

# Does Radiomics Have the Potential to Assess KV-CBCT Image Performance Acquired From Phantom Data Used for Daily QA?

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## INTRODUCTION

- Current CBCT quality assurance (QA) metrics could benefit from increased sensitivity to artifacts due to system malfunction.<sup>1</sup>
- Patient images may be degraded by poor equipment performance, compromising the quality of patient care.
- Utilizing radiomics may increase the QA sensitivity.

## AIM

**Perform** radiomics analysis of CBCT images of a Multiple Imaging Modality Isocentricity (MIMI) phantom (Standard Imaging, Middleton, WI) acquired for daily isocenter coincidence QA.

**Evaluate** the impact of kV x-ray tube performance on the CBCT images.

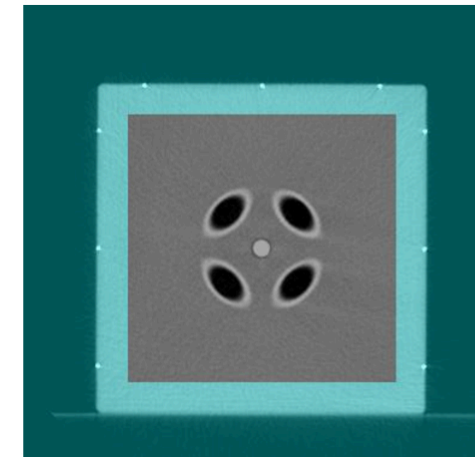
**Assess** the correlation between mechanical failure and radiomic texture features of the MIMI phantom.

## METHOD

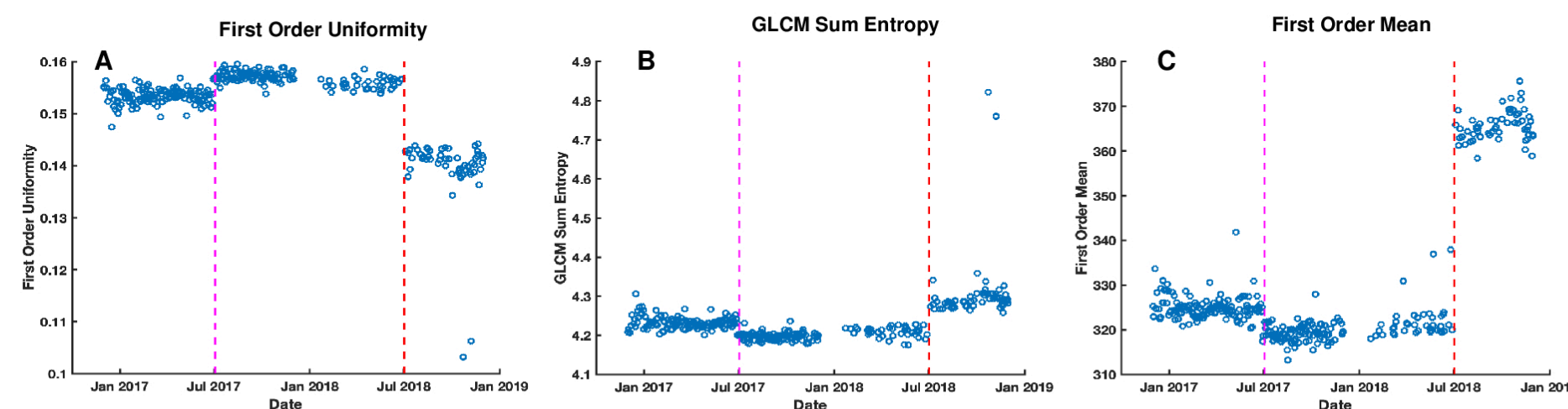
- CBCT scans:
  - Acquired daily using 'Head' scan protocol (100 kV; 300 mAs; full rotation) on a TrueBeam LINAC.
  - Projection data reconstructed using iTools Reconstruction (Varian Medical Systems).
  - A total of 326 scans spanning a two-year date range (12/1/16-11/30/18) were analyzed.
- Radiomics Analysis:
  - The central slice of each scan was identified
  - A 222-by-222 pixel ROI capturing the central area of the phantom (~60% of the entire slice) was applied to each of the central slices. (Figure 1)
  - Pyradiomics was used to extract gray-level co-occurrence matrix (GLCM) sum entropy, first-order uniformity, and first-order mean.<sup>2</sup>

## RESULTS

- All features displayed two distinct shifts from baseline.
  - First shift: July 3, 2017.
  - Second shift: July 2, 2018.
- The first shift corresponded to the degradation of CBCT image quality.
  - As documented from monthly planar kV imaging QA, kV tube performance declined in April 2017.
  - Monthly CBCT QA was performed using a Catphan phantom to assess traditional metrics such as resolution, contrast, uniformity, noise, and geometrical distortion with an in-house platform (MachineQA.com). These tests experienced intermittent failures in the months of June, Aug and Sept of 2017.
- Unlike monthly data, radiomics data of the MIMI phantom acquired daily (Fig. 2A-C) displayed a distinct inflection around July 3, 2017 (magenta line). Thus, the radiomics data can confirm that the CBCT QA worsened around then as well.
- GLCM sum entropy and first-order mean both decreased by  $0.74\% \pm 0.38\%$  and  $1.49\% \pm 0.86\%$ , respectively.
- First order uniformity had the largest variation, increasing by  $2.28\% \pm 0.98\%$ .
- The monthly CBCT QA data over the same time period lacked the sensitivity or sampling frequency to detect this change.
- The second shift corresponded to the kV tube replacement.
- All three features plotted show an apparent shift before and after the replacement, highlighting the impact that tube replacement had on select radiomic features.



**Figure 1.** Selected ROI in the central slice of the phantom excludes surface fiducials to minimize aberration in data values. PyRadiomics analysis on the grayscale region for each scan was performed.



**Figure 2.** (A) first-order uniformity, (B) GLCM sum entropy, and (C) first-order mean for a MIMI phantom. The magenta dotted line indicates when CBCT QA began failing due to worsening kV tube performance around July 3, 2017. The red dotted line indicates when the kV tube was replaced on July 2, 2018. A very distinct pattern occurs in the data prior to and following the dates identified. Figures 2A-C were acquired using a subset of data taken in a counterclockwise rotation of the scanner.

## CONCLUSIONS

- Radiomic analysis indicated that kV x-ray tube replacement directly impacted select components of image texture in daily but not monthly CBCT QA data.
- Radiomics analysis of phantom QA images acquired at high frequency (i.e., daily) over an extended period of time could be used in conjunction with conventional quality metrics to track the overall performance of CBCT equipment.
- Future work will investigate the discrepancies of recorded data which occurred due to varying scan rotation directions (clockwise vs counterclockwise) and different TrueBeam machines. Harmonizing data across machines and scan directions would potentially increase the dataset used for the analysis proposed here, thereby solidifying the results.

## ACKNOWLEDGEMENTS

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