A novel MRI data processing strategy for the reduction of abdomen motion artifacts

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Target audience: Researchers with an interest in motion artifacts removing may benefit from this study.

Introduction: Many techniques to alleviate motion artifacts in abdomen imaging have been implemented in commercial MR systems, such as breath holding and free breathing imaging techniques: respiratory gating, navigator echoes. However, these techniques may not be efficient when images acquired from the patients with breath holding difficulties or irregular breathing. Date processing techniques such as multiple average methods [1, 2] and COCOA [3] have been developed recently for motion artifacts reducing. They employed convolution of k-space data to reduce localized data inconsistencies. These data processing techniques can be incorporated with other techniques mentioned above and then, better image quality is obtained. And they can also be used alone for free breath imaging. A new data processing strategy is introduced in this work to optimize the date convolution procedure and take care of different motion characters exist in multi-coil images to protect the image SNR.

Theory: k-space domain parallel imaging methods work on the principle that the k-space signal can be approximated by a linear combination of signals from neighboring locations in multiple coil elements. This principle is adopted in COCOA for k-space error detection and correction with a fully sampled multi-channel k-space data set. Different convolution kernels used in COCOA may cause different motion artifact residues even with the same kernel level. However, the same kernel level result in the same level of noise amplification and the images after convolutions of same kernel level can be combined linearly to improve the SNR of final images. Fig. 1 shows the combination procedure with same convolution kernel levels. *Wn* can be selected as the nominal error between the data after COCOA and the original data. Then all the motion artifacts are decreased relative to the increased artifacts free signals. In addition, the motion artifact characters in multi-channel images are different because of the regional sensitivity of surface coils. The coils below the back of patient are less sensitive to the motion of the belly. Thus, this channel images can be selected according to the coil locations. And then they are used to substitute the corresponding channel images of the data after multi-kernel COCOA procedure to increase SNR of final image. However, slight motion artifacts caused by the visceral organ pulsation still exist in the signals received from the back coils. COCOA procedure is employed to remove these slight motion artifacts. Finally, images reconstructed with multiple convolution kernel levels are combined linearly to produce the final image. The flowchart of the data processing strategy is shown in the Fig. 2.

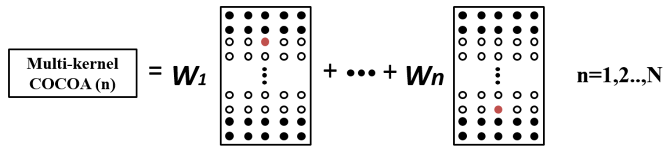

Fig. 1. The linear weighted combination of the same convolution level COCOA images with different kernel shapes.

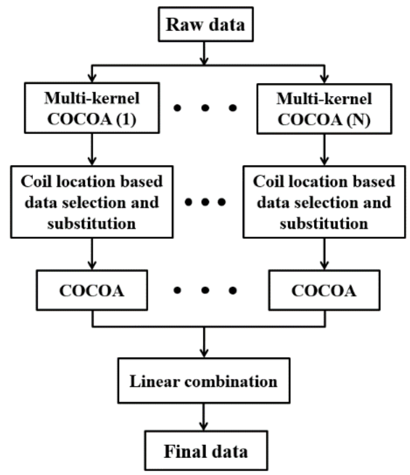

Fig. 2. The flowchart of the new data processing strategy.

Methods and results: To validate the advantage of the new data processing strategy, free breathing images are acquired by FSE sequence with eight-channel coils. Informed consent was obtained from the volunteer in accordance with the institutional review board policy Fig. 3 shows two channel images: one received from the coil near the belly and one below the back. And obvious motion artifacts can be seen in the channel image near the belly. For comparison, both original COCOA and our method are employed to process the motion corrupted data. Fig. 4 shows the original images reconstructed by SOS and the images after the two data processing techniques. Difference images between original images and the results processed by the proposed method are also shown in the Fig.4. The results demonstrated that motion artifacts are almost removed clearly with our method and the SNR of the images are not shown apparent changes.

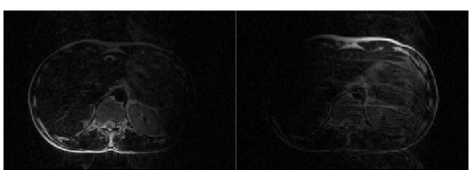

Fig. 3. The two channel images acquired with different coils: the first one is below the back and the other above the belly. Severe motion artifacts are exist in the first image and there are no apparent artifacts in the second image.

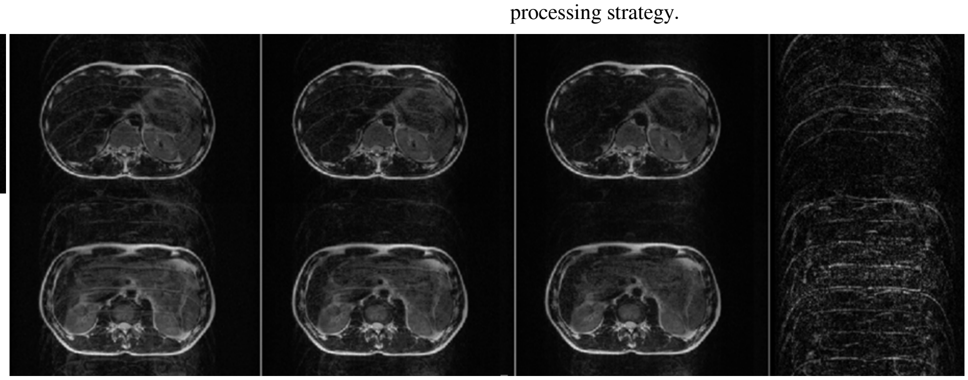

Fig. 4. The two slice images in the first column are the original free breathing images. The second column shows the results after COCOA and the third column shows the images processed by the proposed method. The different maps between images of the first and the third images.

Discussion and conclusion: The new data processing strategy takes full advantages of the multi-kernel COCOA, and coil location based data selection and substitution procedure have protected the SNR of the final image. In vivo experiments showed its advantages over the original COCOA method. And the proposed method can be expanded to other body parts with motion artifacts, such as shoulder shrugging, vascular pulsation.

Reference: [1] Fautz HP, *et al*., MRM 2007;57:226-232. [2] Cao SJ, *et al*., ISMRM 2013;3761. [3] Huang F, *et al*., MRM 2010;64(1):157-166.