

Development and clinical introduction of an inverse planning dose optimization by simulated annealing (IPSA) for high dose rate brachytherapy

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High dose rate brachytherapy is a promising radiation treatment modality that uses temporarily implanted catheters to deliver the curative dose directly in the tumor. A programmable robotic device (the afterloader) moves a single tiny radioactive source (^{192}Ir) along the catheters using a flexible cable attached to the source. With this flexible system, a wide variety of dose distributions can be generated from a given implant simply by adjusting the length of time (dwell time) that the source dwells at any location within the implanted catheters (dwell position). The challenge is to select the optimal sequence of dwell times related to the unique clinical situation of each patient. This treatment-planning problem can be formalized as a combinatorial optimization problem. The optimization algorithm presented in this thesis is conceived to perform this task. An inverse planning (IP) approach has been adopted to guide the optimization process. This means that the optimization is guided by clinical objectives described by means of dose constraints specified to each digitized anatomical structure. A simulated annealing (SA) optimization engine has been designed to solve this particular problem in a short time for clinical applications (about 30 s). This inverse planning by simulated annealing (IPSA) algorithm has been successfully implanted in four institutions: UCSF(1), CHUQ(2), NIH(3), CAV(4). At the moment of writing this thesis, more than 300 patients have been treated at these institutions for a wide variety of anatomical sites. Clinical studies performed by clinicians using IPSA demonstrated that the algorithm produces superior treatment plans from a dosimetric point of view than the conventional method using geometrical optimization. IPSA improves the target dose coverage while minimizing the dose delivered to organs at risk and provides consistent results from one patient to another. Both dosimetric indices and overall procedure time were improved with the clinical introduction of IPSA.

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[Copies of this thesis are available from the author.]