

Target tracking using DMLC for volumetric modulated arc therapy

As a new IMRT treatment technique, VMAT has gained widespread interest in the radiation therapy community¹⁻². VMAT delivery involves continuously rotating gantry and widely varying gantry rotation speed, dose rate, and MLC leaf position. When target motion compensation is incorporated, these delivery parameters require interactive modulations. To ensure that the treatment plan can be delivered without violating limitations of hardware parameters of a linac, a tracking solution needs to consider a number of machine constraints such as maximal permissible gantry speed, dose rate and MLC leaf-velocity. In addition, as VMAT often requires the gantry to accelerate and decelerate frequently to deliver a treatment plan, gantry acceleration constraint should also be taken into account.

A DMLC tracking algorithm has been recently developed capable of delivering VMAT to targets that experience two-dimensional (2D) motions in the beam's eye view (BEV)³. The interdependence between several linac parameters, such as dose rate, gantry angular speed, gantry acceleration and MLC leaf-velocity, and target motion is investigated to formulate the VMAT delivery problem for moving targets. The goal of this algorithm is to achieve optimal delivery efficiency, i.e. the shortest delivery time while minimizing delivery error resulted from target motion.

Logic flow of the DMLC tracking algorithm is shown in Fig.1. The tracking along the direction perpendicular to leaf motion was described in Ref.⁴ Figures 2(a)- 2(d) show optimal delivery parameters a VMAT plan. Red solid lines represent the maximal permissible values for each parameter. For this VMAT tracking delivery, a delivery time of 95.6 s can be achieved, which is only 30.2 s longer than that needed for delivery without tracking. For the optimal delivery, i.e., the shortest delivery time, at least one of the machine parameters reached its maximum at certain beam angles. The delivery time is mainly determined by the gantry speed, which is strongly modulated so that the MLC leaves can have sufficient time to reach the desired positions. The dose rate and MLC leaf-velocity are also significantly modulated as all these delivery parameters are correlated. The discrepancies between the planned and delivered fluence are displayed in Figs. 2(e)-2(g). When the plan is delivered without any tracking, a clear mismatch can be recognized. The fluence is severely blurred along the path of motion. The blurring is significantly removed by employing 1D tracking along the x direction, and best match is achieved with 2D tracking. The average root-mean-square (RMS) difference of the five plans is 14.8 MU for no motion tracking, 3.6 MU for 1D tracking and 2.1 MU for 2D motion tracking.

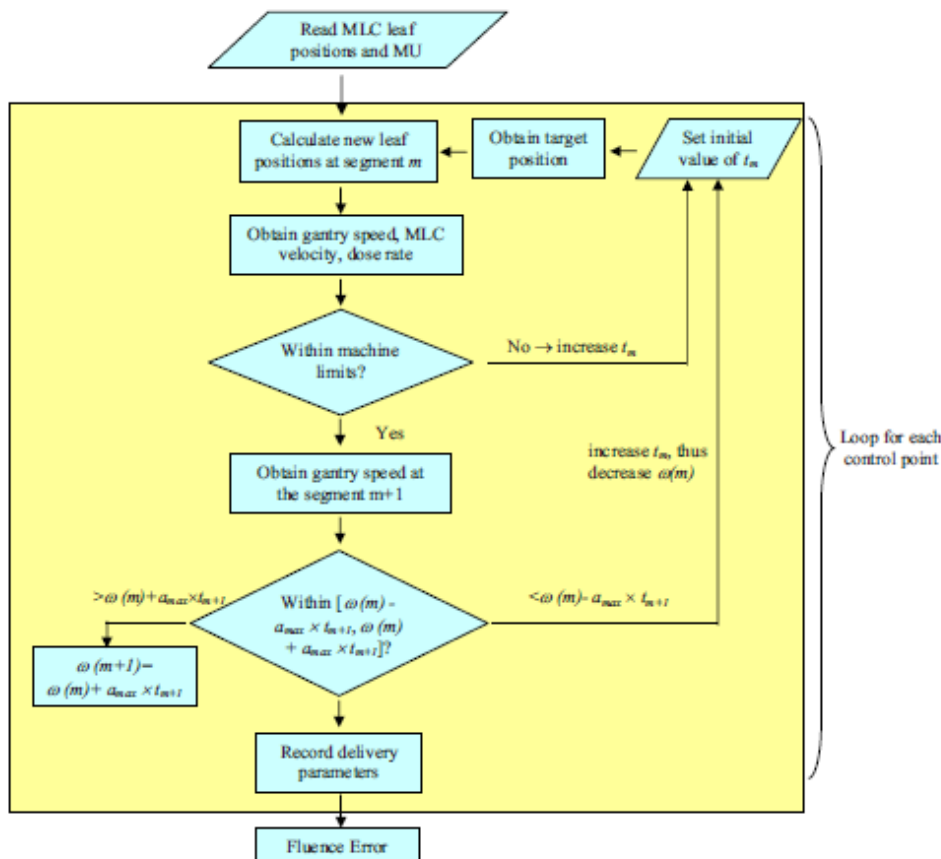


Fig. 1. Logic flow of the DMLC tracking algorithm for VMAT delivery to targets moving in 2D in beam's eye view.

