necessary, modified based on additional information from high resolution CT or MRI.

Proffered Papers: Physics 2: Dose planning: on automation and robustness

OC-0069

Automatic interactive optimization for volumetric modulated arc therapy planning of head and neck cancer

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Purpose/Objective: Intensity modulated radiotherapy treatment planning for sites with many organs-at-risk (OARs) is a complex and labor-intensive process, making it hard to obtain consistent and high quality plans. As a solution, an automatic interactive optimizer (AIO) was developed to be used in conjunction with the Eclipse treatment planning system. AIO performance was benchmarked against clinical plans of 20 head and neck cancer (HNC) patients treated recently at our department using volumetric modulated arc therapy (RapidArc).

Materials and Methods: Our institutional approach to HNC planning uses 3-4 optimization objectives per OAR, evenly placed along the displayed dose-volume histogram (DVH) curve. During the optimization process, the planner attempts to maintain a fixed distance between the objectives and the DVH curve, while weighting factors (optimization priorities) are kept constant. AIO scans the optimization window and uses color-coding to differentiate between OAR DVH-lines, allowing it to automatically adjust the location of optimization objectives far more frequently and consistently, again using fixed priorities. The summed cost function for all OAR objectives is therefore held constant throughout the optimization process, allowing the optimizer to balance sparing of the included OARs. Because planning target volumes (PTVs) are assigned higher priorities than OARs during optimization, AIO can gradually push the OAR objectives to lower dose values at each iteration without underdosing the PTVs.

AIO plans were compared to clinical plans on the basis of i) Mean dose to the oral cavity (D_{oc}), individual and composite salivary glands (D_{sal}) and swallowing muscles (D_{swal}). ii) Boost/elective PTV (PTV_B/PTV_E) volumes receiving more than 95% (V95) and less than 107% (V107) of the prescribed dose. A head and neck radiation oncologist performed blinded evaluation of the clinical and AIO plans.

Results: Planning results were averaged over all 20 patients and are summarized in the Table. Dosimetric parameters in the AIO plans differing significantly (two-sided Student t-test) from the clinical plans are indicated by '†' in the table. Clinically acceptable maximum doses to the brainstem and spinal cord were achieved in all plans. AIO reduced D_{oc}, D_{sal} and D_{swal} by 2.6, 0.8 and 4.3Gy, respectively, while also improving PTV_B/PTV_E V95 and PTV_E V107. 19/20 AIO plans were judged as the superior plan by the radiation oncologist, while quality of the remaining AIO plan was considered similar to the clinical plan. AIO only required a single optimization of 20-35 minutes, whereas clinical plans could have required multiple iterative optimizations.

	Plan		Clinical	AIO
	Boost PTV	V95 (%)	99.1 ± 0.3	99.4 ± 0.4
		V107 (%)	2.0 ± 2.8	1.3 ± 1.3
	Elective PTV	V95 (%)	98.2 ± 1.0	98.0 ± 0.7
		V107 (%)	16.5 ± 9.2	12.0 ± 6.0 †
Mean Dose (Gy)	Contralateral Parotid Gland		20.6 ± 8.3	19.8 ± 7.8 †
	Ipsilateral Parotid Gland		28.1 ± 8.8	27.4 ± 8.8
	Contralateral Submandibular Gland		33.6 ± 11.8	32.1 ± 12.7 †
	Composite Salivary Glands		26.5 ± 7.6	25.7 ± 7.5 †
	Composite Swallowing Muscles		29.5 ± 8.1	25.2 ± 9.2 †
	Oral Cavity		29.0 ± 12.5	26.4 ± 13.0 †

Conclusions: The present results show that AIO can automate treatment planning for complex HNC patients, increasing efficiency while improving quality over manually created plans. AIO has been clinically implemented at our clinic for HNC treatment planning.

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Automatic dose painting workflow: from tumor segmentation to optimization

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Purpose/Objective: Dose painting becomes a popular strategy to increase tumor local control in radiotherapy. However, only a few research centers have developed the tools to apply it to patients. Our aim is to develop an automatic workflow for dose painting, which is integrated in a commercial treatment planning system (TPS).

Materials and Methods: A set of MATLAB® functions (GTVPETCT) are called through scripting from RayStation (RaySearch Laboratories, research version 3.99) to segment the primary tumor (GTV_{PET}) in $^{18}FDG_{PET}$ images, using an automatic gradient-based method. The user selects the lower and upper limits (Gy) for dose escalation. The FDG uptake in each voxel is linearly converted to dose (Gy), starting from the median uptake to avoid background contamination. Optimization can be performed using either a number N of sub-volumes (N selected by the user) or directly on the voxel scale thanks to a customized function developed with the RaySearch research package (C++). The N contours can be used to drive the optimizer towards a dose painting by number prescription (DPBN) or either to perform sub-volume boosting (dose painting by contours) if uniform dose is prescribed inside each contour.

The workflow can be applied for IMRT and proton therapy, but in this work we considered only the latter. To ensure robustness against setup (and range) errors, two strategies are implemented: 1) integration of margins in a dilated prescription; and 2) robust optimization, but only for contour-driven optimization. Work is in progress to extend this feature to voxel-wise optimization.

Plan quality was assessed with Quality Volume Histograms (QVH), where quality (Q) is the ratio of the planned dose to the prescribed dose in each voxel. Robustness is evaluated by calculating the dose perturbed by setup errors (and range errors for protons) gathered in a set of scenarios.

As an illustration, the workflow was applied to a H&N patient, aiming at reproducing a DPBN prescription. Direct voxel-wise optimization and 7 non-uniform dose levels were used for Proton Pencil Beam Scanning.

Results: The DPBN prescription was reproduced successfully for both contour-driven and voxel-wise optimizations: more than 99% of the PTV_{PET} received at least 95% of the prescribed dose ($V_{Q=95\%}$>99%) and less than 1% received more than 105% ($V_{Q=105\%PET}$ achieved perfect target coverage ($V_{Q=95\%}$=100%) and slight overdosing ($V_{Q=105\%}$=9%). Dilated prescriptions yield high