

Improving the ShIRPA physics model

Assessing and improving the physics in ShIRPA (Sheffield Insigneo Radiology Physics App) using anthropomorphic phantom images.

Background

What is ShIRPA:

- Simulates an X-ray unit using a mobile device
- Developed as a teaching aid for radiologists & radiographers
- Demonstrates the effects of voltage (kVp) and milliamperere seconds (mAs) on dose area product (DAP) and image quality

Project objectives:

- Assess the accuracy of the existing physics model in three key metrics - DAP, image noise and image contrast
- Create improved models for each of the above outputs
- Provide insights into the capabilities and limitations of the app

Methods

- Acquired real X-ray images of a pelvic phantom, with corresponding DAP readings
- Real and app-produced images were compared using relative changes in noise and contrast from the same reference image
- Standard deviation was used as a measurement of noise and the intensity drop across a hard to soft tissue interface was used for contrast
- New models were produced using observed trends for each output with varying kVp and mAs

Results

- New model created for DAP prediction:
 $DAP = ((8.182 \times 10^{-9}) \times kVp^2 \times mAs \times Area) + 0.01486$
- Average DAP error decreased from 19.71% in the original app to 8.39% using the new model - Figure 3
- Average noise error decreased from 35% to 27%
- Original noise model was linear. New noise relationship now matches observations :

$$Noise\ Ratio = (8.25 e^{(-7.72 \times Dose\ Ratio)}) + 1$$

- Contrast produced in the app did not represent the true relationship - Figure 4
- A new relationship between kVp, mAs and contrast has been determined to inform a future image production algorithm

Conclusions

- All objectives have been fully or partially achieved
- This project has produced both immediate improvements to the app and the necessary information for further development
- Two new physics models (for DAP and noise) have been produced
- The existing image contrast performance was the weakest and requires significant modification, beyond the scope of this project

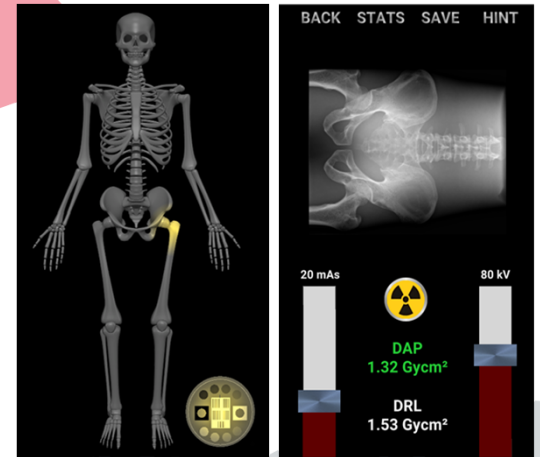


Figure 1: Screenshot of app user interface

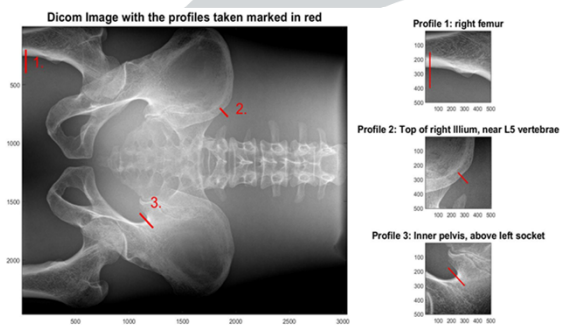


Figure 2: X-ray image with the profiles used for contrast analysis marked in red

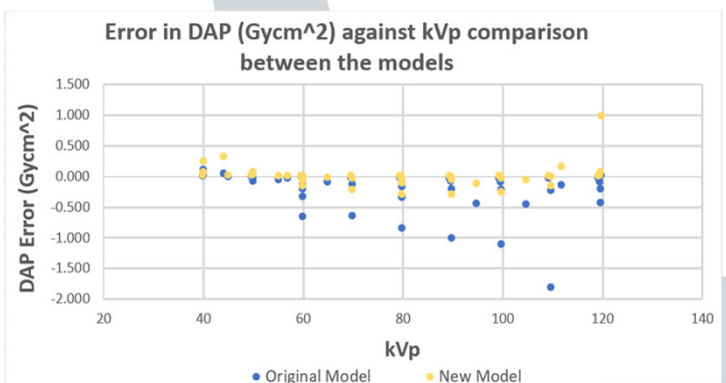


Figure 3: Error in DAP (Gy cm²) against kVp comparison between the original and the new model

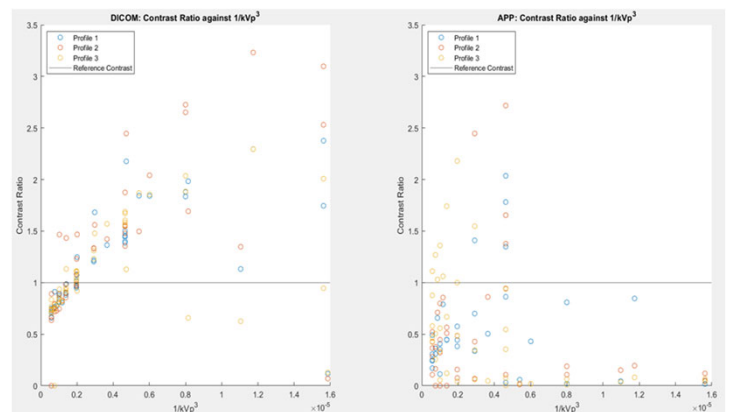


Figure 4: Comparison of contrast ratios in the DICOM images (left) and the App generated images (right)