Application of *k-t* BLAST to Passive Catheter Tracking: Initial Evaluation In-Vivo

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Abstract

k-t BLAST is a method to accelerate dynamic imaging by exploiting spatiotemporal correlations. In this work, it was applied to the monitoring of catheters in a pig's aorta. Cartesian and radial acquisitions were employed for imaging, into which the measurement of training data, as required by *k-t* BLAST, was incorporated. The reconstruction with *k-t* BLAST was carried out off-line, while an adapted sliding window reconstruction was performed on-line. Images obtained with both approaches were compared, showing a considerable gain in temporal resolution and a related reduction in motion blurring and subsampling artifacts with *k-t* BLAST, particularly for the Cartesian acquisitions.

Introduction

The passive tracking of interventional devices in a dynamic environment requires continuous imaging with high temporal and spatial resolutions. Methods for scan time reduction are, therefore, of particular interest to this application. The temporal filtering technique UNFOLD [1] has been demonstrated to provide a reduction by up to a factor of two in interventional imaging [2]. It is, however, limited to such a twofold acceleration in most cases [3]. Recently, *k-t* BLAST was proposed as a generalization of this technique, which permits higher reduction factors [4]. In this work, we investigated the feasibility of applying it to interventional imaging in order to increase the temporal resolution substantially. Since the reconstruction procedure of *k-t* BLAST is somewhat more complicated, the data were reconstructed off-line so far. It was, however, kept simple enough to allow an on-line reconstruction in principle.

Materials and Methods

A catheter with a small parallel resonant circuit attached to its tip [5] was imaged during movement in a pig's aorta. The tuned parallel resonant circuit provided a local enhancement of signal present in its vicinity. The imaging was performed with fully refocused Cartesian and radial sequences on a 1.5 T Intera system (Philips Medical Systems, Best, The Netherlands) using four surface coils for signal reception.

For the Cartesian acquisitions, a variable-density sampling in phase encoding direction was employed to embed the measurement of training data into that of the undersampled imaging data. Typically, the training data consisted of about sixteen central *k*-space lines. For the radial acquisitions, the training data were extracted from the central *k*-space samples of the imaging data without requiring changes to the acquisition.

During the measurement, an adapted sliding window reconstruction, which used only the most recent data for the central *k*-space lines, was performed to give immediate visual feedback to the radiologist. After the measurement, *k-t* BLAST was applied individually to all sets of either four or five consecutive full acquisitions. For the Cartesian acquisitions, the removal of aliasing was attempted. For the radial acquisitions, this was not done in order to simplify the reconstruction. The point-spread function of the acquisition was instead approximated as a delta function, causing the *k-t* BLAST reconstruction to become a Wiener filter in *x-f* space. Thus, an on-line reconstruction of both the Cartesian and the radial acquisitions should be possible in principle. The latency of the reconstruction was fixed to one full acquisition. The individual single coil images were combined using estimates of the coil sensitivities derived similar to the proposal in Ref. 6.

Results

Fig. 1 shows selected images reconstructed with the adapted sliding window reconstruction and with *k-t* BLAST from a measurement with a nominal acceleration factor of eight.

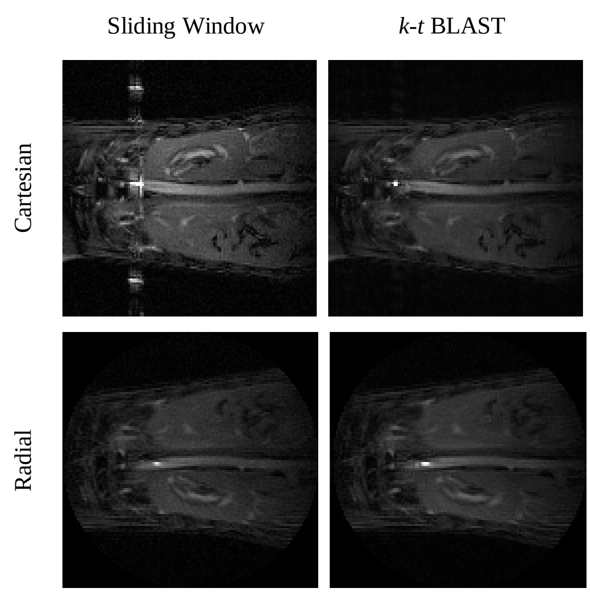

Fig. 1. Variable-density Cartesian and radial imaging with an eightfold segmentation of the acquisition. For both types of acquisitions, corresponding frames reconstructed with an adapted sliding window and *k-t* BLAST are shown.

Discussion and Conclusion

For the Cartesian acquisitions, the sliding window reconstruction produced considerable blurring and ghosting of the enhanced signal that marked the position of the catheter tip. The frequent update of the central *k*-space lines obviously helped little in improving the definition of such a high, localized signal. *k-t* BLAST was able to effectively remove this blurring and suppress most of the ghosting. The latency of one full acquisition was visible, but a further reduction might be possible. For the radial acquisitions, the high tolerance to motion of the radial sampling resulted in only minor streaking artifacts even with the sliding window reconstruction. Nevertheless, image quality was improved further with *k-t* BLAST. The enhanced signal of the catheter tip appeared stronger, and some minor streaking artifacts were removed.

In conclusion, *k-t* BLAST has great potential to provide the increase in temporal or spatial resolution needed to accurately and reliably track interventional devices in the presence of rapid physiological motion or flow.

References

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