Dynamic Coil Selection for Interactive Catheter Tracking with Parallel Imaging

S. Müller[1], R. Umathum[1], S. Ley[2], W. Semmler[1], M. Bock[1]

[1]Medical Physics in Radiology, German Cancer Research Center, Heidelberg, 69120, Germany, [2]Radiology, German Cancer Research Center, Heidelberg, 69120, Germany

Introduction

Interventional procedures such as stent placement or embolisation require a precise localization of the interventional instument and an adaequate visualisation of the surrounding tissue. For many interventional applications MRI would be the imaging modality of choice, since it offers excellent soft tissue contrast in combination with real-time imaging capabilities.

Active MR instrument tracking at high frame rates [1] can be achieved using fast imaging techniques with partial Fourier and parallel image acquisition techniques. So far image acquisition rates of about 4 images/s at 256² image matrices have been achieved. Unfortunately, both techniques accelerate the image acquisition at the cost of an increased reconstruction time, so that real time image reconstruction is often no longer possible.

In this work a dynamic coil selection algorithm is applied to reduce the data load on the reconstruction processor. Coil data are selected for reconstruction based on their relative distance to the current imaging slice. In an animal experiment this technique was combined with parallel image acquisition and active catheter tracking [3].

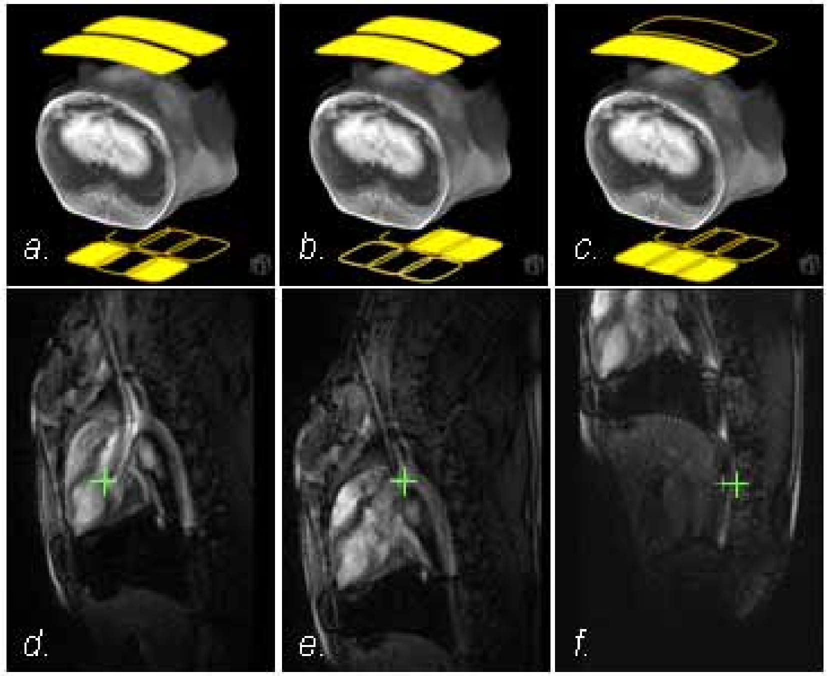

Fig. 1: Three images acquired during an intervention (d,e,f). The active catheter tip is shown as a green cross at three different positions while different coils were used for image reconstruction (a,b,c).

Materials and Methods

For the tracking of active catheters a real-time trueFISP sequence was implemented on a clinical 1.5 Tesla MR system (Siemens Magnetom Symphony, Erlangen, Germany). To achieve an update rate of 4 Hz the following imaging parameters were used: FOV: 300×225 mm², matrix: 256×192, partial Fourier: 4/8, phase resolution: 80%, TR = 4.3 ms, TE = 2.15 ms, $\alpha = 70°$, SL = 8 mm. Between the acquisition of two trueFISP images a tracking block of 28 ms duration was inserted to measure the current catheter position, which was used to automatically align the imaging slice in the next image acquisition. Since position and orientation of the imaging slice are continuously changing during the intervention, a parallel acquisition technique with auto-calibration (GRAPPA [2], acceleration factor 2, 16 reference lines) was required resulting in a final acquisition time per image of 256 ms.

Eight separate receiver channels were available for data acquisition, of which one was exclusively assigned to the tracking coil. The remaining seven receiver channels were connected to seven imaging coils (a posterior 6-element spine array coil and an anterior 2-element flexible body array coil). In a phantom experiment the reconstruction time per image was measured as a function of number of activated coil elements. For four coil elements the reconstruction time did not exceed the acquisition time per image and a real time acquisition was always possible. Therefore, a coil selection algorithm was introduced in the reconstruction which dynamically selected four of the seven coil elements. Data were only included in the reconstruction for those coils that were closest to the current slice position using data from a prior coil localization scan.

The sequence was tested in an animal experiment (female pig, age: 4 months, weight: 30 kg). An active 5F catheter with a solenoid marker coil at the tip was introduced into the carotid artery and advanced to the pig's aorta and heart under real-time image guidance. Images were displayed on an MR-compatible in-room monitor with a latency of less than 1 second.

Results and Discussion

Real time images acquired during catheter motion are shown in Fig. 1 together with a schematic of the reconstructed coil elements. The catheter tip (green cross) is retracted from the heart and pushed through the aortic arch into the abdominal aorta. During the whole procedure the dynamic coil selection algorithm allowed an optimal visualization of the anatomical structures in the vicinity of the catheter coil. Foldover artifacts from distant coils were effectively suppressed, and additional ghosting artifacts from parallel imaging were not observable. Faster reconstruction computers might increase the number of coil elements that can be reconstructed in real time thus rendering dynamic coil selection obsolete for some applications. However, the ever increasing number of coil elements or moving table acquisitions will nevertheless demand an efficient selection algorithm.

References

[1] Bock M, et al. JMRI 19: 580-589 (2004)

[2] Griswold M, et al. MRM 47: 1202-10 (2002)

[3] Müller S., et al. ISMRM 2005, p. 2417

[4] Müller S, 2nd International Workshop on Parallel MRI (2004)