Robust Applicator Registration for Interstitial Gynaecologic Brachytherapy

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Purpose – We present a method for robust localization of the Syed-Neblett gynecologic brachytherapy applicator in intra-operative Magnetic Resonance (MR) imagery by alignment with its computer aided design (CAD) model. This alignment allows us to visualize "virtual needles" prior to the actual insertion.

Methods – Previously, we reported initial development of a software module named "iGyne" using the free and open source software platform *3D Slicer* (http://www.slicer.org). Within iGyne, we reported a registration method based on user-initialized correspondences between 3 points, followed by Iterative Closest Points surface registration of the Syed-Neblett template [2,5]. In this work, we provide additional information to the registration method by including the obturator in the process. Specifically, we have added to the iGyne software module a step that automatically segment the obturator from the rest of the image based on the difference of contrast between the obturator and its surrounding tissues. As an intermediate step, a 3D model is generated from the segmented label map of the obturator, and then an ICP registration (similar to [5]) is used to register the surfaces of both the template and obturator CAD models against their segmentations in the MR images.

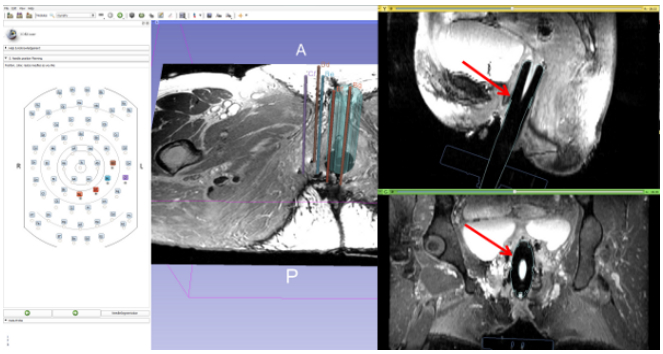

Figure 1. Interface of *iGyne* in *3D Slicer* allowing simulating insertion of needles (left image). Result of the refined ICP registration of the obturator and the template (right images).

Results – We applied this method to six T2-weighted MRI datasets acquired using a Siemens 3T scanner in the Advanced Multimodality Image Guided Operating (AMIGO) suite at Brigham and Women's Hospital.

We computed the quadratic mean distance (Root Mean Square error) between corresponding resulting points – of a manually obtained registration (ground truth) – and of both registration methods described above. We obtained a significant accuracy improvement compared to the previous (template-only) registration method. The RMS error dropped by more than 70% (from 14mm to 4mm). We also obtained a significant computation time improvement (eight times shorter) compared to the GrowCut method [3,4] which was previously used to segment the obturator by asking the user to apply roughly label on its inside and outside. Figure 1 illustrates a representative case. To support open science, all data sets used in this study have been anonymized and made available freely and publicly [6]. Potential users of this data are requested to cite article [2] that provides the overall vision of gynecological brachytherapy in AMIGO.

Case	Initial registration error (mm)	"Template only" error (mm)	"GrowCut" error (mm)	"Auto segmentation" error (mm)
1	21.08	2.01	1.45	3.57
2	18.24	24.61	7.96	6.70
3	7.98	8.46	2.92	7.31
4	8.51	12.17	0.84	6.10
5	17.60	16.75	7.11	0.71
6	22.58	19.74	3.00	1.38
Average	16.00±6.28	13.96±8.14	3.88±2.96	4.30±2.83
Computation Time (s)		32±7	235±124	27±4

Table 1. Evaluation of the RMS error and computation time of the methods named by the column header. The first column presents the evaluation results of the registration state after the first initial landmark registration. RMS error are in millimeters, computation times are in seconds.

Conclusions – In this contribution, we present a registration method for CAD models of the Syed-Neblett template and the obturator for interstitial gynecologic brachytherapy that is available in the iGyne module of the open source software package 3D Slicer. Areas of immediate future work include the further improvements to the accuracy of the method so that it is less than 2mm Root Mean Square error.

References

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[6] BWH/DFCI Gynecological Brachytherapy Open Data Collection. http://www.spl.harvard.edu/publications/item/view/2227

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