Contribution ID: **83** Type: **poster preferred**

A novel analytical method of biological treatment plan optimization

Tuesday, 16 October 2012 16:11 (1 minute)

Modern treatment planning allows the achievement of complex goals. Minimum and maximum doses cannot be considered as adequate figures of merit for the quality of a plan, and that is the reason why a complex set of parameters has to be evaluated when an irradiation plan is to be assessed. Particularly, radiobiological indices are useful tools for this evaluation, as they relate the plan to specific clinical goals. Therefore, when optimizing a treatment plan it is very useful to be able to characterize treatment plans, according to the closeness of their indices to a reference value (a goal or a previous result should be improved). A measure of closeness to the objective dose distribution is needed, and it has to be related to the values of the index. In this work, we propose a type of distance between dose volume histograms that can be used to biologically optimize a treatment plan.

Given a DVH curve, the function F(z)=1-DVH is a distribution function for some random variable (absorbed dose for random points inside the tumour in this case). The Lévy distance between the distribution functions F and G, dL(F,G) can be defined and used as a metric between absorbed dose distributions.

The problem to be considered is whether or not two DVHs inside a given Lévy distance correspond to tumour control probabilities within a specified interval of values. And the inverse problem is to establish the maximum Lévy distance between two DVHs in order to fulfil a constraint on TCP.

TCP is represented as an operator on the set of probability distributions T. If T is an operator, and it is continuous, an upper and lower bound can be found on its values for distribution functions at a distance of R0 from F0. Therefore, given a tolerance on TCP, a set of DVH constraints can be given ensuring that tolerance is fulfilled.

Any functional on DVHs can be treated according to this new theoretical framework, as long as it shows a minimum of good analytical properties of continuity and differentiability, as it is typically the case with radiobiological indices.

This method is has a straightforward application, and shows great flexibility making easier a decision making process.

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Session Classification: Poster Session 1

Track Classification: Biological and Physical Dosimetry