T2 WM HYPERINTENSITY MAPPING AND QUANTIFICATION WITH FSL

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Purpose

T2 White Matter Hyperintensities (WMH)

- A defining feature of Multiple Sclerosis
- Also important in other areas such as Traumatic Brain Injury (TBI) and normal aging
- Improvements in acquisition (e.g. high resolution 3D T2 FLAIR) have improved detection
- WMH volumes (or T2 Lesion Volumes; T2LV) are an important biomarker for summative effect on disability
- Many methods exist for segmentation/volumetrics

Current segmentation methods often:

- Require time-consuming human intervention
- Are proprietary
- Require multiple images

We developed a segmentation method that:

- Is fully automated
- Is freely available
- Requires only a single image

Acquisition

- Siemens Trio 3T MR scanner
- 12 channel head coil
- FLAIR T2-weighted 3D TSE with variable flip angle
- 1mm isotropic resolution
- Saggital prescription
- 7 minute scan time
- TI=2.2s, TE/TR=388ms/6s, GRAPPA=2

Segmentation

We combined various programs within FSL in an intuitive way, explained as a flow chart in the center panel.

[FSL: fMRIB Software Library, fMRIB, Oxford, http://fsl.fmrib.ox.ac.uk/fsl]

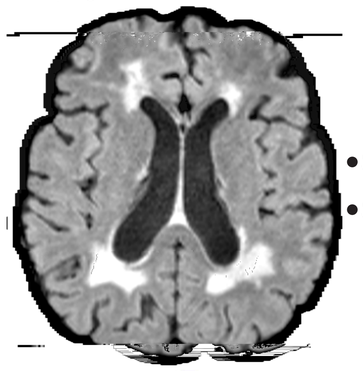
Validation

We scanned and segmented images from 53 MS patients

We validated the ability of our method to predict the degree of clinical disability by calculating Pearson correlations between T2LV and 2 measures of clinical disability

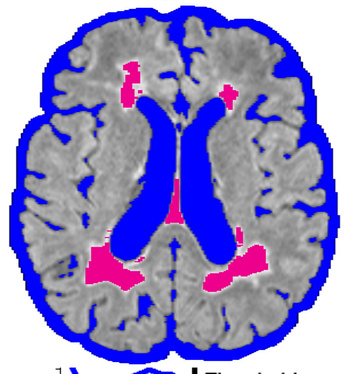
- Expanded Disease Status Scale (EDSS), a composite measure of global disability
- Symbol Digits Modality Test (SDMT), a measure of cognitive processing speed

1

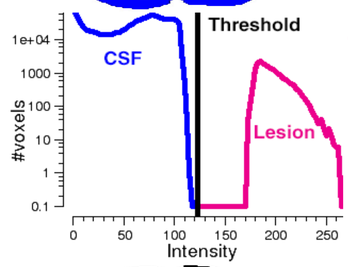


- Strip skull (BET)
- Smooth (FSLMaths)

2



- Segmentation (FAST) into 2 tissue types: brain and CSF
- Due to the gaussian fitting algorithm, hyperintense lesions are classified as CSF
- Bright lesions are trivial to separate from dark CSF via histogram



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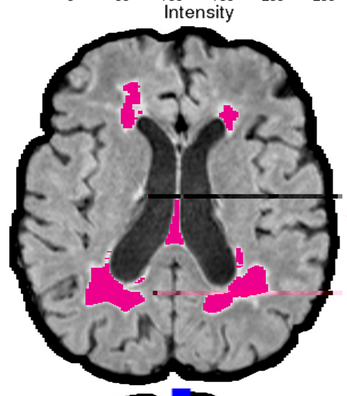

- Hyperintense regions after thresholding

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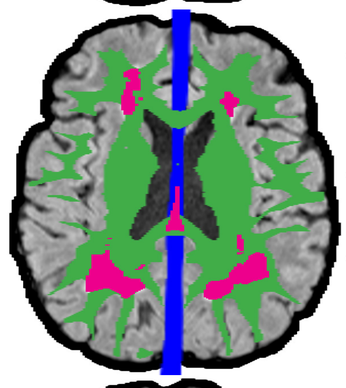
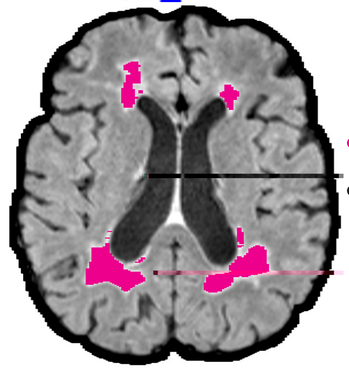


- Nonlinear registration (FNIRT) of standard space (ICBM) masks
- Discard lesions not overlapping WM
- Discard lesions overlapping midsaggital plane

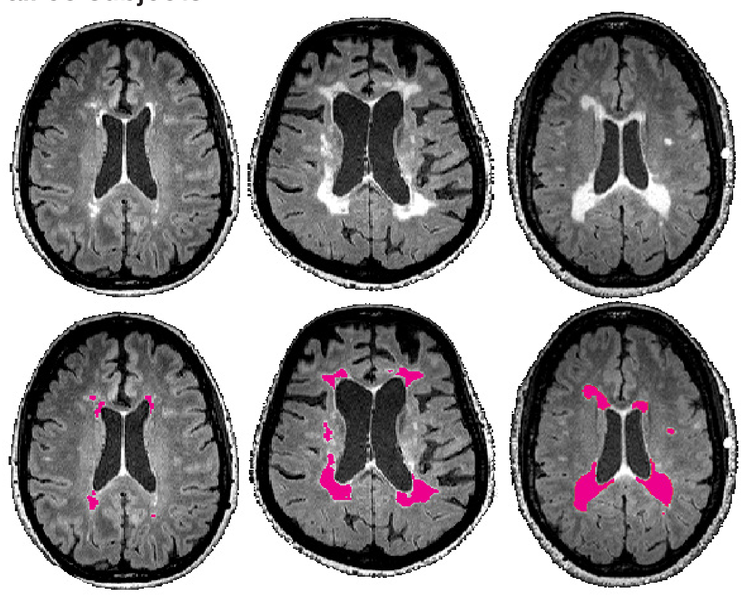
6



- Final lesion map
- T2LV expressed as % brain volume

Results

Our method ran successfully, without human intervention, on all 53 subjects



Representative input images and output lesion maps

Average run time 3.6 hours/subject

- 2.5 hours of this was nonlinear registration

Statistics

- T2LV normally distributed after a log transform
- EDSS and SDMT were normally distributed
- 1 subjet excluded as an outlier, with an SDMT of 102 (mean+3.8 SD)

Descriptive statistics

N=52	Min	Max	Mean	SD
T2LV (% Brain Volume)	0.01	4.01	0.86	1.01
Age (Years)	25	64	51.0[a]	8.4[a]
EDSS (Score)	0.0	7.5	5.5	2.84
SDMT (# Correct)	20	77	46.06	12.16
[a]For EDSS, median and interquartile range are reported instead of mean and SD				

Pearson correlations

- T2LV & EDSS: r=.344, p=.013
- T2LV & SDMT: r=-.499, p=.000

Conclusions

We have produced a lesion mapping that is:

- Intuitive
- Fully automated
- Freely available
- Based on FSL, an already popular and widely-understood toolkit

We validated our method, demonstrating clinical relevance

To the best of our knowledge...

- This is the first fully-automated method to require only a single image.
- This is the first fully-automated method to be validated against clinical markers.

We hope our method will lower costs of lesion mapping and enable better reproducibility across studies of T2 hyperintense lesions in MS and other conditions.