# A Semi-Automatic Brain MR Image Registration Using 2-Level Template Matching

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**Synopsis**

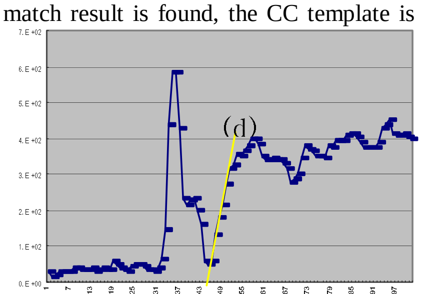
A semi-automatic process of determining 10 necessary points is presented, which is required to register brain MR images based on Talairach atlas. Generally, 10 points are AC, PC, AP, PP, SP, IP, LP, RP and two points for midline. The suggested method reduces user input to 5 points, and finds the necessary points for registration in a more stable manner by finding AC and PC using 2-level shape matching of the corpus callosum in an edge-enhanced image. Remaining points are found using the intensity information of cutview.

**Introduction**

Among several registration methods, feature based methods are favored for its accuracy. One of the few feature-based algorithms used for multi-modal brain images is Talairach-based approach. Talairach and Tournoux introduced a co-planar stereotaxic atlas of the human brain using anatomical information in 1988 and it has been used as a guide for brain registration thereafter [1]. In order to register brain images according to Talairach atlas, anterior commissure (AC) and posterior commissure (PC) must be selected with priority and AP, PP, LP, RP, SP, IP and midline must then be selected to determine the bounding hexahedron of the left and right hemisphere of the cerebrum. Although it is merely a problem of time for well-trained experts, determining AC and PC can be quite troublesome for most of the people without knowledge on brain anatomy. There lies the necessity of computerized registration algorithm.

**Methods**

To acquire midsagittal plane image to be used for template matching, the user has to provide 4 points that constitute two midlines on axial and coronal-view images, respectively, which determine axial and coronal rotation angles. IP is also determined by the user to distinguish cerebrum from cerebellum. The algorithm then automatically determines AC, PC, AP, PP, LP, RP and SP in the following way. First, the midsagittal plane is determined as a result of rotation. It is edge enhanced so that the correlation-based template matching process of corpus callosum (CC) is less dependent upon image intensity. Sobel convolution masks are used here because they show good edge detection performance with relatively low noise sensitivity using simple templates [2]. Before calculating correlation coefficients, the boundaries of the brain is roughly detected in order to resize the given CC template (figure 1 (a)) for best matching result of the template to the target image. Correlation coefficients between the midsagittal plane and the CC template are calculated [3] to determine the position of CC. Once rough match result is found, the CC template is rotated between ±10° and further matched for a more accurate result. Finding CC position can roughly point out AC and PC using the information contained in the CC template. However, they are more or less not accurate because every brain is different in size and shape when observed in detail. For that reason, the area near CC undergoes two more matching processes, each with AC template (including fornix) and PC template (including corpus pineale) as shown in Fig. 1 (b) and (c), respectively. After accurately locating AC and PC, SP is determined by analyzing the intensity along the vertical cut view of sagittal slices. In order to do that, the starting points of the cerebrum is calculated from the intensity of the cut view from front to back of the brain. After that, the highest point among the starting points is determined and set as the SP. For noise insensitivity, the intensities of pixels at the same position from 5 neighbor sagittal planes are averaged as shown on the right before finding the starting points of each vertical line. The starting point of each line is defined as the intercept of the line marked (d). AP, PP, LP and RP are located with the same procedure.



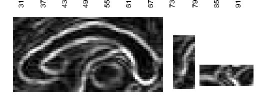



**Fig. 1 (a) (b) (c)**

**Results**

Fig. 2 shows roughly matched CC and Fig. 3 shows accurately matched AC and PC. Fig. 4 shows sagittal, axial, and coronal views of registered brain MR images that is acquired with T1-weight using automatically selected AP, PP, SP, LP and RP.

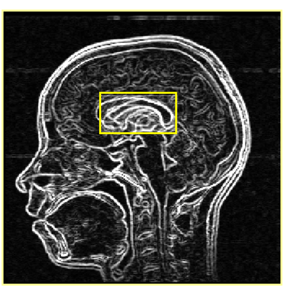


**Fig. 2**

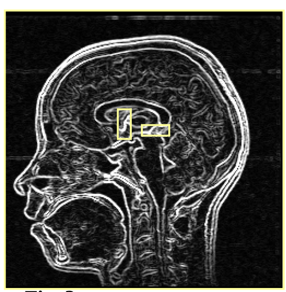


**Fig. 3**

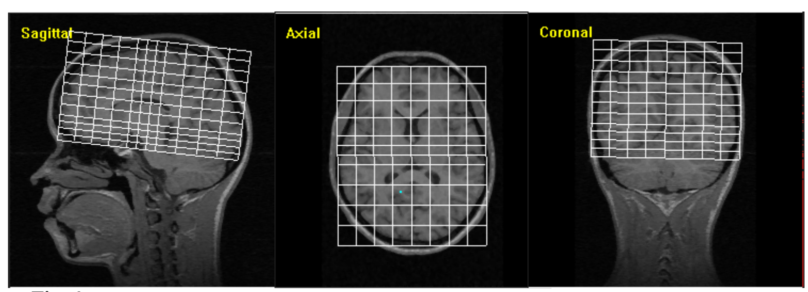



**Fig. 4**

**Conclusions**

The result shows that the Talairach based registration of brain MR images can be performed with less user inputs in number and complexity than general registration process.

**Acknowledgement**

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**Reference**

[1]Talairach J, Tournoux P., Co-Planar Stereotaxic Atlas of the Human Brain. New York, Thieme Medical Publishers, 1988

[2]Pitas I., Digital Image Processing Algorithms and Applications. New York, Wiley-Interscience, 2000

[3]Gonzalez R. C. et al, Digital Image Processing. Massachusetts, Addison-Wesley Publishing Company, 1992