Independent 3D-Dose Calculation Verification for High-Dose Rate (HDR) Brachytherapy using a dicompyler Plug-in

High-dose rate (HDR) brachytherapy is commonly used for many disease sites, including breast, prostate as well as for gynecologic malignancies. The conformal doses produced by HDR ensure a high dose to the tumor region, while limiting the dose to surrounding normal tissues. As part of the overall quality assurance process, AAPM TG-59 recommends an independent check of the dose calculation. In the past, physicists often performed simple checks using idealized source geometries. More recently, commercial products have become available that independently calculate the dose at a few points. With the increased utilization of 3D brachytherapy planning systems, there is a desire to extend these calculations to perform an independent check of dose distribution in three dimensions. In order to accomplish this goal, we have developed a plug-in within the dicompyler platform.

Dicompyler is an extensible open source radiation therapy research platform based on the DICOM standard. It also functions as a cross-platform DICOM RT viewer. The program is written in Python and is built on a number of technologies including: pydicom, wxPython, PIL, and matplotlib and runs on Windows, Mac OS X and Linux.

Briefly, a plug-in was created within dicompyler. Using the DICOM-RT utilities associated within the program, planning files (CT scans, dose matrix, structure sets and dwell times/positions) were exported from BrachyVision (Varian Medical Systems, Palo Alto, CA) and read into dicompyler. Based on the 3D source positions, dose was independently calculated to the same 3D dose matrix as produced by the planning system using a point source calculation algorithm. The advantage of this approach is that it is computationally efficient. Moreover, modifications can be easily made to this algorithm to include an anisotropy factor as well as the Meisberger polynomial. Comparing the area under the curve (AUC) of the dose volume histograms (DVHs) for 12 organs from 37 patients, showed the best agreement (average = -0.70%) between the original plans and those independently calculated using dicompyler with no anisotropy factor and with the Meisberger polynomial.

There are several advantages of using a dose verification plug-in for dicompyler. First, dicompyler is independent of the platform and can be run on all Windows, Mac, and Linux computer systems. Additionally, the calculation is nearly automated requiring the user to only select the folder containing the DICOM-RT files. Thus, very little time is added to the clinical process. Lastly, a full 3D independent dose calculation provides verification of a number of planning parameters including: source positions, source strength, and organ delineation. Combined, it is expected that the clinical utilization of a 3D independent dose calculation may reduce errors produced by planning, as well as provide an independent means of acceptance testing for 3D HDR planning systems.

Figure 1: Screen capture of a DVH graph from dicompyler. Along with the DVH plots, structures are listed on the left and dose information is displayed across the bottom.