

3D Registration of Background-Suppressed ASL Data based on Brain Contours

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TARGET AUDIENCE – Scientists and clinicians with interest in perfusion MRI, ASL and motion correction.

PURPOSE – Motion correction in Arterial Spin Labelling (ASL) is a crucial step, essential to accurately assess brain perfusion. Commonly it is corrected estimating rigid transformations based on intensity-related information. However, the combination of ASL with background suppression and single shot 2D EPI readout leads to a non-uniform magnetization – due to its recovery during acquisition – which might adversely affect traditional intensity-based approaches¹. Moreover, the control/label pairs are conditioned from the magnetized blood in the tissues (2-3% of the total signal). This difference in intensity can mislead conventional techniques. This study describes a novel motion correction technique only based on brain contour points, which are less sensitive to non-uniform magnetization intensity.

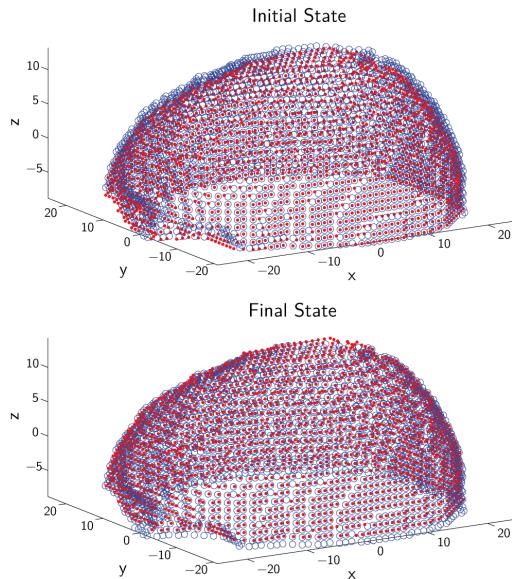


Fig. 1: Example of ICP-driven alignment between moving (red) and reference (blue) cloud points in the case of a translation along the z axis.

RESULTS – Visual comparisons between reference and moving volumes and between reference and corrected volumes showed the higher correspondence between the latter ones (fig. 2). All the computed metrics improved comparing corrected and reference volumes (HD=5.14±4.48mm; MAD=1.59±0.48mm; DC=0.98±0.01) instead of moving and reference ones (HD=6.59±5.62mm; MAD=2.12±1.05mm; DC=0.97±0.04).

DISCUSSION – This study was aimed at determining the feasibility of a 3D registration approach based only on brain boundaries information. This approach might be required when conventional intensity-based technique fail in the presence of non-uniform magnetization due to background suppression application.

CONCLUSION – The proposed technique is based on the extraction of brain contour points by means of image segmentation, and on rigid registration of the obtained cloud points using ICP. The results, albeit preliminary, show that this technique is potentially able to perform 3D motion correction on background-suppressed ASL data without adopting intensity-based registration methods.

REFERENCES

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METHODS – The proposed approach aims at registering to an initial volume (reference) all repetition control acquisitions and tagged acquisitions (moving volumes). The technique consists of a first extraction of brain contour points from both reference and moving volumes followed by an estimation of the roto-translation matrix mapping the acquired data onto the reference. Brain contour points are identified by means of an image segmentation procedure performed on a slice by slice basis. After applying an anisotropic filtering² to the images, a split-and-merge algorithm based on quad-tree decomposition³ is applied, providing brain segmentation. The points extracted from all the slices of the reference and moving volumes compose two different clouds that need to be rigidly aligned. To this end, the roto-translation matrix defining the required rigid 3D transformation between the two clouds is estimated by means of the iterative closest point (ICP) algorithm⁴ (fig. 1). Finally, the computed transformation is applied to the moving volume, thus obtaining a corrected volume, registered to the reference. This approach was tested on 6 volumes (2 initial control acquisition used as reference, 2 subsequent control and 2 tagged acquisitions used as moving volumes) obtained from 2 subjects retrospectively chosen from a cohort of 7 healthy volunteers (age 26±2.3) based on the presence of visually detectable motion. Image acquisition was performed on a 3T scanner (Achieva, PhilipsTM) equipped with a 32-channel coil. A balanced pCASL labelling combined with multi-slice 2D EPI single shot was used with following parameters: TE 16ms, TR 4.7s, labelling duration 1.8s, post-labelling delay 1.8s, two inversion pulses for background suppression (1.89s and 3.22s after the pre-saturation pulse, optimized to suppress the signal of the first slice), 30 axial slices, voxel size 3x3x3.3mm³, SENSE acceleration factor 2.5, 30 label/control pairs for averaging, total acquisition time 4'45". To quantitatively assess the accuracy of the proposed motion correction technique, brain contours were manually traced by an experienced interpreter onto all the axial slices of reference, moving and corrected volumes. Several error metrics (i.e. Hausdorff distance, HD; mean absolute distance, MAD; Dice coefficient, DC) were computed between the three sets of contours and averaged among all the analysed images.

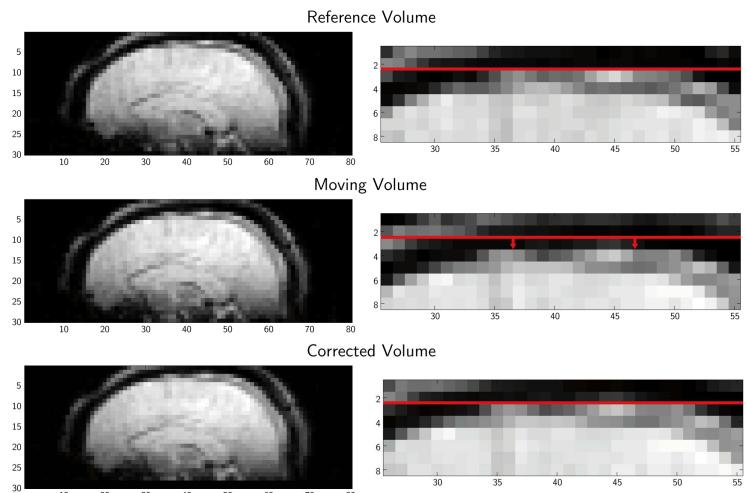


Fig. 2: Comparison between reference, moving and corrected volumes.