Ph.D. Thesis Abstract for Vibha Chaswal

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Adjoint Based Treatment Planning for Brachytherapy: Novel Techniques & Further Developments

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Treatment planning in brachytherapy involves a solution in the form of an acceptable seed and needle configuration fulfilling the treatment planning goals. The target has to be irradiated with uniform prescribed dose with minimal exposure to the adjacent or embedded organs at risk. The number of potential seed positions to choose from is large. More than one seed configuration can fulfill the treatment planning aims. Treatment planning algorithms based on forward dose calculations are iterative in nature as a seed configuration is evaluated against set criteria or constraints and accepted only when they are met.

Methods based on adjoint transport have been proved to generate acceptable treatment planning solutions both in brachytherapy treatment planning and external beam treatment planning. The brachytherapy treatment planning device using adjoint methodology is a Greedy Heuristic (GH) algorithm that generates a solution non-iteratively. The adjoint sensitivity fields operate as a guidance tool for selecting seed positions with the maximum benefit towards depositing dose in the target and sparing the sensitive structure. The GH algorithm thus selects positions one after another and constructs a treatment plan that is acceptable.

This work investigates the development and utility of at least three innovative treatment planning techniques in brachytherapy and a new adjoint based treatment planning device for High Dose Rate (HDR) multi-catheter interstitial brachytherapy. Techniques for Interstitial implant brachytherapy using more than one seed species, directional sources brachytherapy using the anisotropic ^{125}I source and performing permanent seeds brachytherapy without template guidance are some of the innovative techniques discussed. All new techniques are evaluated taking example of prostate sarcoma. A dose-homogeneity based dwell time optimization for HDR brachytherapy treatment planning device is discussed. The multi-catheter HDR technique is evaluated for an accelerated partial breast irradiation case.

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