Original Research

Prospective Registration of Human Head Magnetic Resonance Images for Reproducible Slice Positioning Using Localizer Images

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Purpose: : To facilitate assessing brain tumor growth and progression of stroke lesions by reproducible slice positioning in human head magnetic resonance (MR) images, a method for prospective registration is proposed that adjusts the image slice position without moving the patient and with no additional scans.

Materials and Methods: The gradient reference frame of follow-up examinations was adjusted to achieve the same image slice positioning relative to the patient as in the previous examination. The three-dimensional geometrical transformation parameters for the gradients were determined using two-dimensional image registration of three orthogonal localizer images. The method was developed and evaluated using a phantom with arbitrarily adjustable position. Feasibility for in vivo applications was demonstrated with brain MR imaging (MRI) of healthy volunteers.

Results: Standard retrospective registration was used for assessing the quality of the method. The accuracy of the realignment was 0.0 mm ± 1.2 mm and −0.2° ± 0.9° (mean ± SD) in phantom experiments. In 10 examinations of volunteers, misalignments up to 49.2 mm and 21° were corrected. The accuracy of the realignment after prospective registration was 0.1 mm ± 1.5 mm and 0.2° ± 1.5°.

Conclusion: Image-based prospective registration using localizer images of the pre- and postexaminations is a robust method for reproducible **slice positioning.**

Key Words: prospective registration; slice positioning; MR imaging; neuroimaging; cross-correlation
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FOLLOW-UP EXAMINATIONS of cerebral diseases such as stroke or brain tumors require a precise comparison of changes in unaffected and pathologic tissues (1). Usually, the slices are positioned manually with the use of anatomical landmarks like the intercommissural line. Therefore, additional data have to be acquired in follow-up measurements and visually compared to initial examinations by the physician. Depending on the deviations and the patient's condition, the slices may then be repositioned and images are compared iteratively until sufficient congruence is found. Since this procedure depends on visual estimates and may be very time consuming, an automated algorithm would be of great advantage to both diagnostics and patient handling. To improve diagnostics, especially of small lesions such as Multiple Sclerosis (MS) foci, retrospective registration (2,3) can be used, as it is common in functional magnetic resonance imaging (fMRI) (4). However, these techniques are often compromised by interpolation artifacts (5), in particular at boundaries between different tissue structures.

In MRI, prospective registration can be used to correct for misalignments prior to subsequent measurements without the need for patient repositioning. The corresponding transformation matrix is then used to correct the slice position by adaptation of the gradients. Different approaches for prospective registration have been reported, mainly triggered by the need for real-time motion correction in fMRI. Navigator echoes were developed for imaging moving structures (6,7) and for fMRI (8). The technique was advanced to orbital navigator echoes (9–11) and spherical navigator echoes (12). Image-based methods for prospective motion correction in fMRI were proposed that use typical three-dimensional data sets from fMRI time series (13,14). Recently, a method was introduced that matches localizer images on a three-dimensional statistical atlas of the brain (15).

Interexamination prospective registration for monitoring cerebral diseases requires the development of a method that corrects for larger deviations and potentially altered tissue that might occur after tumor therapy. For clinical applications, the method should be based on fast and robust registration algorithms that use data acquired in the standard clinical settings and that do not rely on information about the underlying pathophysiologic processes. Therefore, we chose a prospective registration method that employed the stan-

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