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Simulated detector characterization in x-ray breast imaging virtual clinical trials

Virtual clinical trials in x-ray breast imaging permit to compare different technical solutions and imaging modalities (2D vs 3D) at reduced costs related to apparatus management and involved personnel, and at reduced times and radiation risks to patients [1,2]. For a fair in-silico reproduction of clinical images, the patient models [3] and the simulated physics assume great importance. In addition, also the replication of the detector characteristics (spatial resolution, noise level and efficiency) is of primary importance. The project AGATA proposes to simulate the detectors with a layer of defined materials. The simulated images are then computed calculating the absorbed dose within the detector layer, and post-processed in order to present characteristics similar to the real ones. The manipulation of the simulated images relies on the knowledge of the intrinsic characteristics of real and simulated detector. With this scope, we evaluated the presampled modulation transfer function (MTF), the detector-response function and the noise power spectrum (NPS) of the simulated detector, as first step for the post-processing manipulations. Two detectors were simulated: 1) the adopted one in the Hologic Selenia Dimension digital breast tomosynthesis (DBT) (0.20 mm-thick a-Se direct flat panel with 70 μm pixel pitch) and 2) the one used in the GE Senographe DS DBT (CsI(Tl) indirect flat panel with 100 μm pixel pitch and scintillator layer 0.25 mm thick). In addition, the impact of simulating the de-excitation processes (Auger emission and fluorescence) were explored. Simulations were performed with a validated code based on Geant4 toolkit vers. 6 and the Option4 physics list. Figure 1 shows the MTF of the simulated a-Se detector. It was evaluated via a 12.5 μm wire, put on the support paddle of the simulated mammographic apparatus. Here, the impact of the simulation of the de-excitation processes (Auger electrons and fluorescence) was evaluated. The simulation of this effects permits a more accurate simulated physics with an increase of the simulation time of about 2 times. Figure 2 compares the presampled MTF of the a-Se detector respect to the CsI simulated detector at 26 kV. The MTF curve falls down its 10% at 12.5 mm-1 in the former case and at 8.8 mm-1 in the latter. As example, figure 3 reports the NPS for the simulated a-Se detector. No postprocessing was applied.

[1] F di Franco et al., Phys. Med. 74 (2020), 133-142.
[2] A Sarno et al., IWBI2020. Vol. 11513, 2020
[3] A Sarno et al., Med Phys (2021).

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