Automatic detection of the Anterior and Posterior Commissures from T1-weighted images

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Introduction

Frame-based interventional MRI often relies on the manual selection of the anterior commissure and of the posterior commissure (AC-PC) line that are often considered as landmarks for the localization of neuroanatomic targets [1], as, for instance, for guiding the implantation of electrodes within the subthalamic nuclei dedicated to deep stimulation in the treatment of Parkinson's disease [2]. In this abstract, we present a fast and fully automatic identification of the AC and PC points from T1–weighted images, thus leading to an automation of the image processing step during the neurosurgery planning. The method is based on the analysis of the mid-sagittal plane (MSP) using parameterless prior knowledge.

Material and Methods

The automatic identification of both commissures is performed and tested on a set of 128 T1-weighted images.

Acquisitions – MPRAGE T1-weighted acquisitions were performed on a Siemens Tim Trio 3T (Siemens Medical Healthcare, Erlangen) equipped with a whole body gradient (40mT/m, 200T/m/s) and a 12-channel head coil, using the following parameters: T_E=2.98ms, T_R=2.3s, T_I=0.9s, FOV=160x240mm^2, matrix 160x240, slice thickness=1mm, leading to millimeter isotropic voxel.

Method – the algorithm is threefold: it first extracts the MSP in which the AC/PC central points are located, based on a symmetry considerations; then, it summons up an *a contrario*-model of the grey level intensity of AC/PC structures, that is specific in T1-weighted data, in order to identify the most meaningful candidates; finally, from prior knowledge about the AC/PC localization, two regions of interest are defined in the MSP in which the two final AC and PC solutions are chosen.

a) *MSP* – the MSP is a prerequisite for the AC and PC detection. Its localization is related to the approximate bilateral symmetry that the human brain exhibits. First initialized as a pure sagittal plane, the MSP will then be rotated and translated using only three degrees of freedom (two rotations around the antero-posterior axis and the superior-inferior axis, plus one translation along the left-right axis) which are enough to robustly extract the MSP. In order to obtain the two rotations and the translation of the MSP, a criterion is built to measure the brain symmetry from both of its sides. The optimum MSP parameters correspond to the set of parameters that optimize the previous criterion. Optimization was performed using a Nelder-Mead simplex using initial parameters set to (0,0,0), and with a maximum of 160 iterations (Fig. 1.a),

b) *Candidate voxels* – AC and PC are small fiber bundles crossing the mid-sagittal plane of the brain that are connected to both brain hemispheres (Fig.1.b). As shown in Fig. 1.b, both commissures depict a high level of intensity gradient in any direction contained in the MSP, whereas this gradient remains low along the direction perpendicular to the MSP. This property of the spatial derivatives of the intensity is used to constrain an *a-contrario* model [3]. Only points sharing this property can be selected as candidates,

c) *Regions of interest (ROI)* – anatomical knowledge are then used to refine the selection into small regions of interest in the MSP. AC is located in the lowest part of the fornix, in front of the brainstem, leading to the blue ROI in Fig. 1.c; and PC is located below the splenium of the corpus callosum, and above the back part of the brainstem, leading to the green ROI in Fig. 1.c. AC and PC are selected from these two regions using two criterions: they have a high contrast in the *a-contrario* images, and their 26-neighborhood contains the maximum number of voxels with maximum intensity derivatives.

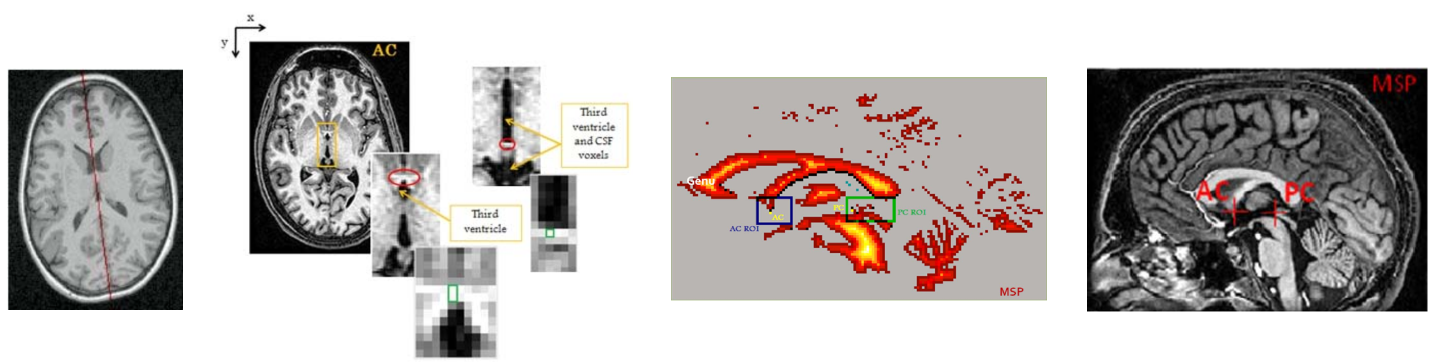
Results and Discussion

The manual identification of both commissures was performed by an expert on a set of 128 T1-weighted images. The automatic AC and PC detection was also applied on this dataset. Fig. 1.d shows the result of the identification on the MSP for one of the subjects. To evaluate the accuracy of this method, we computed the Euclidean distance between the automatically identified commissures, and the manually identified commissures. Tab. 1 shows that the mean error is in the same range as the voxel resolution. The standard deviations show that in the worse case, the error corresponds to the accumulation of two errors in opposite directions (one for the manual depiction, and the other for the automatic identification), which is a very good result since that, in some cases, the manual selection of PC is not straightforward.

The entire AC and PC selection, including the MSP localization, is performed in less than 40 seconds.

Table 1: *mean and standard deviation of the distance between manual and automatic selection*.

	Δ_{AC}	Δ_{PC}
mean (mm)	1.83	1.03
σ (mm)	1.21	3.13



(a) **(b)** **(c)** **(d)**

Figure 1: *(a) the extracted mid-sagittal plane;(b) AC, PC, and the surrounding cerebrospinal fluid can yield a high contrast; (c) the two regions of interest defined from anatomical a priori, and containing AC and PC superimposed to a thresholded image only containing white matter; (d) automatically identified AC and PC points*.

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References

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