Architecture, implementation, and performance of an automatic and high-throughput treatment planning service: The Radiation Planning Assistant

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PURPOSE

To build a web-based automated contouring and planning service for clinics in resource-limited countries, focusing on high-quality, high-throughput and high-availability.

METHOD

CT images are uploaded to the Radiation Planning Assistant (RPA) website, and then automatically distributed to different job schedulers to generate contours, treatment plans, and automated QA checks.

The deep learning scheduler prepares contouring jobs, performs load balancing, and submits jobs to GPU-clusters. Completed jobs are passed to the post-processing scheduler, which merges all segmentation result and generates a PDF report and DICOM-RTSTRUCT file for the user to download.

For treatment planning, pre-processing and pre-plan schedulers compute marked isocenter position and beam geometry, generates basic plan and sends these to Eclipse. The optimization scheduler then distributes jobs to script engines for plan optimization and dose calculation. Finally, the report scheduler generates plan PDF report, DICOM-RTSTRUCTand DICOM-RTPLAN files.

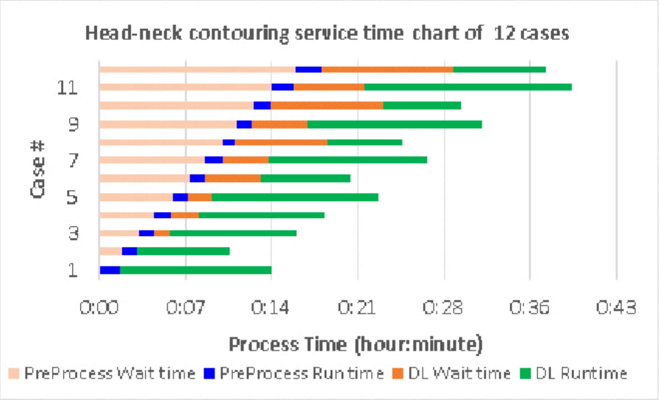
For plan QA, the QA service imports DICOM-RTSTRUCT or DICOM-RTPLAN, generating the following QA jobs: plan quality reporting, dose verification, isocenter QA, contouring QA, beam aperture QA.

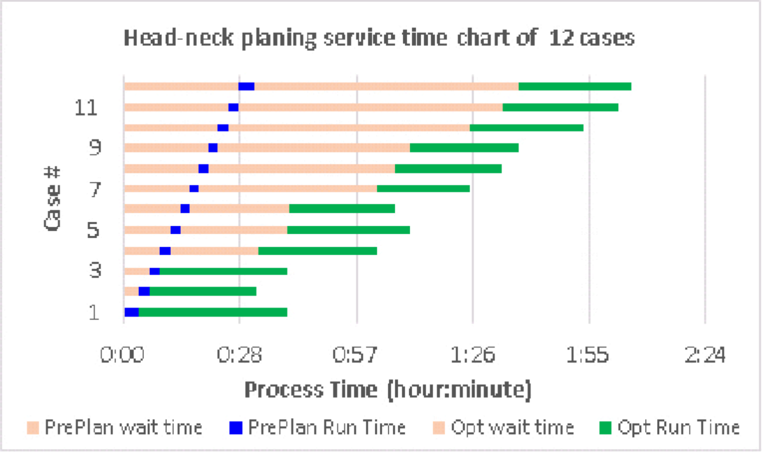
System performance was tested using unloaded (single patient) and heavily loaded (many patients at once) scenarios.

RESULTS

On average, normal tissue (n=21) and CTV contouring a single head-and-neck patient takes 9 minutes. Treatment planning takes 24, 15 and 9 minutes and automated plan QA takes 8, 5 and 4 minutes for head-and-neck (VMAT), chestwall (tangents/sclv, field-in-field) and cervix (4-field) plans, respectively. Under loaded conditions, the system hourly throughput is for head-and-neck contouring is 18 patients/hour. For planning, the throughput is 6, 9, and 16 head-and-neck, chestwall and cervix patients/hour. For QA, the throughput is 18, 22, and 28 patients/hour.

Figures below show planning and contouring processing time when the RPA is pre-loaded with 12 head and neck cases. The bottleneck is the Eclipse optimization time – this is because our current system only has 3 workstations, so we are limited to 3 simultaneous VMAT optimizations. This is easily scalable when we go clinical. Similarly, if more GPUs are added into clusters, the contouring time can be easily scaled down.





Best computation time for one single case

	Contouring	Planning	QA
Head Neck	9 minutes	24 minutes	8 minutes
Chest Wall	NA	15 minutes	5 minutes
Cervix	NA	9 minutes	4 minutes

Max number of cases that can be handled within one hour

	Contouring	Planning	QA
Head Neck	18 cases	6 cases	18 cases
Chest Wall	NA	9 cases	22 cases
Cervix	NA	16 cases	28 cases

CONCLUSIONS

We have implemented a high-throughput automated planning service. The system's performance is scalable to meet the demands of a service designed to offer high-quality radiotherapy contouring and planning to clinics with limited resources.

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