The effect of the Water-Fat Shift differences on automatic co-registration of MR images.

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Introduction

Multispectral image analysis is often used for automatic image segmentation of MR-images. Due to different scan parameters and inter-scan motion, the images of different sequences need to be co-registered prior to further processing. Since manual registration can be very time consuming and is not very reproducible, automatic registration methods are favored. Most approaches used for multi-spectral image registration employ mutual information as a cost function evaluated on pixels of the images. Obviously, the content of the images can have a dramatic impact on the registration's results.

MR-images contain water and fat signals that are displaced relatively to each other due to their different precession frequencies. The displacement occurs in the frequency encoding direction (the anterior-posterior direction in our images), and depends on the strength of the read-out gradient (Fig. 1). In clinical scans, and even in most research scans, the sequences are optimized for contrast, signal-to-noise ratio (SNR), distortion and scan time, and since this usually requires different read-out gradient strengths, this results in different WFS values.

The goal of this work was to investigate the effect of differences in Water-Fat Shift (WFS) on the outcome of automatic co-registration when the whole image is considered.

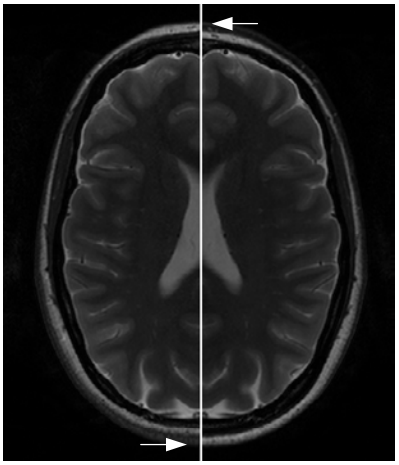

Fig 1. Two T2 weighted images with registered parenchyma, showing the displaced fat of the skin.
Left: WFS = −3 Right: WFS = +3

Material and Methods

The MR images were acquired on a 3 Tesla clinical MR scanner (Philips Medical Systems, Best, The Netherlands). In two healthy volunteers T2 and FLAIR images were scanned with varying WFS parameters (−3, −2, −1, +1, +2, +3 (acquisition) pixels) with a total scanning time of about one hour (FOV 320, reconstruction matrix 512x512 (0.43x0.43 mm), flip angle 90 degrees; T2: 48 slices of 3 mm, TE=90 ms, TR=5000 ms; FLAIR: 25 slices of 5.5 mm, TE=125 ms, TR=11000 ms). For one volunteer the T2 with WFS = +1 was excluded because of technical failure.

Having six FLAIR and six T2 images with different WFS values, 36 combinations of FLAIR to T2 registration are possible. Each of these registrations was done in two steps. **1.** Using an in-house built image registration tool, the images were first registered manually (rigid body) so that the parenchyma of the FLAIR image was registered to the parenchyma in the T2 image. This has been used as gold standard. **2.** This manually registered FLAIR image was hereafter registered to the T2, but now using a fully automatic rigid body registration employing Mutual Information as a cost function [1,2]. For each combination of T2 and FLAIR images, the translation in the anterior-posterior direction has been plotted against the difference of their WFS parameters: WFS-diff = WFS(FLAIR) − WFS(T2) (Fig. 2). This translation can be considered as a measure of registration error.

Results

The plot in Figure 2 shows that a positive WFS-diff results in a positive registration error in the anterior-posterior direction, and a negative WFS-diff in a negative registration error. The plot shows a significant correction between WFS-diff and mis-registration ($p < 0.001$). The majority of the registration errors are larger than the pixel size of 0.43 mm. However, all automatic co-registrations of the images with equal WFS values showed errors smaller than the pixel size.

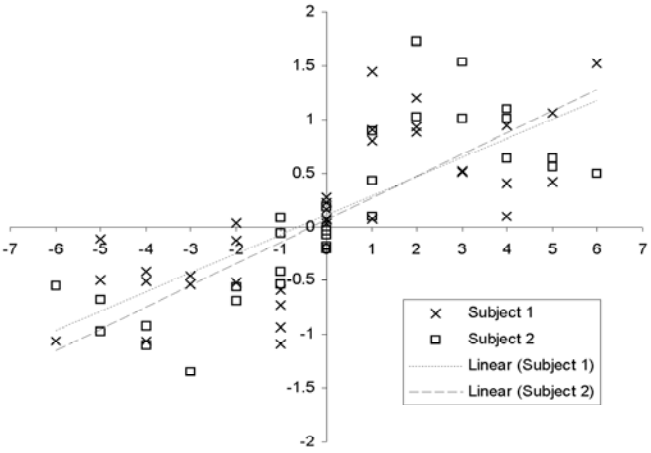

Fig 2. Relation between WFS-diff (Water-Fat-Shift parameter difference, in pixels) and mis-registration in anterior-posterior direction (mm).

Discussion and Conclusion

In this work we show that differences in WFS can lead to co-registration errors when automatic registration is performed on whole images. For optimal whole image registration, the WFS parameters should be equal. In clinical practice this might be difficult to fulfill since other factors as distortion and SNR dominate the choice of the read-out gradient strength. Another option would be to use only a region of interest such that during registration, the mutual information is evaluated on pixels that contain only parenchyma.

An incautious use of rigid or affine transformation for intra-subject image registration will often result in substantial errors for images with different WFS parameters when the whole image is considered.

References

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