Automated Linac QA using scripting and Varian Developer Mode

Keith Pearman, Caroline Vanderstraeten, Nicholas Koch, Dave Wiant, Lane Hayes, Grace Shang, Han Liu, Benjamin Sintay

Cone Health Cancer Center, Greensboro, North Carolina

Purpose

Linac quality assurance (QA) can be time consuming involving set up, execution, analysis and subject to user variability. The purpose of this study is to develop automation tools for Linac QA to improve efficiency, consistency and accuracy.

Methods

Traditionally QA has been performed with graph paper, film, and multiple phantoms with different set-ups. Analysis consists of ruler and vendor provided software. We have developed a single four-phantom method for QA procedures including light-radiation coincidence, kV and MV imaging quality, table motion and isocentricity. These tests are driven by XML scripts that were developed to execute a series of tasks in a specific order using Varian's Truebeam Developer Mode. Analysis is performed in individual MatLab scripts and then auto exported to a system spreadsheet.

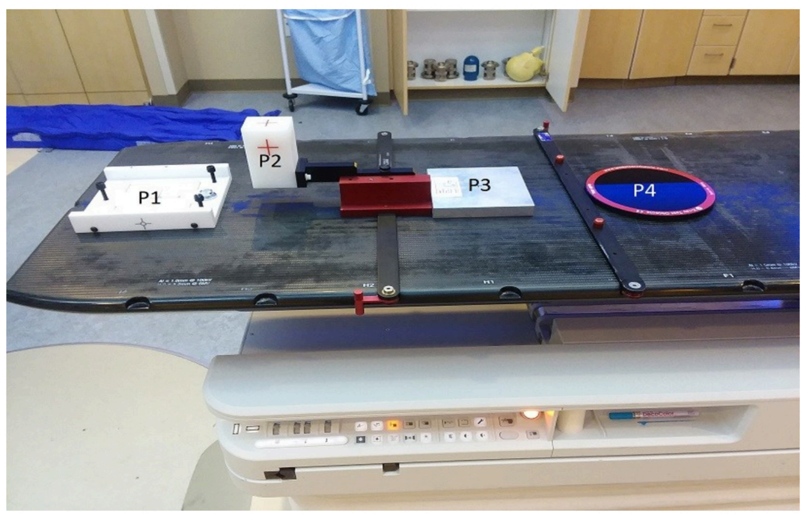

Figure 1: Linac QA procedures using four phantom setup method. P1: light & radiation coincidence phantom; P2: table position & isocentricity IGRT phantom; P3: Vegas phantom; P4: Leeds phantom.

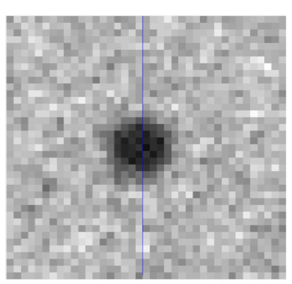

Figure 2: Automatic identification of an imbedded fiducial marker in phantom P2 used to test the isocentricity (isocenter confirmed with MV and kV images) and table translation in three dimensions. Three methods are used to identify the marker location: edge detection along image profiles, center of mass calculation, and mean pixel intensity. The minimum difference from the three methods is reported. For isocentricity the fiducial position is compared to current panel position and a baseline fiducial position, again the lesser difference is reported.

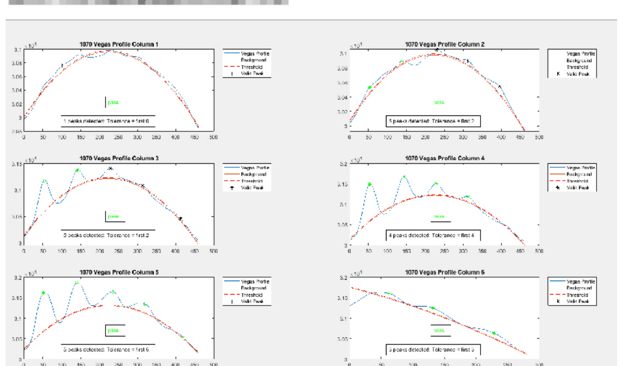

Figure 3: Example of an 6x MV image quality analysis of the Vegas phantom P3. Contrast circles are found by drawing a profile and displayed as peaks. Peak qualification is determined by slope, relative position and background level.

