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Development of a collision prediction tool using Blender for non-coplanar radiotherapy on a C-arm linear accelerator

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Purpose: Non-coplanar treatment techniques on a C-arm linear accelerator have the potential to improve treatment plan quality in comparison to conventional coplanar volumetric modulated arc therapy (VMAT). During treatment planning of dynamic trajectory radiotherapy (DTRT), which extends VMAT by dynamic couch rotation, it is essential to know the gantry and table angle combinations leading to a collision during delivery. In this work, we developed a collision-prediction tool predicting gantry-table combinations leading to a collision of the gantry with the table or the patient.
Methods: A virtual linear accelerator model was created using Blender, a free and open- source 3D computer graphics software toolset, that can be accessed via an integrated python application programming interface. The virtual model includes the gantry, the table, the laser guard and a library of male and female patient models with different sizes and arm positions. The tool predicts for all gantry-table combinations discretized with a certain resolution whether there is a collision between gantry, table and patient model including a safety margin. For this purpose, the user has to specify the input of longitudinal, vertical and lateral table position, patient model from the library and safety margin. The collision prediction tool was experimentally verified. First, the tool is executed to generate collision predictions for each gantry-table combination with a 2° resolution for one input specification and second, these predictions are verified manually at a TrueBeam system.
Results: The true positive ratio, which is the ratio between the number of correctly predicted collision gantry-table combinations and the number of all predicted collision gantry-table combinations, is 82.4%. The true negative ratio, which is the ratio between the number of correctly predicted collision-free combinations and the number of all predicted collision-free combinations, is 99.9%.
Conclusion: A collision prediction tool for non-coplanar radiotherapy treatment planning was successfully developed. The tool enables non-coplanar plan creation with high safety for collision-avoidance.
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Primary authors: GUYER, Gian (Division of Medical Radiation Physics, Inselspital); WYSS, Yanick (ETH Zürich); MÜLLER, Silvan; STAMPANONI, Marco (PSI - Paul Scherrer Institut); MANSER, Peter (Division of Medical Radiation Physics and Department of Radiation Oncology, Inselspital, Bern University Hospital, and University of Bern, Bern, Switzerland); FIX, Michael Karl (Division of Medical Radiation Physics and Department of Radiation Oncology, Inselspital, Bern University Hospital, and University of Bern, Bern, Switzerland)

Presenter: GUYER, Gian (Division of Medical Radiation Physics, Inselspital)

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