ADAPTIVE IMAGING

A major emphasis at the Center for Gamma-ray Imaging is objective or task-based assessment of image quality. In this paradigm, image quality is defined by the performance of a specific observer, performing a specific task on a predetermined class or ensemble of patients. Tasks of interest include lesion detection, lesion classification and estimation of parameters of interest, and the observers can be humans, computer algorithms, or mathematical constructs called ideal observer. Recently we have proposed an approach[1,2] to optimizing a SPECT system for a particular patient as well as a specific diagnostic task.

Patient-specific imaging raises important new theoretical questions. First, since objective measures of image quality are defined statistically, what does it even mean to optimize for a specific patient? What characteristics of the patient are important and how should they be estimated? What system parameters should be altered in response to the estimated patient properties? How much improvement in final task performance can be achieved this way?

To answer these questions, we use a mathematical approach called *implicit ensembles*. The idea is to collect a set of preliminary measurements that narrow down the ensemble of patients from which the particular patient is drawn, rapidly calculate the optimal system configuration for that ensemble, and reconfigure the system for the next set of measurements. If necessary, the process can be iterated.

We are developing two hardware platforms for exploring this concept. The first is a multi-module, multi-resolution (M^3R) system using four modular cameras. As shown in Fig. 1, the system allows manual interchange of pinhole plates and variation of system magnification. Optical Sciences student Jacob Hesterman has used this system to study optimal system design for detection tasks.

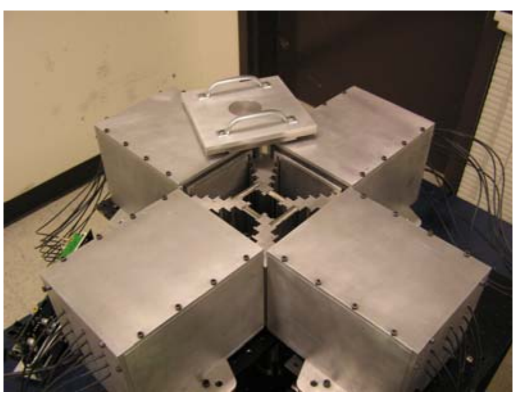

Fig. 1. M^3R system designed by Jacob Hesterman.
developed by Melanie Freed

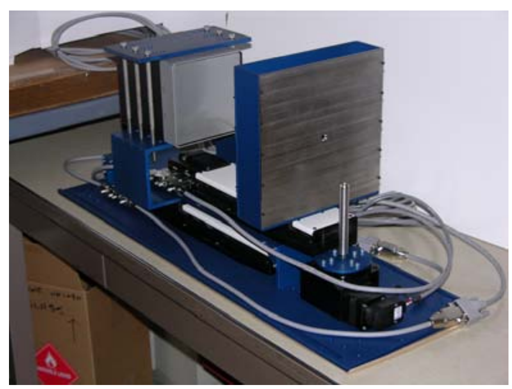

Fig. 2. Prototype adaptive imager
developed by Melanie Freed

A second system, shown in Fig. 2, allows automated variation of pinhole diameter and pattern, aperture-to-object distance and detector-to-aperture distance. The prototype, developed by Optical Science student Melanie Freed, uses a single modular camera, but future versions will have multiple detectors.

1. M. Freed, M. A. Kupinski, L. R. Furenlid, and H. H. Barrett, “Design of an Adaptive SPECT Imager,” Academy of Molecular Imaging Annual Conference, March 25-29, 2006, Orlando, Florida.

2. L. R. Furenlid, M. Freed, J. Y. Hesterman, M. A. Kupinski, E. Clarkson, and H. H. Barrett, “Adaptive imaging techniques for nuclear medicine.” Society of Nuclear Medicine, Annual Meeting, 2006.