IMAGE POST-PROCESSING FOR MRI NOISE REDUCTION IN SIMULTANEOUS ULTRASOUND AND MRI IMAGING

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INTRODUCTION

Concurrent real time MRI and Ultrasound (US) imaging have shown impacts on MR cardiac motion tracking using US as navigation and improvement in scan plane localization for image guided biopsy [1-3]. Theoretically, MRI and US work on totally different principles without the risk of adversely affecting one another. However, putting US transducer into the magnet bore introduces radio frequency interference. Shielding applied at US probe window is capable of reducing the zippers but it also causes severe signal degradation in US [1]. In this work, we propose a post-processing method to erase the zipper noise in corrupted MR images by masking out the periodic zippers and filled in the missing parts with image inpainting.

METHODS

Concurrent MR/US imaging was performed by introducing a portable US system into a 3T whole body MRI system. Noisy MRI images of a standard phantom were captured when the US is running continuously with the transducer placed inside the magnet bore. The noise appears as periodic zippers running perpendicular to the phase encoding axis (vertical axis) in the MR images.

To facilitate the noise removal post-processing, a calibration zipper noise only pattern is obtained prior with the MR transmit power turned off. This noise only pattern provides positional information of the zipper noise. Noted that the periodic zippers were located at same coordinates (i.e. no drift of zippers over time) but with varying intensity, as long as the US and MRI acquisition parameters are unchanged.

We reduced the zipper noise in 2 steps. First, we obtained a mask to zero out the pixels located at the coordinates where the zippers running across. The mask is generated by making a maximum intensity projection (MIP) on the vertical axis, using the calibration MR noise only pattern. This result in a line plot with peaks appears periodically. A manual threshold is then set (at 20% of the maximum intensity) to extract the peaks that reflect the location of the zippers.

Secondly, we restored the image by filling the missing lines using image inpainting. Inpainting is an image interpolating technique to restore the damaged parts of an image by propagating linear structures into the damaged region by diffusion. Here, we implemented the method from [4] to restore the corrupted MRI images.

RESULTS AND DISCUSSION

Fig.1a shows the corrupted MRI image. The RF interference appears as periodic zipper like noises running horizontally in the MR images. Fig. 1b shows the inpainting mask generated using the MIP from the calibrating noise pattern. Fig.1c shows the restored MRI image. The mean and standard deviation (in bracket) of background noise at the yellow ROI before and after using inpainting is 5.94 (8.29) and 4.54 (2.83) respectively. The reconstruction time is ~130 seconds for the image with a matrix size of 256x256.

As shown in the figures, the zipper noise is greatly attenuated and the original phantom image is restored and visually acceptable. The fine details of the phantom are preserved. The large drop in the background noise standard deviation indicating that the zippers with sharp peaks are efficiently removed. However, some residue noise still exists, and this imperfection may be corrected by generating a more accurate inpainting mask, or implementing other filters further at the expense of slight degradation to the signal. Noted that if the zipper noise pattern is not purely horizontal, we can still use the MIP to rotate the image accordingly.

In this work, we present a preliminary method to restore corrupted MRI images due to RF interference introduced by US system. The method may be extended further to reduce interference from other noise sources introduced into MRI images unexpectedly while re-imaging is not feasible.

REFERENCES

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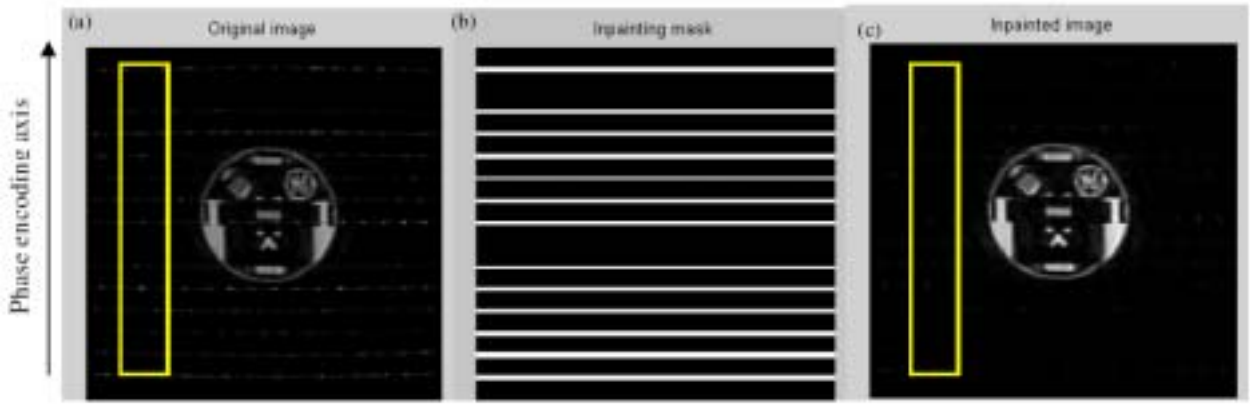

Fig. 1 Comparisons of processed images. (a) Original image corrupted with zipper noise. (b) Inpainting mask obtained from projection at the phase-encoding axis, (c) inpainted image with zipper noise removed.