A Non-Progressive Sampling Volumetric Modulated Arc Therapy (VMAT) Method

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INVENTORS

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OTHER INFORMATION

KEYWORDS

Volumetric modulated arc therapy, VMAT, non-greedy, non-heuristic, optimization, direct aperture optimization

CATEGORIZED AS

- **Medical**
  - Diagnostics
  - Disease: Cancer
  - Imaging
  - Research Tools
  - Software

RELATED CASES

2017-442-0

SUMMARY

UCLA researchers in the Department of Radiation Oncology have developed a novel direct aperture optimization method for volumetric modulated arc therapy (VMAT) to solve the current arc optimization problem.

BACKGROUND

Volumetric modulated arc therapy (VMAT) is a radiation technique that can achieve highly conformal dose distributions with improved target volume coverage and sparing of normal tissues compared with conventional radiotherapy techniques. VMAT is also significantly more efficient in both treatment time and total monitor units compared with conventional static field intensity modulated radiotherapy (IMRT). VMAT delivers radiation by a rotating gantry, changing speed and shape of the beam with a multi-leaf collimator (MLC) and fluence output rate of the medical linear accelerator. Due to the substantially increased beam orientations and the additional machine mechanical constraints such as gantry and the MLC mechanical limits, the arc optimization problem becomes quite complex. Current VMAT optimization has various greedy heuristics employed for an empirical solution, which jeopardizes plan consistency and quality. The progressive sampling method used by various commercial planning systems often results in inferior dosimetry due to the lack of global optimization and becomes computationally challenging as more beams are added for multiple arcs and non-coplanar arcs.

INNOVATION

Researchers at UCLA have developed a novel direct aperture optimization method for VMAT. The comprehensive VMAT (comVMAT) planning is formulated as an optimization problem with an L2-norm fidelity term to penalize the difference between the optimized dose and the prescribed dose, as well as an anisotropic total variation term to promote piecewise continuity in the fluence maps, preparing it for direct aperture optimization. A level set function is used to describe the aperture shapes and the difference between aperture shapes at adjacent angles is penalized to control MLC motion range. A proximal-class optimization solver is adopted to solve the large scale optimization problem, and an alternating optimization strategy is implemented to solve the fluence intensity and aperture shapes simultaneously. The novel non-greedy VMAT approach simultaneously optimizes all beams in an arc and then directly generates deliverable apertures. The single arc VMAT approach thus fully utilizes the digital Linac's capability in dose rate and gantry rotation speed modulation. In practice, the new single VMAT algorithm generates plans superior to existing VMAT algorithms utilizing two arcs.

APPLICATIONS

- Volumetric modulated arc therapy (VMAT) planning system

ADVANTAGES

- By comprehensively optimizing all beams, the comVMAT optimizer is able to allow some selected beams to deliver higher intensities, yielding a dose distribution that resembles a static beam IMRT plan with beam orientation optimization.

STATE OF DEVELOPMENT

When the single arc comVMAT plans, optimized using an alternating optimization strategy, were compared against the clinical VMAT (clnVMAT) plans utilizing two overlapping coplanar arcs for treatment, comVMAT plans were able to consistently reduce the dose to all organs-at-risk (OARs) as compared to the clnVMAT plans.

RELATED MATERIALS

- D. Nguyen, Q. Lyu, D. Ruan, D. O'Connor, D. A. Low, and K. Sheng, A comprehensive formulation for volumetric modulated arc therapy planning, in Medical Physics, 2016.

PATENT STATUS

Country	Type	Number	Dated	Case
United States Of America	Issued Patent	10,857,386	12/08/2020	2017-442

ADDITIONAL TECHNOLOGIES BY THESE INVENTORS

▶ Automated Beam Orientation and Scanning Spot Spacing Optimization for Robust Heavy Ion Radiotherapy Therapy

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