BEYOND THE DVH
--- SPATIAL AND BIOLOGICAL RADIOTHERAPY TREATMENT PLANNING

by

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DISSERTATION

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ABSTRACT

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Major: Medical Physics

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Purpose: Both spatial and biological information are necessary in order to perform true optimization of a treatment plan and for predicting clinical outcome. The goal of this work is to develop an enhanced treatment plan evaluation tool which incorporates biological parameters and retains spatial dose information.

Methods: A software system named SABER (**S**patial **A**nd **B**iological **E**valuation for **R**adiotherapy) is developed which provides biological plan evaluation with a novel combination of features. It incorporates hyperradiosensitivity using the induced-repair model and applies the new concept of Dose Convolution Filter (DCF) to simulate dose wash-out effects due to cell migration, bystander effect, and tissue motion during treatment. Further, the concept of spatial dose-volume histogram (sDVH) is introduced to evaluate and potentially optimize the spatial dose distribution in the target volume. Finally, generalized equivalent uniform dose (gEUD) and gEUD in 2Gy fractions ($gEUD_2$) are derived from physical dose distribution and equivalent dose

distribution in 2Gy fractions, respectively. The software provides three models for calculation of Tumor Control Probability (TCP), Normal Tissue Complication Probability (NTCP), and Complication-free TCP (P+). TCP, NTCP and P+ are provided as a function of prescribed dose and multi-variable TCP, NTCP and P+ plots are provided to illustrate the dependence upon individual parameters used to calculate these quantities.

Results: By retaining both spatial and biological information about the dose distribution, SABER is able to distinguish features of radiotherapy treatment plans not discernible using commercial systems. Plans that have similar dose-volume histograms may have different spatial and biological characteristics, and the application of novel tools such as sDVH and DCF within SABER and the choice of radiobiological models may substantially change the predicted plan metrics such as TCP and NTCP, and thus change the relative plan ranking. The voxel-by-voxel TCP model makes it feasible to incorporate spatial variations of clonogen densities, radiosensitivities, and fractionation sensitivities as those data become available.

Conclusions: The SABER software incorporates both spatial and biological information into the treatment planning process. This may significantly alter the predicted TCP and NTCP and thus the choice of treatment plan. Thus SABER can help the planner compare and choose more biologically optimal treatment plans and potentially predict treatment outcome more accurately.