Development of PC-based Radiation Therapy Planning System

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ABSTRACT

The main principle of radiation therapy is to deliver optimum dose to tumor to increase tumor cure probability while minimizing dose to critical normal structure to reduce complications. RTP system is required for proper dose plan in radiation therapy treatment. The main goal of this research is to develop dose model for photon, electron, and brachytherapy, and to display dose distribution on patient images with optimum process. The main items developed in this research includes: (1) user requirements and quality control; analysis of user requirement in RTP, networking between RTP and relevant equipment, quality control using phantom for clinical application (2) dose model in RTP; photon, electron, brachytherapy, modifying dose model (3) image processing and 3D visualization; 2D image processing, auto contouring, image reconstruction, 3D visualization (4) object modeling and graphic user interface; development of total software structure, step-by-step planning procedure, window design and user-interface. Our final product show strong capability for routine and advance RTP planning.
Keywords: RTP, Dose Model, Image Processing, 3D Visualization

1. INTRODUCTION

It has been shown in the past [1], that conventional two dimensional treatment planning can produce side effects where critical organs are close to the target volume. In 2dimensional RTP, even if the dose distribution in the central plane fits the target volume and avoid critical organs a quite different situation can be found in off-axis planes. Therefore three dimensional treatment planning should be applied. The main problem of three dimensional treatment plannings are: user requirements and clinical applications; development of dose model in radiation therapy; image processing and 3D visualization for radiation therapy; object modeling and graphic user interface (GUI). The objective of this paper is to contribute to the ongoing evaluation of the feasibility and utility of 3D RTP.Clinical examples are presented to demonstrate the usefulness of such techniques. An effort is made to define the needed technical development that must procede a general utilization of 3D radiation treatment planning method.

2. MATERALS AND METHODS

2.1 Dose Model

Non-coplanar beam treatment requires a 3-D planning system to calculate doses and display patient information. We have developed algorithms to calculate doses at any point in the patient for any specified beam configuration. The dose algorithm operates on the 3-D patient representation stored as a set of multiple trasverse sectional contours. It calculates primary and scatter separately for photon beam. Pensil beam model has been used for electron beam. In both cases, the depth required in the calculation is determined by a ray tracying technique [2,3]. Correction for tissue inhomogenity is implemented. Sivert Integral has been used for dose calculation for the brachytherapy.

2.2 Display of Doses

Since the treatment beams are non-coplanar, it is essential to calculate dose throughout the patient volume. Contour lines from the 3D dose array can be calculated and displayed as isodose curve, superimposed to transversal CT slices or oblique reconstructions such as sgittal or coronal. Only simultaneous display of several CT sections with isodoses gives a fairly realistic impression of the 3-D isodose surface.

2.3 RTP System

The system should have the capability to calculate doses using three-dimensional patient data as well as the exact beam geometries. Calculation time is much longer than for a two-dimensional calculation because the entire set of patient contours has to be manuplated. Because of this type of computation, and because a huge amount of data must be stored for processing, Multi-processing with high performance CPU is adequate. Our current planning system is run on a IBM compatible PC with Windows 2000 environment. We have developed efficient GUI system which have interactive display to allow the user to display and manuplate patient data and dose matrices.

3. RESULTS

As an example, a 2-D or 3-D plan of a abdoman irradiation is presented. The dose distribution of a of a two orthogonal photon beam and one electron beam are shown in Fig.1 and 2. Figure 3 shows dose distribution for cervics using brachytherapy. We have found that the simultaneous display of the transverse distributions with normal tissue contours superimposed, provides the most complete and unambiguous. We developed a view at solid 3-D models of target volume and critical organs with 3-D beam configurations and 3-D dose display [Fig. 4]. The previously entered volumes of interest can be seen from a certain point in 3-D space as solid surfaces. The advantage of the 3-D display method is that the dose coverage of the entire target volume can be seenfromone or two different viewing angles. We also developed evaluation method using dose volume histogram (DVH). DVH is very useful in summarizing the three-dimensional dose distribution is to show the amount of normal tissue receiving more than a specified dose level.

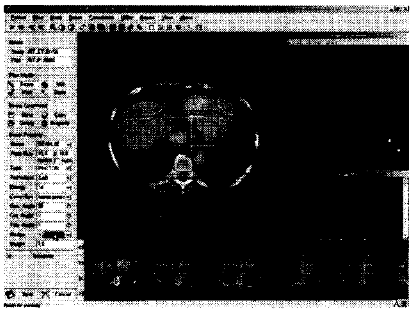

Fig. 1. Dose calculation for photon beam

Fig. 2. Dose calculation for electron beam

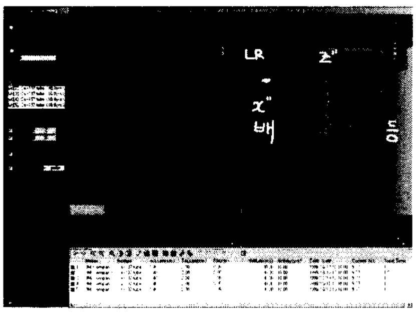

Fig. 3. Dose calculation for Brachytherapy

Fig. 4. 3D visualization for beam and dose distribution

4. CONCLUSION

In order to take the full advantage of the 3-D dose calculation, powerful dose calculation and display techniques are necessary in the treatment planning program. In our RTP the result of the dose calculation can be displayed as isodoses in 3-D images of the volumes of interests. The result show that these three dimensional techniques of dose calculation and isodose display with efficient GUI developed, can improve the treatment plans.

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