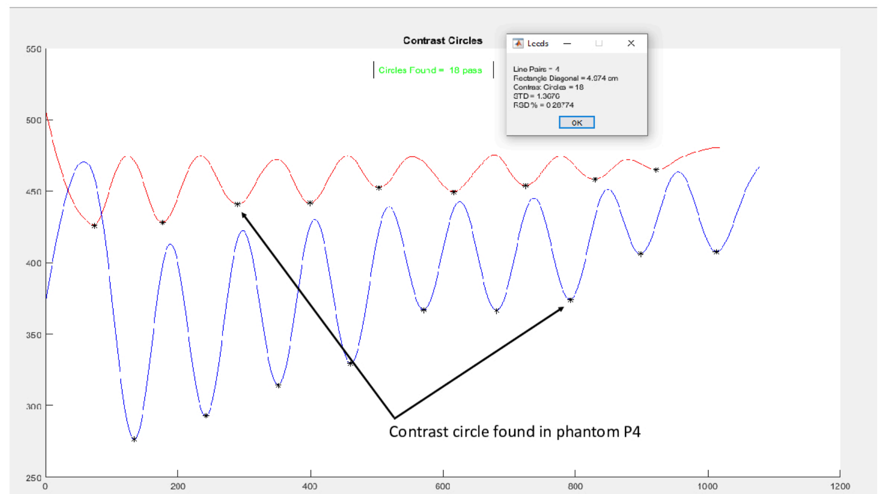

Figure 4: Example of kV image quality analysis of the Leeds phantom P4. A circular profile is drawn and the troughs are found and counted. The data display box includes a box diagonal measurement, line pairs for resolution, standard deviation and RSD percent.

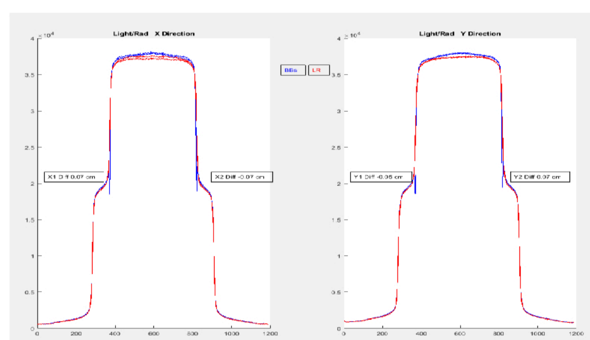

Figure 5: Light vs radiation coincidence analysis using phantom P1. The light field is aligned manually to the phantom fiducials then compared to the radiation edge. The difference is reported.

Additionally, non-phantom QA procedures have also been developed including field size, dose rate, MLC position, MLC and gantry speed, star shot, Winston-Lutz and Half Beam Block.

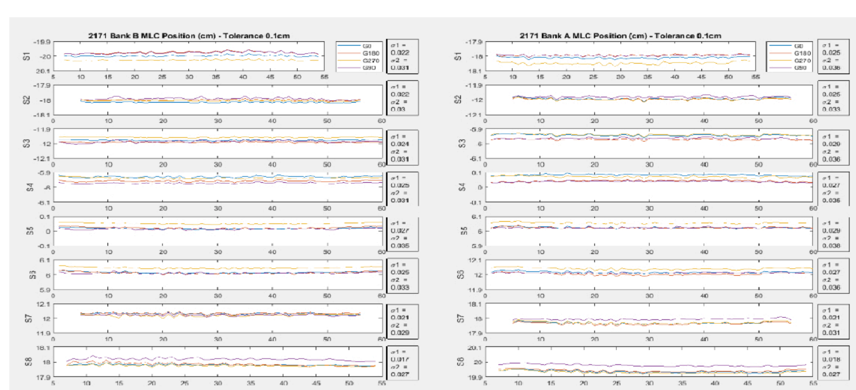

Figure 6: Example of MLC analysis by script. Four gantry angles represented. S1-S8 represents 8 separate images. X axis is the leaf number. Y axis is the absolute leaf position. $\sigma 1$ is the SD of a gantry angle and $\sigma 2$ is the SD of all gantry angles. Tolerance is represented by the border range.

