Assessment of texture feature robustness using a novel 3D-printed phantom

Karl D Spuhler, PhD; Jose Teruel, PhD; Paulina Galavis, PhD
NYU Langone Health New York, NY

PURPOSE

Radiomics is an exciting family of emerging techniques which can support data-driven clinical decision making at the patient-level

With increased image guidance in radiation oncology, it should be possible to leverage these data for radiomics modelling

Radiomics models rely on a highly dimensional feature space, and models must be built off of robust and repeatable features

We seek to develop a phantom to develop a robust CBCT radiomics pipeline

Here, we explore the robustness and reliability of CBCT texture features.

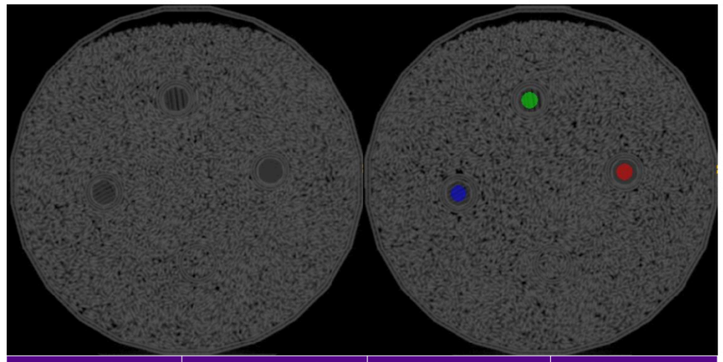
METHODS

A custom designed, 3D-printed phantom with five custom-printed rods of various materials, infill shapes and densities was used to acquire clinical CBCT images on two Varian TrueBeam Linacs.

Texture feature (TF) reproducibility was evaluated across and within two Linacs from three consecutive CBCT-scans each from head/neck and thorax protocols. Region of interest (ROI) of ~6.2 cm^3 from each rod were used to extract TF using the PyRadiomics software, three rods were inserted in this study.

One-way ANOVA model of the intra-class correlation coefficient (ICC(3,1)) was used to evaluate TF reproducibility, with features showing ICC values above 0.9 considered robust if their Bonferroni-corrected p-value was below 0.05.

FIGURES



Rod	Material	Infill Pattern	Infill Density
ROI 1 (Red)	PLA	Triangle	50%
ROI 2 (Blue)	Nylon	Triangle	50%
ROI 3 (Green)	PLA	Lines	50%

Figure 1. Top. Axial cross-section of the phantom used in this study. Bottom. Material and printing parameters for the rods analyzed.

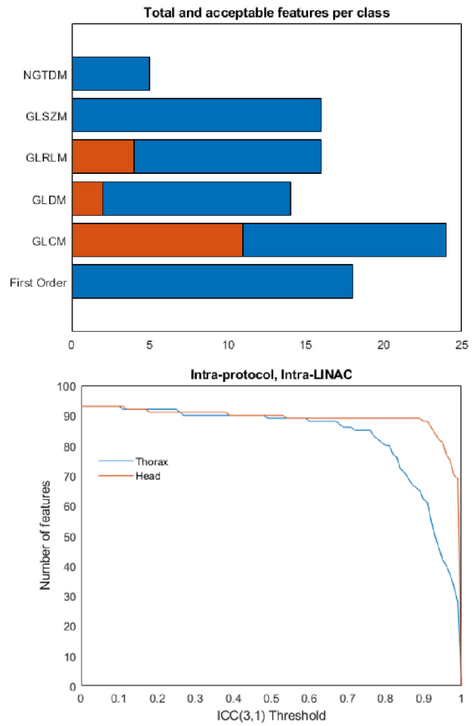


Figure 3. Top. Distribution of acceptable features by feature class. Bottom. Number of acceptable features (multiple comparison corrected) as a function of ICC threshold.

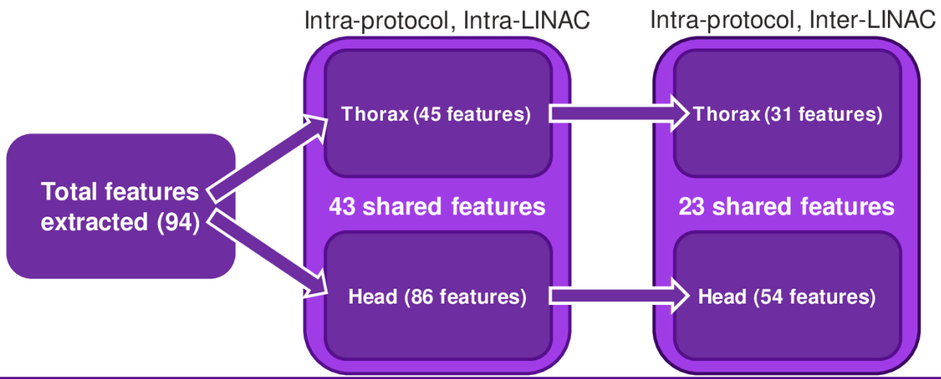


Figure 2. Overview of results gathered in this study.

RESULTS

The 3D-printed phantom (cylinder: d=22cm, h=25.5cm) comprises slots for interchangeable rods (d=1cm, h=10-20cm) to evaluate different types of materials. It enables rapid development and testing of new materials and prints.

For intra-LINAC analysis, we see that a total of 45 features for the thorax protocol and 86 for the head protocol passed at the ICC(3,1)>0.9 threshold. 43 of these features were reproducible for both protocols, but it is important to note that no features were reproducible in inter-protocol analysis.

For inter-LINAC analysis, 31 and 54 features discovered to be reproducible in the intra-LINAC analysis had ICC(3,1)>0.9 for thorax and head respectively; 23 were reproducible across LINACs for both protocols. No features exhibited ICC(3, 1)>0.9 for inter-protocol stability.

CONCLUSIONS

We have developed a novel 3D phantom which can be easily used in multi-institutional studies to evaluate feature robustness. There is a rich, multidimensional feature space which is well-suited for radiomics modelling of LINAC CBCT datasets, However, studies must use consistent imaging protocols.

CONTACT INFORMATION

Karl D Spuhler, PhD
karl.spuhler@nyulangone.org

ACKNOWLEDGEMENTS

Patrick Whelan, NYU Health Sciences Library
Pyradiomics v3.0:
https://github.com/Radiomics/pyradiomics