Compounding Automation Features from Multiple APIs for Automated Linac Quality Assurance

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INTRODUCTION

The planning, generation and distribution of plans for linear accelerator quality assurance (QA) can be a time-consuming and laborious task possibly resulting in inconsistent measurements or suboptimal QA plans. Static gantry QA plans can be generated from imported text multi-leaf collimator (MLC) control-point definition files or manually generating control point parameters from within the treatment planning system (TPS) while volumetric modulated arc therapy (VMAT) plans require DICOM file references for plan delivery. Depending on the parameters of the DICOM control point definitions, plan modification can be difficult and plan recreation, which is often needed when image caching causes slow plan load times, requires manual modification of the DICOM files. API features within the TPS and oncology information system (OIS) allow for automated generation of both standard and custom plans for linear accelerator quality assurance.

METHODS

Quality assurance plan generation may require a substantial effort in generation or modification **[Figure 1].**

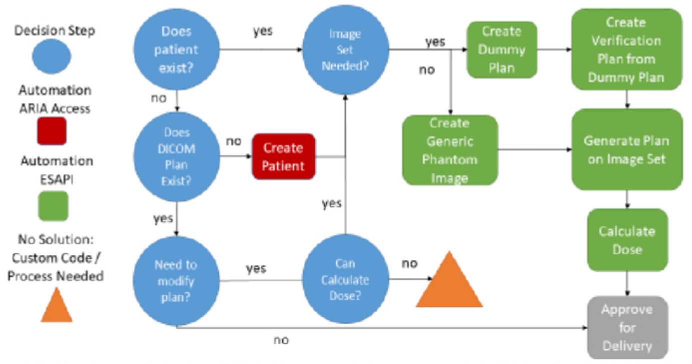


Figure 1: Process for manually generating quality assurance plans with colors indicating pieces that can be automated through clinical APIs

For instance, if the plan requires a standard image set for imaging or dosimetry purposes, the user may be required to first generate a verification plan to link the image set to the newly generated patient. If the QA plan is from a standard plan set, it may be difficult to modify the DICOM file without custom code– the control point parameters are outside of the limitation of the treatment planning system– or reimport the plan to another patient if that plan already exists in the TPS.

A custom application was built utilizing features from the Eclipse Scripting API (ESAPI) and ARIA Web Service to generate patients and plans for quality assurance purposes (Varian Medical Systems, Palo Alto, CA). This application was utilized to generate quality assurance plans of varying complexity and allows for the generation of consistent quality assurance plans quickly and efficiently.

RESULTS

Within the TPS, VMAT plans require constant gantry angle variation between each control point. Therefore, the control points of VMAT plans must be re-sampled to a constant gantry angle limit. When re-sampling, the RA QA test was able to be reproduced with the monitor unit (MU) and gantry angle difference of 0.025 (±0.17) MU and 0.131 (±0.25) degrees with the maximum MU and gantry angle differences being 0.4MU and 0.33 degrees, respectively **[Table 1]**.

The RA QA fields were delivered with the standard vendor provided plans and the automation generated plans. The trajectory log file analysis shows the automated plan varies the gantry speed as the test intends, but not identical to the vendor provided plan **[Figure 5]**. The resultant differences in the RA QA analysis is also shown **[Figure 6]** with average corrected reading of 14.92 and 14.95 across all bands for manual and automated plans, respectively**.** From all ROIs analysed, the average of absolute deviations from the manual plan concluded with 0.16% while the automated plan improved to 0.13%.

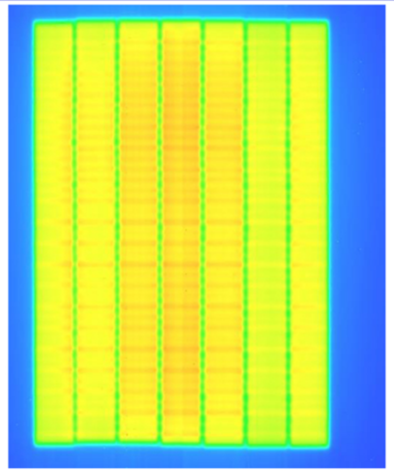


Figure 4: Dose Rate Gantry Speed test in the RA QA plan image

Figure 2: Auto QA Builder application for the automated generation of quality assurance plans.

