

Accuracy and Repeatability of Automatic Slice Positioning compared with Manual Slice Positioning

T. Benner¹, J. J. Wisco¹, A. van der Kouwe¹, B. Fischl¹, A. G. Sorensen¹

¹Athinoula A. Martinos Center, Charlestown, MA, United States

Introduction

Methods for automatic scan prescription have been presented previously [1-4]. In this study, we used the method described in [4]. Based on a statistical atlas of the brain, this method calculates the rigid transformation matrix between the head position according to a quick 3-D localizer and the target position. Subsequent scans are then aligned using the found transformation matrix.

Methods

The patient population for this study was drawn from patients who were scheduled for a clinical scan of the head at a 1.5 T MRI system (Siemens Medical Solutions, Erlangen, Germany). Five subjects were included to date. After inclusion in the study, each patient was scheduled for a second session at least 2 weeks after the initial visit. In each imaging session, the following scan block was performed twice: a) 3-plane scout, b) auto-alignment scout, c) T2 FSE with manual slice prescription, and d) T2 FSE with auto-alignment. The patient was asked to get up between the first and second scan block. In addition, the head pillow was repositioned to ensure that the patient's head did not fall back in the previous position. In the first scan session, additional clinical scans were performed as scheduled after the two scan blocks. In the second scan session, two of the described scan blocks were performed only. The scan parameters for the T2 FSE scan were the ones used in a regular clinical protocol: TR 4230 ms, TE 95 ms, FoV 230 mm, 23 slices, 5 mm slice thickness, 1 mm gap, matrix size 256x192 interpolated to 512x384, scan time 2:38 min:s.

Co-registration of follow-up with initial T2 FSE scans was performed for inter-session and intra-session scans for manually prescribed and auto-aligned scans, respectively. FLIRT v5.0 (FMRIB's Linear Image Registration Tool [5]) was used for co-registration. Translations and rotations (Euler angles) were determined from the co-registration matrix. Root mean square errors (RMSE) were calculated between the initial and follow-up scans before and after co-registration. The volume of RMSE calculation was limited to a sphere with a radius of 80 mm centered in the middle of the scan volume to eliminate co-registration artifacts at the edges of the volume.

Results and Conclusion

Figure 1 (a-d, h-k) shows slices matched for the location of the tumor of all 4 T2 scans for the same subject for manual slice prescription (top panel) and auto-alignment (bottom panel), respectively. One can see that the variation of the slice orientation is larger for the manual prescription as compared to auto-alignment. After co-registration of the follow-up scans to the initial scan (e-g, l-n) the images for all scan sessions look comparable. Table 1 shows the minimum and maximum translations and rotations needed to align the follow-up scans with the initial scan for all subjects. The variance of all translations and rotations is significantly higher for the manually prescribed scans compared to the auto-aligned scans ($p < 0.05$). RMSE was significantly higher before than after co-registration for manual slice prescription ($p < 0.05$). No significant difference was found for the auto-aligned data. The auto-alignment procedure did not fail for any of the scanned subjects.

While images can be co-registered after the acquisition this is usually not possible in clinical routine and results in blurred images as well as lost coverage. The studied auto-align method was found to be robust and provides repeatable and accurate image positioning.

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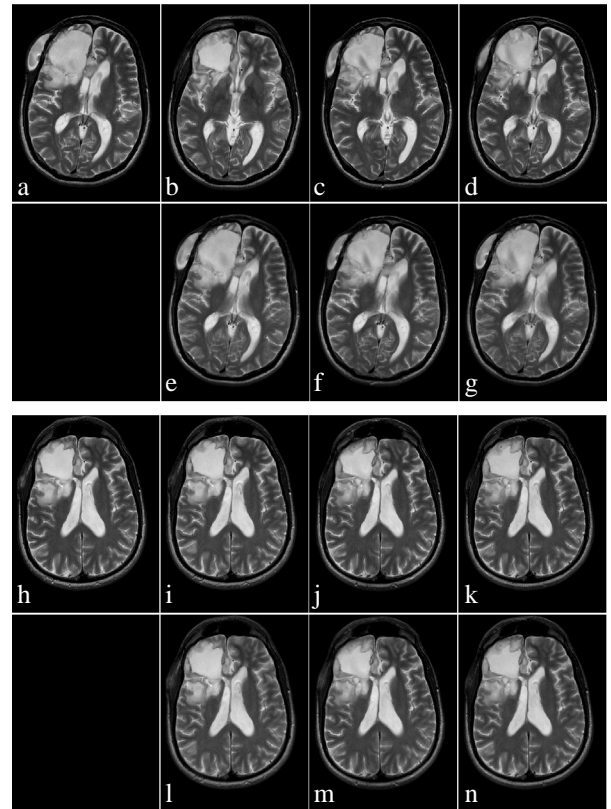


Figure 1: Original images of subject no. 2 for manual (a-d) and auto-align (h-k) slice prescription for all 4 T2 scans. Scan 1 (a, h) and 2 (b, i) of 1st session, scan 1 (c, j) and 2 (d, k) of 2nd session. Images after co-registration of follow-up scans (b-d, i-k) to the initial scans (a, h) are shown in e-g and l-n for manual slice prescription and auto-alignment, respectively. Slices shown are most closely matched for the location of the tumor. Note the different slice tilt for manual and auto-align prescription. This is caused by the manual alignment according to the AC-PC line compared to a fixed reference orientation for auto-alignment.

Table 1: Minimum and maximum translations and rotations resulting from co-registration using FLIRT for slice prescription done manually and using auto-align, respectively.

		Translation [mm]			Rotation [degree]		
		X	Y	Z	X	Y	Z
Manual	min.	-13.1	-14.3	-20.0	-7.3	-4.2	-6.5
	max.	14.8	26.8	22.3	7.8	3.7	9.6
Auto-align	min.	-2.7	-2.6	-3.4	-1.5	-0.6	-2.1
	max.	3.2	2.4	4.2	1.4	2.0	1.7