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Task-based detectability-combined cascaded-systems model for the design of sandwich detectors for single-shot dual-energy imaging

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Single-shot dual-energy imaging (DEI) using a sandwich-like multilayer detector is promising because it is immune to motion artifacts and it can relatively emphasize high-frequency contents [1]. Since the sandwich detector uses the beam-hardening difference between two detector layers for energy separation, the imaging performance is largely dependent on the detector design (i.e. scintillators and interlayer filter) for given imaging tasks. In addition, the DE reconstruction parameter (i.e. tissue-cancellation factor) and imaging technique (i.e. energy) should be determined as a function of imaging task. We previously introduced a cascaded-systems model for the design of sandwich detectors [2]. However, the model is limited to the detector design in terms of signal-and-noise performance but not the imaging task.
We extend the previous model to incorporate the detectability functioning for several imaging tasks. The model also includes simple observer models such as prewhitening and non-prewhitening matched filters, including human eye filter and internal noise. As a result, the model can be used to optimize the sandwich detector designs, including the DE reconstruction parameter and imaging technique, with respect to simple imaging tasks. Figure 1 shows an example result for the optimization procedure of DE reconstruction parameter and imaging technique. We describe the developed model in detail and present the optimization results of sandwich detector designs appropriate to different imaging applications.

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