FEASIBILITY OF IN-VIVO SOURCE POSITION VERIFICATION DURING HIGH DOSE RATE PROSTATE BRACHYTHERAPY USING A 2D DIODE ARRAY

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Introduction: Due to uncertainties in the identification of catheters during planning of high dose rate (HDR) brachytherapy treatments, as well as the potential for catheter shifts in the time between imaging and treatment, there exists a need for real-time source position verification to ensure safe and accurate treatment delivery. This study aims to assess the feasibility of source position verification using a 2D diode array embedded below the patient in a carbon fibre couch. Both CT based and real time trans-rectal ultrasound (TRUS) based treatment planning methods were investigated.

Materials and Methods: Monte Carlo simulations of source positions from a HDR prostate brachytherapy treatment were performed using Monte Carlo methods, through the Geant4 platform [1]. An Ir-192 Flexisource (Isodose Control, Veenendaal, The Netherlands) was simulated inside a voxelized patient geometry, and the response of each detector in the couch embedded ‘Magic Plate’ diode array was evaluated. The ‘Magic Plate’ is a two-dimensional silicon diode array developed at the Centre of Medical Radiation Physics (CMRP), University of Wollongong, Australia, originally as a tool for intensity modulated radiation therapy (IMRT) quality assurance. The detector response was then used to determine the distance of all detectors in the array to each of the source positions. Finally, the source position was triangulated using a proprietary algorithm. The simulations were then repeated with a TRUS probe positioned inside the rectum of the voxelized patient. The TRUS probe introduces an inhomogeneity that negatively effects the triangulation accuracy. A modified algorithm was developed to improve the source position verification in the presence of the TRUS probe.

Results: The accuracy of source position localization using the diode array embedded in the patient couch was found to be approximately of 2.1 ± 0.81 mm (k = 1) when all detectors in the array were used in the localization algorithm. Re-calculation of the simulations with all voxels assigned a density of water improved this localization accuracy to within 1 mm. The presence of the TRUS probe was found to decrease the source position localization accuracy to 6.26 ± 0.85 mm. However, modification of the algorithm to account for the presence of the inhomogeneities introduced by the TRUS probe improved the source position localization accuracy to 2.20 ± 1.07 mm.

Conclusions: The effect of tissue inhomogeneities in the patient geometry on source localization accuracy during a HDR prostate brachytherapy treatment was examined through Monte Carlo calculations. The localization accuracy was found to be affected by the inhomogeneities, with the inclusion of a TRUS probe inside the rectum significantly decreasing the accuracy of the system. However, a modification to the source position localization algorithm was found to compensate for the effect yhe TRUS probe. Future studies will focus on optimizing the registration of Magic Plate and patient coordinate systems through the use of rigid registration to the prostate template and stepper system.

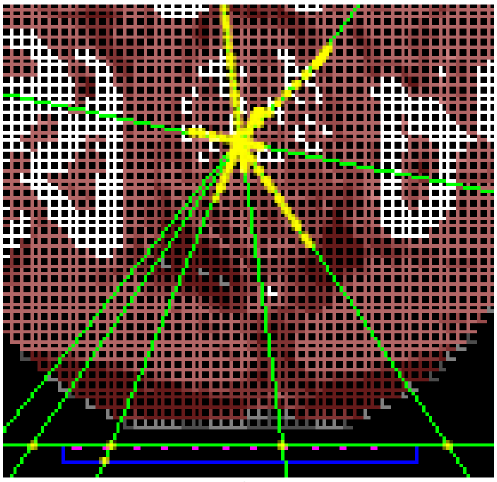

Figure 1. Partial axial view of voxelized patient geometry in Geant4 source position simulations.

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References:

1. Geant4 Collaboration (S. Agostinelli et al.), *Nucl. Instrum. Meth. Phys. Res*. A **506**, 250-303 (2003).
2. Characterization of a novel two dimensional diode array, the “magic plate” as a radiation detector for radiation therapy treatment (J. Wong et al.), *Med. Phys.* **39**(5):2544-2558 (2012).