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Automatic Eclipse Planning Using Script and RapidPlan for Prostate SBRT

A. ALARCÓN[1] and C.D VENENCIA[1]
1 Instituto Zunino, Fundación Marie Curie, Córdoba-Argentina

Instituto Zunino
Fundación Marie Curie

INTRODUCTION

Intensity-modulated radiotherapy (VMAT) is a standard technique in radiotherapy with dosimetric advantages. However, the process is time-consuming and susceptible to user error. In stereotactic body radiation (SBRT) the complication is greater. In the age of automation, artificial intelligence, and data storage, it is possible to take advantage of using knowledge-based planning algorithms (KBP, "Rapidplan") [1] and application development environments. (ESAPI, C #), for the automation of this process.

AIM

Prostate SBRT planning requires multiple plan configuration and optimization for a good result. This procedure is done by the dosimetrist, is time-consuming, and could have user's errors. The objective of this work was to generate a plan automatic clinically acceptable using Eclipse's ESAPI and Rapidplan.

METHODS

Knowledge-based planning "Rapidplan" vs 15.6, Eclipse scripting application programming interface (ESAPI) vs 15.6, and Microsoft Visual Studio 2019 were used for write and compile a serie of applications and plugin script in C #, executable in Eclipse to automate the planning process (Fig. 1). It includes the creation of planning structures, VMAT plan generation (technique, prescription, and isocenter), optimization based on RapidPlan, dose calculation, and plan evaluation (automatic dosimetric data extraction from ARIA database with "standalone" application, Fig. 3). RapidPlan model for prostate SBRT with lymph node (SBRT_36/25Gy) was created using 41 plans and for prostate SBRT alone (SBRT_36Gy) 57 plans were used. 24 plans, for each SBRT technique, were used to compare automatic versus manual treatment planning. The adjustment statistics of the Rapidplan data were verified through the coefficient R_2, distribution χ_2 and MSE. The comparison was done using treatment planning time (from CT's uploading to objectives verification), CI (RTOG conformity index) PCI (Paddick's conformity index), PTV_D95%, PTV_D2%, and MU. A quality score (QS) index was used, it is defined as a dose weighted difference sum for each objective above a tolerance (Ideal QS is 100). Statistical significance was evaluated using 2-tailed student's T-test with a significance of 0.05 [1].

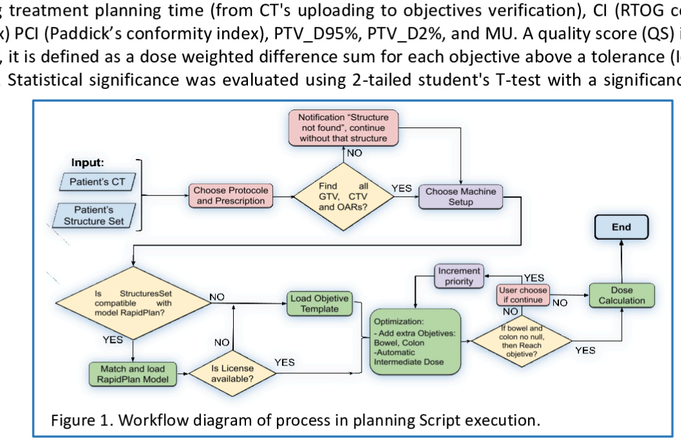

Figure 1. Workflow diagram of process in planning Script execution.

RESULTS

Fit statistic for SBRT_36Gy (SBRT_36 / 25Gy) model maximum R2 value of 0.90 (0.899)and minimum value for χ_2 was 1,022(1.003), booth values show there is no "overfitting".

