Medical Dosimetry 43 (2018) 195–204

Medical Dosimetry

journal homepage: www.meddos.org

Dosimetry Contribution:

External beam planning module of Eclipse for external beam radiation therapy

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A R T I C L E   I N F O

Article history:
Received 8 March 2018
Accepted 9 March 2018

Keywords:
Radiation treatment planning
Treatment planning systems
Conformal radiation therapy
Intensity-modulated radiation therapy
Volumetric-modulated arc therapy
Electron beam therapy

A B S T R A C T

Eclipse is a 3-dimensional (3D) treatment planning system for radiation therapy offered by Varian Medical Systems, Inc. The system has the network connectivity for the electronic transfer of image datasets and digital data communication among different equipment. The scope of this project for this special issue of *Medical Dosimetry* on 3D treatment planning systems is the assessment of planning tools in the external beam planning module of Eclipse to generate optimized treatment plans for patients undergoing external beam radiation therapy. This treatment planning system is relatively mature to be able to generate (1) simple treatment plans, (2) conformal radiation therapy plans, (3) static intensity-modulated radiation therapy (IMRT) plans, (4) volumetric-modulated arc therapy (VMAT) plans, and (5) treatment plans for electron beam therapy. The treatment planning tools are relatively plentiful to assist in the radiation therapy treatment planning. Some new features have been incorporated in the latest version and are helpful for making high-quality treatment plans. However, the location of the tools is not intuitive, and hence, familiarity with the user interface is essential to the efficient use of the treatment planning system. In addition, there are a number of dose algorithms available for the computation of dose distributions. The understanding of each dose computation algorithm is essential for the optimal use of this treatment planning system.

Introduction

Eclipse is a commercially available 3-dimensional (3D) treatment planning system for radiation therapy offered by Varian Medical Systems, Inc. It was introduced to the public at the American Association of Physicist in Medicine annual meeting held at Salt Lake City, Utah, in 2001 as a high-performance windows-based treatment planning system.[1] At that time, a windows-based personal computer had the most advanced graphics (hardware and software) to perform fast display of 3D dose clouds, isodose surfaces, and surface dose mapping, in addition to the advanced processor for rapid dose calculations. These features enable the users to visualize whether a treatment strategy will provide adequate tumor dose coverage in 3 dimensions or further adjustment to optimize the treatment plans is needed. Furthermore, the windows-based systems are more compatible with the

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https://doi.org/10.1016/j.meddos.2018.03.003

network system generally used in a typical hospital for network connectivity. Since then, the Eclipse treatment planning system has undergone a number of upgrades or revisions. The current version (15.5) is an integrated and comprehensive system that supports different types of treatment modalities.[2] These modalities include photons, electrons, protons, brachytherapy, and cobalt therapy.

This treatment planning system is organized as multiple modules consistent with the modalities. Each particular module is designed to support a special planning task or a treatment delivery system. Each module is accessible through the licensing methodology. The scope of this article within this project on 3D treatment planning systems is the assessment of planning tools in the external beam planning module to generate optimized treatment plans for patients undergoing external beam radiation therapy. This module supports C-arm-type medical linear accelerators as the radiation dose delivery system, in particular, those produced by the same manufacturer. The other modality modules, brachytherapy treatment planning and proton beam treatment planning, are being described by colleagues in this special issue.

Methods and Materials

The C-arm-type of medical linear accelerators are widely accessible and available in most radiation oncology facilities. It was introduced as part of the high-energy photon beam radiation therapy machines to perform rotational radiation therapy. The radiation therapy machine is hinged at the gantry stand to allow the rotation of the radiation source around the patient as shown in Fig. 1. In addition, the radiation therapy machine has a collimator and a multileaf collimation (MLC) system that rotates around the beam axis. As introduced, the computer-controlled MLC system was intended as a replacement to cerrobend blocks to shape the treatment fields.[3] Immediately after the introduction, it was realized that the MLC can also be used to modulate beam intensity to support intensity-modulated radiation therapy (IMRT) treatment technique.[4] The treatment couch can also rotate about an axis to allow more options for the selection of the beam orientation with respect to the patient. The gantry axis, the collimator axis, and the treatment couch axis intersect at a point called the isocenter of the radiation therapy machine. These radiation therapy machines are capable of performing static or stationary fields, as well as rotational fields, making them the most versatile machines for treating lesions at any anatomical site within the patient.

Fig. 1. A typical Varian medical linear accelerator. (Color version of figure is available online.)

Unlike in the past, the 3D treatment planning utilizes image-based technology and relies on a large image dataset. Hence, the system must have a large storage capacity, and the transfer of the image dataset from the computed tomography (CT)-simulation system through the network to the planning system has to be seamless. The image dataset can be retrieved and downloaded into the treatment planning system without loss of any clinical information. The image dataset has to be processed for treatment planning, and the typical processing tasks include (1) the removal of the CT table, (2) the placement of an alignment point of the lasers for the initial treatment setup, (3) the reassignment of the CT coordinates, (4) the performance of patient body contouring, and (5) image registration, if needed.

The 3D treatment process starts from the immobilization of the patient, CT simulation, treatment planning, plan verification, patient treatment positioning, and thereafter dose delivery. The state-of-the-art immobilization of patients is generally done as a whole-body immobilization with devices holding the patient from the head to the leg. The immobilization is done to ensure that the patient can be comfortable, as well as locked in or attached to the treatment couch for the purpose of performing image-guided radiation therapy. Unless it is requested, the helical CT scanning is typically performed using 3-mm-thick slices and covers all tumors and anatomical sites under consideration for radiation therapy.

Segmentation or contouring in 3D treatment planning refers to the delineation of the tumor volume and critical structures. The contouring criteria are given in International Commission on Radiation Units and Measurements Report No. 62, where the GTV refers to the gross target volume, CTV is the clinical target volume, ITV is the internal target volume, and PTV is the planning target volume consisting of the CTV or ITV plus margins.[5] In those cases where the tumor is difficult to determine, other modalities, such as magnetic resonance imaging, positron-emission tomography, or single-photon emission tomography, are used to assist in the determination of the treatment target through image fusion process. Both manual and automatic image registrations are accessible for the image registration adjustment. Critical structures, usually referred to as organs at risk, are also