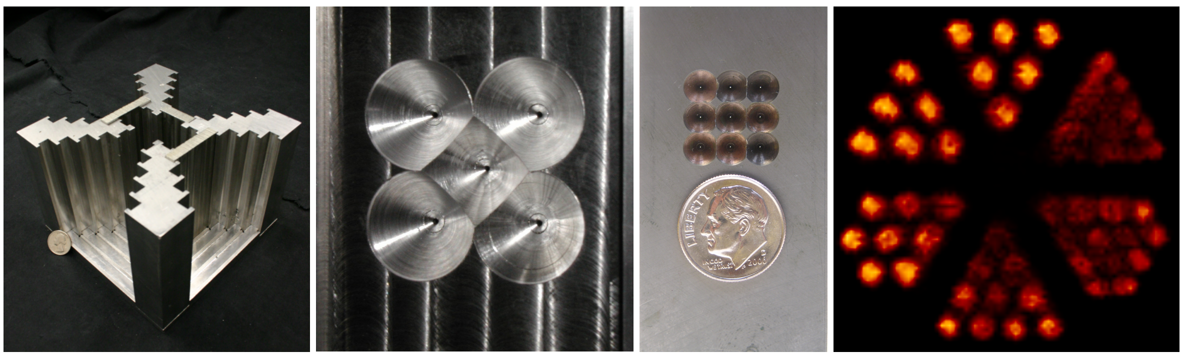
The Multi-Module, Multi-Resolution (M^3R) SPECT System

Researchers in medical imaging are continually striving to improve imaging systems. In many ways, imaging hardware represents the cornerstone of these improvements. No matter how refined reconstruction and processing algorithms become, their effectiveness will always depend on the quality of the data gathered by the imaging system itself. Therefore, the optimization of imaging hardware must constitute one of the principal goals in improving an imaging system. We have designed and built a small-animal system known as the multi-module, multi-resolution (M^3R) SPECT system that is well-suited for hardware assessment and optimization [1]. The system consists of four modular gamma cameras situated around a Cerrobend shielding assembly that provides for the easy interchange of pinhole apertures. The entire system is elevated, allowing a rotation stage to be placed underneath for tomographic data acquisition. M^3R enables easy modification of parameters such as magnification, pinhole diameter, pinhole number, and degree of multiplexing. Initial work on M^3R involved the design and construction of the shielding assembly, pictured in Figure 1(a), and several pinhole apertures, two of which are shown in Figure 1(b)-(c).



(a) (b) (c) (d)

Figure 1: (a) M^3R shielding assembly. (b) A pinhole aperture containing five 1-mm pinholes. (c) A pinhole aperture containing nine 250-μm pinholes. (d) Example reconstruction of a hot-rod phantom. Column diameters range from $D = 0.7 - 1.2$ mm with $2 \times D$ center-to-center spacing.

Prior to system evaluation, existing calibration procedures were adapted to address the challenges presented by M^3R's unique system design. This work involved the development of a fast maximum-likelihood (ML) position estimation algorithm capable of implementation in hardware [2] and the extension of system matrix measurement and interpolation methods for use with multiple-pinhole apertures. An example reconstruction from a hot-rod phantom is shown in Figure 1(d). Following successful calibration and trial phantom measurements, several apertures and aperture combinations were evaluated using rigorous, objective methods. The results of these observer studies indicate the need for task-specific aperture design and the potential gain in observer performance through the use of properly designed multiple-pinhole multiplexed apertures for certain tasks [3]. M^3R has proven itself as a useful research tool, enabling the evaluation and improvement of SPECT apertures and serving as a testbed for a variety of image-quality studies.

References

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[3] J. Y. Hesterman, M. A. Kupinski, E. Clarkson, and H. H. Barrett, Hardware assessment using the multi-module, multi-resolution system (M^3R) - A signal-detection study, *Medical Physics*, 2007 (Tentatively Accepted).