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A template based automation method for optimization using a commercial treatment planning system

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INTRODUCTION

Automation has continuously improved both efficiency and quality in radiotherapy workflow, due to growing application of AI technologies. Automatic treatment planning is still an intricate problem because of the complicated relationship between the plan quality evaluation and a large set of input parameters of the beam arrangement and the constraints for optimization. We have developed an auto-planning platform which is interfaced to a commercial treatment planning system (TPS, Elekta Monaco). The process of searching for an optimized input parameter set is performed separately from the TPS, in order to make it suitable for applying and testing various machine learning methods.

METHOD

Unmanned planning trials with Elekta Monaco were performed consecutively with the input parameters updated in a plan template. Automatic launching a new plan trial was implemented using a generic automation test tool called Robot Framework. Dosimetric parameters of a generated plan, including the results in Monaco plan evaluation module, and data captured in the process of Monaco optimization were automatically exported to a plan quality evaluation system. Monaco optimization data revealed how an organ-at-risk (OAR) constraint impacted target dose coverage and how it was adaptively adjusted. Information in the plan evaluation system was fed into the template modifier, the central piece of our automation platform, for determination of the input planning parameters for the next trial, as depicted in Fig.1. The template modifier was developed in Python to mimic the thought process of an experienced planner. Some details in template modifier of our current implementation were shown in Fig.2. A treatment plan was considered acceptable if all prescribed constraints were met.

RESULTS

Five prostate cases and five head & neck cases were auto-planned for VMAT and compared with the clinical plans used for patients' treatment, as the dose distribution and DVHs of a typical prostate case and a head & neck case shown in Fig. 3-4 and Fig. 5-6, respectively. As seen in Table 1 and 2, auto-plans had similar dosimetric parameters for plan acceptance as the clinical plans. Some OAR dose were significantly lower in the auto-plans, thus the machine performed better than an experienced planner. In this work, auto-planning trials were performed for fluence optimization only, and an optimal input parameter set was used for an uninterrupted full optimization in Monaco to generate a deliverable plan. On average it took on average 15 or 25 iterations, respectively, for a prostate or a head & neck case to obtain an optimal constraint set following the rules in the template modifier. This added less than 10 minutes to the time for a single Monaco planning trial for the final plan with a guaranteed success for meeting dosimetric acceptance criteria.

