Feasibility Study of Automatic Motion Probe Setting Method for Cardiovascular Magnetic Resonance Imaging

Shigehide Kuhara[1], Shuhei Nitta[2], Taichiro Shiodera[2], Tomoyuki Takeguchi[2], Kenichi Yokoyama[3], Rieko Ishimura[3], and Toshiaki Nitatori[3]

[1]MRI Systems Development Department, Toshiba Medical Systems Corporation, Otawara-shi, Tochigi, Japan, [2]Corporate Research & Development Center, Toshiba Corporation, Kawasaki-shi, Kanagawa, Japan, [3]Department of Radiology, Faculty of Medicine, Kyorin University, Mitaka-shi, Tokyo, Japan

Target audience:

Technologists, radiologists, and image processing researchers involved with cardiovascular magnetic resonance imaging.

Purpose:

Automatic motion probe setting is expected to be useful for simplifying diagnostic imaging procedures such as whole-heart MR imaging employing motion correction to obtain high-resolution images during free breathing. This is because manual setting of the motion probe remains a time-consuming task, even for expert technologists. In this paper, we propose an automatic motion probe setting method based on detection of the heart region and the position of the top of the right hemidiaphragm. The system employs an atlas-based segmentation technique [1] to detect the heart region and the position of the top of the right hemidiaphragm at the same time.

Methods:

First, the input volume was registered to a prepared model volume with manual annotation of the heart region and the position of the top of the right hemidiaphragm. Second, two planes positioned as cross sections passing through the top of the right hemidiaphragm and not overlapping the imaging area of the heart were determined for motion probe setting. To evaluate the accuracy of the proposed method, the distance errors in the x and y directions and the Euclidean errors of the position of the top of the right hemidiaphragm between the results obtained by the proposed method and by manual annotation were measured. In addition, the inter-observer error was also measured by analyzing the differences between two manual annotations.

Results:

An ECG-non-gated 3D fast field echo (FFE) single volume covering the entire chest area was acquired using a 1.5-T MRI scanner during a single breath-hold. The scanning conditions were TR/TE = 3.7/1.3, FOV = 500x350x350 mm^3 (coronal slab), and readout/phase/slice encode steps = 256/64/35. The acquisition time was 9 seconds. The proposed method successfully segmented the heart region and detected the position of the top of the right hemidiaphragm for motion probe setting (figure 1) in 48 datasets from 15 healthy volunteers and 51 datasets from 32 patients. The distance error and the inter-observer error were 4.83±5.3 and 9.12±8.82 mm in the x direction and 3.66±3.29 and 4.13±8.78 mm in the y direction, respectively (figure 2). The distance error in the z direction was not considered because this corresponds to the longitudinal direction of the motion probe and therefore has no significant effect on the accuracy of motion correction. The Euclidean distance error and the inter-observer error were 11.04±4.73 and 14.76±19.13 mm, respectively (figure 2). The processing time was approximately 1.6 seconds (2.5-GHz CPU, single-thread processing).

Discussion:

The results indicate that the proposed method provides sufficient accuracy for use in the clinical setting, because the distance errors of this method were found to be smaller than the inter-observer error.

Conclusion:

An automatic motion probe setting method is proposed. The evaluation results showed that the position of the top of the right hemidiaphragm could be detected by the proposed method almost as accurately as by manual annotation. Our method is also able to detect other anatomical regions or positions at the same time, and we therefore plan to further improve this method so that it can detect the tops of both the left and right hemidiaphragms in order to achieve even more effective motion probe setting, with the optimal motion probe position selected according to the relative motions of the two hemidiaphragms and the heart.

Reference:

1. Nitta S et al. Proc. ESMRMB 2012, No.761

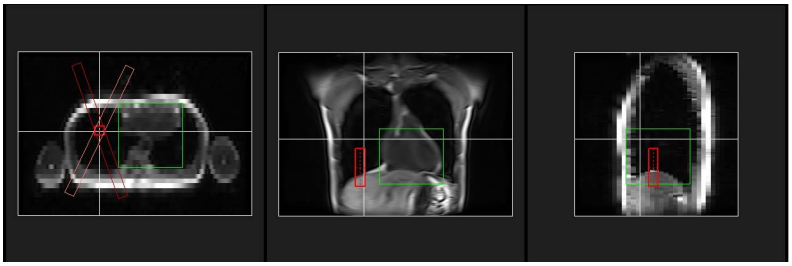

Fig. 1 Example of automatic motion probe setting for an actual patient.

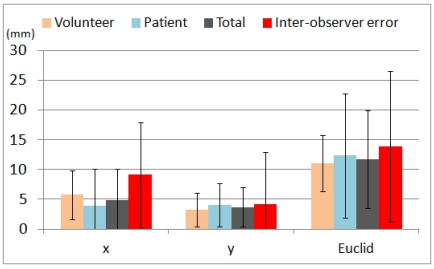

Fig. 2 Distance errors in automatic motion probe setting and inter-observer error between two manual annotations.