Automated scan prescription for MRI liver scans

T. Goto[1], and H. Kabasawa[1]
[1]Global Applied Science Laboratory, GE Healthcare, Hino-shi, Tokyo, Japan

Introduction

Automated scan prescription is a valuable tool for not only simplifying the workflow of MRI examinations, but also for achieving accurate and consistent slice positioning in an operator-independent fashion. Compared to other target organs, the liver is relatively easier to conduct an MRI scan prescription on the liver. Nevertheless, a few slices are sometimes not detected in a scan, and this is dependent on the skill of the operator. Only one unique approach has been proposed [1] for an automated slice prescription of the liver. However, the accuracy and required computation time were not suited for practical implementation. Our aim was to achieve an acceptable slice positioning accuracy within a practical computation time for the automated scan prescription of the liver.

Methods

The planning procedure for an MR scan of the liver primarily consists of determining the axial planes between the superior and inferior margins of the liver by identifying these edges on the localized image. Accurate detection of both edges of the liver constitutes the most important part of the implementation process. Figure 1 shows the block diagram of our proposed method. Firstly, 3D scout data (256x256x120) was acquired using the T1-weighted Fast SPGR sequence (LAVA-XV) with breath holding, parallel imaging and FAT suppression. The scan time was 17 seconds and the protocol was axial 3D, TR/TE=3.5/1.7 ms, 62.5 KHz BW, 400x320x360 mm FOV and a 256x160x60 acquisition matrix. This protocol effectively enhanced the contrast of the liver. After denoising with a 3D median filter, the intensity was corrected using a homomorphic filter [2]. Automatic thresholding removed intestinal contents, which have a higher signal than the liver and thus impedes on the liver shape detection process. To reduce the computation time, a coronal projection image extracted from the 3D data set was used for liver shape detection using a 2D Active Shape model (ASM). In our method, we assumed that the position of the superior and inferior edges in the coronal projection image corresponded to the actual edges of the liver. To validate this assumption, we manually compared positions in the coronal projection image with positions in 3D volume images. A reference point, termed the anchor point (red cross in Figure 2), was determined as a peak and saddle point of the 1D projection of the column and row directions, respectively. The mean shape of the ASM was determined by matching the anchor point with the ASM anchor landmark (Figure 3). To improve accuracy, edge detection with dynamic programming [3] was applied by tracking from the anchor landmark in a clockwise direction (blue dot circles in Figure 3). For the other landmarks, the position of the edge was established at the point where there was maximal cross correlation between the derivative of the signal changes on the profile line and the corresponding template built from the training data of each landmark. Following institutional review and approval, our method was tested on 38 healthy volunteers. In addition, 15 clinical data sets were analyzed offline after reformatting the data matrix..

Results and Discussion

The mean difference between the edge positions of the coronal projection image and the original 3D image was less than 2 mm with a standard deviation of 2 mm. These values were acceptable for determining both edges of the liver using the coronal projection image. Figure 3 shows the liver shape detection results. The yellow rectangle depicts the scan range determined by the detected superior and inferior edges. Table 1 shows the edge detection error in the volunteer data, calculated by the difference between the proposed algorithm result and the manually-identified edge position in 3D volume images. Since there is a clear boundary between the lung and the liver, the degree of positioning error at the superior edge was less than half of that at the inferior edge. However, this is acceptable as a 7-8 mm thickness and 1-2 mm spacing are commonly used as the parameters for the axial planes and 2 missing slices are equivalent to 14-20 mm. Thus, a maximum error of 15 mm is acceptable when 2 slices are missing, and a standard deviation of 5.4 mm is within the acceptable range at the 99 % confidence level. The computation time was 12.3 seconds on a Pentium 4.3GHz machine with 3 GB memory. This algorithm was computed either during the parallel imaging reference scan or during intensity correction following the 3D scout scan, thus, resulting in no increase in the total examination time.

Conclusion

Our proposed, new method for automated scan prescription for MRI liver imaging demonstrates sufficient accuracy at practical computational times. The application of 2D ASM to the 2D coronal projection image simplified processing, resulting in reduced computation time. Modifications to the edge detection method based on the landmark location additionally contributed to achieve sufficient accuracy.

Reference

1. P. Koken et al, MRM 62(1):1067-1072 (2009)
2. B. H. Brinkmann et al., IEEE Trans. on Med. Imaging 17(2): 161-171 (1998)
3. J. Liu and J. K. Udupa, IEEE Trans. on Med. Imaging 28(4): 571-584 (2009)

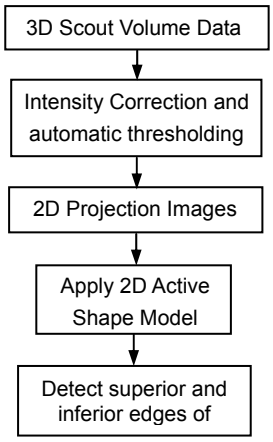

Figure 1: Block diagram

error [mm]	Mean	S.D.	Max.
Superior Edge	2.7	2.5	6.0
Inferior Edge	2.2	5.4	15.0

Table 1 Detection error of superior and inferior edges

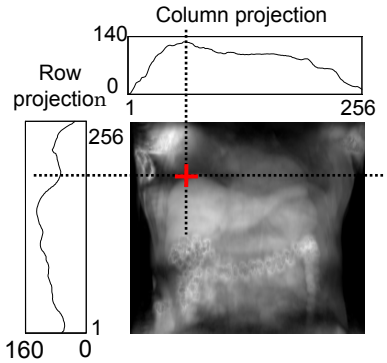

Figure 2 Coronal projection and anchor point (red)

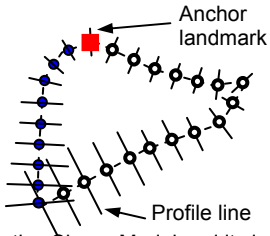

Figure 3 2D Active Shape Model and its landmarks

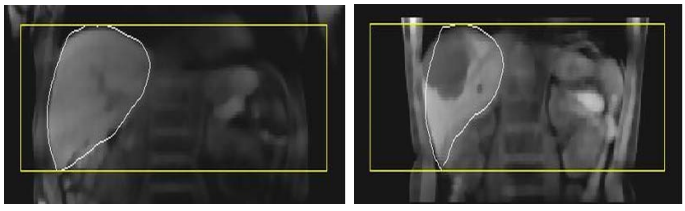

Figure 4 Shape detection results of liver (a) healthy vlunteer (b) patient