An Automatic Localization of Anterior Commissure and Posterior Commissure in MR Images Using Hierarchical Attribute Vectors

Ke Gan[1], Jianli Wang[2], Sica Christopher[2], and Daisheng Luo[1]

[1]College of Electronics and Information Engineering, Sichuan University, Chengdu, Sichuan, China, People's Republic of, [2]Department of Radiology, College of Medicine, Pennsylvania State University, Hershey, PA, United States

Introduction: The anterior commissure (AC) and posterior commissure (PC) of the human brain are important landmarks in neuroimaging. Precise localization of these landmarks is critical in many brain image post-processing procedures. In many cases, such as when processing large data sets from ADNI [1] and OASIS [2], the gold standard, manual labeling is not efficient. The current available automatic AC/PC detection methods have various problems, e.g. the dependence on the successful localization of the corpus callous [3], the limitation to a specific imaging modality, or high failure rates [4]. Here we present a hierarchical attribute vector guided approach for fully automatic detection of AC/PC in MR images with high computational efficiency and reliability.

Methodology: 1.Preprocessing: A normal T1-w image with the AC/PC manually labeled by an experienced neuroradiologist was used as a template image (Fig. 1a). The dynamic range of image intensity in both template image and target image (Fig. 1b) were automatically adjusted by intensity histogram normalization. **2. Brain tissue segmentation:** An unsupervised clustering based segmentation algorithm was applied to segment both template and target images into four tissue types: CSF, grey matter, white matter and others. **3. Generating edge strength maps:** In order to facilitate the localization of AC/PC in the brain images, an edge attribute was introduced. A sober edge detector was applied to the pre-processed images to generate edge strength maps at various spatial resolutions. **4. Generating likelihood maps based on distance measurement:** The labels for grey and white matters (generated in Step 2) were combined to create a brain mask. The Euclidean distance map was then calculated based on this mask. The distance values for the AC/PC are normally less than 2mm. Based upon this assumption, we converted the distance values to likelihood values, which indicate the likelihood to be a correct AC/PC location. **5. Generating multi-resolution attribute vectors:** The attribute vector was defined for each voxel in a volumetric image at various spatial resolutions. Each attribute vector contained: tissue type information (generated in Step 2), edge strength (generated in Step 3), image intensity, and likelihood value (generated in Step 4). **6. Hierarchical attribute vector matching:** The attribute vectors of the predefined AC/PC voxels in the template image were utilized for hierarchically matching of attribute vectors in the target image at various spatial resolutions. The similarity between the attribute vectors of the template AC/PC and that of the target image was evaluated by fast normalized cross-correlation [5]. The similarity maps generated at various spatial resolutions were combined to create a composite similarity map (Fig. 1c-d). **7. Peak value detection in the composite similarity map:** The peak value in the similarity map was detected and its coordinates were recorded for the labeling of AC/PC in the target image.

Results and Conclusion: To evaluate the performance of the proposed method, we conducted three experiments. In the first experiment, we applied our method to 100 randomly selected T1-w MR images from ADNI database, and compared the results with the manually labeled AC/PC by a neuroradiologist. The Euclidean distance between the manually and automatically determined AC/PC was used as a measurement of localization accuracy. A distance less than 5 mm was identified as a successful matching. The number of successful matching was divided by the total number of tests was used to measure the localization reliability. In the second experiment, we applied our method to 9 sets of T1-w MRI images of AD subjects with the highest clinic dementia rating (CDR) scores from the ADNI database to test its tolerance to brain atrophy. The results of these two experiments showed the new method is accurate (Table 1 and 2) and not sensitive to brain atrophy (Table 2). In the third experiment, 50 sets of T1-w images were processed using our method on a computer with an AMD dual-core 2.7GHz processor and 4GB RAMs. The total processing time was 15 minutes, which demonstrated the computational efficiency of our method. A novel hierarchical attribute vector guided matching method for automatic AC/PC localization in brain MR images is presented. Experimental results presented showed the accuracy and efficiency of the new method compared with manual delineation. In addition, this method can be applied to other image modalities, e.g., T2-w image and CT.

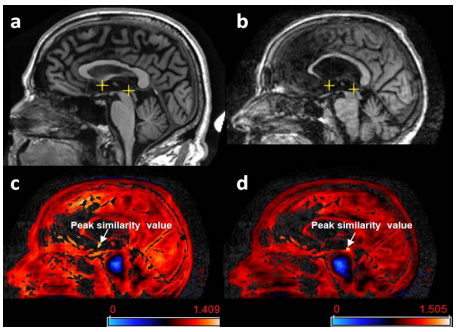

Figure 1. (a) A template image with AC/PC delineated by a neuroradiologist. **(b)** A target image from ADNI database (CDR 3.0) with AC/PC detected by our new method. **(c)** Color-coded composite similarity map of the attribute vector of AC in **a** compared with the attribute vectors of all points in **b**. **(d)** Color-coded composite similarity map of attribute vector of PC in **a** compared with the attribute vectors of all points in **b**.

Table 1. Statistics of accuracy between manual and automatic labeled AC/PC in 100 sets of MR images

Landmark	Average Localization Accuracy	Localization Reliability
AC	1.23mm	100%
PC	1.14mm	100%

Table 2. Statistics of accuracy between manual and automatic labeled AC/PC in 9 MR images of AD with CDR 3.0

Landmark	Average Localization Accuracy	Localization Reliability
AC	1.78mm	89.9%
PC	1.56mm	100%

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