Applications of Signal Detection Theory to the Performance of Medical Imaging Systems, Human Observers and Artificial Intelligence

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The study was in applied mathematics and computer science and investigated applications of signal detection theory to medical imaging. A substantial part of the experimental work involved receiver operating characteristic (ROC) analysis and contrast resolution thresholds of human observer performance in detection tasks. Quantitative comparisons were made with artificial intelligence (neural network) systems. Signal detection techniques were also used in the evaluation of specific imaging methods.

ABSTRACT

An investigation was carried out to evaluate diagnostic performance in medical radiology. A critical review of methods available for the assessment of image quality in terms of physical objective measurements and quantitative observer performance was followed by a series of experiments which applied the signal detection techniques of Receiver Operating Characteristics (ROC) to radiographic problems.

An appraisal of the performance of six currently available imaging systems designed for chest radiography was performed using expert observers and an anthropomorphic phantom. Results showed a range of abilities to demonstrate pulmonary nodules (ROC areas of 0.866 to 0.691). The ROC outcomes for the

imaging systems were shown to correlate well with signal to noise ratio (SNR) measurements for the images (0.78, p 0.05) although comparisons of ROC and threshold detection indices (HT) gave a lower level of agreement (0.6, p 0.05). The SNR method of image evaluation could probably be used as an alternative to ROC techniques in routine quality assurance procedures of image assessment although this should not be interpreted a direct indicator of diagnostic performance.

Observers from a group of undergraduate radiography students were tested by an ROC study into their ability to detect pulmonary lesions in chest images. Their ROC areas (*Az*) ranged from 0.616 to 0.857 (mean 0.74) compared with an expert mean score of 0.872. The low score for the students was investigated in terms of the cognitive task and their search strategy training. Their (*Az*) scores showed no significant correlation with simple psychometric tests.

An artificial neural network (ANN) was tested against radiologists, radiographers and student radiographers in its ability to identify fractures in wrist radiographs. All observers performed to a similar level of ROC *Az* score but the artificial intelligence showed higher specificity values. This attribute was used as a filter to remove some of the normals from the test population and resulted in changes to the mean *Az* score for the human observers.