Automated Scan Plane Planning for Brain MRI using 2D Scout Images

S. Yokosawa[1], Y. Taniguchi[1], Y. Bito[1], H. Nagao[2], M. Tachibana[2], M. Ishida[2], A. Shiromaru[2], and H. Itagaki[2]
[1]Central Research Laboratory, Hitachi, Ltd., Kokubunji-shi, Tokyo, Japan, [2]Hitachi Medical Corporation, Kashiwa-shi, Chiba, Japan

Introduction

Automated scan plane planning is expected to provide consistent scan plane prescriptions and to improve MRI scanner usability. Consistent scan planes are useful for follow-up examinations. The typical workflow of a scan plane setup requires careful manual positioning, and it suffers from inter-operator variability. Furthermore, having to perform a scan plane setup for each examination is stressful for the operator. In the past, some automated systems for brain MRI have been demonstrated [1]. These systems use 3D image data in order to prescribe a scan plane while a typical manual setup uses 2D multi-slice images. Generally, the acquisition time of 3D scans is longer than that of 2D scans. Therefore, the total time for scan plane prescription was longer than that for a manual setup.

In the present work, we propose a faster automated scan plane planning method for the brain using 2D multi-slice orthogonal three-plane scout images. We applied our proposed method to healthy volunteers and compared automatically defined scan plane positions with those manually defined. The results showed that our method prescribed scan planes quickly and with acceptable accuracy in clinical practice.

Method

In our method, an algorithm is used to prescribe scan planes using 2D multi-slice orthogonal three-plane scout images, which can be acquired rapidly. Furthermore, our algorithm can prescribe scan plane faster than other methods that use 3D data due to the smaller 2D data size. Our algorithm consists of three steps. In the first step, the spatial location of the mid-sagittal plane was calculated using axial and coronal images. In this procedure, the algorithm used the morphological feature in which the mid-sagittal plane divides the left and right brain symmetrically, and it also used the signal intensity on the mid-sagittal plane, which is lower than that on the surrounding tissue such as the brain parenchyma. In the second step, the algorithm identifies patient orientation using the obtained spatial location of the mid-sagittal plane, and then determines the next step. If the calculated spatial location of the mid-sagittal plane is within the range of the sagittal scout image plane, the algorithm interpolates the signal intensity from the sagittal images and makes the mid-sagittal plane. If this is not the case, the processing terminates. In the third step, the anatomical structures on the obtained mid-sagittal plane are identified using an active shape model [2]. A required scan plane is previously defined on a template image of the standard mid-sagittal plane and the mutual anatomical information is saved. The algorithm prescribes a scan plane based on the correlation between the identified anatomical structures on the obtained mid-sagittal plane and the predefined anatomical information of the required scan plane.

Scout images were acquired using an RSSG (RF spoiled steady-state acquisition with rewound gradient echo) sequence on a 1.5 T system (ECHELON Vega®, Hitachi Medical Corporation, Japan) with a QD head coil. Scan parameters were as follows: TR/TE = 30/1.5 ms, FOV = 270 mm, Matrix size = 128 × 128, thickness/interval = 10/10 mm, flip angle = 40°, five slices each in sagittal, coronal, and axial orientations. The acquisition time was about 15 seconds. After obtaining written informed consent, 17 healthy volunteers were scanned. Each volunteer was scanned more than once, including cases where their position was rotated intentionally, and 97 sets of scout images were finally obtained. The processing of scan plane prescription was performed on an off-line platform. The entire process took approximately 2 seconds on our platform (running Windows on Intel(R) Core(TM) 2 Duo, 3.0 GHz).

The performance of the algorithm was compared to positions from manual planning using the example of three scan planes (A was parallel to a line connecting the nasal root with the lower pons and perpendicular to the mid-sagittal plane; B was parallel to a line connecting the lower pituitary with the cerebellar pit and perpendicular to the mid-sagittal plane; C was parallel to the brainstem and perpendicular to the mid-sagittal plane). Two estimators who were qualified radiological technicians, divided 97 sets of scout images into sets of images that they could manually prescribe scan planes for, and then manually defined three scan planes on each selected scout image. The accuracy of the automatically prescribed scan planes was measured by the angular difference in degrees between the manually defined scan planes and the automatically defined ones.

