

Automated Navigator Tracker positioning for MRI liver scans

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Introduction

The Navigator Echo sequence [1] is frequently used to compensate for respiratory motion during abdominal MRI scans. However, the navigator signal might be contaminated by the signals from the heart or large lung vessels, which in turn degrade the image quality of the navigator echo-based abdominal scan. To minimize contamination and obtain a proper navigator signal, the Navigator Tracker, which is responsible for the excitation of the Navigator signal, must be placed accurately. Placement accuracy is often dependent on the skill of the operator. To improve the workflow, an additional 3D scout scan is not required when incorporating the automated feature. The aim of this research is to demonstrate that the Navigator Tracker can be automatically positioned with a certain degree of accuracy and practical computation time using a typical three-plane localizer (2D scout scan) dataset.

Methods

Figure 1 illustrates the block diagram of our proposed method. First, 2D images are acquired using a three-plane localizer usually run at the beginning of a MR exam. We used either SSFSE (TR/TE=1141/80.9 ms, 62.5 kHz BW, 40 cm FOV, 320x192 acquisition matrix, 16 s scan time) or FSPGR (TR/TE=4.7/1.2 ms, 31 kHz BW, 48 cm FOV, 256x128 acquisition matrix, 12 s scan time) as the three-plane localizer without intensity correction. All images were resized to form 256x256 image matrices and 5 axial images were used to extract the maximum length of the right / left (R/L) and anterior / posterior (A/P) body direction using the thresholding technique. The approximate location of the boundary between the lung and liver was calculated by matching with a simple binary template. This ensured that the edges representing the derivative points near that particular boundary in each coronal image (total 7 images) and inside the body were detected. Furthermore, the edges of the liver dome were determined using a priori information, based on the mean pixel intensity of the 2 selected rectangular areas depicted in Figure 2. One area covers 5x5 adjacent pixels above the detected edge, while a second area of the same size is located below the detected edge. If the edge is located at the boundary between the lung and liver, the mean value of the upper area should be less than that of the lower area by a certain amount. This ensures the effective removal of the false edges. The liver dome edges with the most superior location in the 7 coronal images are selected, and the exact curve of the liver dome is extracted by dynamic programming (DP) [2]. The start and end points of the DP correspond to the leftmost and rightmost edges, respectively. Experienced Navigator Tracker positioning operators concur that the Tracker should be positioned at the peak of the liver dome, away from the lung and heart walls. Therefore, our method locates the dome peak by determining the highest point of the curve fitted to the polynomial expression to eliminate the noise from the surrounding areas such as liver vessels, and cysts. Thus, the R/L and S/I locations of the Navigator Tracker are accurately determined. The most superior location of the coronal slice containing the detected curve was used to determine the A/P location of the Navigator Tracker.

Results and Discussion

The red cross-mark in figure 3 indicates the detected location of the Navigator Tracker in the selected coronal slice. The available a priori information was helpful in effectively selecting the true liver dome edges. Neither the edges of the lung vessels nor any part of the heart were detected. Fifty-one healthy volunteer datasets consisting of 28 SSFSE images and 23 FSPGR images were tested off-line. The prior information was switched by which sequence was selected. Table 1 shows the mean and standard deviation of the difference between the manually and automatically detected dome locations obtained using our proposed method. The negative values of the R/L, S/I, and A/P indicate that the detected location was offset in the right, superior, and anterior directions, respectively. The S/I location is very accurate since there is a clear edge between the lung and the liver. The R/L location has a tendency to shift to the right of the dome peak. This is acceptable because the dome peak is often located close to the left heart wall. However, the variance is the largest because the dome shape depends on the respiratory condition and body structure of the patient. In this method, the thickness of the coronal slice determines the accuracy of the A/P location. The computation time involved a few seconds on a Core i5 laptop with a 2 GB memory, which is practical in an actual workflow environment. A limitation of the present study is that the proposed method was tested offline on volunteer data. However, our method would be effective on real patient data, as the liver dome is rarely deformed near the lower liver edge following surgery.

Conclusion

We proposed a new automated Navigator Tracker positioning method for MRI liver scans and demonstrated the efficacy of the proposed method in a group of 51 volunteers. The application of the 2D three-plane localizer images will simplify processing and improve workflow, requiring a very short computation time.

Reference

1. R. L. Edelman and J. P. Felmlee, Radiology 173, 255-263 (1989)
2. B. H. Brinkmann et al., IEEE Trans. on Med. Imaging 17(2): 161-171 (1998)

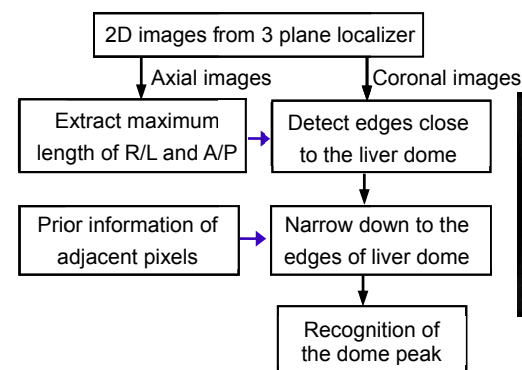


Figure 1: Block diagram

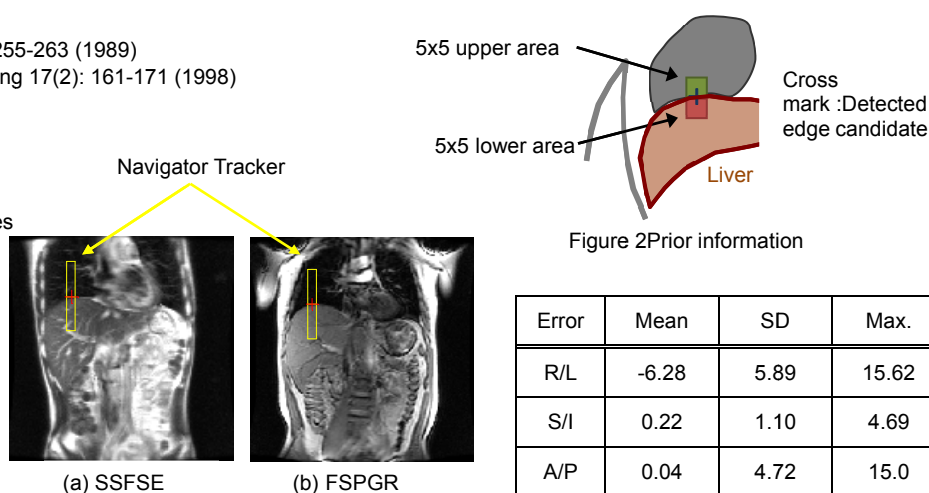


Figure 3 Navigator Trackers automatically positioned in different volunteers (a) and (b)

Table 1 Navigator Tracker positioning error