Navigator Gated Imaging with Phase Based Edge Detection

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Introduction: Navigator echo technique has been widely used to reduce respiratory motion artifacts in cardiac and abdominal free breathing imaging. Accurate position detection of the diaphragm is essential for this technique and several algorithms are proposed [1][2]. However, as most algorithms rely on the magnitude of the navigator spatial profile, they have some difficulties in the accurate detection when the imaging region overlaps the navigator tracker and the tracker is partially saturated by the RF pulse of the imaging sequence. In this work, we present a new navigator algorithm, which improves the accuracy of the position detection even with the saturation effect, and demonstrate its application to 2D abdominal imaging.

Methods: A navigator gated 2D Fast SPGR pulse sequence was used for all experiments. At the beginning of each TR, a navigator echo was acquired using a pencil beam excitation with 10° flip angle and 256 data points. The acquired navigator echo was then Fourier-transformed into 1D spatial profile, and the edge detection technique [1] was applied to the middle 128 points of unwrapped phase data of the spatial profile to detect the position of the diaphragm. In the navigator gated acquisition, the k-space data were discarded if the respiratory displacement acquired by the navigator echo was outside of the acceptance threshold.
Free breathing scans were performed on a 1.5T scanner (Signa HDx, GE Healthcare, Waukesha, WI) using 8-element body phased array coil. 2D Fast SPGR sequence was utilized with the following imaging parameters: TE=1.5ms, TR=210ms, flip=80°, receiver BW=±31.25kHz, FOV=40cm, slice thickness=8mm, spacing=0mm, matrix size 384x224, ASSET, Spatial SAT SI, Fat SAT. Axial imaging slices were positioned across the lung and liver, and the navigator tracker was positioned across the right hemi-diaphragm. Slices were acquired in an interleaved fashion.

Results and Discussion: The unwrapped phase data showed less susceptibility to the saturation effect than magnitude data. Though saturation effects were obvious in the magnitude of the spatial profile (Fig. 1a), they could be negligible in the phase profile (Fig. 1b). For comparison, profiles without the saturation effect are shown in Fig. 1c and 1d. As the dotted lines show in the Fig. 1c and 1d, the position of the edge in the phase data shifted from that in the magnitude data. However, this shift did not affect the relative respiratory displacement used in the navigator gated acquisition.
The position of the diaphragm was detected by applying the edge detection to the phase profile, even when the edge was not clear in the magnitude profile (Fig. 2). Moreover, this algorithm was applicable to the different acquisitions, which had different slice saturation, without additional processing, though least-squares analysis [2] requires reference signals for both acquisitions. The disturbance of the phase data directly affected the detection in this algorithm. The variance of the phase data in the lung became sometimes large probably because of the blood flow, and the position of the navigator tracker was an important factor for the stability of the detection.
Navigator gated images with this algorithm showed less motion artifacts (Fig. 3). Though scan time with the navigator gated acquisition became 3 times longer or more than that with breath-hold acquisition, this application will be clinically useful for the patients who have difficulty holding their breath.

Conclusion: A navigator algorithm insensitive to the saturation effect was presented and it was applied to 2D abdominal imaging. Further work will be carried out to increase the accuracy of this algorithm and to utilize this algorithm for slice tracking applications.

References: [1] Du et al., J Cardiovasc Magn Reson. 2004; 6: 483-490. [2] Wang et al., Magn Reson Med. 1996; 36: 117-123.

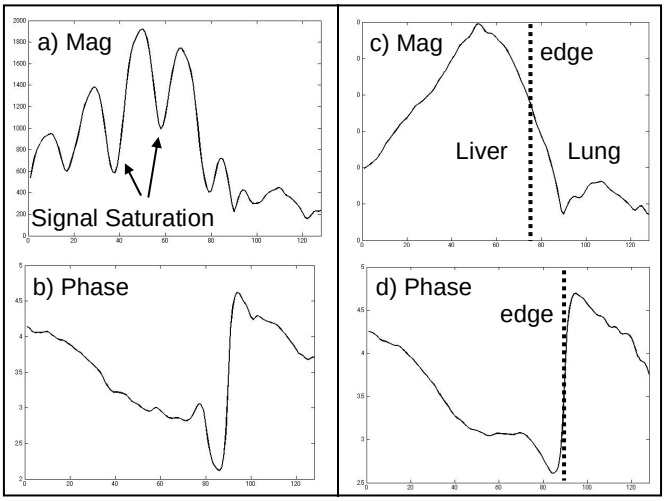

Fig. 1 Typical spatial profile of a navigator echo signal (a) & b) with saturation, c) & d) without saturation)

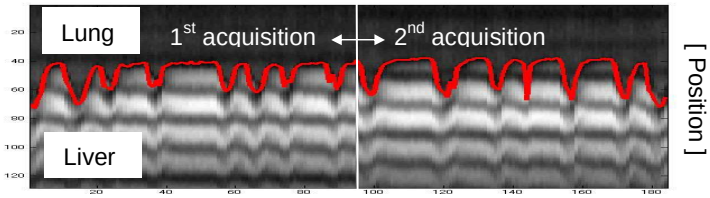

Fig. 2 Detected edges with phase based edge detection (red line) and navigator signal (background image)

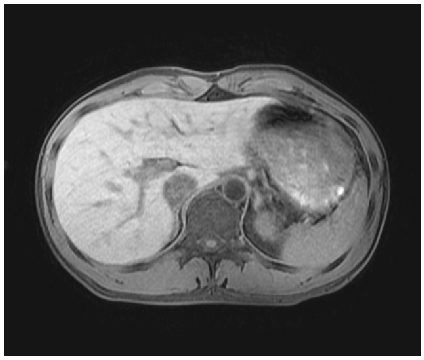

Fig. 3 Navigator Gated 2D Fast SPGR with phase based edge detection