Results and Discussion

Table 1 gives the distribution of the 97 sets of scout images in terms of whether a scan plane could be prescribed by the estimators and by the algorithm. One estimator was able to prescribe scan planes on 73 out of 97 scout images, and the other estimator was able to prescribe scan planes on 84 scout images. On the other hand, the algorithm was able to prescribe scan planes on 85 scout images. Although judgment varied between the individuals, the algorithm was always able to set scan planes using the scout images that the estimators selected. Figure 1 shows sample scout images and three automatically prescribed scan planes. The far right column represents calculated images of the mid-sagittal plane. As shown in the figure, the algorithm did not rely on minor variations in patient orientation. Table 2 shows the results of accuracy by the estimators. For all scan planes, the angular difference between automatically and manually prescribed scan planes was within 5°.

The 2D scout images are limited to the range of the scan location. Therefore, the algorithm does not deal with scout images on all patient orientations, but decides whether the scan plane prescription will be carried out depending on the patient orientation calculated from the scout images. Even when the scan planes prescription is not carried out due to the patient orientation, measuring the second scout scan changing the scout orientation still has an advantage on speed.

Conclusion

We have proposed a method for automatic scan plane planning for the brain using 2D multi-slice orthogonal three-plane scout images. An algorithm prescribes a scan plane quickly and with acceptable accuracy in clinical practice.

References

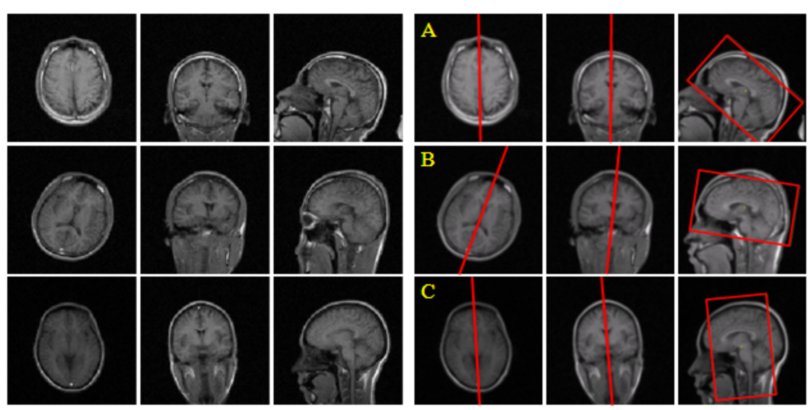
[1] Itti L., et al., Magn Reson Med., **45**, pp 486-494, 2001. [2] Cootes TF, et al., CVIU , **61**(1), pp 38-59, 1995.

Table 1. Results indicating whether or not to prescribe scan plane using scout image.

		Algorithm	
		Possible	Impossible
Estimator 1	Possible	73	0
	Impossible	12	12
Estimator 2	Possible	84	0
	Impossible	1	12

Table 2. Results of angular difference |θ| between automatically and manually prescribed scan planes.

Scan plane	Estimator 1			Estimator 2		
	$\lvert\theta\rvert \le 2^\circ$	$2^\circ < \lvert\theta\rvert \le 5^\circ$	$5^\circ < \lvert\theta\rvert$	$\lvert\theta\rvert \le 2^\circ$	$2^\circ < \lvert\theta\rvert \le 5^\circ$	$5^\circ < \lvert\theta\rvert$
A	71/73	2/73	0/73	78/84	6/84	0/84
B	70/73	3/73	0/73	78/84	6/84	0/84
C	4/73	69/73	0/73	75/84	9/84	0/84



(i) Scout images (ii) Automatically defined scan plane

Figure 1. Three automatically prescribed scan planes.