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Development of a lexicographic automatic intensity optimization process

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Purpose: To develop an automatic intensity optimization (AIO) process for volumetric modulated arc therapy (VMAT) and intensity-modulated radiotherapy (IMRT), using the Eclipse scripting API (ESAPI).

Methods: A multi-round and multi-group lexicographic optimization process is developed interfacing the Eclipse treatment planning system via ESAPI.

The input of the AIO process is the field setup for the patient and a treatment site-specific starting list of objectives consisting of dose-volume and mean dose objectives for target volumes and organs-at-risk (OARs), ranked in priority groups (PG) according to their clinical importance.

The PGs are optimized in multiple sequential optimizations using the Eclipse Photon-Optimizer (PO). After each PO optimization, results are pinned by additional objectives with higher optimization weight at the achieved objective results. In subsequent PO optimizations over PGs, objectives are hardened towards favourable dose, if the previous objective results of other PGs are not deteriorated by the hardened objective.

The lexicographic ordering of the AIO process is verified using a synthetic water cylinder with central cylindrical target and three concentric symmetrically distributed OARs, with the same objectives for each OAR assigned to different PGs. Additionally, pareto-optimality is checked by manual re-optimization.

The AIO is further applied to a clinically motivated head-and-neck cancer case.

For both cases, treatment plans with two full VMAT arcs are generated.

Results: For the synthetic case, OARs show mean dose differences of >10%, with higher dose in OARs ranked in lower PGs, confirming lexicographic ordering. Manual hardening of one objective leads to worse results for other objectives, confirming pareto-optimality. For the clinically motivated plan, AIO spared OARs from higher-ranked PGs better than manual optimization (spinal cord Dmax 13.4 Gy vs. 19.4 Gy), with higher doses in OARs from lower-ranked PGs (right submandibular gland Dmean 15.3 Gy vs. 11.2 Gy).

Conclusion: Successful implementation of a lexicographic AIO process for VMAT and IMRT plans using ESAPI is demonstrated on an academic and a clinically motivated case.

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