MUHREC – A RECONSTRUCTION TOOL FOR NEUTRON AND X-RAY TOMOGRAPHY

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Summary: This paper describes the recent advances in the MuhRec software, which is a framework for computed tomography reconstruction based on filtered back projection. MuhRec was developed at the Paul Scherrer Institut to support research and users at the neutron imaging beamlines. Its advancement within the European project SINE2020 aims to provide to the neutron imaging community a general tool for tomographic image reconstruction.

1. Introduction

MuhRec is a multi platform non-commercial software for computed tomography (CT) reconstruction that has been developed to support users at the neutron imaging beamlines [1]. The reconstruction engine is designed to allow for a flexible configuration of an arbitrary set of pre-processing modules followed by one back projection module featuring parallel beam geometry. For neutron imaging experiments, the most common configuration includes: i) computation of attenuation images from raw data with normalization to reference images, ii) spot cleaning iii) ring cleaning, iv) projection filter and v) back projection for parallel beam geometry. Both command line and GUI modes are available, to facilitate users to set up the reconstructor and execute the processing.

Its modular structure enables the extension with new reconstruction algorithms or pre-processing modules. Among these, implementations of the wavelet-based ring cleaning filter [2] and the adaptive filter [3] have been recently added.

In this scenario, MuhRec was chosen as one of the tools for image processing within the European project SINE2020 (www.sine2020.eu, [Accessed 27 January 2017]), to provide the neutron imaging community a general tool for image reconstruction of tomographic datasets.

The main advancement described in this paper is the support of cone-beam geometry in MuhRec. The motivation for cone-beam CT (CBCT) reconstruction support is twofold. First, the neutron beam is slightly divergent, resulting in non negligible cone beam effect in some experiments. Furthermore, there is an increasing number of second modality installation using X-rays on neutron imaging beamlines world-wide. The cone beam reconstructor is thus required to reconstruct the data from both modalities.

2. Methods

The CBCT reconstruction option uses the Feldkamp-Davis-Kress (FDK) algorithm [4] that was derived from the open source library plastimatch (www.plastimatch.org, [Accessed 27 January 2017]) implementation and adapted to work within the MuhRec environment. The GUI was accordingly modified to include the CBCT parameters that describe the geometrical relationship between the source, the detector and the sample: source to object distance (SOD), source to detector distance (SDD) and the piercing point, i.e. the point on the detector closest to the source (Figure 1 section a). Such parameters can be calibrated before the CT acquisition. From these, MuhRec provides methods to compute the projection matrices needed from the reconstructor that map the 3D space of the sample into the 2D radiograph for each rotation position. Furthermore, two main deviations from aligned 3D circular geometry are taken into account: i) the non central rotation axis, when the source, the centre of rotation and the piercing point do not lie in a straight line and ii) the tilt of the rotation axis, when the direction of the rotation axis is not parallel to the columns of the detector. These are the most common misalignments in our experiments and

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the projection matrices are accordingly computed to prevent artefacts in the back projected volume.
With CB geometry, arbitrary sizes of field of view and voxel size can be set for the back projected volume. Through the MuhRec GUI it is possible either to automatically compute the maximum isotropic voxel resolution and size of the reconstructed volume or set custom values.
As a test dataset for CBCT reconstruction, we employed the X-ray recent installation at the ICON beamline at PSI (X-ray source Hamamatsu model L212161-07. 75W, 40-150kV and amorphous silicon flat panel detector Varian 2530HE, pixel pitch 139µm) to acquire an x-CT of a “Kinder surprise” chocolate egg with a toy surprise inside. Several CTs were acquired to simulate different geometrical misalignments condition, by translating and tilting the turn table. 375 projections were acquired over 360 degrees with the following x-ray configuration: 80kV, 100µA, 1s exposure time (4fps). SOD and SDD were calibrated using two laser distance sensors mounted on the source and detector, measuring the distances from the sample position respectively. The magnification M=(SOD/SDD) was equal 2.53. A basic pre-processing pipeline was set before the FDK reconstructor featuring the normalization to the reference dark current and open beam images and the reconstruction filter.

3. Results and Conclusions

Results of the reconstructed “Kinder egg” test data are shown in Figure 1 section b, where the reconstructed volume is visualized by means of orthogonal slices as well as volume rendering. This pilot study shows the potential of MuhRec in reconstructing neutron and x-ray CBCT. A performance test and comparison with commercial software is needed and will be done before the next release of the software. Open source release of the software is also foreseen during 2017.
The development of MuhRec is on-going and we intend to add many more features. Main efforts are towards the inclusion of different reconstruction technique, such as the FDK algorithm here presented and iterative reconstruction techniques. Moreover, future development will include support for different image formats and further pre-processing modules.

References

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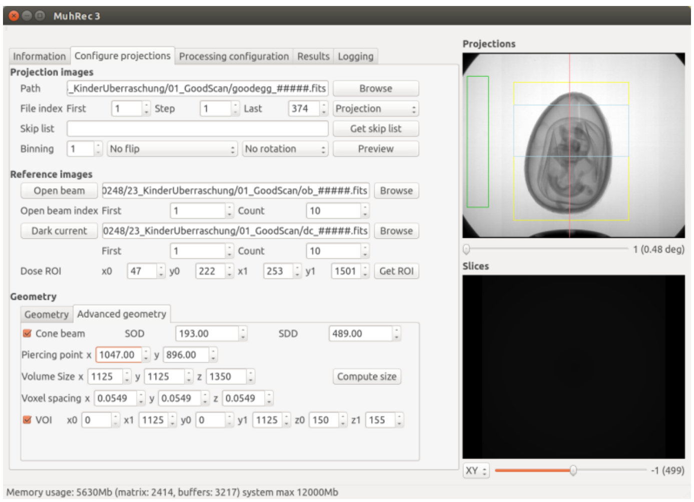
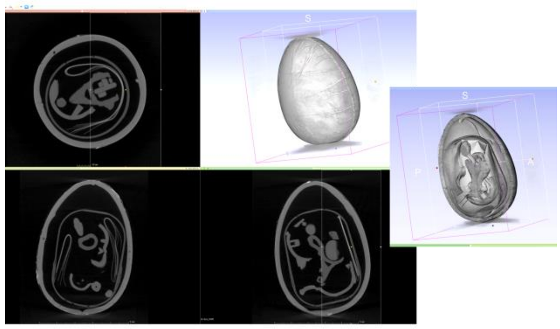


(a)



(b)

Figure 1: (a) MuhRec graphical user interface with CBCT support. (b) The results of CBCT reconstruction in the “Kinder egg” test data, ortogonal slices view and volume rendering