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Atrium Health

The Impact of Knowledge-Based Planning and Multicriteria Optimization On Treatment Planning

J. ROGERS[1], A. BOE[1], M. DIMASCIO[1], W. RAMER[1], J. STANULUS[1]
[1]Rock Hill Radiation Therapy Clinic, Levine Cancer Center, Atrium Health, Rock Hill, SC

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Introduction

Knowledge-based treatment planning, such as RapidPlan® from Varian Medical Systems, has changed the landscape of radiation therapy treatment planning. Not only does this enable physicists and dosimetrists to evaluate plan quality by utilizing historical treatment planning data, but it also can increase throughput by leveraging automation. Combined with Multi-criteria Optimization and the Eclipse Scripting API (ESAPI), automated treatment planning workflows can be created to converge on knowledge-based, trade-off explored, treatment plans. This can have a positive impact in the clinic for turnaround times as well as plan quality.

Aim

To calculate the impact of knowledge-based planning and Multi-Criteria Optimization (MCO) on the efficiency of treatment planning workflows.

Method

Four custom RapidPlan® models were created utilizing historical plans in a network of centers. The focus was on generalized prostate, lung, hippocampal avoidance whole brain, and head and neck sites. Specialized data mining tools were developed to locate the treatment plans that were candidates for the model. These tools use SQL-based queries to find patients based on structure ID wildcard searches, diagnosis, gender, and the site and prescription information. The models were adjusted until most optimizations with the applied DVH Estimations gave clinically acceptable solutions after one full run. Plan quality metrics were analyzed by DVH analysis to our site's protocols in Radformation's ClearCheck ESAPI plugin. The new treatment planning workflows were tracked by analyzing the Care Paths in ARIA compared to plans optimized with and without the RapidPlan models being applied. Furthermore, a fully automated solution was created using the ESAPI to show proof of concept of the speed at which the optimizations could converge on passing clinical results based on DVH analysis.

Results

RapidPlan Model Creation and Utilization

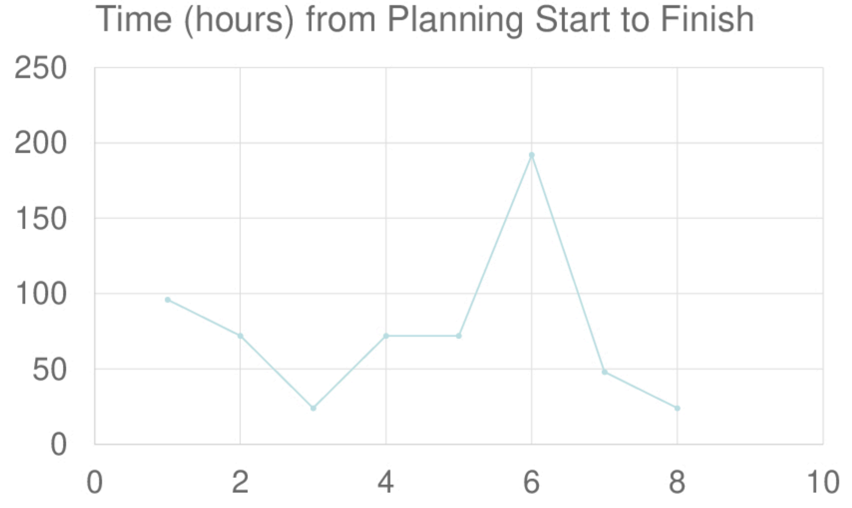
Custom RapidPlan models were created for the following sites, along with the number of plans and total structures modeled:

Model Name	# of Plans	# of Structures
LCI Prostate	151	9
LCI HN	163	24
LCI HA BRAIN	45	12
LCI LUNG	86	7

The LCI Prostate has been the most active model, in use clinically, with 59 plans having been done using the model. The LCI HN and LCI Lung models have had 4 patients under beam each. To date, the LCI HA Brain has not been used clinically, only in testing. Therefore, for illustration purposed of workflow, only the LCI Prostate model will be shown.

