Experimental characterization of convolution kernels for intensity modulated radiation therapy (in Spanish)

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The first part of the thesis reviews the photon and electron interaction mechanisms in a medium and the basic dosimetry concepts. Photon dose calculation algorithms are summarized, including tissue-phantom ratio (TPR) calculations, convolution-superposition and pencil beam models, and Monte Carlo methods.

A procedure for characterizing the radiation beams generated in a linear accelerator has been developed, as well as a dose calculation algorithm applicable to intensity modulated beams. The beam characterization is experimental and is based on a pencil beam deconvolution procedure using the Hankel transform. This transform enables the work with fields with rotational symmetry, using one variable to represent two-dimensional signals. Two different geometric shapes for the incident fluence have been used. A circular collimator made of lead, with a diameter of 50 mm, was manufactured for obtaining a two-dimensional circular step function. The mathematical problems encountered when analyzing the signal suggested the possibility of using a Gaussian fluence, whose Hankel transform is also a Gaussian function. A tungsten filter was manufactured for generating this fluence shape. The pencil beam kernels derived with both fluences were used to calculate the output factor curves, that were compared with the experimental one.

A pencil beam calculation algorithm based on the kernels obtained was also developed. For testing the calculation accuracy of the whole system a series of measurements in modulated fields in homogeneous media were taken, including absolute dose values at single points measured with ionization chamber, relative dose profiles measured with linear array of diodes and radiographic film, and two dimensional dose distributions measured with film. The gamma index criteria was used to compare the differences between the calculated and measured dose distributions. The practical issues of dose measurement in modulated and small fields are discussed from a

methodological point of view. The selection of the most suitable detector for each situation has been justified.

The measurements taken and their comparison with the calculations performed demonstrate that it is a valid method for dose calculation for intensity modulated beams. The percentage of points passing the gamma index criteria (3 %, 3mm) is higher than 97 % for most of the presented cases. The comparisons performed between the calculations of the developed algorithm, the experimental measurements, and the calculations from a commercial treatment planning system are satisfactory. The differences in the absolute dose values at single points calculated with the algorithm with measurements are mainly into the [-2.3, 4.3] % interval, with a mean value of 1.4 %. The agreement between the dose calculation at single points with the algorithm and a commercial planning system is between ± 5 % for most of the evaluated fields. These last two comparisons were performed without taking into account the distance criterion, so the single points studied could lie in a high dose gradient area.

Last the polymer gel dosimetry is introduced. In its application to this study, it will be able to enable the characterization of the radiation beams in three dimensions with one measurement. The existing difficulties that make this technique being still a matter of research are discussed.

The convolution kernel measured in this work is purely experimental. This property enables this system being a double check system for the absorbed dose calculated with the modern commercial treatment planning systems, that usually employ convolution kernels calculated by Monte Carlo simulations. Extensions of this work are the application to charged particles and the dose calculation based on fluence measurements obtained with an electronic portal imaging device.

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