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A fully automatic pipeline for estimation of regional brain volume change using Jacobian integration

Introduction

Regional brain volume change is employed as a marker to assess disease progression and potential treatment effects within a clinical trial setting.

The Boundary Shift Integral (BSI; Freeborough, 1997) is commonly employed gold-standard method for estimating volume change. This method often requires manual or semi-automatic segmentations and is limited to regions with clear anatomical boundaries.

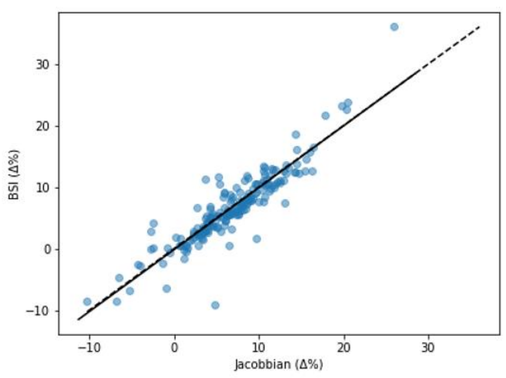
Here we investigate the use of a fully automatic Jacobian Integration (JI) approach for estimating volume change which has the potential to estimate volume change in regions lacking distinct anatomical bounds as required by the BSI pipeline

Results

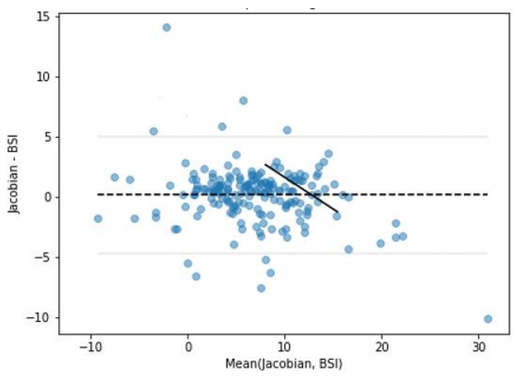
190 subjects with baseline and 1-year follow-up T1-weighted MR images were processed with the proposed JI pipeline and compared to BSI values for the lateral ventricles (VBSI), initialised with manual segmentations, 4 subjects were identified with failed registration.

When compared to VBSI we note significant correlation ($r=0.909$, $p<<0.001$) in reported percentage volume change from baseline for subjects processed with the JI pipeline. A mean difference in percentage volume of -0.12% (SD: 2.4%) was observed.

PERCENTAGE VOLUME CHANGE VENTRICLE JI : VBSI

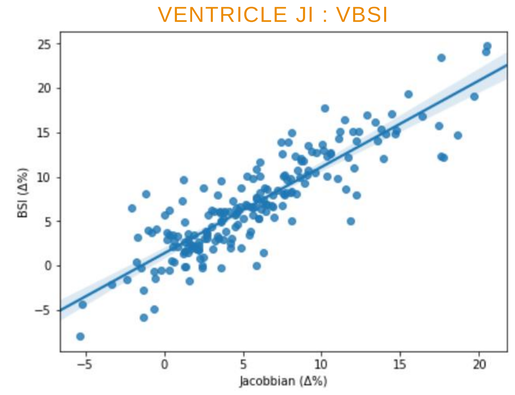


PERCENTAGE VOLUME CHANGE VENTRICLE JI - VBSI

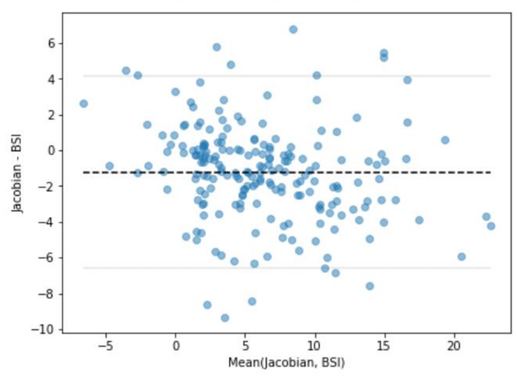


205 subjects with 1 year follow-up from the ADNI cohort were processed with JI pipeline and ventricle volume changes compared to VBSI values provided from ADNI. 4 subjects failed registration. A significant correlation ($r=0.875$ $p<<0.001$) was observed between JI and VBSI, with a mean percentage volume difference of 1.23%,

PERCENTAGE VOLUME CHANGE VENTRICLE JI : VBSI

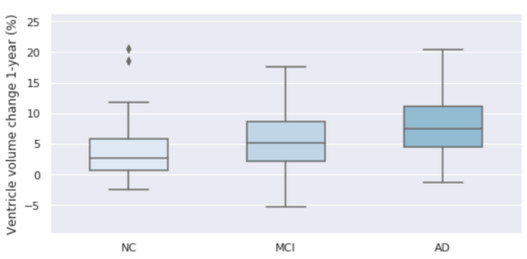


PERCENTAGE VOLUME CHANGE VENTRICLE JI - VBSI

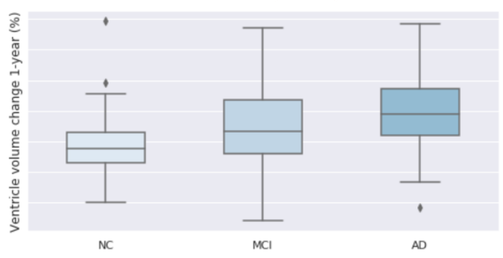


Comparing ventricle volumes between control (NC; N=57), cognitively impaired (MCI; N=100) and Alzheimer's disease (AD;N=44) groups reveals similar means and effect sizes.

