Automatic Segmentation of the Prostate in MR Images using a Prior Knowledge of Shape, Geometry and Gradient Information

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Introduction: To segment the prostate in MR images is a critical first step for the diagnosis, staging and treatment of prostate cancer. Manually outlining the prostate is tedious and subjective tasks. Due to its poor tissue contrast and shape variation, it is difficult to segment the prostate automatically. In this study, we propose a reliable and reproducible segmentation method of the prostate in MR images using a prior knowledge of shape, geometry and gradient information.

Methods: The MR images were obtained on a 3.0 Tesla Philips Gyroscan Intera system for seventy-five subjects with prostate cancer. Each image had a matrix size of 480x480, 512x512, 528x528 or 576x576 pixels with in-plane resolutions ranging from 0.29 to 0.31mm. The slice spacing was 3.9 or 4.0mm and the number of images per scan ranged from 24 to 28. The prostate surface is generated by 3D active shape model using adaptive density profile and multiresolution technique. To prevent holes from occurring by the convergence of the surface shape on the local optima, the hole is eliminated by 3D shape correction using geometry information. In the apex of the prostate which has a large anatomical variation, the boundary is refined by 2D contour correction using gradient information. The corrected surface shape is often represented as rugged shape which is generated by the limited number of vertices and it is reconstructed by using surface modeling and smoothing.

Results: The segmentation results using the proposed method were visually assessed. Fig.1 shows that the prostate in subject with general shape was accurately segmented. In addition, the prostate in subject with large anatomical variation was robustly segmented. All the evaluations were performed on an Intel Core2Quad PC containing 2.4 GHz CPU and 3.0GBytes of main memory. The performance of proposed method was evaluated by comparing the manual outlining of two radiologists. The average distance difference was 0.34±0.16mm for manual1 versus automatic and 0.35±0.14mm for manual2 versus automatic while that of inter-radiologists was 0.12±0.16mm. There was no significant difference in Dice similarity coefficient (97.80±1.26%, 97.46±1.63% and 99.10±1.60% respectively; all p > .05 by paired t-test) and volume (34.09±12.01cc, 34.16±12.11cc and 33.85±12.35cc, respectively; all p > .05 by paired t-tests). The total processing time was 35 seconds on average.

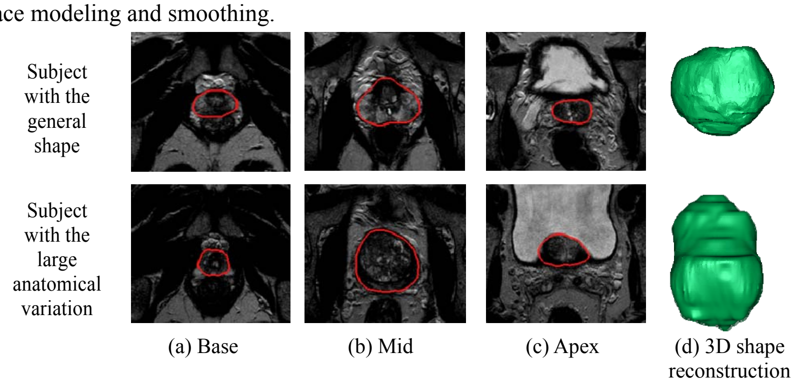
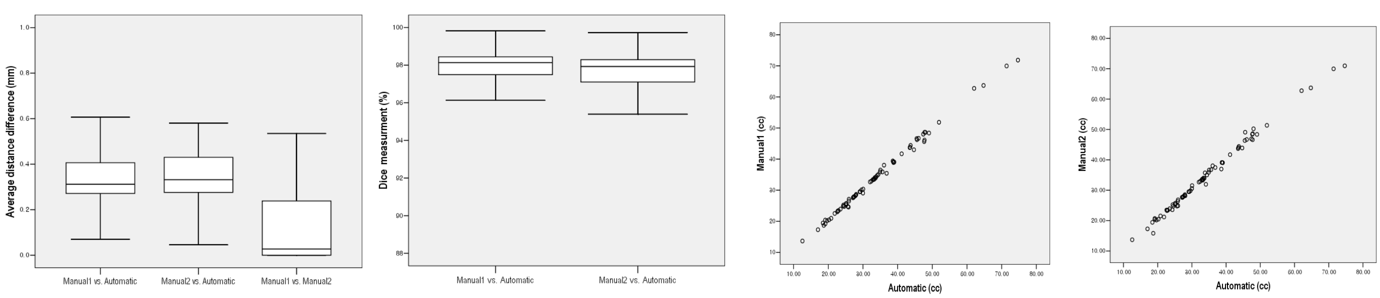


Fig. 1. **The results of proposed segmentation method**



(a) Average distance difference (b) Dice similarity coefficient (c) Prostate volume

Fig. 2. The results of accuracy evaluation between manual method and automatic method

Conclusions: We have developed a reliable and reproducible segmentation method of the prostate in MR images. Our 3D active shape model using adaptive density profile and hole elimination extracts the prostate boundary without the leakage to the surrounding tissue. In case of the apex with a large anatomical variation, the boundary is refined by our 2D contour correction using gradient information. Our method can be used to diagnose a prostate cancer and BPH (Benign Prostatic Hyperplasia) and plan a radiation therapy treatment of prostate cancer.