A NOVEL SNR ESTIMATION TECHNIQUE APPLICABLE TO CLINICAL PARALLEL MR IMAGES: TRIPLE BAND-WIDTH SINGLE ACQUISITION METHOD (TRISAM)

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INTRODUCTION

A number of methods have been proposed for evaluating signal-to-noise ratio (SNR) of MR images; however, each has its own drawback and advantage [1-4]. Random noise component is basically estimated by calculating a standard deviation (SD) of some region of interest (ROI). In evaluation of clinical images, accurate measurement of the noise component is difficult due to complicated structures of human anatomy in a single image method and misregistration in a two-image difference method. Figure 2 (a) shows a typical image with apparent misregistration artifacts due to patient motion and physiological motion such as blood flow. Therefore, the background method, where the SD is calculated in background noise area, is often employed in an SNR measurement in clinical images.

Recently, array coil and parallel MRI (PI) technology have been widely applied in clinical examinations; however, PI causes spatial variation of noise on the final images caused by signal intensity correction of coil sensitivity and a geometric factor effect through the unfolding procedure. Therefore, a straight visualization method of spatial noise variation (noise map) is strongly desired.

On the other hand, "single acquisition, two-image difference method" was proposed [5], which includes 1) two times oversampling acquisition with twice the field of view (FOV), 2) generation of two normal images using odd and even data, and 3) generation of a noise image by subtracting these two images. Unfortunately, since low-pass-filter characteristics appear in the central part of the image in this method (Fig. 1a, arrow), it is not appropriate to use in a noise map generation.

The purpose of this study is to propose a noise mapping method applicable in clinical images. A newly developed "Triple Band-Width Single Acquisition Method (TriSAM)", utilizing three time wider band-width (BW), and its application to the brain images are described.

MATERIALS and METHODS

Proposed Technique: The basic idea of proposed technique is shown in Fig. 1b. Low-pass-filter characteristics appear in the boundary part of the image (arrow). Corresponding to the wider BW, a larger FOV in the read-out (RO) direction should be selected. A four-time larger FOV (quadruple oversampling in time domain) is used here. Normal FOV images are obtained from 4-times sub-sampled four sets of raw data (I1-I4). And then, two subtracted "noise images" N1=I1-I3, N2=I2-I4 are obtained. Pairing is selected so as to avoid noise correlation.

Experiments: All experiments were performed using a 1.5-T clinical imager. First, a uniform phantom study is performed using whole-body coil. Estimated noise SD based on TriSAM images is compared with SD from normal image data.

Next, normal volunteer studies are carried out, after obtaining informed consent. A 5-channnel head coil is employed in this study. The following parameters were used: SE(500/15), 256x256 matrix (256 acquisition), FOV 20x20cm, NEX 2, Section slice thickness 5 mm, sensitivity correction, no post-processed filter. Following images are acquired for noise estimation;

A) Normal BW, normal sampling: BW=41.7kHz, 256 acquisition, RO-FOV 20cm, 2 scans,
B) Double BW, double sampling : BW=83.3kHz, 512 acquisition, RO-FOV 40cm,
C) Triple BW, quadruple sampling : BW=125kHz, 1024 acquisition, RO-FOV 80cm.

Case B), C) is corresponding to original method [5] and TriSAM, respectively. In TriSAM case, parallel images were also obtained with speed-up factor (SF) of 2 and 3.

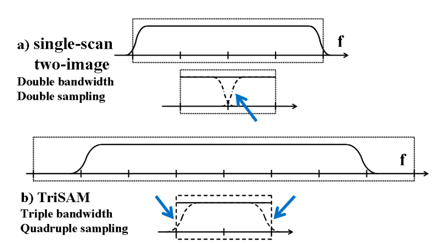

Fig.1 Wraparound noise characteristics with sub-sampling procedure

RESULTS

The phantom experiment shows that TriSAM properly estimates the noise SD even in the central area in the RO direction. Measured SD is 33.6 for N1 and 13.4 for normal scan image. The calculated ratio 2.51 is about square root of 6, which is theoretically expected. Figure 2 shows several subtraction images obtained by (a) two-scan two-image method as mentioned in introduction, (b) single-scan two-image method, and (c) proposed TriSAM. Note that the low level noise is in the central area in (b) (arrowhead). Figure 3 shows TriSAM images obtained with Parallel MRI: (a), (b), and (c), with SF=1, 2 and 3, respectively. Spatial noise variation is clearly visualized (arrows). The image (d) is a "g-factor based" noise map which is calculated from inner information (complex coil sensitivities) for comparison.

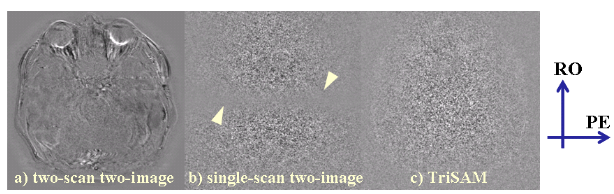

Fig.2 Difference images (noise images)

DISCUSSION

Several noise maps with no specific artifacts were obtained, as expected. TriSAM works well with parallel MRI. It is because the image separation in the RO direction in this oversampling method is completely independent from unfolding procedure in the phase encoding direction. TriSAM is not directly applicable to non-Cartecian cases [6], however, Cartecian is the most important case. Furthermore, we have confirmed the consistency between the TriSAM noise images and the g-factor based noise map. Note that these noise maps can be obtained with originally intended images with no extra-scan time, although there are several limitations such as oversampling capability in the wide BW data acquisition and extra software requirement including access to the k-space raw data.

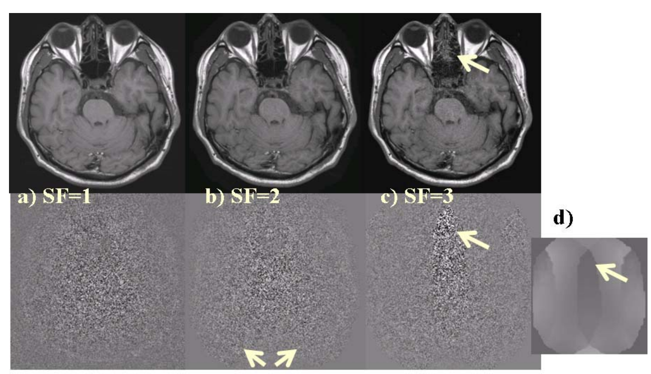

Fig.3 TriSAM noise images with Parallel MRI

CONCLUSION

We have developed a new technique TriSAM, in which noise maps can be obtained with no extra scan time. Application of this technique with parallel imaging to the head images on a volunteer provides the misregistration free noise images. The TriSAM is considered to be one of the most practical SNR estimation approaches.

REFERENCES

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