FaCT: FastSPECT II and CT

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***Abstract*—The Center for Gamma-Ray Imaging is building a helical-scan cone-beam X-ray CT system to augment its FastSPECT II imager. Data from the CT system will not only provide complementary anatomical information, but will be used to guide the SPECT acquisition.**

I. Motivation

The Center for Gamma Ray Imaging is building a high-resolution small-animal helical scan cone beam CT system to complement its existing SPECT system, FastSPECT II. The CT system has its own gantry and can be separated to work in a stand-alone mode. We plan to use the system as a test bed for acquiring physiologically-gated 4-D cardiac CT and for investigating new design features. Additionally, we intend to use our CT system to acquire and analyze scans before SPECT imaging to take full advantage of prior knowledge of the object to control image acquisition in FastSPECT II.

II. System Design

A broad range of optical, mechanical, and electrical issues have been taken into account while designing the X-ray CT system.

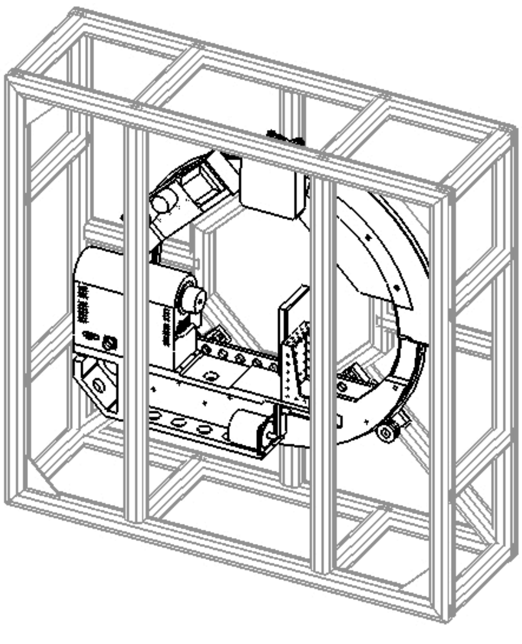

Fig. 1. 3-D design rendering of the FaCT X-ray CT system.

A. Optical Design

This system provides high-resolution imaging capabilities by pairing a 6 μm focal spot X-ray source with a 2048 $\times$ 1000 pixel X-ray camera. Source and detector are mounted on a monolithic beam at a fixed 25-cm separation. Multiple projections of the object are obtained by rotating the source and detector around the object. Image magnification can be adjusted by radially translating the source and detector assembly relative to an object placed on the central axis of rotation.

B. Mechanical Design

The large motions in a helical-scan CT system and the sensitivity of the reconstructed resolution to movement tolerances mean that careful attention to mechanical design is required. The rotating gantry must be balanced for smooth operation. Our system maintains dynamic balance by employing a moving counterweight to offset the movement of the source/detector element for magnification adjustment. Finite-element analysis has been performed to ensure that the relative movement between source and detector due to loading is within tolerances throughout the acquisition arc.

C. Electrical Design

Commercial helical-scan CT systems typically accomplish continuous rotation by the use of a large, multi-channel slip ring that transmits power and data. Our design takes a novel approach to achieving continuous rotation. A small, inexpensive 3-channel slip ring transmits standard electric power. The data-acquisition computer, X-ray tube power source, and all detector electronics are mounted on the rotating gantry, and communication for system control and data handling is accomplished through standard wireless networking protocols.

III. Software

The gantry-mounted computer is available as an acquisition slave that is controlled over a wireless network by a main workstation. This computer permits image data to be preprocessed and compressed before being offloaded for reconstruction.

We will use a Katsevich-style inversion algorithm for final tomographic reconstructions for data analysis. Faster approximate methods will be used to estimate object parameters for controlling the SPECT acquisition. The combined FaCT system will provide 7 image dimensions: fully 3-D CT plus 4-D (x,y,z,t) SPECT.

IV. Current Status and Conclusion

The FaCT system is currently being assembled after a lengthy design and fabrication process. When commissioned, it will transform CGRI's FastSPECT II system into a dual-modality small-animal imager, as well as provide a state-of-the-art stand-alone CT capability and provide data for investigation of adaptive SPECT imaging.