Purpose: Dual-gating is a novel method proposed to enhance the delivery efficiency of respiratory-gated IMRT by delivering the beam at both inhale and exhale. Here, we develop a treatment planning framework for dual-gated IMRT (DG-IMRT) without compromising tumor coverage or normal tissue sparing. We produce a DG-IMRT plan for a lung tumor case with ~1.5 cm motion and compare to a conventional IMRT plan gated at exhale.

Methods: Implementation of DG-IMRT requires individual inhale and exhale fluences during each of the gating windows. Rather than optimizing the inhale and exhale plans separately, the inverse treatment planning problem is formulated to optimize over both plans simultaneously, producing inhale and exhale fluences that achieve the ideal total dose. To achieve dose accumulation of the inhale and exhale doses, deformable image registration is used to register the inhale dose to the exhale geometry. The treatment planning framework is evaluated on a lung patient case with ~1.5 cm tumor motion.

Results: Comparison of the dual-gated and single-gated plans demonstrate that dual gating enables improved PTV dose homogeneity, with a 2.7 Gy increase in minimum dose to the PTV, and a 4.6 Gy decrease in maximum dose to the PTV. The DG-IMRT plan also exhibits lower maximum doses to the ipsilateral lung, but slightly higher maximum doses to the contralateral lung, heart, and spinal cord.

Conclusions: The treatment planning results demonstrate that the proposed framework can produce IMRT plans equivalent to or better than conventional IMRT plans gated at exhale. In the presence of free breathing, dual-gating can improve respiration-delivery efficiency by up to a factor of two and perhaps even greater when combined with coaching to encourage brief breath-holds at inhale and exhale.

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