TREATMENT PLANNING: IMRT OPTIMIZATION – BASIC
AND ADVANCED TECHNIQUES

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Abstract This chapter will give an introduction on the different available intensity modulated radiation therapy (IMRT) optimization techniques.

Keywords: IMRT; optimization

1. Introduction

This chapter will give an introduction on the different available intensity modulated radiation therapy (IMRT) optimization techniques. The first part of this chapter explains the basic features of IMRT while the second part is intended as an outlook of what is currently under investigation by researchers all around the world. For a more comprehensive overview of IMRT the reader is referenced to the books of Professor Steve Webb\textsuperscript{14,15} or recently published review papers.\textsuperscript{1}

2. The basics of IMRT optimization

The aim of every treatment technique is to achieve a conformal dose distribution to the target while reducing the dose to any organs at risk (OAR). The typical example used to demonstrate the features of IMRT is a horse shoe shaped target with an OAR in the middle (Fig. 1).

During conventional treatment planning all geometrical parameters are adapted by the treatment planner in such a way as to obtain the best possible treatment plan. Typical free parameters are the energy, the isocenter position inside the patient, the beam directions, the leaf positions and the weighting
factor of the fluence. After these parameters are fixed the treatment planning system (TPS) starts the dose calculation and the resulting dose distribution is analysed. If the result is not sufficient to achieve the predefined constraints the user manually adapts the free parameters and restarts the dose calculation. This workflow is called forward treatment planning. The main difference between conventional therapy and IMRT is that the fluence distribution from one beam direction is not uniform any more but the 2D fluence distribution is now a function of the position x and y in the beam’s eye view coordinate system. On the left side of Fig. 1 the yellow arrows for each beam have the same length at each position inside the treatment field whereas on the right side these lengths of the arrows are modulated. Due to this modulation the resulting 3D dose distribution for IMRT improves the sparing of the OAR (green). This chapter will briefly explain how this fluence modulation is calculated based on the planning constraints set by the treatment planner. Since for the IMRT planning process the user defines the dose distribution that he would like to obtain and the system then calculates the treatment parameters using a mathematical optimization algorithm this process is called inverse treatment planning.

The standard loop of an inverse treatment planning system is outlined in Fig. 2 and consists of the following boxes:

1. Treatment Parameters
2. Dose Calculation
3. Objective Function based on clinical experience
4. Optimization algorithm

Figure 1. Principle of inverse planning. (Images taken from: Schlegel and Mahr, “3D Conformal Radiation Therapy: multimedia introduction to methods and techniques”, 2nd revised and enhanced edition, Springer Verlag.)