The automatic treatment planning time for SBRT_36Gy (SBRT_36 / 25Gy) was 13 ± 5 min (22 ± 8 min) and the corresponding manual time was 49 ± 15 min (40 ± 12 min). Reducing time planning. The statistical comparison (Table 1) shows: plan values (manual; automatic) for PTV D98% of SBRT_36Gy are (35.6 ± 0.4; 35.4 ± 0.2 Gy) and (35.7 ± 1.3; 35.7 ± 1.1 Gy) for SBRT_36/25Gy, PTV D2% (39.1 ± 0.3; 39.0 ± 0.2) and (39.7 ± 1.1; 39.5 ± 1.1), showing differences ~0.5%, very uniform for PTVs. The MU total were (2473 ± 180/2556 ± 118 MU) for SBRT_36Gy and (2468 ± 383/2377 ± 248 MU) for SBRT_36/25Gy with manual/automatic respectively, showing no increase of complexity. If we analyze the DVHs, Figure 2 shows the average DVH of the 24 plans analyzed for SBRT_36/25Gy plans, good correlation between both methods. In OAR (Fig. 4 and 5) show the existence of a greater standard deviation as expected, due to anatomy, however, the averages are statistically similar. The QS were (manual / automatic) (92.5 ± 10.1 / 93.4 ± 7.5) for SBRT_36/25Gy and (95.1 ± 7.5/95.1 ± 5.3) for SBRT_36Gy, with slight improvement in automatic plans.

	Metric			Manual			Aautomatic				
Structure	Condition [Gy]	Tolerance [Gy]	Objective [Gy]	Mean ± Std [Gy]	[Max;Min] [Gy]	Quality Index	Mean ± Std [Gy]	[Max;Min] [Gy]	Quality Index	Cumulative Dif[%]	
PTV Prostate	D(98%Vol)	D>34.0	D>35.00	35.7 ± 1.3	[37.0;32.5]	CI = 0.93 ± 0.08	35.7±1.1	[36.8;34.5]	CI = 0.92 ± 0.04	0.001	0.887
	D(95%Vol)	D>35.0	D>36.25	36.2 ± 1.3	[37.3;33.5]	Paddick CI = 1.21±0.11	36.2±1.2	[37.0;35.2]	Paddick CI = 1.18±0.05	0.03%	0.926
	D(2%Vol)	D<42.0	D<40.00	39.7 ± 1.1	[41.2;38.8]	GI = 7.17 ± 3.9	39.5±1.1	[41.6;38.8]	GI = 7.51 ± 4.23	0.005	0.030
PTV-PRVs!	D(98%Vol)	D>35.0	D>36.00	36.6 ± 1.1	[37.7;35.6]		36.5±1.1	[39.9;36.1]		0.14%	0.330
	D(95%Vol)	D>35.5	D>36.25	36.8 ± 1.1	[37.8;36.1]		36.8±1.1	[37.3;36.3]		0.002	0.163
	D(2%Vol)	D<42.0	D<40.00	39.7 ± 1.1	[41.2;38.8]		39.5±1.1	[41.6;38.9]		0.50%	0.032
PTV Lymph Nodes	D(98%Vol)	D>23	D>24.5	25 ± 0.6	[25.4;23.0]		25.0±0.4	[25.5;23.9]		0.000	0.933
	D(95%Vol)	D>23.5	D>25	25.3 ± 0.4	[25.6;23.7]		25.3±0.4	[25.7;24.2]		-0.04%	0.872
Bladder	D(40%Vol)	D<20.0	D<18.00	15.4 ± 3.0	[18.0; 3.4]		15.2±3.1	[18.2;2.9]		0.000	0.077
	D(10%Vol)	D<38.0	D<36.25	26.8 ± 2.4	[31.5;22.2]		26.9±2.4	[30.9;21.8]		0.47%	0.801
	D(5cc Vol)	D<39.0	D<37.00	36.8 ± 1.3	[40.7;34.6]		36.6±1.4	[40.5;34.7]		-0.012	0.032
Rectum	D(40%Vol)	D<22.0	D<18.00	16.7 ± 6.5	[36.0;12.8]		16.9±6.4	[35.9;12.8]		-1.01%	0.173
	D(10%Vol)	D<35.0	D<32.60	28.9 ± 4.1	[36.4;20.8]		29.2±4.1	[36.4;21.5]		-0.004	0.088
	D(1cc Vol)	D<39.0	D<36.00	35.4 ± 1.1	[37.5;33.0]		35.4±1.0	[37.6;33.2]		0.06%	0.938
Rectum_A	D(2%Vol)	D<39.0	D<36.00	35.5 ± 1.1	[38.0;33.3]		35.5±1.1	[38.1;33.8]		-0.013	0.874
Rectum_P	D(2%Vol)	D<20.0	D<16.00	15.8 ± 0.5	[16.5;14.2]		16.0±0.3	[16.5;15.5]		-2.10%	0.089
FemoralJoint_L	D(5%Vol)	D<19.0	D<16.00	14.6 ± 1.6	[16.0 ; 8.1]		14.9±1.1	[17.5;12]		-0.011	0.198
FemoralJoint_R	D(5%Vol)	D<19.0	D<16.00	14.6 ± 1.5	[15.7 ; 8.4]		14.8±1.2	[16.3;10.9]		0.23%	0.581
Urethra	D(2%Vol)	D<40.0	D<38.00	38.1 ± 1.2	[41.7;36.8]		38.0±1.2	[41.1;37.4]		0.005	0.217
Trigone	D(2%Vol)	D<40.0	D<38.00	37.9 ± 1.3	[41.4;35.7]		37.7±1.3	[41.1;36.2]		0.60%	0.039
Monitor Units	<3000 UM			2468 ± 383 UM			2377 ± 248 UM				
Score Quality		SQ > 80	SQ = 100	92.4 + 10.2			93.2 ± 7.6 UM				