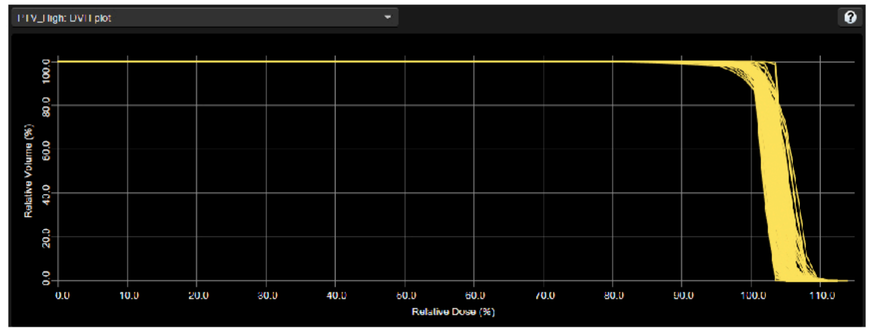
Average Turnaround Time With the Prostate Model

With the plans that used the LCI Prostate model, the average turnaround time from the approval of contours to the final plan approval was 3.1 days with a sample size of 8 patients. This is reduced from more than 3 days from prior scheduled plan turnaround for IMRT in our clinic. This could be attributed to both RapidPlan and other clinical workflow enhancements. Current workflows in our clinic have been reflected to schedule patients sooner.

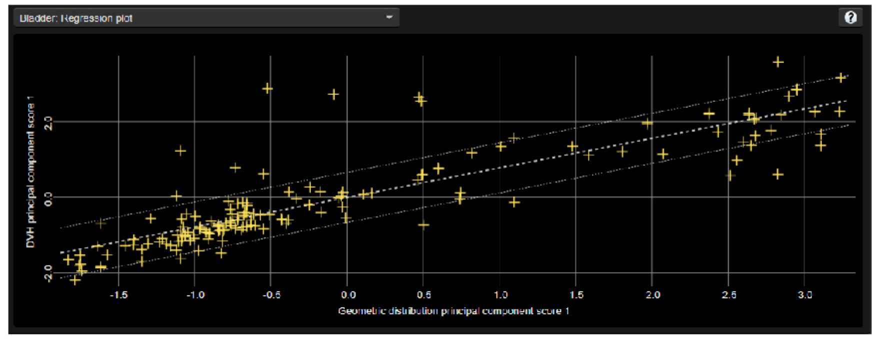


Model Quality Assessment

The models were assessed for accuracy by looking at the regression and residuals plots and analyzing the principle component analysis scores. It was determined that more cases had a positive effect on the overall modeling. All models took a few days to add the patients, but patients have been being added to the models have been continuously since the initial training.



Example of DVH Plot in Model Configuration



Example of Regression plots for OAR, in the case the Bladder of the custom model

Optimization and Automation with RapidPlan and MCO

Using ESAPI (v15.x, with writable capabilities), a standalone application was made that created the plan based off naming conventions, attached the CT in the context, mapped the structures to the RapidPlan model, and optimized. After optimization, the trade-offs were chosen from the calculated plan (GPU enabled), and these were iterated compared to the objectives clinically used from ClearCheck. The total process in code took on average 20 minutes with 2 iterations before passing the constraints. This has not been used clinically yet, but it does show promise.

Conclusions

The combination of RapidPlan, automation with ESAPI, and MCO is changing workflows in our clinic. There are already significant gains with the prostate model in our plan turnaround times and certain plan quality metrics. Since RapidPlan optimizes to the line objectives set in the model, volumetric constraints are being met much easier that max dose, small volume constraints. This is what is typically driving iterations in the optimizations. MCO is helping that problem in code, but this has yet to make it into our current clinical workflows. Clinical Protocols in Eclipse are now being created to use Plan Objectives to evaluate the dose in the trade-off exploration workspace in real-time. This will greatly improve our utilization of MCO prior to the code being approved for clinical use. The workflows will be reevaluated once MCO is being utilized for all optimized plans to measure the impact on turnaround times.

References

1. Eclipse Scripting API Reference Guide (15.5), November 2017, Varian Medical Systems
2. Eclipse Scripting API Online Help (15.5), November 2017, Varian Medical Systems
3. RapidPlan Custom Model Verification tip EC13.5-QTS-02, May 2015, Varian Medical Systems

Contact Info

jonathan.rogers@atriumhealth.org

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