of white matter lesions in older people) and a new approach we developed, applying them to gold standard test scans for older people.

Materials and Methods: We analyzed brain images obtained from 14 subjects (73.4 ±10 years old) selected from 3 studies of healthy men (n=6) and patients with mild stroke symptoms (n=8) giving a full range of WML load (from almost none to severe), using a 1.5T GE Echospeed MR scanner. Our method is based on data fusion of two types of structural magnetic resonance (MR) images registered and modulated in frequency to non-contiguous spectral bands of the visible spectrum (from 380 to 750 nm approximately). The combination of T1 and T2 facilitates the brain segmentation automatically into 3 classes: normal WM, CSF/vessels and WMLs/GM. Once the CSF is masked, we use the combination of T2* and FLAIR to extract the WMLs. The Minimum Variance Quantization (MVQ) method allows us to quantify the volumes of the segmented tissues.

Results: The software made for this purpose and some comparisons are illustrated in Table 1and Figure 1. As seen, the intra-class correlation coefficient for our method is higher with a similarity index of 0.9, and it has the highest repeatability index compared to all the other methods tested.



A B C

Figure 1. A: Extraction of normal WM and WMLs by our software using Spectral Fusion (SF) and MVQ (new method), B: Segmented brain by our new method fusing T2* and FLAIR (axial view), C: Example of misclassified and omitted WML (semi-automatic) by thresholding in a FLAIR sample.

Methods (Classifiers)	Needs Sample Reg.	Mean difference between 2 measurements (same SR)	Mean difference between 2 measurements (different SR)	Intraclass corr. coefficient (only considering WMLs)
Gaussian cluster	Yes	0.78 %	2 %	0.95
K Nearest Neighbour	Yes	0.7 %	1.7 %	0.96
Nearest Neighbour	Yes	0.77 %	1.7 %	0.96
Neural Networks	Yes	0.67 %	2 %	0.94
Parzen Windows	Yes	0.89 %	3 %	0.88
SF and MVQ (new)	No	0	0	0.98

Table 1. Intra-observer Reliability of the Automated Tissue Classifiers applied to the sample

Conclusions: These initial data suggest that the multispectral classifier presented is faster (does not need sample regions), accurate (considerably reduces the total squared error between the original pixels and the colours assigned from a colour map, by splitting the cluster with the largest principal eigenvector before other clusters in the same quantization level), observer independent and, increases the reliability and repeatability of WML volume measurement.

Acknowledgement:

This work has been sponsored by the foundation "Help the Aged" and the UK Medical Research Council as part of the project "Disconnected Mind: LBC 1936". The imaging was performed in the SFC Brain Imaging Research Centre (www/sbirc.ac.uk).