Image Processing on Magnetic Resonance Images of Female Pelvic Cavity using Deformable Models

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Introduction

Magnetic resonance imaging (MRI) is a popular imaging modality in the study of female pelvic floor dysfunctions (PFD). The acquired image data need to be processed in order to perform biomechanical analysis; in this process, segmentation and reconstruction are two critical steps that determine the accuracy of the three-dimensional (3D) models of the structures. However, due to the complex anatomy of the female pelvis, manual processing is very time-consuming. Consequently, computer-aided image processing pipelines are demanded.

Methods

In our work, an image processing pipeline based on deformable models is proposed; the urinary bladder, vagina, rectum, and levator ani muscle on magnetic resonance images were focused. Various clues such as intensity contrast, intensity distribution, and prior knowledge are incorporated into the deformable models to carry out the segmentation and reconstruction. The sequence of segmentation follows the “simple-to-complex” rule: as the levator ani muscle has the most complicated shapes and imaging appearances, the pelvic organs are segmented first. The difference and similarity of the imaging appearance among the three pelvic organs and their surrounding tissues are used; a coupling algorithm was proposed that can achieve the simultaneous segmentation of the three organs. In addition, a two-step algorithm was developed to segment the inner and outer boundaries of the urinary bladder. Then, the locations and the boundaries of pelvic organs were used to assist the segmentation of the levator ani muscle; a shape guided deformable model was proposed, which introduced a spatial influence field to drive the contour to the correct boundary. For the reconstruction, a deformable model was derived based on an energy functional defined by the weighted distance to the cross-sectional boundaries of the tissue; the algorithm takes advantage of the information from multiple views of MRI and provides a flexible way to build a reliable 3D model with more geometric details.

Results & Conclusion

The image processing pipeline developed can effectively segment the MR image data and reconstruct the 3D models of the involved pelvic structures. Experiments and case studies will be used to show and discuss the effectiveness of the algorithms developed and to compare their performances to manual operations and other algorithms through quantitative analysis. The main obstacles and techniques that can improve the performance of the algorithms will also be discussed.

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Reference

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