Evaluating the Effect of Alzheimer's Disease Status on Co-Registration Accuracy of PET and MRI Brain Scans[*]

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Abstract—Does the clinical status of patients with either Alzheimer's disease or mild cognitive impairment when compared with the normal healthy status of control subjects have an effect on the co-registration accuracy of the participants PET and MRI brain scans? An initial evaluation reveals that a statistically significant difference may exist in co-registration accuracy with some popular algorithms for the different groups of participants' brain scans. These differences suggest that investigators should use appropriate caution when reviewing fusion studies of co-registered PET and MRI brain scans.

I. INTRODUCTION

A variety of registration algorithms are available in clinical and research software to create fusion displays of PET and MRI brain scans. Accurate image registration remains an important concern for scientists and physicians when analyzing and reviewing brain scans in clinical trials aimed at better understanding and treating dementias such as Alzheimer's Disease (AD). There have been a variety of papers comparing the accuracy of different PET-MRI registration algorithms. For example, a study compared nine PET-MRI registration algorithms using different image similarity metrics [1]. However, there has been no study about the effect of brain degeneration as a result of AD on PET-MRI registration accuracy. We seek to determine whether a significant difference exists for PET-MRI registration accuracy between levels of progression of AD. As alternative to the null hypothesis of no association, we hypothesize that differences may arise as a result of different rates of progression detected by PET and MRI possibly as a linear correlation, or first a linear and then inverse correlation, ie, first worsening then improving co-registration accuracy.

II. METHODS

MRI and PET brain image data was acquired through 66 brain scan pairs from 22 patients in the AIBL dataset. These patients had undergone some form of brain deterioration. Each time point of a patient was classified as healthy normal controls (HNC), mild cognitive impairment (MCI), or AD. Each of the MRI brain scans was registered to the PET scan using four different co-registration algorithms, SPM 12 [2], SPM 8, SPM 5, and elastix (EX) [3]. Joint entropy (JE) and mean squared error (MSE) were the quantitative metrics used to evaluate the co-registration accuracy.

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III. RESULTS

The null hypothesis was no significant difference in registration accuracy because of patient condition. To test this hypothesis, a one-way within-subject analysis of variance test was conducted for each pair of metric and algorithm. For both metrics with the three SPM algorithms, the null hypothesis was rejected at the 5% confidence level, indicating a significant difference in co-registration accuracy as a result of patient condition, ie, categorical group. For both metrics with the EX algorithm, the null hypothesis could not be rejected at the 5% confidence level. The rejection of the null hypothesis for the three SPM algorithms was caused by the differences of co-registration accuracy occurring for all 3 groups AD, MCI and HNC.

IV. DISCUSSION

Because we remain concerned that significant differences may exist across different patient conditions when using some PET-MRI registration algorithms, investigators should take appropriate care when choosing which algorithm to use for registration of PET and MRI brain scans for different patient conditions. Investigators should also use caution when comparing co-registration results between brain scans with different patient conditions because these fusions might be inaccurate. These claims of differences in co-registration accuracy because of patient condition are further confirmed by the fact that independent metrics returned the same result.

V. CONCLUSION AND FUTURE WORK

Significant differences exist in PET-MRI registration accuracy for some co-registration algorithms in association with a patient's neurodegenerative status within the AD spectrum. In order to investigate further our initial results, we plan to expand our study to include more patients. We also plan on using more types of serial sampling statistics to determine more carefully what type of correlation exists between patient condition and co-registration accuracy.

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