1.9.4. STUDY ON PARAMETER VARIATION OF AN INDUSTRIAL COMPUTED TOMOGRAPHY SIMULATION TOOL CONCERNING DIMENSIONAL MEASUREMENT DEVIATIONS

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Motivation. X-ray computed tomography is a common method for non-destructive testing. A relative new and challenging application in the field of computed-tomography (CT) is metrology, which has to fulfil the demands of today's standards for quality control. The achievable measurement deviations mainly depend on the CT data's quality and in addition on the used evaluation algorithms. Adjustable CT device parameters like X-ray source voltage, anode current, filter plates, detector integration time and the measurement conditions are influencing this image quality, whether the resulting data includes sharp edges and less artefacts or the data is not suitable for a subsequent evaluation procedure. Selection and optimisation of these parameters nowadays has to be done by an experienced system operator, which leads to subjective measurement results. A CT simulation software would be able to do this optimization process automatically and generate user independent device parameters and thus results. Monte-Carlo simulations are able to represent the interactions of X-rays with matter very accurate, but due to their high computational costs, Monte-Carlo simulations are not suitable for the required optimisation of a complete CT scan with a high number of projections.

The objective of this work is a time optimized simulation for industrial cone beam CT's, which models all essential interactions at a sufficient accuracy, for the mentioned optimisation of measurement parameters. Subsequently dimensional features of the simulated datasets are evaluated using a commercial tool for dimensional measurement to determine the measurement deviations.

Modelling of a polychromatic X-ray cone beam computed tomography system (3DCT). A 3DCT system as shown in fig. 1 consists of an X-ray source, a rotary table and an X-ray sensitive detector. During a full discrete turn of the specimen, penetration images which contain the spatial X-ray attenuation are recorded. Using these images it is

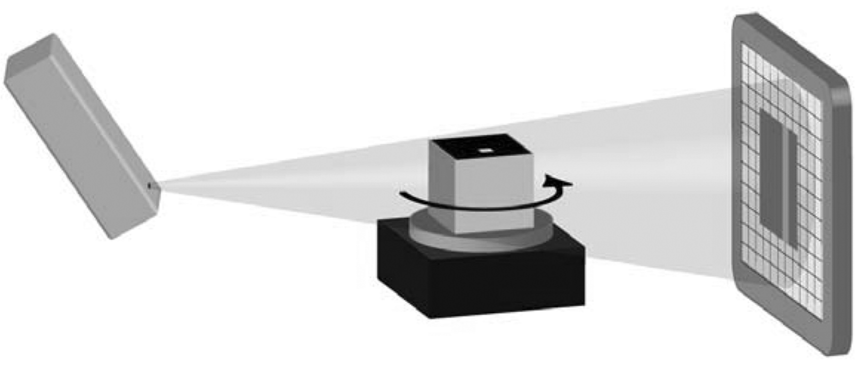

Fig. 1. Schematic of a cone beam computed-tomography system

possible to reconstruct the fully inner and outer structure of the specimen. The reconstruction method used within this work is a Filtered Back-projection.

The modelling process of a 3DCT system had to cover the following sections, an X-ray source model, interactions of X-rays with the object matter and the development of a detector model.

The Simulation uses an X-ray source model published by H. Ebel [1]. It allows the calculation of polychromatic spectra consisting of Bremsstrahlung and characteristic radiation.

The virtual specimen is represented by a surface model consisting of a triangle mesh and an assigned material, which is defined by mass weighted total formulas. The elemental cross sections and differential cross sections are given by Brunneti et al. [3].

A Raytracing algorithm [2] calculates the attenuation lengths L along an ideal ray from the source to a point on the detector, whereas the whole sensor area has to be covered with ideal rays. Subsequently the X-ray source spectrum is attenuated by the determined attenuation lengths, weighted with an detector efficiency (energy) and finally summed up to grey values. Effects caused by beam hardening are thus completely covered.

In addition to the calculation of unscattered X-ray projections the simulation tool offers the opportunity to consider first order scatter effects within the inspected specimen. With some approximations it is possible to reduce this scatter process to N_E convolutions, where the operator has twice the size of the detector dimension and N_E is the number of used energy channels.

Furthermore detector inherent scatter is modelled by convolutions with large point spread function (PSF) kernels.

The whole CT Simulation process has been implemented on the CPU using C++ and on the GPU additionally using the NVidia toolkit CUDA.

Investigations and results. A study on the influence of CT measurement parameters will be published by doing simulation series for selected acquisition parameters and a chosen specimen. The goal of this investigation is to determine the best measurement parameter combination for a specific measurement task. The optimisation criteria will be deviations of dimensional measurement features to their nominal values by applying a subsequent evaluation. The analysis of distances and diameters will be done using a commercial tool for metrology – Carl Zeiss Calypso. Preliminary work has shown that the parameters X-ray source voltage, anode current, filter plate and the number of projections used for the reconstruction show the highest influence on the result. Therefore the presented work will focus on these parameters.

References:

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