A single-exposure dual-energy computed radiography technique for improved nodule detection and classification in chest imaging

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The detection and classification of pulmonary nodules is of great interest in chest radiography. Nodules are often indicative of primary cancer, and their detection is particularly important in asymptomatic patients. The ability to classify nodules as calcified or non-calcified is important because calcification is a positive indicator that the nodule is benign. Dual-energy methods offer the potential to improve both the detection and classification of nodules by allowing the formation of material-selective images. Tissue-selective images can improve detection by virtue of the elimination of obscuring rib structure. Bone-selective images are essentially calcium images, allowing classification of the nodule. A dual-energy technique is introduced which uses a computed radiography system to acquire dual-energy chest radiographs in a single-exposure. All aspects of the dual-energy technique are described, with particular emphasis on scatter-correction, beam-hardening correction, and noise-reduction algorithms. The adaptive noise-reduction algorithm employed improves material-selective signal-to-noise ratio by up to a factor of seven with minimal sacrifice in selectivity. A clinical comparison study is described, undertaken to compare the dual-energy technique to conventional chest radiography for the tasks of nodule detection and classification. Observer performance data were collected using the Free Response Observer Characteristic (FROC) method and the bi-normal Alternative FROC (AFROC) performance model. Results of the comparison study, analyzed using two common multiple observer statistical models, showed that the dual-energy technique was superior to conventional chest radiography for detection of nodules at a statistically significant level $(p < .05).$ Discussion of the comparison study emphasizes the unique combination of data collection and analysis techniques employed, as well as the limitations of comparison techniques in the larger context of technology assessment.