Performance Evaluation Comparison of Registration Methods for PET and MRI Brain Scans

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Abstract

In routine clinical imaging, PET and MR images often undergo co-registration, however, methods for co-registration may vary. The significance of differences between methods has not been previously determined. Registration accuracy was calculated both qualitatively and quantitatively using different metrics. Both the quantitative metrics and subsequent visual inspection confirm that there exists a significant difference between different registration methods. Because a difference does exist across co-registration methods, clinicians and researchers must take appropriate care when choosing what method to use for PET-MR co-registration.

Objectives

A variety of registration algorithms are available in both clinical and research software to create fusion displays of PET and MRI brain scans. However, there has not been any recent evaluation and comparison of the performance of these methods. We sought to determine whether a significant difference exists between various PET and MR co-registration methods for brain scans. Another objective was to create a brain scan viewer which displays registered PET and MRI brain scans in order to determine whether a difference does exist across algorithms.

Methods

Initial experiments have been completed on 12 patients from the AIBL dataset with the registration algorithms found in the Elastix, SPM5, SPM8 and SPM12 software packages. SPM 12, SPM 8, and SPM 5 use different variations of normalized mutual information for image registration, whereas Elastix uses mutual information. Joint entropy and mean squared error were calculated as quantitative metrics to evaluate the registration of the PET and MRI brain scans for each patient for each algorithm. Using a custom-designed viewer for brain scan registrations, qualitative visual inspections were performed to cross-check the quantitative metric results. This brain scan registration viewer has been developed specifically for the visualization of fused PET and MRI brain scans using the MATLAB programming language and visualization tools. The viewer can be toggled between viewing one or comparing two brain scans as demonstrated by Figures 1 and 2.

Fig. 1: Co-Registered PET-MRI Brain Scan Viewer

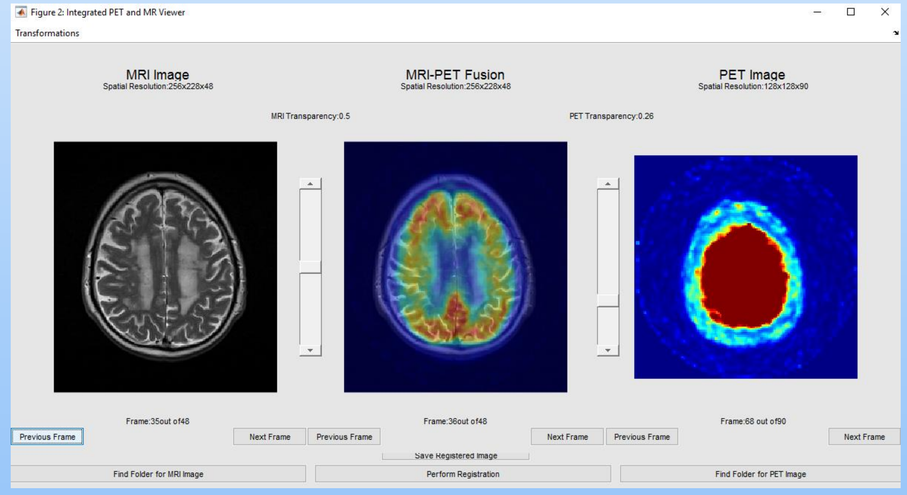


Fig. 2: PET-MRI Brain Scan Viewer in Dual Scan Comparison Mode

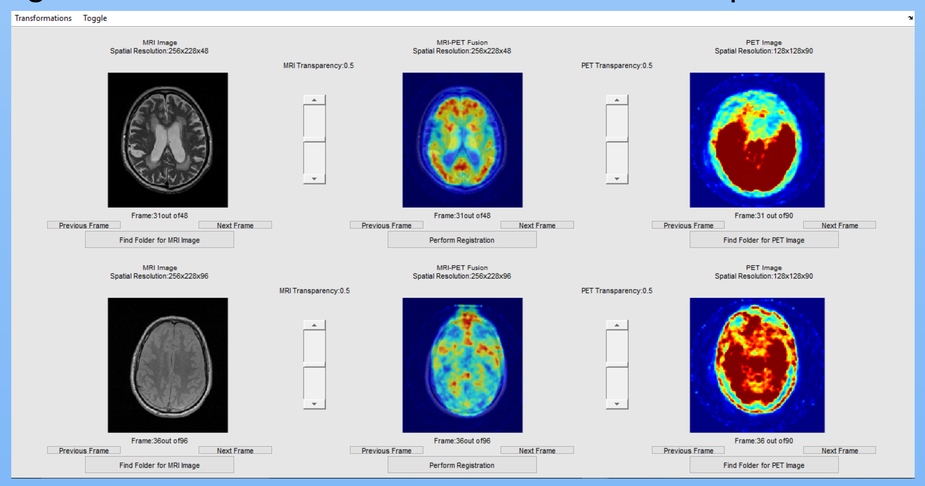
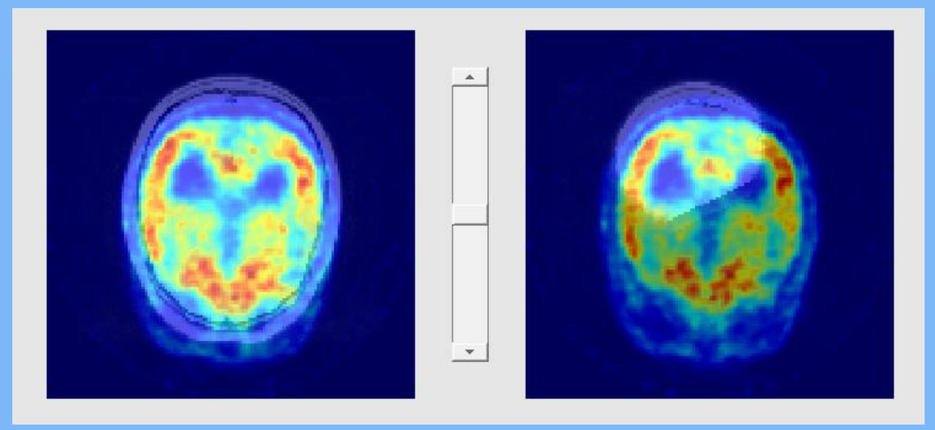


Fig. 3: Registration using different algorithms (Elastix on left, SPM 12 on right)



Results

Both the quantitative metrics and visual inspections confirm that a significant difference may exist between different registration methods. The average difference in mean squared error across all patients was 21% with the highest being 47%. In certain cases revealed by visual examination of all slices of a given patient's registered PET and MRI brain scans, dramatic differences between algorithms may occur with obvious misalignment of features with one algorithm but without any obvious misalignment with another algorithm. Figure 3 shows a huge discrepancy between the registration from Elastix (on the left) and that of SPM 12 (on the right).

Discussion

Because we remain concerned that significant differences may exist across different co-registration methods, investigators should take appropriate care when choosing which implementation of which algorithm to use for co-registration of PET and MRI brain scans. Further, because we have observed instances for which a given algorithm may yield proper alignment for some slices and improper alignment for other slices, caution should be exercised by an investigator prior to assuming that the PET and MRI scans for a given patient have been fused correctly for all slices. We plan to continue our experiments to include evaluation of more registration algorithms on a much larger sample of patient brain scans to obtain more accurate statistics for the quantitative performance evaluation of currently available registration algorithms.

Conclusion

Initial experiments suggest that a significant difference may exist between different PET-MRI registration methods when applied to brain scans using currently available software packages.

References

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