A Reconstruction Method for Non-rigid Motion Compensation in Brain MRI

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Introduction

Most existing motion compensation techniques for brain MRI [1-6] assume that head motion is rigid. In fact, many kinds of non-rigid motion such as eye movement (eye ball rolling), skin movement (frowning), and jaw movement (swallowing, yawning), can also cause serious spatially local artifacts in brain imaging. These inevitable problems have not been carefully addressed. To remove these artifacts, methods comprising data rejection and reconstruction with remaining unpolluted data can be used [4-6]. However, the reconstruction with partial data could result in potential artifacts, such as reduced signal to noise ratio (SNR) and loss of contrast. In this work, it is proposed to use the image reconstructed with all of the acquired *k*-space data, which is locally artifact corrupted but with high SNR, as a regularization term in reconstruction to achieve an image with low artifact level and high SNR.

Theory

Fig. 1 shows the flowchart of the proposed method. Either navigators [1, 2, 5] or *k*-space data consistency [4, 6, 7] can be used to detect the locations of the motion corrupted data. Since non-rigid motion cannot be corrected using motion parameters, such as rotation angle and translation distance, these motion corrupted data have to be rejected. After data rejection from the partially acquired data set, the remaining motion free data often have a high reduction factor with a random undersampling as shown in Figure 2. In the reconstruction step, if only the remaining unpolluted data are used in reconstruction [4-6], reduced SNR, loss of contrast, and residual aliasing artifacts could occur. If all acquired data are used in reconstruction, like in Data COnvolution and Combination OperAtion (COCOA) [7], residual artifacts could be observed. However, the non-rigid motion usually produces spatially localized artifacts. Therefore, it is possible to use the image reconstructed with all acquired data, which has high SNR and local artifacts, as prior information in regularized parallel imaging [8, 9]. The red ellipse in Fig. 1 shows the key idea in this method. In this way, an image with high SNR (due to the similarity to the prior information) but low artifact level (due to the PPI using motion free acquired data and sensitivity maps for example) can be reconstructed.

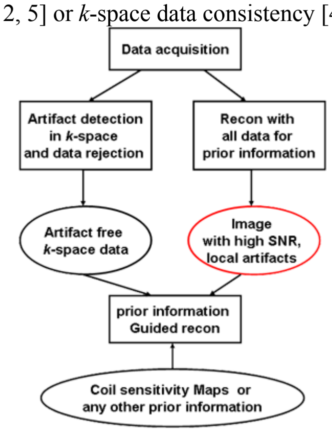

Figure 1. Flowchart of the proposed method

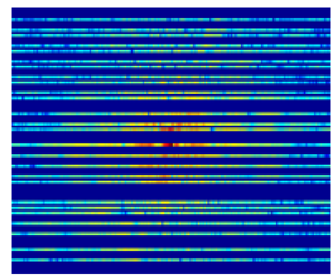

Figure 2. One example of motion free *k*-space data after data rejection.

Methods and Results:

T2w TSE brain images were acquired using an 8-channel head coil on a 3T Philips Achieva system. During acquisition, a subtle movement of the high signal intensity skin in this T2w TSE scan introduced ghosting artifacts in the phase encode direction. The SENSE factor of the acquired data was 2. COCOA [7] was used to detect the motion corrupted data (to generate motion free data like Fig. 2). The reconstruction with all acquired *k*-space data (R = 2), Figs. 3a and 3e, were used as prior information in regularized reconstruction [9] with remaining motion free *k*-space data. Fig. 3 shows the results and comparisons. The last row shows the improvement using the proposed method.

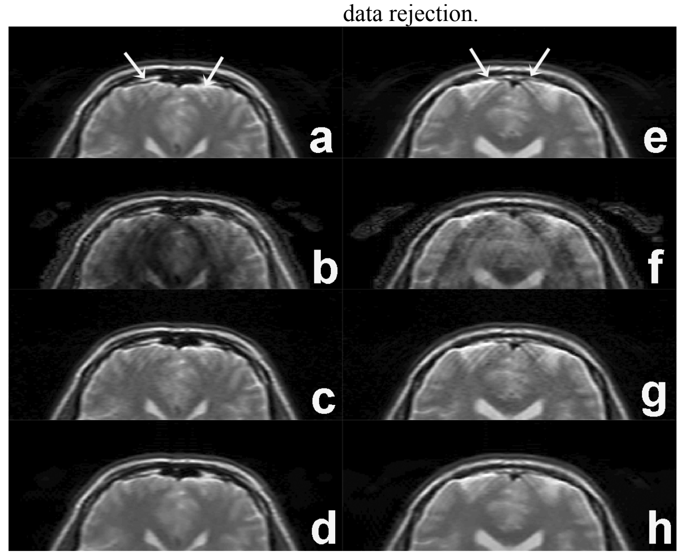

Figure 3. Results of the proposed method for skin motion. a) - d) are images before correction (a), after correction by PPI without prior information (b), by COCOA (c), and by the proposed method (d). e)-h) show another example. The white arrows demonstrate the locations of motion artifacts.

Discussions and Conclusion:

From Fig. 3, it can be seen that subtle skin movement can produce serious motion artifacts (Figs. 3a and 3e). COCOA could not remove the artifacts (Figs. 3c and 3g). Without using the reconstruction with all acquired data (Figs. 3a and 3e) as prior information, SENSE reconstructions with highly accelerated motion free data resulted in serious artifacts (Figs. 3b and 3f). Using the prior information, high SNR and low motion artifacts images were generated (Figs. 3d and 3h). In this work, artifacts due to skin motion were used as specific example of non-rigid motion in brain MRI. In principle, the proposed method can be used for all spatially local artifacts. In conclusion, a reconstruction method using a motion corrupted image as prior information is introduced for non-rigid motion compensation in brain MRI. Artifact levels can be reduced with well preserved SNR.

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