

Automatic Segmentation of the Medial and Lateral Meniscus in Knee MRI using Chan-Vese Model with Shape Prior

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Purpose: For diagnosis of meniscus tears and its reconstruction, an automated segmentation of the medial and lateral meniscus from MR knee images is a critical first step. However, there are several difficulties in automatically segmenting the meniscus due to similar signal intensities of the meniscus to its adjacent soft tissues such as cartilage and ligament and large shape variation and thin shape of the anterior and posterior horn of the meniscus. To overcome these difficulties, we propose an automated segmentation method of the meniscus from knee MR images using Chan-Vese model with shape prior.

Methods: The knee MR images were acquired on a Philips Intera-achieva 3.0T MR scanner for ten subjects. In-plane resolution was $0.31 \times 0.31 \text{mm}^2$ and slice thickness was 0.5 or 1.0mm. Matrix size was 512×512 pixels and the number of sagittal slices ranged from 74 to 93. Our method is composed of three main steps. First, meniscus candidates are extracted by automatically estimating a threshold value using Gaussian Mixture Modeling. Second, cartilage which has similar signal intensity with the meniscus and has a horizontally thin and long shape is removed by shape analysis. Third, Chan-Vese model with shape prior is performed to segment the meniscus without leakage to its neighbor ligament.

Results: The segmentation results using our proposed method were visually assessed in Figure 1. Using shape prior, the meniscus was segmented without leakage to its neighbor ligament. To evaluate the performance of proposed method with and without shape prior, Dice similarity and average symmetric distance(ASD) were measured by comparing the manual outlining of a radiologist. The Dice similarity coefficient was $93.30 \pm 1.78\%$ for manual versus proposed method with shape prior and $89.09 \pm 4.03\%$ for manual versus proposed method without shape prior. The ASD was $0.18 \pm 0.06 \text{mm}$ for manual versus proposed method with shape prior and $0.40 \pm 0.20 \text{mm}$ for manual versus proposed method without shape prior.

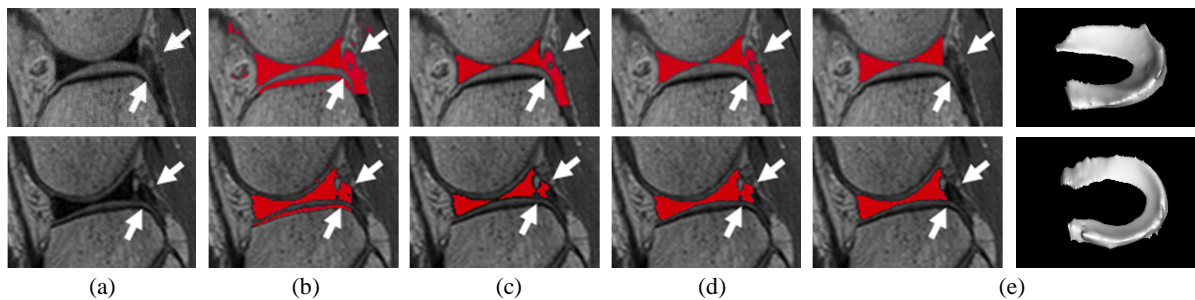


Fig.1. The results of proposed segmentation method in sagittal view: (a) original image, (b) GMM result, (c) shape analysis result, (d) proposed method without shape prior, (e) proposed method with shape prior in two and three-dimensionally.

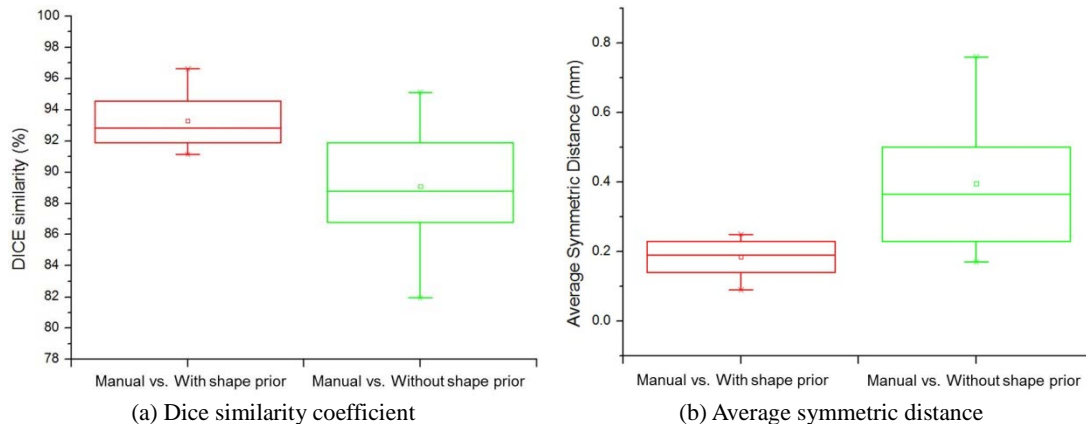


Fig.2. The results of accuracy evaluation in meniscus segmentation with and without shape prior

Conclusion: We have developed an automatic segmentation method for the meniscus in MR knee images using Chan-Vese model with shape prior. Our proposed method with shape prior extracts the meniscus without leakage to its adjacent soft tissues such as cartilage and ligament.

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