# Reproducible Slice Positioning of Human Head MR Images by Prospective Registration using Localizer Images

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Problem: The assessment of brain tumor growth and progression of stroke lesions is facilitated by reproducible slice positioning of human head MR images [1]. Any necessary adjustment of the position can be made without moving the patient because MRI scanners offer the possibility of shifting and rotating image planes by manipulating the magnetic field gradients.

Materials and Methods: Prospective registration prior to diagnostic scans was used to calculate the updated gradient reference frame for reproducible slice positioning in follow-up examinations. The proposed method used the standard localizer images and required no additional measurement for the realignment: The three perpendicular localizer images from the pre- and post examinations were cross-correlated pairwise, yielding rotation and shifts of the head and thus the gradient transformation matrix [2]. Before and after prospective registration diagnostic images were recorded. For faster performance the registration was calculated on an external PC (P4, 1.6 GHz). The method was developed using a gel phantom mounted in an adjustable carrier that was reoriented in all six degrees of freedom. 10 examinations of healthy volunteers were performed.

Results: A representative registration result using localizer images is shown in Fig. 1. The realignment of the follow-up scans was evaluated with retrospective 3-D rigid-body registration using the standard registration software AIR 5.2.2 [3]. The remaining misalignment after prospective registration in 12 phantom experiments was $\Delta s = 0.1$ mm $\pm 1.2$ mm and $\Delta\varphi = -0.2° \pm 0.9°$. The volunteer examinations resulted in an accuracy of $\Delta s = 0.1$ mm $\pm 1.5$ mm and $\Delta\varphi = 0.2 \pm 1.5°$ (mean $\pm$ standard deviation). The diagnostic images of one volunteer experiment are shown in Fig. 2. The calculation time was approximately 50 seconds and the overall time for prospective registration was five minutes.

Conclusion: Prospective registration using localizer images was successfully tested on phantoms and healthy volunteers. Realigned and referenced images matched well and with good accuracy. Compared to a full rigid-body 3-D registration, the procedure was very time-efficient since the registration could be accomplished using only three 2-D images. No additional data had to be acquired prior to the examination. Since patient motion cannot be excluded during registration and examination an additional real-time motion correction would ensure identical slice positions.

References:
[1] Bernarding J et al., Magn. Reson. Med. 2000;43:52-61.
[2] Ward HA et al., Magn. Reson. Med. 2000;43:459-469.
[3] Woods RP et al., J. Comput. Assist. Tomography, 1992;16:620-633.
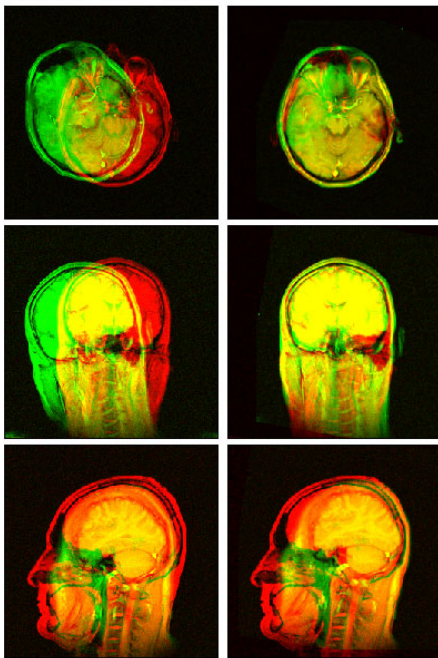


Fig. 1: Localizer images before (left column) and after (right column) registration. From top to bottom: transversal, coronal, and sagittal slices. The initial localizers are red and the follow-up localizers are green. Yellow pixels are red and green.
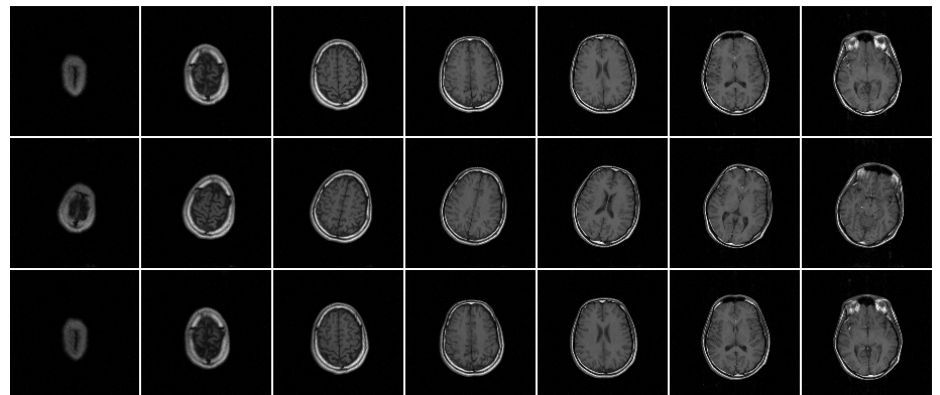


Fig.2: MR images of one volunteer before (top row) and after (mid row) motion of the head. The mismatch between the two positions of the head can easily be seen by visual inspection. The images with corrected slice positioning after prospective registration are shown in the bottom row. The mismatch apparent in the localizer images is corrected and the images appear identical.