

MARS: A 3D spectroscopic x-ray imaging device based on Medipix

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Abstract

A spectroscopic x-ray CT scanner, providing both spatial and energy resolution was built. Tomographic datasets from mice have been acquired to evaluate the potential benefits of spectroscopic imaging in biomedical applications.

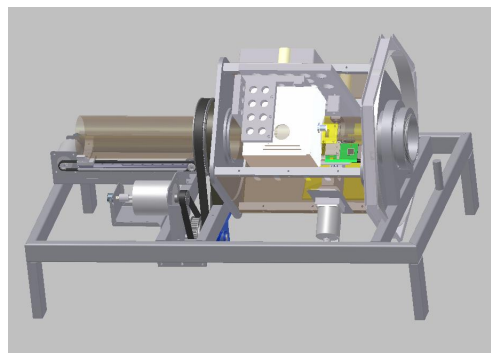
Purpose

The aim of our work was to construct an x-ray CT scanner capable of acquiring a 3D dataset in multiple energy bins. Since it provides spatial and energy resolution at the same time, the device is referred to as MARS (Medipix All Resolution System).

Groups within the Medipix collaboration (i.e. [1]) as well as suppliers of medical x-ray systems [2] have worked on reconstructing the material composition from radiographs. Our scanner will enable to further enhance these techniques with the availability of tomographic images.

Setup

The scanner combines a micro focus x-ray tube with the Medipix-2 detector developed at CERN. The micro focus tube and high voltage generator are assembled on one side of the gantry. On the opposite side, a Medipix-2 quad is placed. Both rotate 360 degrees around the object, which is contained within a Perspex pipe with a maximal diameter of 90 mm. The field of view can be enlarged by translating the detector and moving the pipe. This setup allows imaging living and wet objects.



(a) CAD drawing of the scanner

The data is processed using cone beam filtered back projection to create a 3D dataset. The energy resolution of the Medipix chip is characterised by an FWHM of approximately 2.5 keV over the whole energy range. In the current configuration, a voxel size of 43 microns is achieved. Our scanner layout (a) is modular and will shortly be upgraded with the Medipix-3 detector [3].

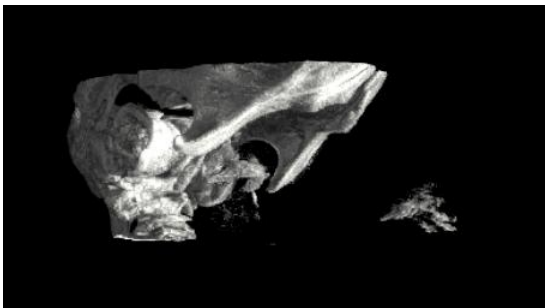
Advantages

Combining the broad energy spectrum of the tube with a energy resolving detector enables us to acquire data in a chosen energy bin. This configuration is contrary to the approach of dual-energy-CT, where a modification of the energy spectrum of the tube is used.

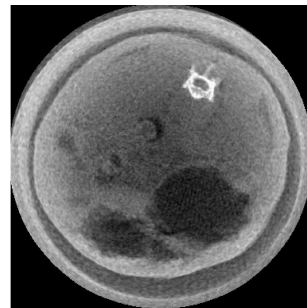
One of the benefits of our setup is the use of only one x-ray tube and no overlapping spectra as in dual-energy CT. With the Medipix 3 chip, where eight energy bins are measured simultaneously, there will be one single source of Poisson noise. When implemented in a human scanner, this reduces both acquisition time and patient dose. It will providing low noise spectroscopic images and eliminate registration artefacts from patient repositioning.

Results

The scanner is beeing operated at Christchurch Hospital. Its stability, accuracy and image quality have been proven and tested. Initial measurements of phantoms and a range of small objects, including several mice were successful (see b,c).



(b) Rendering of a mouse skull and paws



(c) Crossection of a mouse abdomen

Conclusion

The scanner is able to provide 3D spectroscopic x-ray images of small animal and pathology specimens. Image processing and display techniques for the novel energy information are now being developed. First clinical applications have being investigated, further experiments will be done using pathology specimens and mouse models of diseases. Work on spectroscopic material reconstruction is ongoing [4]. The work was funded in part by RANZCR's 2007 GE Prize.

References

- [1] M. Firsching, T. Michel, G. Anton, "First measurements of material reconstruction in X-ray imaging with the medipix2 detector," Nuclear Science Symposium Conference Record, 2007 NSS '07. IEEE, vol.4, no., pp.2736-2740, Oct. 26 2007-Nov. 3 2007
- [2] E Roessl, R Proksa, "K-edge imaging in X-ray computed tomography using multi-bin photon counting detectors", Phys.Med.Biol. 52:4679-4696, 2007.
- [3] R. Ballabriga, M. Campbell, E. H. M. Heijne, X. Llopart, L. Tlustos, "The Medipix3 Prototype, a Pixel Readout Chip Working in Single Photon Counting Mode with Improved Spectrometric Performance", proceedings of Nuclear Science Symposium IEEE 2006, October 2006.
- [4] M. Firsching, A. Butler, T. Michel, G. Anton, "Contrast agent recognition in small animal CT using the Medipix2 detector", submitted to the 10th IWORID, Jun. 29 2008 - Jul. 3 2008