

3D Modeling of Pelvic Organs and Pelvic Floor Muscles in Magnetic Resonance Images

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In the recent years, high prevalence of pelvic floor dysfunctions has led to more and more research work focus on the biological and biomechanical behavior of the related muscles and their relationships with the other pelvic organs^[1]. Magnetic resonance imaging, due to some important issues, such as safety and enhanced resolution of soft tissues, is a preferred imaging modality for those works. However, the information provided in each slice (2D image) discards the spatial continuity between the neighbored slices. Consequently, medical technicians cannot obtain an intuitive and comprehensive understanding of the imaging organs through the acquired 3D slice volumes. Accurate 3D models of pelvic organs, mainly of the pelvic floor muscles, are needed to assist a thorough scope on the structures in the pelvic cavity and are valuable for clinical diagnosis.

The normal way to obtain 3D models from 3D slice volumes is to first sketch the boundaries of the different organs (or structures) in each 2D slice, and then use the sequential contours to build the surfaces. Nevertheless, the complex background in MR images of pelvic cavity should be carefully handled. Additionally, the influence of noise and partial volume effect (PVE) tend to blur the boundaries of organs and structures. Usually, this feature makes the segmentation mainly dependent on manual operations. There are some algorithms already proposed to segment certain pelvic structures^[2-4]. Among them, bladder and rectum are the most targeted pelvic cavity organs, because they have clearer appearances when compared with other organs; while the vagina and the pelvic floor muscles are usually less concerned due to their poor resolution, which forms a big challenge for automatic or semi-automatic segmentation^[4].

In our method, 3D modeling follows the normal way by reconstruction from the series of 2D contours, adopting a modeling sequence from the easy to the hard segmentation problem. Thus, organs in MR images, such as bladder and rectum, which normally suffer less influence by noise or PVE, are segmented first basing on their comparably stable shapes or intensity values. Therefore, in each 2D slice, these organs are segmented by intensity-based algorithms, such as the region growing and the watershed algorithm or deformable models, like the fast marching and the geodesic active contour algorithm^[4]. Discussions on the algorithm selections to accomplish those segmentations will be presented with the illustration of examples. Then, the locations and the shapes of those segmented organs are assumed as a priori knowledge and are used as spatial clues to identify the approximated locations of other more complex imaged organs. Thus, new deformable models are designed to segment the outer boundary of the vagina and the boundary of pelvic floor muscles, and intensity contrast, prior shape information, and spatial relationship between the organs and structures are incorporated to the deformable models to fulfill the segmentation, Figure 1. Effectiveness of the proposed algorithm will be analyzed through several example cases with the comparisons to the results obtained by more traditional algorithms.

3D models of pelvic organs and pelvic floor muscles obtained by our algorithms will be compared with the ones built from manual segmentations. Based on the comparisons done, the feasibility of automatic segmentation and reconstruction of organs from MR images of pelvic cavity are concluded;

also, the presentation will summarize the perspectives of further work.

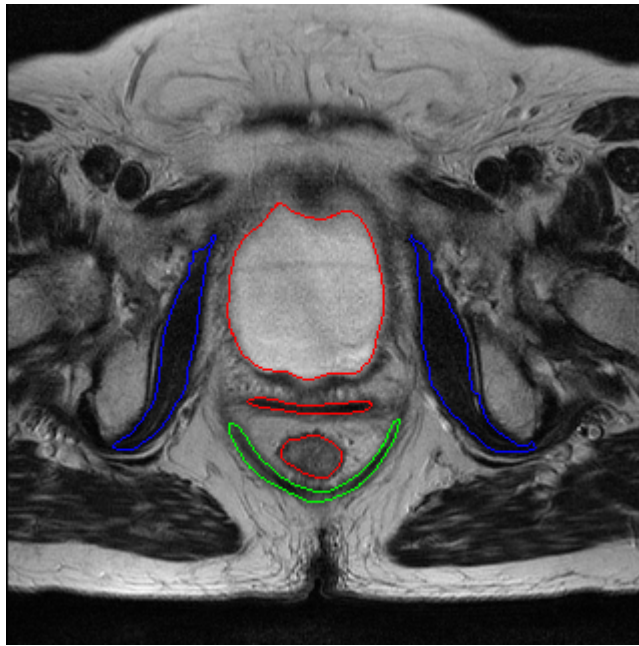


Figure 1. Segmentation results in a 2D image slice by the adopted algorithms: boundaries of levator ani (green), obturator internus (blue), bladder, vagina, and rectum (red, from up to down).

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References

- [1] G. M. Buchsbaum, E. E. Duecy, L. A. Kerr, L. S. Huang, D. S. Guzick. Urinary incontinence in nulliparous women and their parous sisters. *Obstet Gynecol.* 106(6):1253-1258. 2005.
- [2] M. Mazonakis, J. Damilakis, H. Varveris, P. Prassopoulos, N. Gourtsoyiannis. Image segmentation in treatment planning for prostate cancer using the region growing technique. *Br J Radiol.* 74 (2001):243-248. 2001.
- [3] D. Pasquier, T. Lacornerie, V. Maximilien, R. Jean, L. Eric, B. Nacim. Automatic segmentation of pelvic structures from magnetic resonance images for prostate cancer radiotherapy. *Int J Radiat Oncol Biol Phys.* 68(2):592-600. 2007.
- [4] Z. Ma, J. Tavares, R. Jorge, T. Mascarenhas. A review of algorithms for medical image segmentation and their applications to the female pelvic cavity. *Computer Methods in Biomechanics and Biomedical Engineering*, DOI: 10.1080/10255840903131878, in press. 2009.