Inverse treatment planning with a biological objective and physical dose constraints

An inverse treatment planning (ITP) technique is proposed which aims at maximizing the local tumor control probability (TCP) while keeping the dose to healthy tissues below specified levels. The use of TCP-based objective function in the optimization process escalates the dose in the target with severe penalties for cold spots. The inverse of the TCP is shown to be a convex function of the pencil beam weights and therefore a suitable objective for minimization. The linear constraints require that the dose to critical structures be below selected limits and that the pencil beam weights be non-negative. While the dose constraints do not account explicitly for dose-volume considerations, they are relevant for organs with serial architecture, such as the spinal cord. Since both the objective function and the constraints are convex functions of the pencil beam weights, the previously reported continuous penalty function method (CPFM)[1] can also be applied to the proposed here formulation of the ITP problem. Furthermore, due to the convexity of the objective function and the constraints, the CPFM solution is also a global solution of the inverse problem. Contrary to the ITP techniques based on dose reconstruction, this technique does not introduce hot spots outside the target. It can serve as a dose escalation engine for treatment sites, which involve serial critical organs.

[1] D. H. Hristov and B. G. Fallone, “A continuous penalty function method for inverse treatment planning,” Med. Phys., 25(2), 208-223, 1998.