Medical Dosimetry ■■ (2018) ■■–■■

Medical Dosimetry

journal homepage: www.meddos.org

Dosimetry Contribution:

RayStation: External beam treatment planning system

Dayna Bodensteiner, RT (R) (T), CMD

RaySearch Americas, Stockholm, Sweden

ARTICLE INFO

Article history:
Received 20 February 2018
Accepted 21 February 2018

Keywords:
Treatment planning system
RaySearch
RayStation
Robustness
Automation
Speed
MCO
Multicriteria optimization
VMAT
IMRT
Proton
Monte Carlo
Automatic breast
Structure definition
Fallback planning
Tomotherapy
Plan explorer

ABSTRACT

RaySearch Laboratories is a world leader in the field of advanced software and creator of the RayStation treatment planning system for radiation therapy. The aim with RayStation is to deliver an unmatched user experience and leading functionality. Unique features described here include multiatlas based autosegmentation for contouring, deformable registration with 2 different algorithms, multicriteria optimization, Plan Explorer, fallback planning, ultrafast computation speed, and 4-dimensional (4D) adaptive radiation therapy. RayStation can be used to plan for electrons and photons on traditional linacs, for protons on various delivery systems, and for Accuray's helical TomoTherapy system. This paper describes some of these modalities, with reference to clinical cases and including descriptions of the impact on workflow.

RaySearch External Beam Treatment Planning System

Since its formation in 2000, RaySearch has had a clear goal: to improve chances of survival and quality of life for patients with cancer through innovative software. However, the RaySearch story actually starts earlier. In 1994, founder Johan Löf wrote his master's degree thesis at Karolinska Institute in Stockholm, Sweden, on Radiation Treatment of Moving Tumors. This marked the start of a long journey to develop the software platform that would become the foundation for RayStation. Advanced algorithms were the forte of Johan and the team he put together, and this skill resulted in an early

Declaration of Interest: The author is an employee of RaySearch Laboratories, in the position of Director of Product Management for RaySearch Americas. Dayna Bodensteiner has a background as a medical dosimetrist and this paper is geared primarily toward staff involved with radiation therapy treatment planning. The main focus is practical information about the software, while customer quotes are included to convey opinions based on usage. Contribution acknowledgement from Paul Redstone, copy editor, Björn Hårdemark, Deputy CEO of RaySearch Laboratories and Marc Mlyn, CMD, MBA.

Reprint requests to Dayna Bodensteiner, RT (R) (T), CMD, RaySearch Americas, Stockholm, Sweden.

E-mail: dboden@raysearchlabs.com; dboden22@gmail.com

https://doi.org/10.1016/j.meddos.2018.02.013

partnership agreement with Philips Radiation Oncology Systems to create an intensity-modulated radiation therapy (IMRT) optimization module. Further collaborations with companies such as Varian, Nucletron, and IBA resulted in RaySearch algorithms being used in thousands of cancer centers around the world. In 2008, RaySearch began development of its own treatment planning system, which was released as RayStation in 2011. The aim of this paper is to outline some of the innovative technologies found in RayStation.

RaySearch believes that software has unlimited potential to improve cancer treatment. To have an impact, the software must be fast, easy to use, and have the flexibility to meet each clinic's needs. This holds true for all portions of the software, from patient modeling and contouring delineation to advanced modules such as MCO, Plan Explorer, and proton planning.

Structure Definition

RayStation contains two autocontouring modules: model-based segmentation (MBS) and multiatlas-based segmentation. For MBS, a large library of organs is delivered with the system for head and neck, chest, abdomen, and pelvis. This library can be expanded with other organs specific to the clinic or by adding samples to the existing models. RayStation's MBS is unique in that the models are saved with the computed tomography (CT) data they were drawn on. The system uses a registration algorithm with the most common CT to know where to drop the organs. Multiple organs are placed in approximate locations, then the algorithm further adapts the regions based on the current patients' anatomy. If further adjustments are required, RayStation has easy-to-use tools to deform in any plane or to add hint contours to steer the system.

Another automatic contouring method in RayStation is multiatlas-based segmentation, which is based on rigid and deformable registration. The atlases contain CT or magnetic resonance image sets with manually drawn structures, structures generated with MBS, and a combination of structures generated with the region of interest (ROI) algebra or margin tools. When a set of atlases is loaded for a new patient, the best image set matches are calculated using rigid registration. For all of those, a deformable registration is computed, and the structures are mapped across the deformation. This gives a number of segmentation results that are eventually merged to one result using a fusion algorithm. As a final step, any MBS and algebra structures are adapted to the anatomy.

RayStation also includes a variety of manual contouring tools for patient modeling. These include a smart brush with edge detection, and smart interpolation, where a dashed line shows the interpolated contour that can adjust to find the grayscale edge of the structure. It is even possible to draw during cine mode of a 4-dimensional (4D) CT, in the sagittal or coronal plane. ROI Algebra is a powerful tool utilizing Boolean expressions. Another unique feature is the ability to save the margins used to create a planning target volume (PTV) expansion as a derived ROI. If either of the structures is changed, the user is notified that the Boolean expression is mismatched, allowing them to update as necessary. This feature also enables anyone reviewing the plan to see which margins were used to create the structure.

"The contouring tools in RayStation have been nothing short of amazing and are geared towards efficiency. The whole platform makes it very easy for the physician," says Dr. Aaron Ambrad, Radiation Oncologist at Ironwood Cancer Centers in Phoenix, Arizona. He adds: "I had a patient recently with simultaneous diagnoses of hepatocellular carcinoma and a transverse colon cancer. She was too weak for surgery and radiation therapy was required for both areas. The tumors were very close to each other. RayStation enabled us to deform the registration using the different CT data sets required for both setups and deform the dose so that I could see the overlap region and tailor the treatments specifically to prevent too much dose to a critical structure. This is a feature we did not have on any platforms we have previously used."

Deformable Registration

RayStation offers standard rigid registration for use with CT, MRI, positron emission tomography, and cone beam computed tomography (CBCT) images. It also includes two powerful deformable registration algorithms. The first is ANACONDA, which stands for Anatomically Constraining Deformation Algorithm and is also referred to as "hybrid". This is because the algorithm is driven both by the image set data or intensities and by the contours selected. In other words, deformable registrations are "steered" by controlling ROIs and by focus ROIs, determined by the user. This feature is unique to RayStation and makes it possible to maintain the integrity of anatomical structures, even in areas where image information is less reliable. Algorithms that are purely based on image information are limited as they can only regularize the deformation field by applying some degree of smoothing. Published studies have shown good results for this algorithm, and a more detailed description can be found on the RaySearch website.

The second deformation algorithm in RayStation is Morfeus, which is a biomechanical deformation image registration developed at Princess Margaret Hospital in Toronto, Canada, and licensed by RaySearch. Morfeus is a structure-guided algorithm that requires regions of interest on both the target and reference data sets. The algorithm supports sliding interfaces, which makes it useful for areas such as