DESIGN AND DEVELOPMENT OF A CT IMAGING SYSTEM FOR SMALL ANIMALS

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Introduction: Positron emission tomography (PET) studies of small animals benefits from the registration of the functional information they provide with accurate anatomic images provided by dedicated computed tomography (CT) scanners. These scanners have to achieve the micrometric resolution requirements needed to locate structures in small laboratory animals like mice and rats. This work reports on a prototype based on a solid state semiconductor X-ray sensor and a microfocus Xray source.

Methods and Materials: The system uses a 80kV microfocus X-ray source with a focal spot size of 8μm (Hamamatsu L6731-01), communicated with a standard PC computer by means of a RS-232C interface. A digital X-ray image sensor (Hamamatsu C7942) was used for the image acquisition. The device integrates in one compact flat panel a CsI scintillator plate, a photodiode array with FET switches, and a signal processing IC chip. The image intrinsic resolution is 2400x2400 pixels, covering an active area of 120x120 mm. The sensor interfaces with the computer through a 12-bit parallel port leading to a digital frame grabber card. This configuration reaches a transfer rate up to nine frames/sec performing a 4x4 binning, four frames/sec with a 2x2 binning, and two frames/sec when no binning is performed. The source and the sensor are placed in a rotating gantry also controlled by the computer, conforming a cone-beam geometry. Source, gantry, sensor and frame-grabber are sequentially operated by the computer to obtain the projection data set needed to reconstruct the object being scanned. Once the projections have been acquired, sent to the computer and post-processed to correct sensor non-uniformities, a SART iterative reconstruction adapted to the specific cone-beam geometry is performed to obtain the final tomographic images.

Results: Estimates of performance characteristics of the CT prototype were computed, resulting a central spatial resolution of 25mm. Figure 1 shows a image from a CT study of a mouse, where a 8x8 binning was performed obtaining a resolution of 200mm.

Discussion: The solid state semiconductor X-ray sensor allows to obtain a big field of view (FOV) and a high spatial resolution without the need of multiple tessellated CCD sensors which usually demand complex optical tapers placed between the scintillator screen and the sensors themselves. The absence of physical separation between the scintillator plate and photodiode array and the amplification stage included in the flat panel reduces acquisition noise. This compact configuration can achieve high data transfer rates thus resulting in short study times, which are critical in in vivo studies of mice and rats to avoid movement of the specimen during the study. Further work in the CT scanner prototype is required in order to get better reconstruction performance, both in spatial resolution reached and in computing time requirements. Exact reconstruction algorithms suited for cone-beam geometry are being implemented and will be included in further development stages of the system.

Conclusion: An operative small animal dedicated CT prototype based on a microfocus X-ray source and a semiconductor X-ray sensor has been developed and characterized. Anatomic images have been acquired using a preliminary SART reconstruction algorithm adapted for the specific cone-beam geometry. This 3-D images have proved to be useful to the researchers in the locationof relevant anatomic structures in the specimens being studied.

Figure 1. *Brightest point volume rendering from 3-D SART reconstructed volume of 280x280x280 voxels. Note the cone-beam artifact in the upper and lower slices due to the 180 degrees projection data restriction.*