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Evaluation of MR Image Normalization Methods for Cerebral Small Vessel Disease

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Abstract

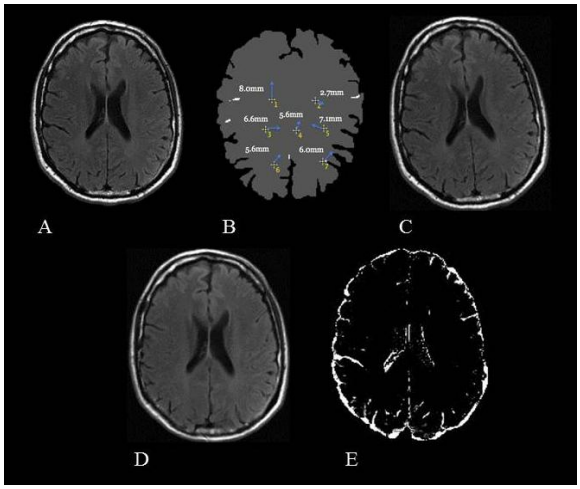

Figure 1. SyN normalization routine of FLAIR image A) Original image B) Movement of control points to warp image C) Warped image D) Normalized image E) Percent difference image between original (A) and normalized (D) image

The quantitative analysis of magnetic resonance (MR) images requires accurate spatial normalization. This technique requires transforming one image so that it has the same shape, size and orientation as a template. Since normalization aims to minimize the signal intensity difference between two images, areas with diffuse signal abnormalities are often incorrectly transformed. It is therefore important to determine whether normalization programs that employ large deformation frameworks are more accurate than those that use small deformation frameworks. This is particularly relevant when looking at images of patients with cerebral small vessel disease (SVD), which is a group of pathological processes that results in subcortical lesions. A deformation field, defined by the user, was applied to twelve sets of patient scans consisting of T1-weighted, proton density (PD), and Fluid attenuated inversion recovery (FLAIR) images. Three widely used normalization programs that employ small (FNIRT, ANTS) and large (SyN) deformation frameworks were utilized to normalize the warped scans to the original images. Relative percent error was then generated for each sequence by finding the percent difference between the normalized and original image. Figure 1 shows the sequence of images produced using the SyN normalization routine for one slice of a FLAIR image. It was found that every MR sequence normalized using SyN (large deformation framework) had a smaller percent difference than images normalized using FNIRT or ANTS (small deformation framework). Using SyN, the relative percent errors were: ϵ_{T1}= 8.1%, ϵ_{PD} = 5.8%, ϵ_{FLAIR} = 30.8%. The images normalized with FNIRT had relative percent errors of: ϵ_{T1} = 8.5%, ϵ_{PD} = 56.8%, ϵ_{FLAIR} = 66.6% and using ANTS, the relative percent errors were: ϵ_{T1}= 15.6%, ϵ_{PD} = 10.3%, ϵ_{FLAIR} = 52.3%. It was concluded that the large deformation framework was the more robust method of normalizing MR images with SVD.