Monte Carlo Simulation of X-ray beam design for multi-energy imaging with charge-integrating detector Using GATE

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Multi-energy X-ray imaging systems have been widely used for clinical examinations .In order to enhance the imaging quality of these X-ray systems, a dual-energy system that can obtain specific information has been developed in order to discriminate different materials. Although the dual-energy system shows reliable performance for clinical applications, it is necessary to improve the method in order to minimize radiation dose, reduce projection error, and increase image contrast. The purpose of this study is to develop a triple energy technique that can discriminate three materials for the purpose of enhancing imaging quality and patient safety. The X-ray system tube voltage was varied from 40 to 90 kV, and filters (that can generate three X-ray energies) were installed, consisting of pure elemental materials in foil form (including Al, Cu, I, Ba, Ce, Gd, Er, and W). The X-ray beam was evaluated with respect to mean energy ratio, contrast variation ratio, and exposure efficiency. In order to estimate the performance of the suggested technique, Monte Carlo was conducted, and the results were compared to the photon-counting method. As a result, the density maps of iodine, aluminum, and polymethyl methacrylate(PMMA) using the X-ray beam were more accurate in comparison to that obtained with the photon-counting method. According to the results, the suggested triple energy technique can improve the accuracy of the determination of thickness of density. Moreover, the X-ray beam could reduce unnecessary patient dose.