High Spatial and Temporal Resolution Free Breathing Cardiac CINE-GRICS : 512x512 vs 128x128 matrix

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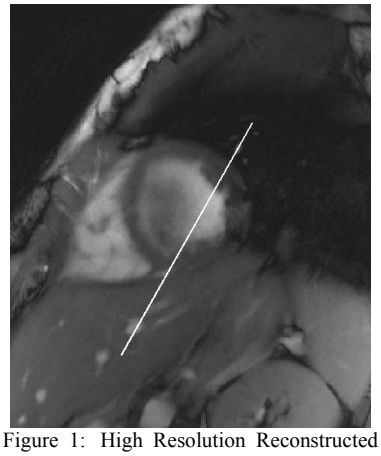

Figure 1: High Resolution Reconstructed image (512x512 matrix). white line : section used in the TM mode of figure 2.

INTRODUCTION

Generalized Reconstruction by Inversion of Coupled Systems (GRICS) (1) is an approach aiming at correcting motion artifacts (2) and generalizing parallel imaging (3). It enables free-breathing MR Imaging of cardiac structures (4,5,6). This reconstruction process is constrained by physiological signals, such as respiratory belt amplitude and ECG (4). Other approaches have been proposed to improve imaging of moving structures by means of fast acquisition in k-t space (7,8), or using a motion model (9). However, since GRICS is applied to a free breathing reconstruction, it enables any chosen spatial or temporal resolution. Spatial and temporal resolutions are gained at the cost of longer acquisition and reconstruction times, so the enhancement going from a 128x128 to a 512x512 matrix should be quantified.

METHODS

A short axis slice was acquired on a 1.5 T Signa HDx MR system (GE Healthcare, Milwaukee, WI) using multi-phase balanced-SSFP sequences in free breathing (TR 6.1ms, TE 2.8ms, FOV 34cm, 512x512 matrix, 45° flip angle, 8mm slice thickness, 3 times 25 temporal phases for a total of 235s). K-space line ordering was modified to enable a wider time distribution between adjacent k-space lines. Physiological signals were collected using a modified version of the Maglife monitoring system (Schiller Médical, Wissembourg, France) (10). To reconstruct the multi-phase data, three input signals were directly used, including two respiratory belts (thorax and abdomen). ECG recording was used to determine the R-waves and assign each k-space line to their corresponding cardiac phase. The CINE-GRICS reconstruction (4) involves the reconstruction of 14 cardiac phases, called key frames. Each key frame is reconstructed with standard GRICS (1), using respiratory belts, and a cardiac phase signal derived from the ECG, accounting for small cardiac deformations within the frame. To obtain a high temporal resolution CINE loop of 112 images per RR interval, 8 images have to be generated between two consecutive key frames. This is done by first applying the respective displacement field to both key frames images with the physiological signals at interpolating time and then building the weighted average of the two images. Reconstructions produced 128, 256 and 512 square images which were zero filled to 512^2 in order to compare image quality, both qualitatively (difference image movies) and quantitatively, using entropy-based metrics.

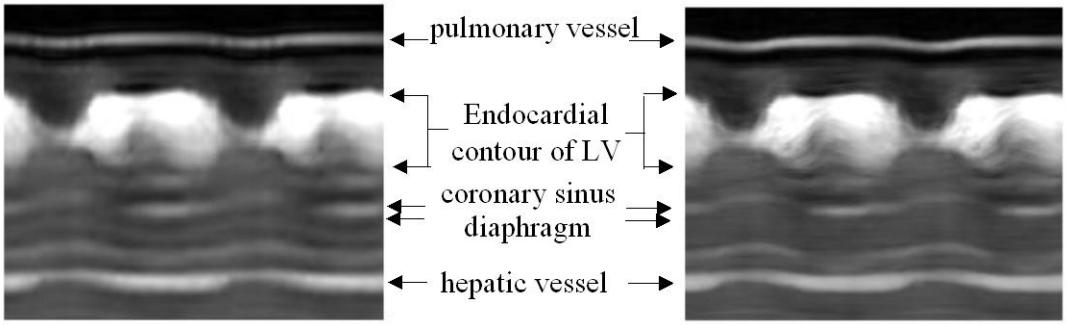

Figure 2: For the section of figure 1 Time Motion presentation of the CINE loop of 112 time phases per RR interval. (left) 128x128 matrix (right) 512x512 matrix

RESULTS

To display the increase in sharpness of the high resolution cine loop a section was manually drawn across the heart (Fig. 1). The time motion (TM) presentation along two RR intervals clearly show better depiction of pulmonary and hepatic vessel as well as less blurring of the endocardial contour (Fig. 2). The absolute value of the relative differences of the two images (Fig. 3) point to the location were most gain in resolution is achieve. On the tree cine loops of respective native resolution of 128^2, 256^2 and 512^2 , for pixels greater than 2% of there maximum intensity the global entropy and the global entropy of the gradient norm were computed. The mean entropy difference is 0.035 +/- 0.011 (128 vs 512) and 0.063 +/- 0.008 (256 vs 512) . The mean entropy difference of the gradient norm is - 0.081 +/- 0.017 (128 vs 512) and 0.033 +/- 0.012 (256 vs 512). Since for entropy difference, the less is better and for entropy difference of the gradient norm, more is better, these data show a quantitatively increase in image quality going form 128^2 to 512^2.

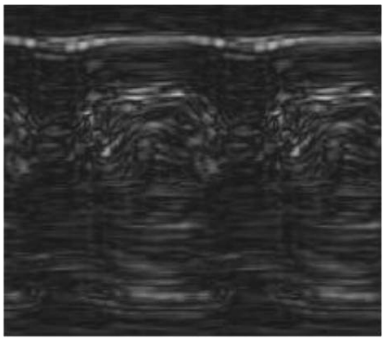

Figure 3: Absolute relative differences of the both images in TM mode of figure 2.

CONCLUSION

It is possible to reconstruct high spatial and temporal resolution CINE-GRICS loop based on an acquisition of less than 4 minutes. The produced images have noticeable improvement in sharpness compared to a zero filled image with 4 times less spatial resolution.

REFERENCES

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