Table 1. Statistical results of the dosimetric comparison between both planning techniques, for the percentage differences the reference is the manual plan.

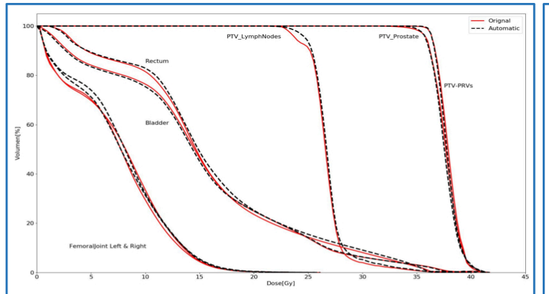

Figura 2. Average DVH of the 24 cases analyzed in SBRT_36/25Gy, solid line for original and segmented line for automatic plans

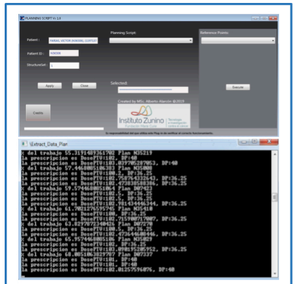

Figura 3. Graphical interface. Top for planning and Bottom for metric extraction

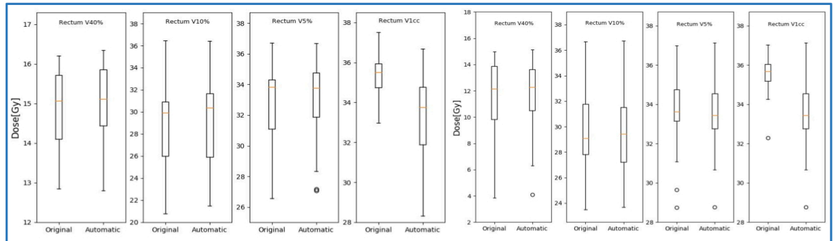

Figura 4. Comparison of clinical protocol dose values for rectum for booth methods. Left SBRT_36Gy and right SBRT_36/25Gy

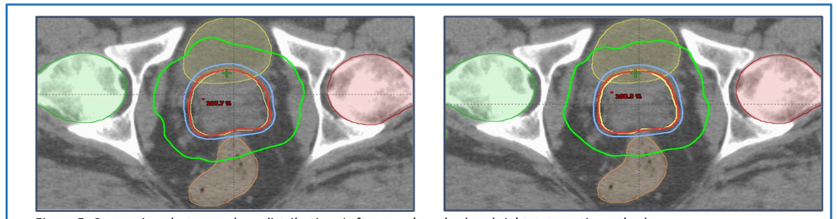

Figura 5. Comparison between dose distribution. Left manual method and right automatic method

CONCLUSIONS

The planning automation process is feasible for prostate SBRT and was successfully implemented. ESAPI allows standardizing planning criteria. RapidPlan models for prostate SBRT alone and lymph node were developed and implemented. Automatic plans using ESAPI and RapidPlan without user intervention are clinically acceptable and similar to manual plan. The process reduces planning time and eliminates random planning errors, regardless of the user's skills.

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CONTACT INFORMATION

Contact to A. Alarcón, M.Sc. and D. Venencia, PhD, for more detailed information.

aalarcon@institutozunino.org
dvenencia@institutozunino.org