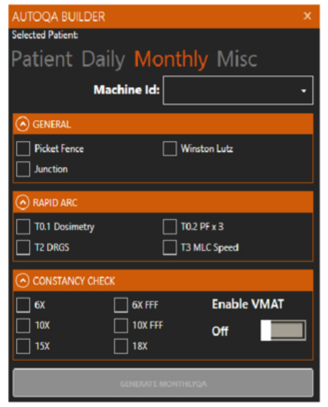
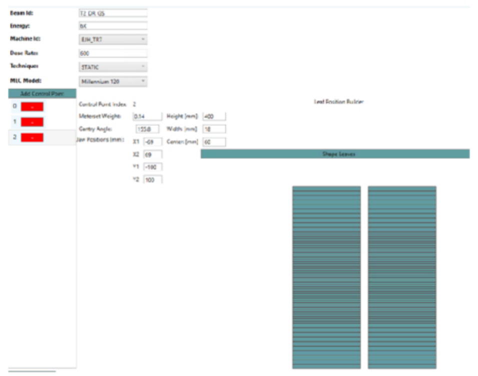


Figure 3: Custom MLC shaping application for the generation of static gantry and VMAT plans into a beam configuration template



Index	Meterset Weight (MU)	Gantry Angle	Leaf A [mm]	Leaf B [mm]	Index	Meterset Weight (MU)	Gantry Angle	Leaf A [mm]	Leaf B [mm]
0	0.00 (0)	179.00	69.0	69.0	0	0.00 (0)	179.00	69.0	69.0
1	0.02 (8)	169.00	51.0	69.0	15	0.02 (8)	169.1	51.0	69.0
2	0.14 (56)	155.80	51.0	69.0	35	0.14 (56)	155.9	51.0	69.0
3	0.16 (64)	145.80	31.0	49.0	50	0.1596 (63.84)	146.0	31.0	49.0
4	0.28 (112)	131.13	31.0	49.0	73	0.2806 (112.24)	130.8	31.0	49.0
5	0.30 (120)	121.13	11.0	29.0	87	0.2991 (119.64)	121.6	11.0	29.0
6	0.42 (168)	104.63	11.0	29.0	113	0.4204 (168.16)	104.4	11.0	29.0
7	0.44 (176)	94.63	-9.0	9.0	128	0.4406 (176.24)	94.5	-9.0	9.0
8	0.56 (224)	74.01	-9.0	9.0	159	0.56 (224)	74.1	-9.0	9.0
9	0.58 (232)	64.01	-29.0	-11.0	174	0.5796 (231.88)	64.2	-29.0	-11.0
10	0.70 (280)	36.51	-29.0	-11.0	216	0.70 (280)	36.5	-29.0	-11.0
11	0.72 (288)	26.51	-49.0	-31.0	231	0.72 (288)	26.6	-49.0	-31.0
12	0.84 (336)	345.26	-49.0	-31.0	293	0.839 (335.6)	345.7	-49.0	-31.0
13	0.86 (344)	335.26	-69.0	-51.0	308	0.86 (344)	335.8	-69.0	-51.0
14	0.98 (392)	252.76	-69.0	-51.0	433	0.9799 (392)	253.3	-69.0	-51.0
15	1.00 (400)	242.76	-69.0	-69.0	449	1.00 (400)	242.8	-69.0	-69.0

Table 1: Comparison of RA QA field control point parameters and re-sampled automated planning control point parameters.