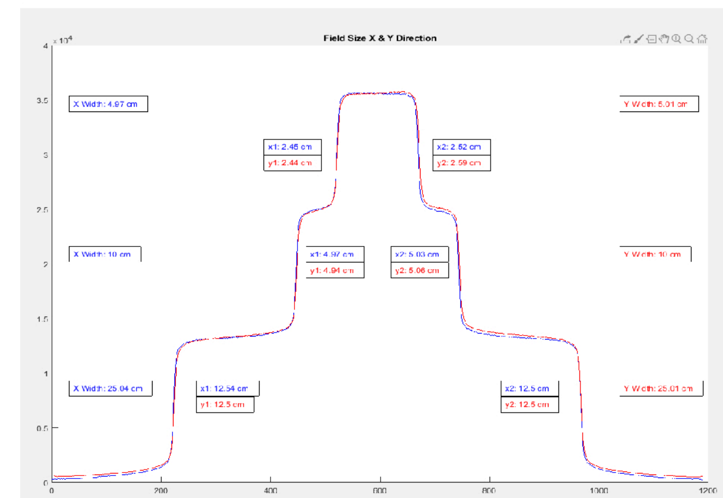

Figure 7: Example of field size analysis. Two profiles are drawn across three field sizes (5 cm, 10 cm and 25 cm) in the X and Y directions and then the width is calculated. The edges are found using a FWHM.

Results and Discussion

Overall time savings were 2.5 hours per Linac on a monthly basis. MLC position, star shots and Winston-Lutz giving the largest savings. Consistency improvements (standard deviation) were observed for most tests using the new methods. For example: field size improved from 0.11mm to 0.04mm and table motion improved from 0.17mm to 0.12mm. No SD change was observed for Isocentricity. We noticed a decrease in SD from 0.33mm to 0.41mm for light-radiation coincidence test, likely due to the new method having the jaws manually adjusted to match the light field. There was a small drop in accuracy for field size possible due to calibration being performed with the graph paper and not the script. Isocentricity showed an increase in measurement accuracy from 0.47mm to 0.15mm. Table motion also indicated a increase in measurement accuracy from 0.20mm to 0.16mm. Dose rate, gantry and MLC speed test were not previously performed and have no comparison. Winston –Lutz has always been performed with a automated script. See the results chart.

Results Chart

	Frequency	S.U.E Time N.M.	S.U.E Time O.M.	Loss/Gain Time	A.D.E. Time N.M.	A.D.E. Time O.M.	Loss/Gain Time	Sensitivity (NM)	Time Saved (minutes) per Linac			
MLC Position	Monthly	8	80	-72	0.5	5.0	-4.5	0.03 cm	Monthly		Yearly	
Half Beam Block	Monthly	1	6	-5	0.1	0.5	-0.4	-	-150.8		-220.8	
Winston-Lutz	Weekly (4x)	6	44	-38	-	-	-	-				
Leeds	Monthly	1	2	-1	0.1	3.0	-2.9	-				
Vegas	Monthly	1	2	-1	0.1	0.5	-0.4	-				
Star Shots	Yearly	5	75	-70	-	-	-	-				
									SD NM	SD OM	Ratio	N.o.M
Light Rad	Monthly	1	6	-5	0.1	3.0	-2.9	-	0.041	0.033	0.799	48
Field Size	Monthly	1	6	-5	0.1	2.0	-1.9	0.05	0.004	0.011	2.821	60
									% Diff NM	% Diff OM	Ratio	N.o.M
Field Size (target)	Monthly	-	-	-	-	-	-	-	-0.792	0.477	0.602	48
									Error(cm) NM	Error(cm) OM	Ratio	N.o.M
Table Motion	Monthly	1	2	-1	0.1	2.0	-1.9	-	0.016 (SD =0.012)	0.020 (SD=0.017)	1.250	36
ISO Centricity	Monthly	1	7	-6	0.1	2.0	-1.9	-	0.015 (SD=0.014)	0.047 (SD=0.014)	3.230	96
Dose Rate, Gantry and MLC Speed - not previously performed												

S.U.E- set up and execution. N.M. - new method. O.M. - old method. A.D.E. - analysis & data entry. N.o.M - number of measurements. Loss/Gain - negative is an improvement. Time units are in minutes. SD - standard deviation.

Table 1: Comparison of automated QA method to manual method.

Conclusion

QA automation is proven to be viable, efficient, consistent and accurate option compared to manual methods with improvements to accuracy and consistency . Time saving is one of the most valuable aspects of QA automation.