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Estimating X-Ray Spectra for Digital Mammography by Using the Expectation Maximization Algorithm: A Monte Carlo Simulation Study

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Abstract : With the widespread use of digital mammography (DM), radiation dose evaluation of breasts has become important. X-ray spectra are one of the key factors that influence the absorbed dose of glandular tissue. In this study, we estimated the X-ray spectrum of DM using the expectation maximization (EM) algorithm with the transmission measurement data. The interpolating polynomial model proposed by Boone was applied to generate the initial guess of the DM spectrum with the target/filter combination of Mo/Mo and the tube voltage of 26 kVp. The Monte Carlo N-particle code (MCNP5) was used to tally the transmission data through aluminum sheets of 0.2 to 3 mm. The X-ray spectrum was reconstructed by using the EM algorithm iteratively. The influence of the initial guess for EM reconstruction was evaluated. The percentage error of the average energy between the reference spectrum inputted for Monte Carlo simulation and the spectrum estimated by the EM algorithm was -0.14%. The normalized root mean square error (NRMSE) and the normalized root max square error (NRMaSE) between both spectra were 0.6% and 2.3%, respectively. We conclude that the EM algorithm with transmission measurement data is a convenient and useful tool for estimating x-ray spectra for DM in clinical practice.

Keywords : digital mammography, expectation maximization algorithm, X-Ray spectrum, X-Ray
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