Collision detection for external beam radiation therapy applications in SlicerRT

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INTRODUCTION: Collision detection is important in external beam radiation therapy to help eliminate the need for dry-runs that confirm the usability of selected beam angles and prevent patient-machine collisions. Medical technology companies have developed commercial treatment planning systems (TPS) to assist radiation oncology teams with determining proper radiation doses and visualization including automated collision detection. Unfortunately, commercial TPS are expensive and proprietary restricting their use, especially in RT research. Thus, we propose the development of a collision detection module in SlicerRT, which is an open-source radiation therapy research toolkit [1] based on the 3D Slicer medical image visualization and analysis platform.

METHODS: We use an openly accessible geometric model of the Varian TrueBeam™ STx downloaded from 3D Warehouse. The model is separated into its multiple components and loaded into the SlicerRT radiation therapy research toolkit [1], which is based on the 3D Slicer medical image visualization and analysis platform. Additional treatment device models such as applicator holder and electron applicator models are created in Solid Edge™ based on visits to Kingston General Hospital where pictures of the device geometry and measurements were taken. The IEC standard specifies the set of movements and motion ranges for all RT machines. Thus, the rigid transformation matrices are developed to be in compliance with the standard's coordinate system hierarchy, which ensures the module will work will all types of RT machines. The automated collision detection applies the vtkCollisionDetectionFilter class from the vtkbioeng library [2]. Detection is performed between all the possible machine component pairs and additional treatment devices to ensure that all possible collisions could be detected.

RESULTS: The REV visualization and automated collision detection were implemented as a Room's eye View C++ module in SlicerRT. Two commonly encountered RT plans: a head and neck plan and a prostate plan were loaded into the module for testing. The module was integrated into the existing open-source TPS so that the machine was automatically transformed based on the loaded RT plan. The machine's movements were accurately modelled based on the IEC standard (Fig. 1). The automated collision detection was tested by changing the geometric parameters of machine to purposely cause collisions between machine components. The module was able to accurately indicate collisions between each pair of machine components, machine-patient collisions, and all collisions that were happening simultaneously.

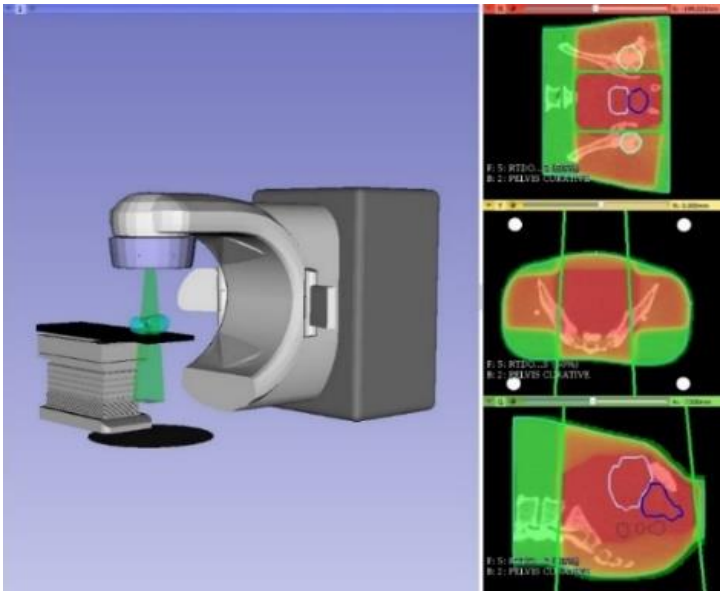

Fig. 1: Modelling of treatment machine, RT beam, and room based on geometric parameters for prostate RT plan.

CONCLUSION: A software module providing room's eye view visualization with automated collision detection was developed as a component of an open-source application in SlicerRT. The visualization and safety features provided by the open-source application will be improved due to this software module. The creation of additional treatment device models such as electron applicators position the module as being useful for certain RT research settings such as electron beam therapy.

REFERENCES:

[1] C. Pinter, A. Lasso, A. Wang, D. Jaffray, and G. Fichtinger, "SlicerRT: Radiation therapy research toolkit for 3D Slicer," Medical Physics, vol. 39, no. 10, p. 6332, 2012.
[2] vtkbioeng. http://www.bioengineering-research.com/software/vtkbioeng. (as of December 2016).