Workshop Radiotherapy & Mathematics

Title: Radiotherapy optimization methods for modulated beams in Monte Carlo treatment planning

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Summary: Cancer treatment is undertaken by three medical applications, concomitant in many cases: surgery, chemotherapy and radiotherapy. Apart from chemotherapy, which addresses the issue as a systemic disease, the other two techniques consider the tumor as a target volume to be resected or irradiated, either with the knife or with radiation. Currently, radiotherapy has increased its prominence thanks to new technologies in focus and beam shaping. Although there are few proton therapy centers, where the problem can be considered quasi-ballistic, conventional teletherapy based on electromagnetic radiation has evolved tremendously with the advent of multileaf collimators (MLC), whose versatility for shaping the beam, allows not only the adjustment to spare health tissue (3D conformed), but also to achieve the modulation of the beam fluence in order to use heterogeneous intensity beam capable of take into account the different densities and thicknesses of the tissues to reach the tumor, as well as the capricious shapes of the volumes to be treated and their positions relative to healthy structures where the dose should be as low as possible (IMRT).

These modulated fields can be delivered by means of the irradiation through a dynamic movement of the leaves (sliding windows) or by a number of segments or apertures with different fluencies (step&shoot). The planning necessary to calculate the weights or fluence (a controlled irradiation time) for each aperture or for the dynamic movement is a mathematical problem extensively referenced even in mathematical journals (Linear and Nonlinear Models and Algorithms in Intensity-Modulated Radiation Therapy. LINEAR ALGEBRA AND ITS APPLICATIONS Vol. 428). Moreover, the dose calculation is a problem linked to the no local deposition of the energy of the primary particles in the beam and new others generated from the interactions with the head of the linear accelerator or with the patient. The electromagnetic shower of particles is well described by the physic by means the corresponding probability distribution functions. Basically, these probabilities of events are dependent on the energy, the atomic number of the atoms in the molecules forming the tissue and the density of them. The more accurate solution of the dose distribution has to be obtained by means of a numeric method as Monte Carlo simulation. This method is already considered as the gold standard of the dose calculation engines, although it means an important time consuming. The implementation in the daily clinical activity of these mathematical techniques is a hot topic in radiotherapy today.