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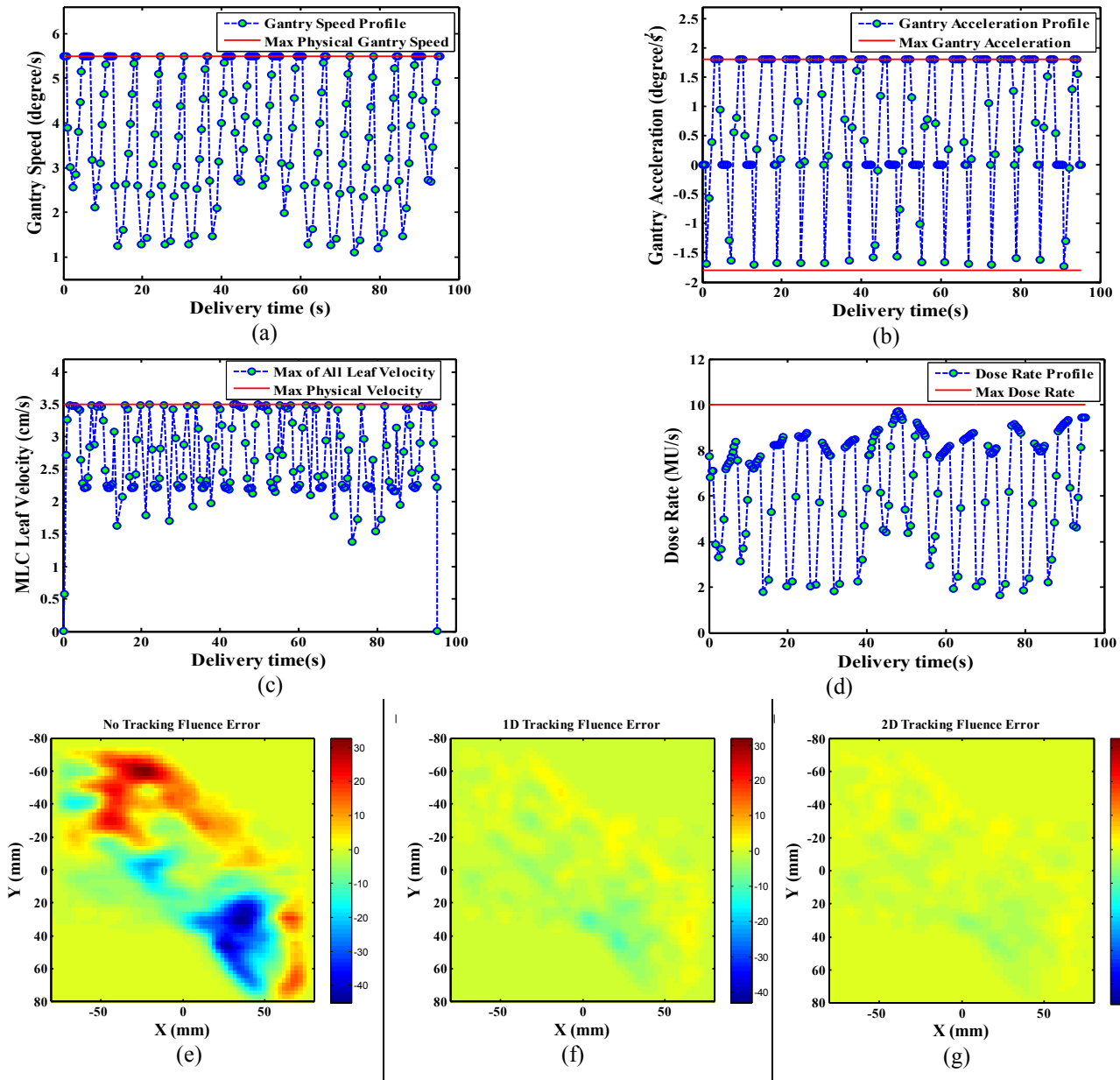


Fig. 2. Optimal delivery parameters for a VMAT plan with 2D DMLC tracking as a function of time in a 360° single arc. (a) Gantry speed, (b) gantry acceleration, (c) MLC leaf-velocity, (d) dose rate. The discrepancies between the planned and delivered fluence for (e) No tracking, (f) 1D tracking and (g) 2D tracing.

References

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