Image Processing for MR-guided

Gynecologic Interstitial Brachytherapy in AMIGO

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Purpose

Interstitial brachytherapy, the delivery of planned radiation dose directly to the tissue via hollow needles inserted into the tumor and surrounding anatomy, is an effective treatment for gynecological cancer [1]. The purpose of the software module described here is to provide assistance to the physician in determining the optimal distribution and insertion depth of needles that provide maximal tumor coverage, while minimizing dose to the surrounding organs of interest such as the rectum, the bladder, and the sigmoid colon.

Methods and Materials

3D Slicer [2] is a free and open source software package for medical image analysis and visualization. iGyne(with its workflow shown in Fig.1) is a 3D Slicer module designed for MR-guided interstitial brachytherapy planning for gynecologic cancer in the Advanced Multimodality Image Guided Operating Suite (AMIGO) at Brigham and Women's Hospital. Use of the iGyne in AMIGO includes the following steps:

- 1) CAD models of the interstitial template and vaginal obturator are loaded;
- 2) MR scan of the patient with the template sutured to the perineum and the obturator placed in the vaginal canal is transferred to 3D Slicer using the DICOM protocol;
- 3) An initial rigid registration is computed from 3 corresponding point pairs provided by the user on the template holes(as shown in Fig.2); 4) The registration is refined using the Iterated Closest Point [3] algorithm for rigid registration (as shown in Fig.3);

Conclusions

While the current version of iGyne address some important aspects of the planning task, including robust registration, needle visualization, user-friendly interface, it remains under active development for additional features such as integration with needle tracking hardware, which are essential in order to realize its full benefit for MR-guided needle guidance in AMIGO.



Figure 2. The screenshot of the initial registration result

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- 5) Optionally, segmentation and visualization of 3D models of the tumor are obtained rapidly using editing capabilities of 3D Slicer,
- 6) Finally, virtual needles are selected on a schematic of the template and rendered in the 2D and 3D views, with the insertion depth independently adjustable for each needle. This allows for ease of visualization of spatial relationships among the needles, tumors, and surrounding anatomical structures can be clearly observed, and hence ease in determination of the optimal number and positions of the needles, as well as insertion depth (as shown in Fig.4)





Figure 3. The screenshot of the refined registration result in iGyne



Figure 4. The visualization of the tumor and selected needles in iGyne

Acknowledgements

The authors would like to acknowledge the support of the AMIGO team in enabling this clinical study, Kanokpis Townamchai, M.D. for performing the manual segmentations of the medical images, members of the *Slicer Community*, especially

Figure 1. The workflow of the iGyne and its relevant algorithms

Steve Pieper, Ph.D., for creating a platform that enabled iGyne. This work is supported by the National Institutes of Health (NIH) grants P41EB015898, R03EB013792 and U54EB005149, and Dr. Viswanathan receives support from NIH

grant K07CA117979.

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9th Interventional MRI Symposium September 22-23, 2012 Joseph B. Martin Conference Center, Harvard Medical School, Boston, Massachusetts

Results

A software module for MR-guided gynecologic brachytherapy has been developed for the established 3D slicer open source software platform using wellregarded toolkits in computer graphics and medical image processing such as VTK, ITK, CTK, and QT [4]. Furthermore, a multi-stage registration method is presented to register the CAD template model to the MRI image volume.