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**PRESENTATION TITLE**

Towards fast adaptive VMAT sequencing for the MRI-linac

**AUTHOR(S)**

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**ABSTRACT**

**Purpose:** The combination of MRI and linear accelerator machines enables volumetric imaging of the patient anatomical changes during treatment. We have previously developed the Adaptive Sequencer (ASEQ), a sequencing methodology for fixed-beam IMRT able to account for anatomical deformations in various treatment scenarios. In this work, we extend ASEQ to support volumetric modulated arc therapy (VMAT) sequencing enabling future adaptive MRI-guided arc therapy treatments on the MRI-linac.

**Materials & Methods:** Given an ideal dose distribution, ASEQ (Figure 1) iteratively generates segments targeting the latest anatomical state of the patient and reduces the remaining dose to be delivered accordingly.

In the new VMAT implementation (Figure 2), the 360 degree arc is initially discretized in 3 degree increments yielding 120 fixed-beam angles. The angles are split into finer beam elements and their individual fluence contribution is calculated. The ideal dose distribution taking into account the clinical constraints is optimized using an inverse dose optimization algorithm. Subsequently, during every ASEQ iteration, the optimal segments are delivered.
iteration a fluence optimization updates the fluence map of each discrete beam. These maps are independently segmented leading to a single deliverable segment per angle.

The connectivity of the neighbouring segments is then evaluated in terms of max leaf and jaw distances. The maximum tolerances and Monitor Units (MU) are derived such that, ideally, the gantry maintains maximum speed (10 revolutions/min for the MRI-linac) during delivery. The segments violating these values are replaced by interpolated shapes between the two closest valid segments, leading to a fully connected deliverable arc. After processing the segments into control points with the appropriate weights, the arc dose is calculated and subtracted from the remaining dose. This process continues until a certain number of arcs has been delivered and is followed by an arc/segment weight optimization (ASWO) which adjusts the arc segment MUs to fully converge to the original prescribed dose.

Results: ASEQ VMAT plans were generated for one prostate case meeting the clinical constraints. The standard ASWO plan resulted in a very conformal dose distribution around the PTV, considerably sparing the surrounding OARs compared to a 5-beam IMRT ASEQ plan (Figure 3). The total optimization time was 6.5 min for 10 arcs resulting in an estimated delivery time of 2.1 min. As a preliminary result, the optimization also managed to converge without the post-processing ASWO after 15 arcs.

Conclusions: We extended ASEQ to support VMAT sequencing while adhering to machine delivery constraints. One ASEQ VMAT plan containing 10 full arcs is generated in less than 7 minutes, with each new optimized arc taking less than 30 seconds. We are now investigating the method’s ability to converge without post-processing steps and, further, the inclusion of anatomical deformations into the fast volumetric optimization. The increased modulation of the multi-arc plans and fast delivery of the MRI-linac enable numerous possibilities for online plan adaptation.