ADNI Alzheimer's Disease Neuroimaging Initiative

Brain and Ventricular Boundary Shift Integral

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Summary

We describe the processing methods in the brain and ventricular boundary shift integral (BSI). The brain and ventricles were first semi-automatically delineated from the T_1-weighted MRI scans. The repeat scans were then registered to the baseline scans using 9-degree-of-freedom registration. The intensity inhomogeneity between the baseline and registered repeat scans was corrected using the differential bias correction. Finally, BSI was calculated over the boundaries of the brain and ventricles respectively using the registered and corrected scans.

Methods

We now describe each step in the brain and ventricular BSI in more details.

Brain delineation

The brain regions in the baseline scans were delineated using a semi-automated technique based on intensity thresholding and mathematical morphology (Freeborough *et al.* 1997). The brain regions in the repeat scans were delineated by automated region propagation using the baseline brain regions of the same subject. The baseline scans were registered to the repeat scans using affine registration (to align the images globally) and nonrigid registration based on B-splines (to align the images locally) (Rueckert *et al.* 1999). The baseline brain regions were transformed into the repeat scans using the results of the registrations.

Ventricles delineation

After registering the scans to the MNI 305 atlas, the ventricles of the scans were semi-automatically delineated using intensity thresholding, region growing and mathematical morphology (Freeborough *et al* 1997).

Image registration

The baseline and repeat brain scans were registered over the delineated region (the brain or ventricles) using a 9-degree-of-freedom registration algorithm (Woods *et al.* 1998). The repeat scans were transformed using the results of the registration.

Differential bias correction

Differential bias correction (DBC) was applied to correct the intensity inhomogeneity artifacts between the baseline and transformed repeat images (Lewis and Fox 2004). A kernel radius of 5 was used in DBC.

Calculation of BSI

The union and intersection regions of the baseline and repeat regions (the brain or ventricles) were computed. After dilating the union region once and eroding the intersection region once, the boundary shift region is given by the XOR (exclusive or) of the dilated union region and the eroded intersect region.

1. For classic-BSI, the intensity of registered and DBC-corrected baseline and repeat scans were normalized by dividing by the mean intensity inside the intersect region of the baseline and repeat brain regions. BSI was calculated using a manually-chosen intensity window of [0.45, 0.65] (Freeborough and Fox 1997).

2. For KN-BSI, the intensities of CSF, GM and WM in the registered and DBC-corrected baseline and repeat scans were estimated using *k*-means clustering. Linear regression between the corresponding mean intensities (CSF, GM, WM and interior brain region) of the two scans were performed and the results were used to normalize the intensity of the two scans. The intensity window was automatically chosen to be $[I_{CSF\ mean}+I_{CSF\ sd}, I_{GM\ mean}-I_{GM\ sd}]$, where $I_{CSF\ mean}$, $I_{CSF\ sd}$, $I_{GM\ mean}$ and $I_{GM\ sd}$ are the mean and standard deviation of CSF intensity, and the mean and standard deviation of GM intensity. BSI was then calculated (Leung *et al.* 2010).

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