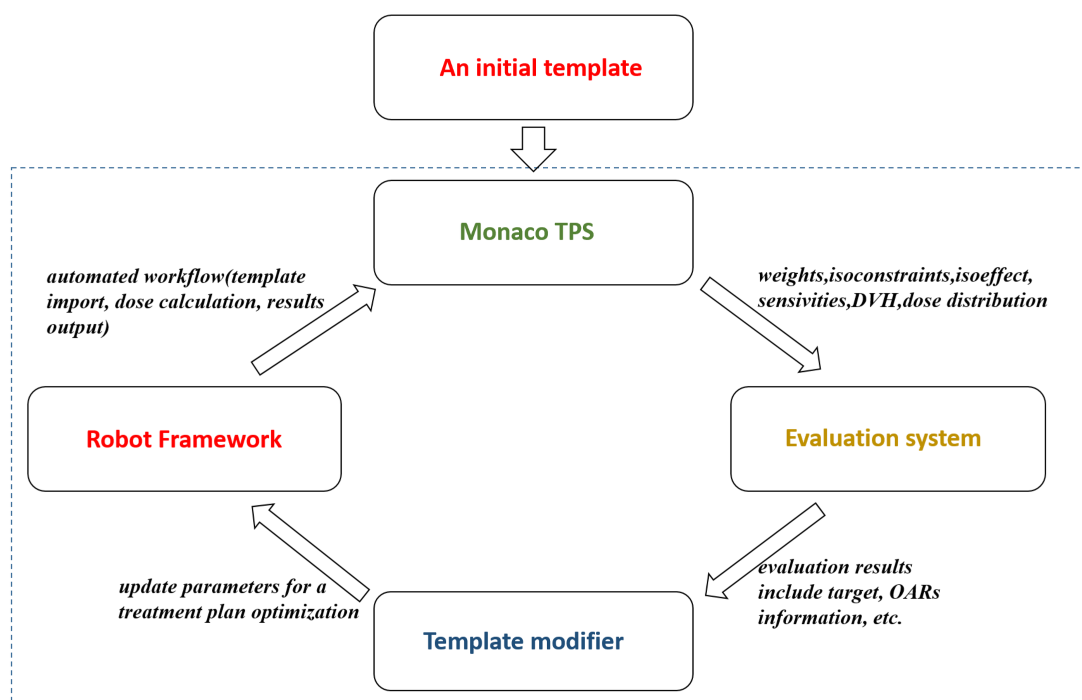

Fig.1. The auto-planning platform

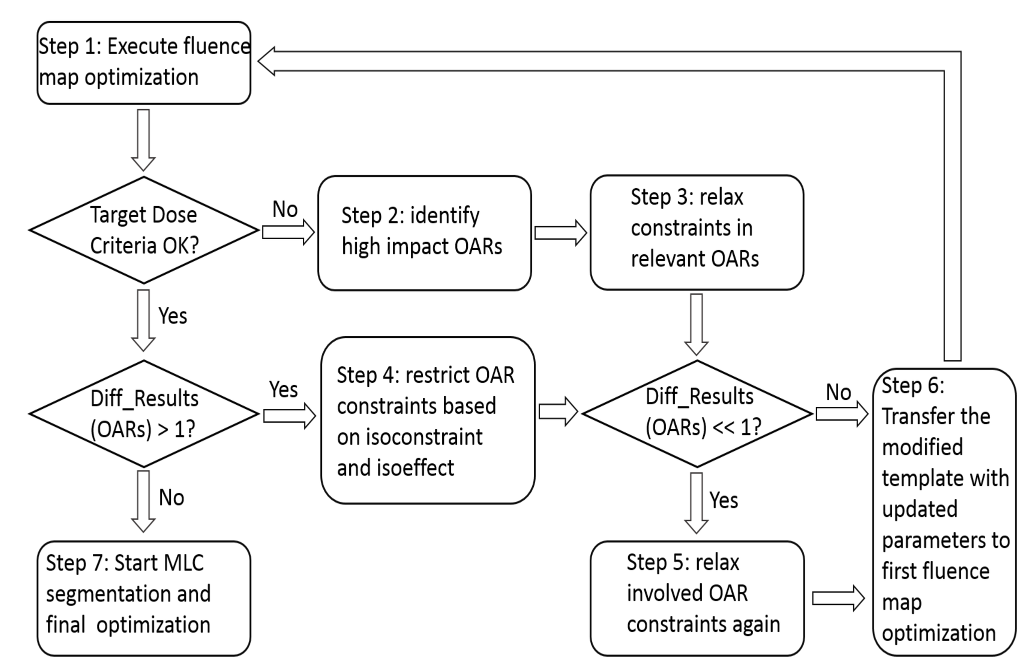

Fig.2. Details of template modifier.(Diff_Results = Autual Results / Prepscription)

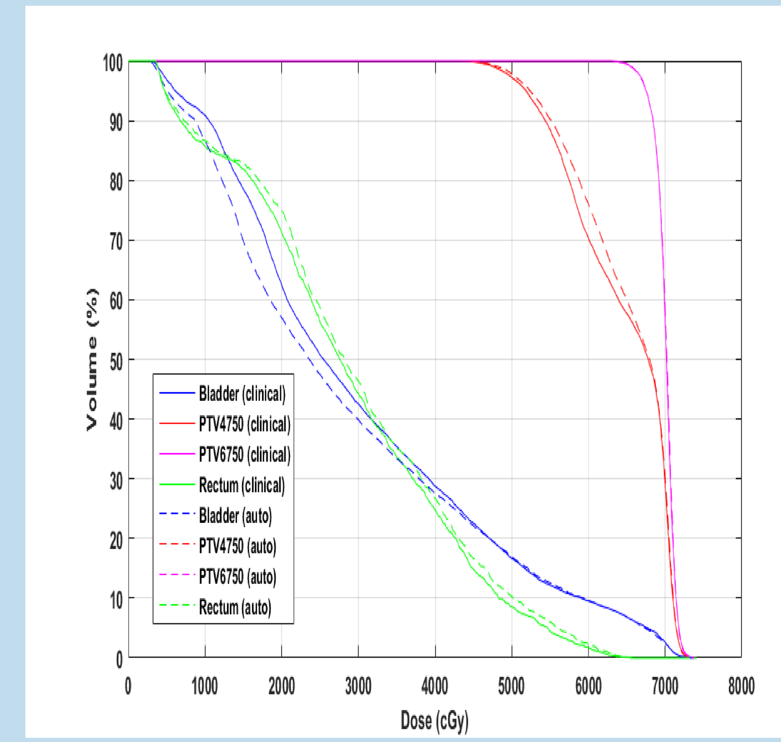

Fig.4. Final DVH comparison between auto and clinical prostate plans. (15 iterations)

