Master's Thesis Engineering Technology 2023-2024

Whole-body dMRI With EPI Distortion Correction: A Prospective Cross-sectional Observational Study

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Introduction

Whole-body diffusion weighted imaging (WBDWI) is widely performed in clinical practice but suffers from **geometric distortions** due to single-shot echo planar imaging (SS-EPI) acquisition techniques [1], [2]. An inline SS-EPI **distortion correction** method (EPIC) is available for brain scans, but not for WBDWI. Therefore, this thesis investigates EPIC in the context of WBDWI. The first objective of this study is the **implementation of EPIC** into a whole-body protocol. Secondly, the protocol will be **tested** on three healthy volunteers. Third, the performance of EPIC is **quantitatively investigated** by comparing corrected images to uncorrected images.

Materials and methods

A 3 T MRI scanner is used to conduct the study on **three healthy volunteers**. Five quantitative criteria are evaluated to compare corrected and uncorrected images: the **position of the spinal cord** with respect to undistorted T2-weighted (T2w) images (figure 1), **similarity** of segmented structures with respect to T2w images (figure 2), **inter-station alignment** (figure 3), apparent diffusion coefficient (**ADC**) values and signal-to-noise ratio (**SNR**) (figure 4).

Quantitative approach 1

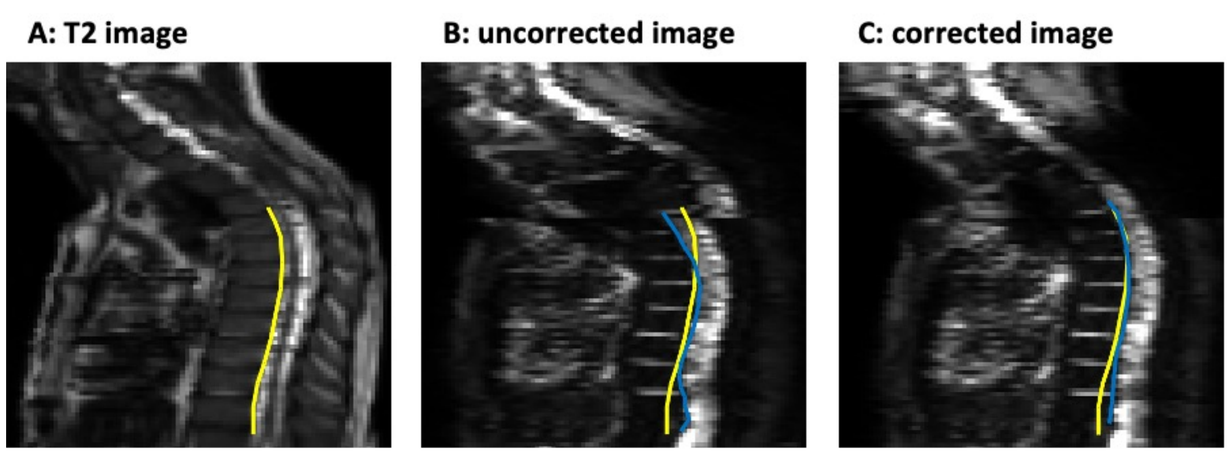

Figure 1. Sagittal slice of the thoracic station. Section marked for the evaluation of positional difference between T2w (A), uncorrected b0 diffusion (B) and corrected b0 diffusion (C) images.

Marked blue lines are evaluated in terms of **positional difference** with respect to the yellow line through 30 consecutive axial slices.

Quantitative approach 2

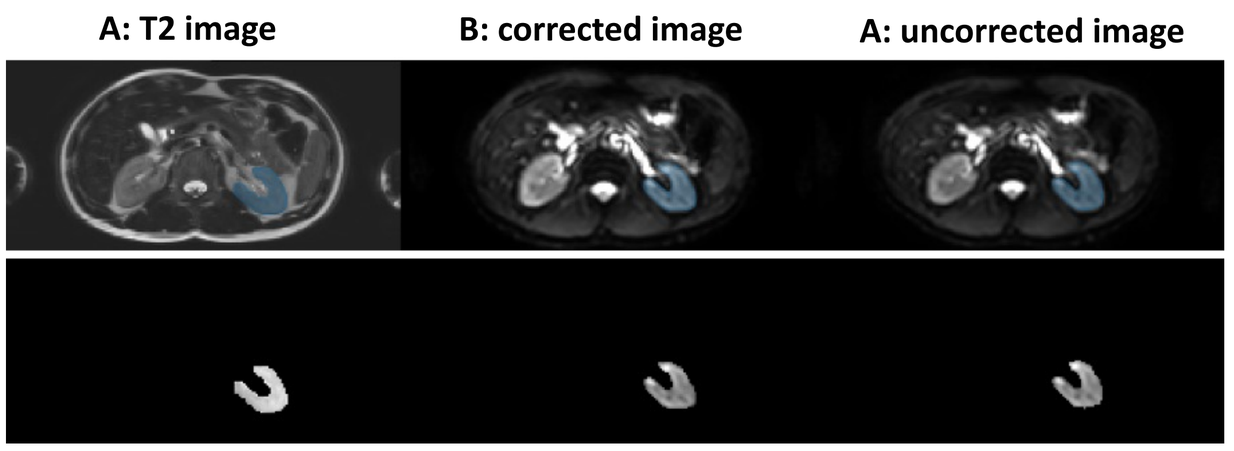

Figure 2. Procedure to calculate mutual information for station 2, (A) T2w image, (B) corrected b0 diffusion image, (C) uncorrected b0 diffusion image.

