Markov Chain Monte Carlo Computations of Ideal-Observer Performance

We advocate a task-based approach for assessing image quality which states that image quality should be measured by how well an observer can perform a medically relevant task using the images produced by a specific imaging system. For the task of tumor (or signal) detection, the Bayesian ideal observer sets an upper bound on observer performance; no other observer can perform better than the ideal observer given the same amount of information. Thus, the performance of the Bayesian ideal observer can be useful for assessing the quality of imaging hardware. That is, the imaging system with the highest ideal-observer performance is the best. The difficulty lies in the fact that the Bayesian ideal observer requires full knowledge of the statistics of the image data under both the signal-present and signal-absent hypotheses. This seemingly insurmountable obstacle was overcome by using a statistical technique known as Markov-Chain Monte Carlo, or MCMC. We initially studied the MCMC technique in simulation using 2-D lumpy object models. We recently extended those simulations to account for 3-D lumpy objects and pinhole SPECT imaging systems of any possible configuration. Hence, we can assess ideal-observer performance for systems like FastSPECT II and M^3R and can optimize these systems based on ideal-observer performance. As an example, consider a two-pinhole, single- detector imaging system. Therefore, the only variable to optimize is pinhole separation which controls the amount of overlap or multi-plexing of the two pinhole images. Using code created by Kevin Gross, we were able to assess the change in performance as the amount of multi-plexing varied from a great deal (i.e., a small pinhole separation) to very little (i.e., a large pinhole separation). The results of this type of study are shown in Figure 1.

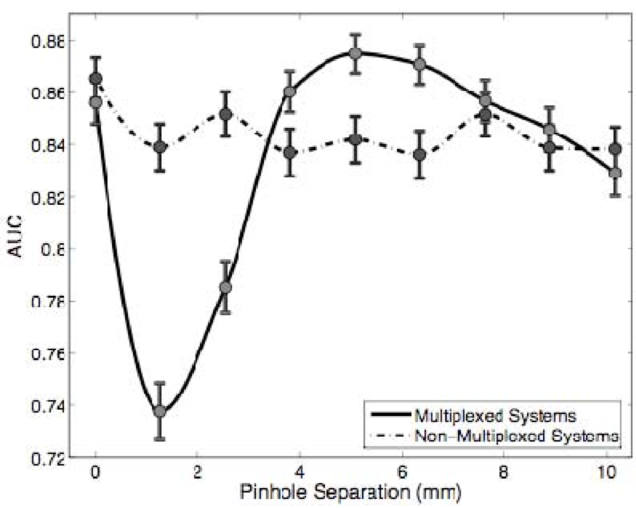

Fig. 1. The AUC of the ideal observer for both multiplexed and non-multiplexed imaging systems as a function of pinhole separation.

M. A. Kupinski, J. W. Hoppin, E. Clarkson, and H. H. Barrett, "Ideal-observer computation in medical imaging with use of Markov-chain Monte Carlo", *J .Opt. Soc. Am. A*, 20, 430-438, 2003.