Research Week 2021

Surface Radiation Dose Modeling for Fluoroscopically Guided Interventions

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Keywords

Fluoroscopy, Peak Skin Dose, MATLAB, Fluoroscopically Guided Intervention, Radiation Dosimetry

Abstract

Fluoroscopically Guided Interventions (FGIs) are procedures which use real-time x-ray imaging to guide surgeries. Due to the complexity of these cases, radiation doses can be high enough to cause skin injury. It is a medical physicist's role to provide guidance on Substantial Radiation Dose Levels (SRDLs) and trigger physician follow-up if a patient is at risk of radiation injury.

Patient management following FGIs is based on a physicist's calculation of peak skin dose (PSD), however accurate skin dose calculation for FGIs is difficult due to complicated geometry and automatic changes in the x-ray spectrum throughout these procedures. OHSU uses a third party service, Imalogix™, for surface dose mapping and PSD calculation. However, the calculations that Imalogix™ provides have not been calibrated for our fluoroscopy systems.

This research focused on dose modeling and calculation from Radiation Dose Structured Report (RDSR) data, with the eventual goal of developing calibration factors to improve PSD calculation accuracy. This project involved two stages: (1) an interactive MATLAB™ graphical user interface (GUI) was made to validate the beam and table movement, (2) clinical data was used to generate a skin dose map.

A GUI was used to visualize real-time changes of angulation, translation, beam size, and the resulting surface dose map (Figure 1). The patient was represented as an elliptical cylinder with a rotational and translational offset determined by the table tilt and positioning. The beam geometry was parameterized by the field size and two rotation angles describing the orientation of the C-arm. Dose to the patient surface was computed for regions within the x-ray beam based on their distance from the x-ray source.

A program was then created to parse RDSR data and generate a total surface dose map for a procedure. Each irradiation event's surface dose map was calculated and summed to produce the final dose map (Figure 2B). Additionally, each beam position was plotted to illustrate beam movement during the procedure (Figure 2A).

Combined with dose measurements, this research will provide a way to improve the dose mapping service currently used by OHSU. This will ultimately improve patient care by providing more accurate dose levels to trigger patient follow-up.

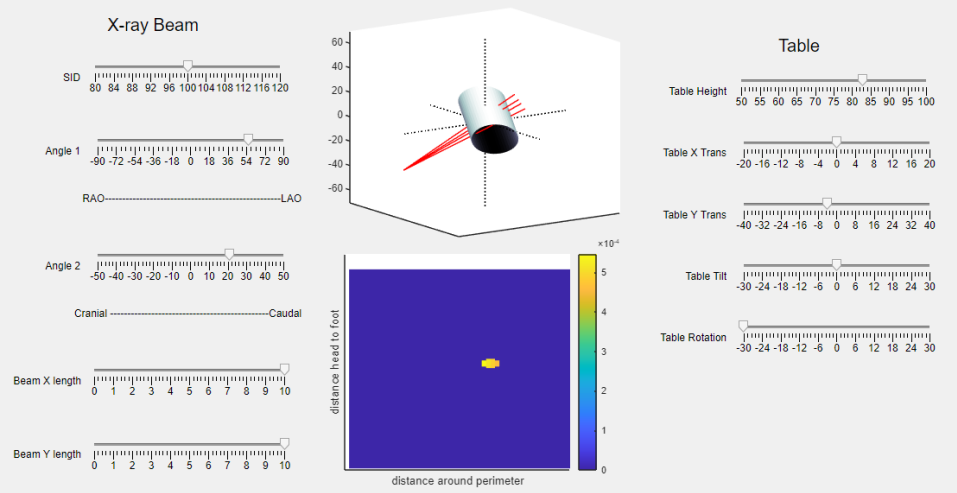

Figure 1: Matlab GUI for real-time surface dose visualization with movement of the x-ray beam and table.

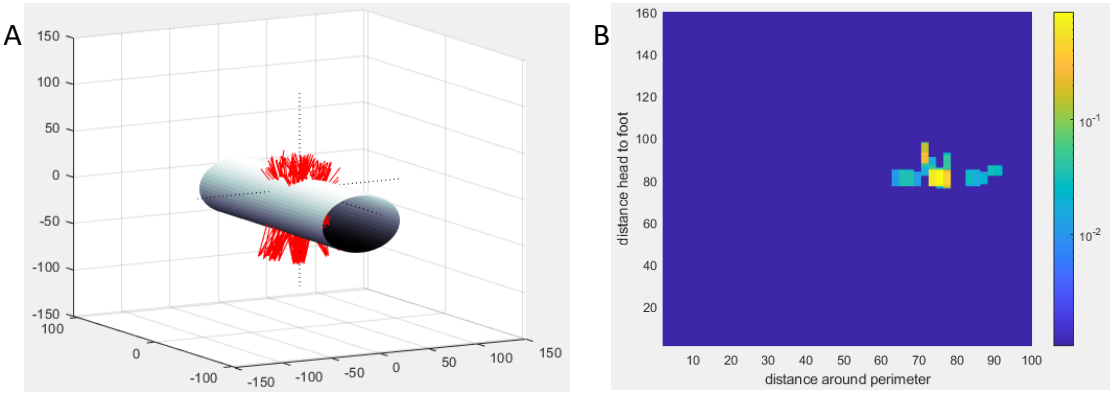

Figure 2: (A) This shows the beam angulation used during the 81 irradiation events used in this FGI procedure. (B) The surface dose map shows a maximum dose of ~0.8 mGy was delivered to the patient's skin. Note the colormap has been changed to a log scale for better visualization of the spatial dose distribution.