A JACOBIAN-BASED METHOD TO ASSESS CHANGES IN CORTICAL THICKNESS
APPLICATION TO ADNI DATA AND COMPARISON WITH LONGITUDINAL FREESURFER

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INTRODUCTION

- Brain cortical thickness measured with MRI shows ability to discriminate between Normal Controls (NC), Mild Cognitive Impairment (MCI) and AD subjects.
- Longitudinal analysis allows assessing disease progression and treatment efficacy in the context of clinical trials.
- Several automated methods have been proposed. The aim of this work is to compare a Jacobian-based method to FreeSurfer Longitudinal, using ADNI-1 data.

METHODS

Data
- Cortical thickness measurements were performed on the 3D T1-weighted sequences of 619 subjects’ MRI scans with 3 follow-ups, Month 6, Month 12 and Month 24 (171 NC, 190 MCI who did not convert to AD within 24 months, 144 MCI who converted and 114 AD) from the ADNI database (http://adni.loni.ucla.edu).

Image Analysis
- The proposed method uses the Jacobian map to compute longitudinal change in cortical thickness [1].
- Each pair of scans is pre-processed as follows (Figure 1 & 2): N3-correction, registration in a mid-way space to avoid bias towards either timepoint and deformation field computation using a symmetric log-demons registration algorithm with a robust cross-correlation metric to compute the Jacobian map [2-3].
- Baseline cortical thickness is assessed by solving Laplace’s equation, building the set of paths between the inner and outer cortical surfaces and deriving the average thickness from them.
- On follow-ups, thickness is obtained by weighting path lengths with the Jacobian map.

Statistical Analysis
- This technique was quantitatively compared to FreeSurfer Longitudinal v4.4 (http://surfer.nmr.mgh.harvard.edu) using Pearson’s correlation.
- Their respective ability to discriminate between ADNI groups was assessed by ROC analysis.
- Their potential to detect treatment effect was assessed by computing effect size.
- Finally, the temporal regularity of each measurement was assessed by computing the average R² from per-patient linear regressions.

RESULTS

- Jacobian-based results were strongly correlated (r=0.73, p<0.001) to FreeSurfer Longitudinal.
- ROC analysis of change in cortical thickness showed improved group separation at each timepoint, improved temporal regularity and effect size compared to FreeSurfer Longitudinal (see Figure 2 and Tables 1 & 2).

CONCLUSION

- A fully automated pipeline for robust calculation of longitudinal changes in cortical thickness was proposed.
- This method provided results consistent with FreeSurfer Longitudinal, outperforming the latter in terms of group separation, temporal regularity and effect size.
- Further testing will have to be completed, including test/retest, to validate its use for clinical trials.