Purpose: Commercial intensity-modulated-arc-therapy (IMAT) implementations rely on a 100% beam-on duty-cycle to achieve high efficiency. With moving targets, real-time tracking or gating may be applied. Tracking is technically challenging and gating reduces efficiency by lowering the duty-cycle. By combining burst-mode rIMRT (in which all dose is administered while the gantry is within a few degrees of a beam optimization point [OP]), with a motion pre-emption strategy and intrafractional imaging, we demonstrate an efficient implementation of motion-adaptive rIMRT.

Methods: 1. An rIMRT plan is created with 36±“72 OPs. A gantry rotating at 6 degrees/s takes 3±“6s to reach successive OPs. This coincides with the natural breathing period. 2. A Fourier-descriptor-based trajectory model is fitted to target features identified in pre-treatment CBCT projections. The model predicts feature location at any combination of gantry angle and breathing phase. 3. The model sets the gantry speed to place the gantry at the next beam OP just in time as the target arrives at the planned position. In-line projection images are acquired immediately before and during beam delivery. Treatment ensues only if the target position is correct (verification completes within 50ms, so maximum misdelivery possible at 2000MU/min is within 2MU). In cases of irregular breathing, the system gracefully defaults to gated-IMRT.

Results: For a MA-rIMRT delivery of 750MU at 2000MU/min, treatment duration increases from 154s (regular rIMRT) to 199s (5s respiration cycle).

Conclusions: With predictable patient breathing, MA-rIMRT delivery times are competitive with conventional IMAT. High treatment accuracy is easily achieved, since there is no tracking lag and since the beam shape is static during delivery. Contemporary linacs rely on non-realtime communication systems (typically Ethernet) to control time-critical elements such as the MLC. Since such variable-delay systems pose formidable problems in terms of predictive control, our approach offers a pragmatic alternative to tracking.

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