Faulty trigger and motion artifact canceling in cardiac MRI using SPACE-RIP

P-A. Vuissoz[1], F. Odille[1], C. Pasquier[1], W. S. Hoge[2], W. E. Kyriakos[2], and J. Felblinger[1]
[1]IADI, Nancy University; INSERM ERI 13, Nancy, France, [2]Brigham and Women's Hospital, Boston, MA, United States


Fig. 1 : Moving phantom setup.

INTRODUCTION:

Multiple receiver channels used in parallel MRI produce an over determined data set for image reconstruction. This has been used to shorten scan time through SENSE [1] or SPACE-RIP [2] reconstruction on under sampled k-space. It has been proposed to trade this over determination to increase spatial resolution, temporal resolution or eliminate artifacts [3]. In cardiac MRI, faulty triggering or motion induced by lengthy breath holds may impair some parts of the sampled k-space, producing blurring or motion artifact in the reconstructed image. Here, we propose a post processing artifact correction technique to determine and discard data within the corrupted acquisition, and reconstruct the reduced data set using the SPACE-RIP image reconstruction algorithms. Results on four healthy subjects and two moving phantoms are shown.

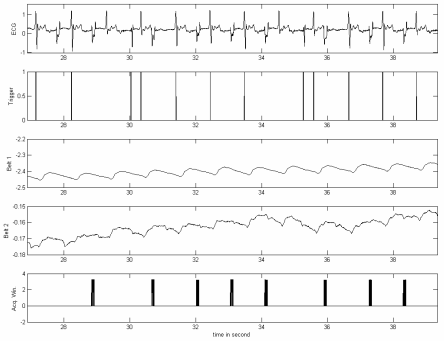
Fig. 2 : Physiological recording. Triggers of shots 2 and 6 are not correct.

METHODS:

All MR experiments were performed on a 1.5 T GE SIGNA Excite HD MR system (General Electric, Milwaukee, WI). An 8 channel phased array coil was centered on a moving phantom (Fig. 1) or subject thorax. Signal from a respiratory belt and ECG was carried by the Maglife (Schiller Médical, France) patient monitoring system and recorded along with MRI gradients and acquisition window signal on the Signal Analyzer and Event Controller (SAEC) custom computer and electronics [4]. The SAEC was used to generate a double respiratory/cardiac trigger for a gated black blood fast spin echo sequence. An ASSET (GE SENSE implementation) calibration was performed to enable the standard reconstruction and generation of DICOM file. A fully sampled reference image was also acquired to create the sensitivity map (32 phases) used in the SPACE-RIP algorithm. The acquisition (320/256 matrix, TE 36 ms, ASSET Factor 2, Thickness 7 mm, Phase direction R/L) was done with 8 shots of 16 echoes each (128 phases, every other lines). We manually generated a faulty trigger on some shots of the acquisition (Fig. 2) to acquire some part of the k-space in systole, the other shots were acquired in diastole.

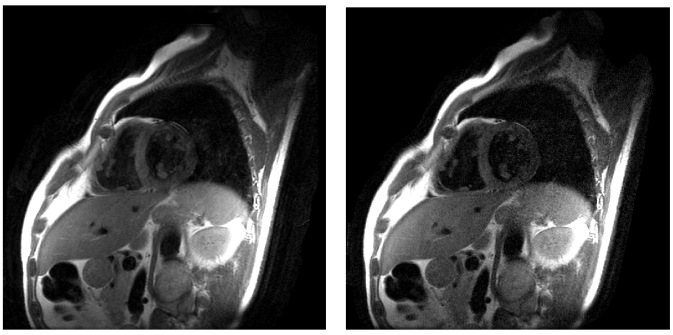
Fig. 3 : (left) standard reconstruction (right) SPACE-RIP reconstruction with shots 2 and 6 discarded.

RESULTS:

Contrary to other approaches where the full data set is needed to detect corruption in k-space (3), the corrupted shot is detected by use of SAEC external sensor recording alone. Motion artifacts are visible on the standard reconstruction with the full data set (Fig. 3 and 4 left). With two bad shots, some artifacts have been introduced in the superior and anterior part of the left ventricle (a double fat line is clearly visible and some structure in the lung too). By removing these corrupted shots from the data set the regular sampling pattern is broken. Therefore SPACE-RIP reconstruction was applied to remove the motion artifacts (Fig. 3 and 4 right). The corresponding acceleration factor is then about 2.6 and therefore the noise has increased. The reproducibility and robustness of the method has been tested on twelve acquisitions. With either phantoms or human subjects, motion artifacts could be removed with robust reconstructions at a slight noise penalty.

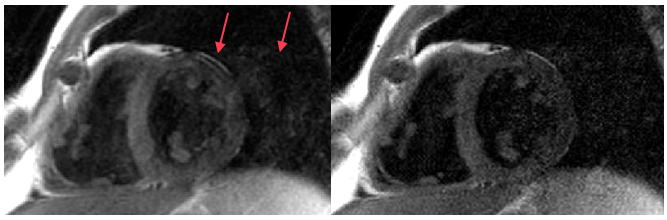
Fig. 4 : a region of interest zoom in Fig. 3 (left) standard reconstruction (right) SPACE-RIP reconstruction with removed corrupted shots

DISCUSSION:

In this work, we show the feasibility of using SPACE-RIP to reconstruct k-space data sets that have been partially discarded due to motion or faulty triggering contamination. Our results on phantom and healthy subjects show good artifact suppression. We show that it is possible to improve black blood Fast spin echo cardiac images in monitoring and suppress faulty triggered acquisition using SPACE-RIP parallel reconstruction algorithm.

REFERENCES:

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