TABLE1	Prostate	VMAT
5 cases	Human(mean)	Auto(mean)
PTV67.5Gy	97.2%	97.1%
PTV47.5Gy	95.6%	95.7%
BladderV60Gy	7.8%	5.1%
BladderV40Gy	26.3%	24.7%
RectumV62.5Gy	2.0%	3.8%
RectumV50Gy	12.4%	14.0%
Pubic Bone62.5Gy	8.2%	4.0%
FemoralHeadDmax	41.2Gy	40.8Gy

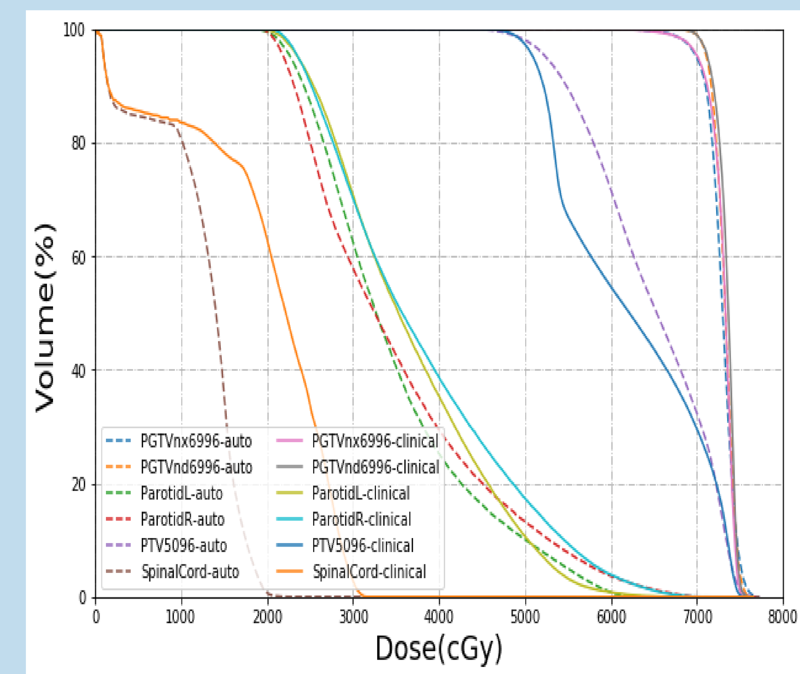

Fig.6. Final DVH comparison between auto and clinical H&N plan. (30 iterations)

TABLE2	H&N	VMAT
5 cases	Human(mean)	Auto(mean)
PGTVnx69.9Gy	96.5%	95.9%
PGTVnd69.9Gy	98.5%	97.1%
PTV50.9Gy	97.2%	95.8%
BrainstemDmax	47.9 Gy	41.8 Gy
SpinalCordDmax	33.6 Gy	25.5 Gy
LensDmax	3.3 Gy	3.8 Gy
OpticNervesDmax	21.6 Gy	24.6 Gy
OpticChiasmDmax	22.1 Gy	26.1 Gy
ParotidsV50Gy	24.1%	18.7%
EsophagusDmean	31.6 Gy	29.5 Gy
MandibleDmean	37.0 Gy	32.4 Gy