PERCENTAGE VOLUME CHANGE JI



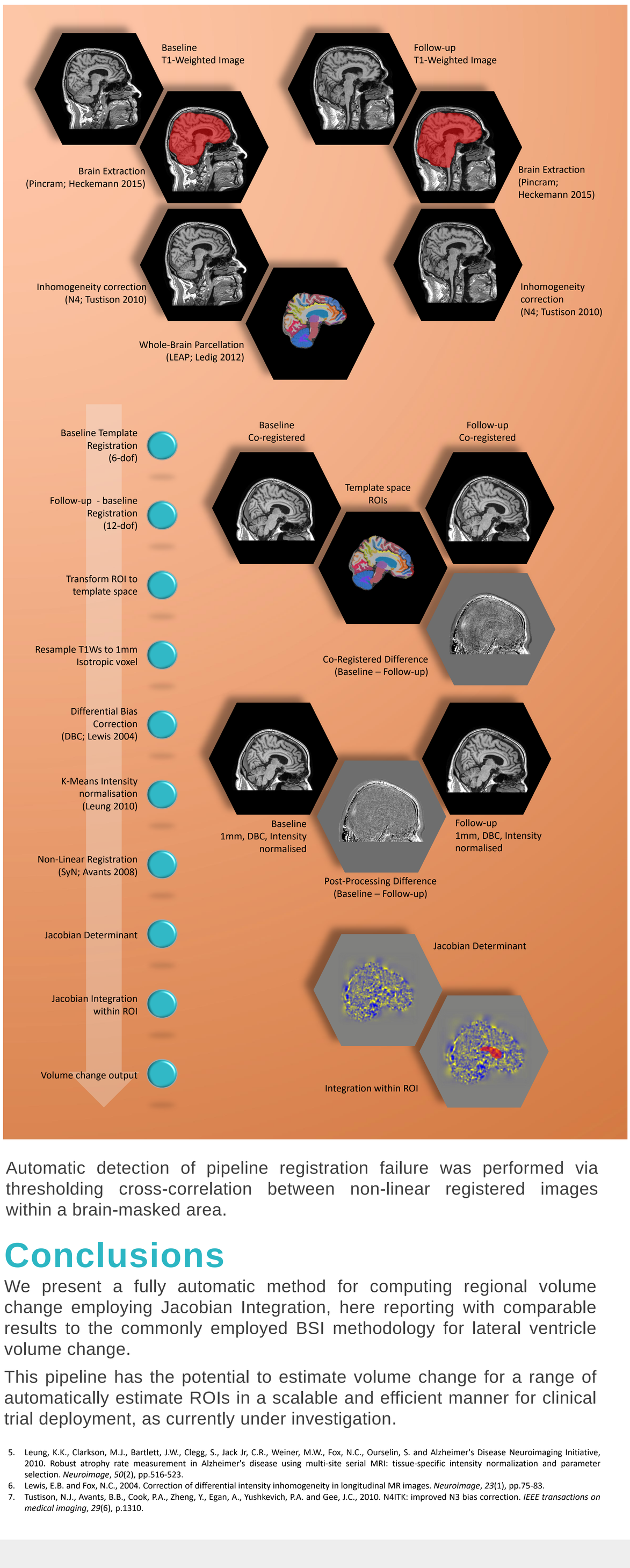
PERCENTAGE VOLUME CHANGE VBSI (ADNI)



		JI		VBSI	
	N	mean	stdev	mean	stdev
NC	57	3.91	4.48	4.48	4.65
MCI	100	5.66	4.97	7.14	5.44
AD	44	7.99	4.94	9.49	5.79

Methodology

We have implemented a fully-automatic pipeline for estimation of longitudinal volume change between T1W images for regions of interest within a whole brain parcellation schema.



Automatic detection of pipeline registration failure was performed via thresholding cross-correlation between non-linear registered images within a brain-masked area.

Conclusions

We present a fully automatic method for computing regional volume change employing Jacobian Integration, here reporting with comparable results to the commonly employed BSI methodology for lateral ventricle volume change.

This pipeline has the potential to estimate volume change for a range of automatically estimate ROIs in a scalable and efficient manner for clinical trial deployment, as currently under investigation.

References

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