Mutual information (MI) of segmented structures is calculated for each station through three consecutive axial slices using the MATLAB mi() function [3].

Quantitative approach 3

Six consecutive axial slices are evaluated at the **inter-stational border**.

Absolute distance between consecutive markers on the anterior spinal cord is calculated.

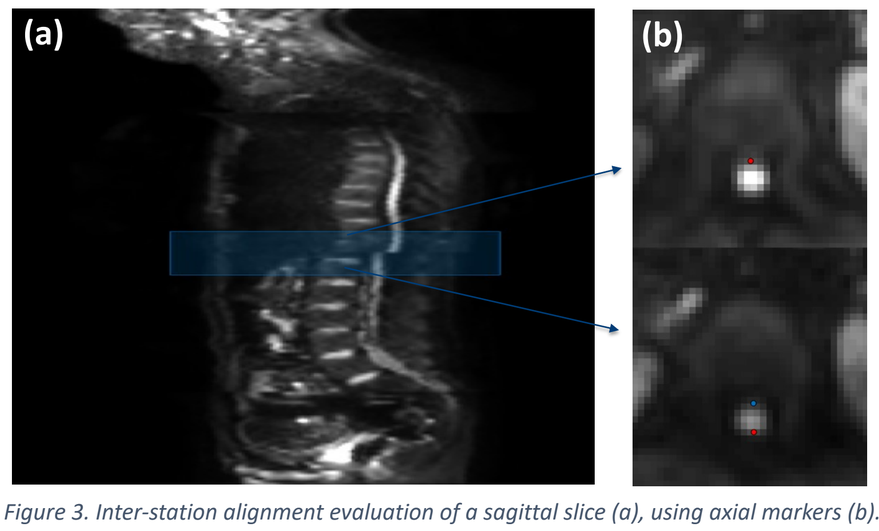

Figure 3. Inter-station alignment evaluation of a sagittal slice (a), using axial markers (b).

Quantitative approach 4 and 5

Through three consecutive slices, the **ADC value** is measured for all stations.

Figure 4 is an example of the **ADC measurement** in the third station. In a similar way, **SNR** values are measured on images: the circular region of interest (R1) is then used to calculate standard deviation.

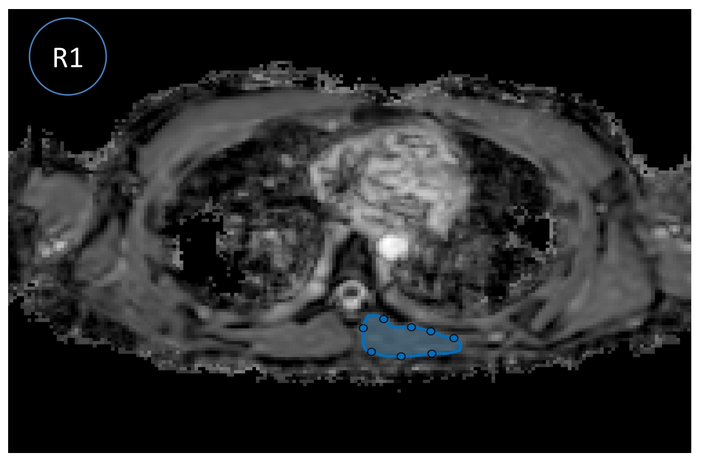

Figure 4. ADC measurement in the third station. R1 is added in SNR measurements to measure the standard deviation of the background signal.

Results

The maximum difference in **ADC values** is less than 4.5%. **SNR** improvements and reductions are measured of up to 58% and 13%, respectively. EPIC reduces **distortion of the spinal cord** by a mean value of 60% and improves **inter-station alignment** by an average of 51%. **Mutual information** of b0 and b1000 diffusion images with respect to T2 images is an average of 0.037 greater when EPIC is used.

Conclusion

To conclude, EPIC does not change **ADC** values of tissues notably but can increase or decrease the **SNR**. **Inter-station alignment**, **spinal cord distortion**, and **similarity** of structures is improved by applying EPIC. A dedicated whole-body protocol with EPIC has been made, which can be further used for testing on a clinical patient population.

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[3] J. Delpiano. *Fast mutual information of two images or signals.* (2024). MATLAB Central File Exchange. [Online]. Available: https://www.mathworks.com/matlabcentral/fileexchange/13289-fast-mutual-information-of-two-images-or-signals

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