HYPR MR Fluoroscopy

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INTRODUCTION

Catheter tracking and visualization require both good spatial and temporal resolution. In MR, simultaneously achieving both of these has been difficult. To date, passive device tracking/visualizaion techniques have typically been implemented using 2D techniques [1-2]. 2D catheter tracking, however, does not convey even qualitative information about motion in the projection direction. This nullifies one of the major advantages MR has over X-ray – its 3D imaging capability. In order to take full advantage of the capabilities of MR for MRI-guided catheter-based minimally invasive interventions, there is a need to develop very fast imaging techniques. We have recently developed a non-iterative reconstruction technique called HYPR (HighlY constrained back PRojection) [3] to further increase the permissible undersampling of temporally evolving acquisitions by exploiting the idea of avoiding redundant *k*-space information. This technique, when used in combination with radial or hybrid radial/Cartesian acquisition techniques, provides relatively artifact free images with large undersampling factors and is well suited for real-time catheter tracking and visualization and can pave the way for MR fluoroscopy approaching the speed of X-ray fluoroscopy to perform wholly MRI-guided catheter-based minimally invasive interventional procedures. Using HYPR in combination with MR-visible coated therapeutic devices such as catheters [4] can allow tracking/visualization of the entire device with high temporal resolution independent of its orientation in the static magnetic field. The objective of this study was to perform *in vitro* and *in vivo* evaluation of HYPR technique to passively track/visualize catheter filled with dilute Gd-DTPA or coated with MR-visible coatings.

MATERIALS AND METHODS

All the initial experiments were performed by using 6 F catheters filled with dilute Gd-DTPA in phantoms while moving catheters back and forth. Catheter tracking images were obtained using either a 2D PR or a 3D hybrid radial/Cartesian (interleaved stack of stars) acquisition technique. In 3D, for each subset of interleaved radial acquisition in the *kx-ky* plane, a series of *kz* partitions are acquired. The image reconstruction was performed offline using standard filtered backprojection (FBP) and HYPR algorithms. Typically, 4-8 partitions with 36 mm slab thickness, and RBW = ±62.5 kHz, 256 X 8-16 projections per partition are acquired.

RESULTS AND DISCUSSION

Figures 1 and 2 show temporal snapshots of a moving catheter filled with dilute Gd in canine carotid and aorta, respectively. The images were reconstructed with the FBP and HYPR techniques using only 20 projections (an undersampling factor of 20) per time frame. Composite images were formed using five time frames that advance in time. As clearly seen from the images, the HYPR technique provides relatively artifact-free and high SNR catheter images (top) with the catheter clearly visible, whereas the FBP reconstruction leads to images (bottom) with low SNR and considerable streak artifacts that make catheter visualization impossible. The HYPR individual time frame images are relatively artifact free because the SNR of each individual time frame is determined by the SNR derived from all data acquired/used in the composite image. SNR gain, artifact reduction, and temporal response will depend on how large a temporal aperture can be used to form the composite images.

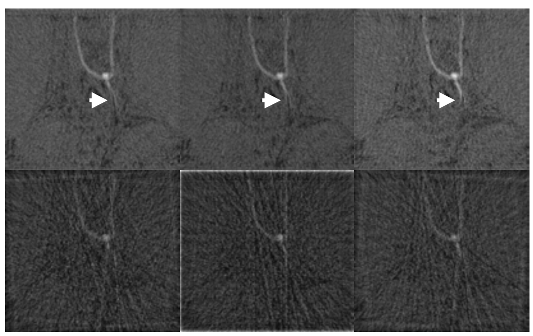

Figure 1: *Comparison of HYPR (top) and FBP reconstruction (bottom). Images were reconstructed using 20 projections per frame (an undersampling factor of 20).*

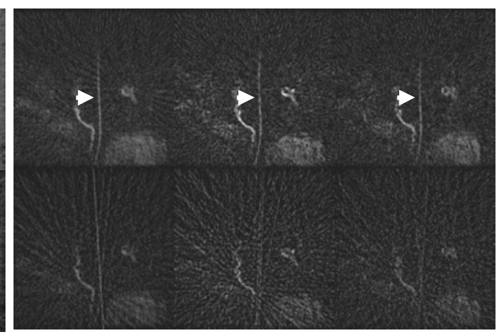

Figure 2: *Comparison of three temporal snapshots of a moving catheter in canine aorto reconstructed using the HYPR (top) and FBP techniques (bottom). Images were reconstructed using 20 projections per frame (an undersampling factor of 20).*

CONCLUSIONS

Our preliminary results suggest that the HYPR technique for passive catheter tracking/visualization of coated or filled catheters with Gd-DTPA is feasible and may offer advantages over other passive and active tracking techniques by providing relatively streak-artifact free images with good SNR and speed up factors of 10-40 or more. Further studies are underway to optimize the HYPR technique and perform animal experiments.

REFERENCES

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