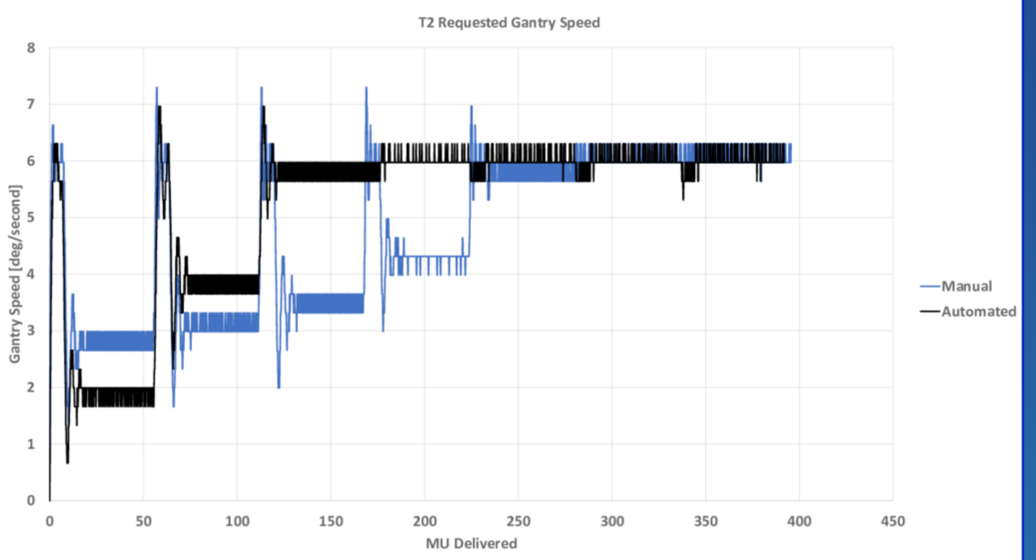


Figure 5: Comparison of gantry speed between manual and automated plans during the Dose Rate Gantry Speed RapidArc QA test.

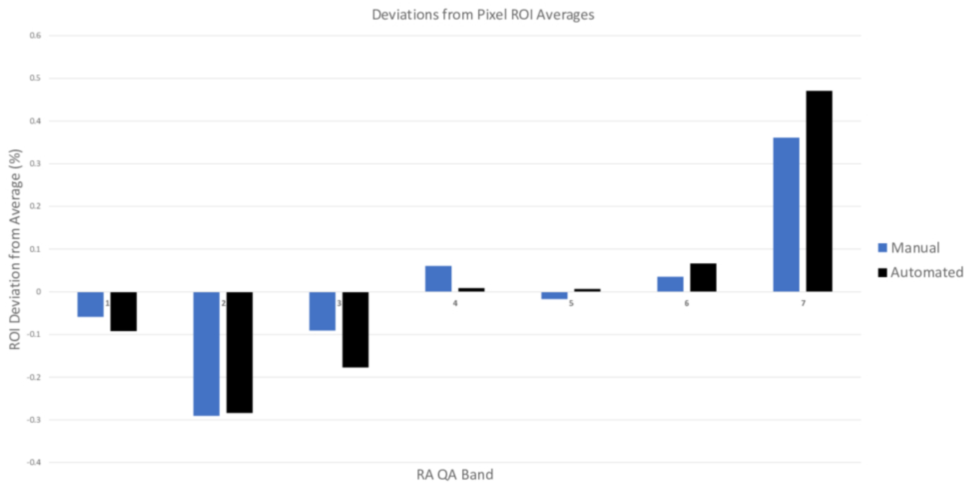


Figure 6: ROI deviation for the mean of all ROIs as a standard method for RA QA analysis.

METHODS CONT.

The AutoQA Builder application allows for the generation of new patients using the ARIA Access API. Quality assurance plans for Daily and Monthly QA as well as miscellaneous QA plans can be generated with the TPS API **[Figure 2]**. This application utilizes JSON beam template files to allow the custom design of QA fields and efficient distribution through the use of the AutoQA Builder tool **[Figure 3].**

In order to show the efficacy of the quality assurance application, the results of a commonly delivered complex QA plan– the Dose Rate Gantry Speed RapidArc QA (RA QA) Tests provided by Varian Medical Systems– are presented in this work. This test is currently analyzed by dividing the normalized mean value within 7 banded ROIs by the average of all 7 bands and testing the deviation from the mean of each individual band **[Figure 4]**..

CONCLUSIONS

Automated generation of linear accelerator quality assurance plans allows for the precise implementation of consistent plan deliveries across all machines within the institution, thereby reducing the burden on the record and verify system to load high volume image data sets for daily imaging QA. The plan shown in this study, the RA QA Dose Rate Gantry Speed test, cannot be modified in the TPS due to the control point spacing beyond the TPS limitation for dose calculation. It can also only be loaded into the TPS one time before anonymization is required in order to create a duplicate test patient.

Currently, the AutoQA Builder application has been utilized in the creation of 92 distinct QA plans for daily QA– plans regenerated every 3 months due to large image file caching, monthly and quarterly QA fields, and QA fields generated for EPID dosimetry and linac commissioning.

REFERENCES

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CONTACT INFORMATION

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