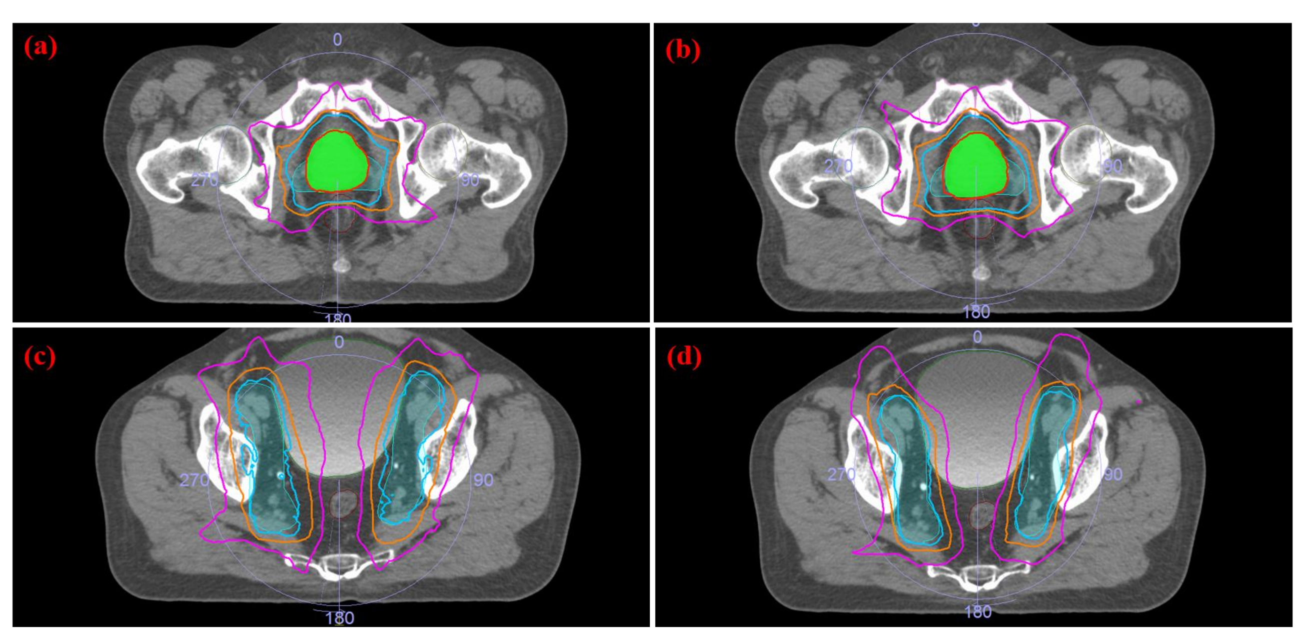

Fig.3. Comparison of the isodose distribution of auto (b, d) and clinical (a, c) prostate plans.

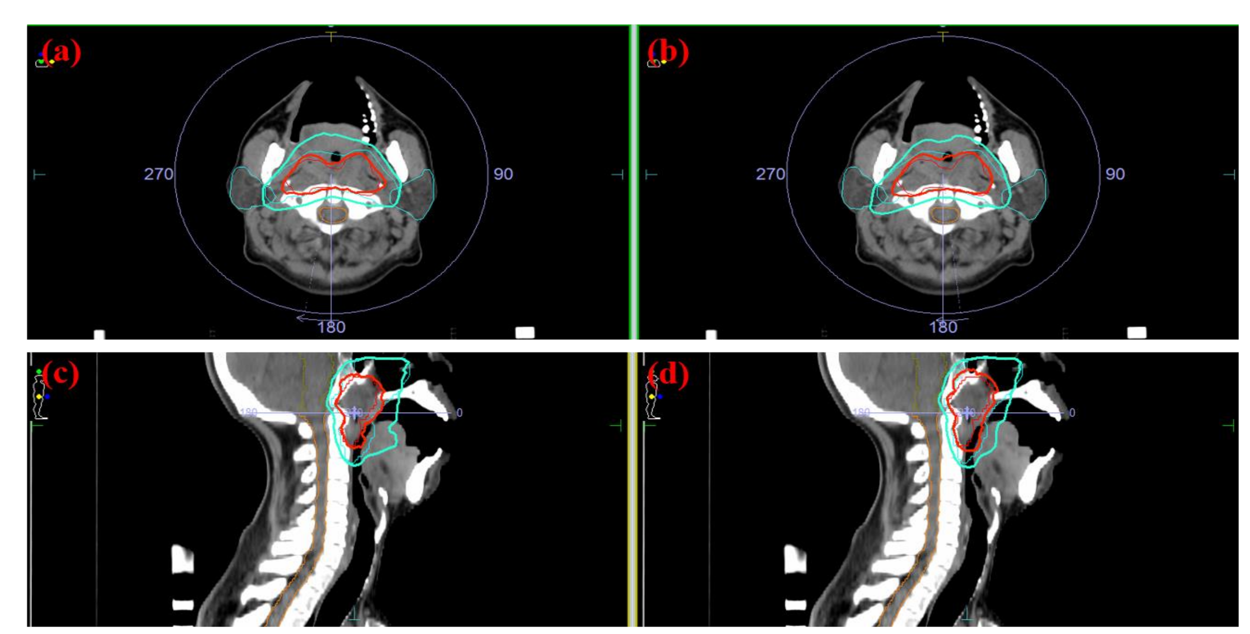

Fig.5. Comparison of the isodose distribution of auto (b, d) and clinical (a, c) H&N planning

CONCLUSIONS

1. An auto-planning platform has been developed to interface with Monaco, and it is ready for clinical use. It can reduce the work for planners in searching for optimal constraint set by repeated plan trials.
2. The platform has a structure that can easily facilitate applications of machine learning techniques for future development.