High-Energy 3-D X-ray Tomography for Container Inspection

Theobald O.J. Fuchs, Frank Sukowski, Christian Schorr, Tobias Schön, Stefan Schröpfer, Ulf Hassler, Thomas Hofmann, Nils Reims, Michael Boehnel, Markus Firsching
Fraunhofer Development Center for X-ray Technology
Germany
theobald.fuchs@iis.fraunhofer.de

Abstract:

The field of sea freight container inspection has been driven by the U.S. home resolution number one “H.R.1” in the last decade. This law motivated various major research projects inside and outside Europe. The Fraunhofer Development Center X-ray Technology EZRT in Fürth / Germany was partner in ECSIT a three-year project funded by the German ministry for science and research.

Within this context, the Fraunhofer EZRT evaluated methods and technologies to enable the high-energy 3-D imaging for inspection of large objects like the sea freight containers mentioned above, but also of complete cars, wings of airplanes or wind power plants for non-destructive testing (NDT) issues.

In particular, the efforts focused on the following: high-energy 3-D X-ray physics, inspection procedures for large objects, material-selective Computed Tomography (CT), 2-D and 3-D image processing to support the detection of illicit contents in packed goods and the development of radiation-resistant X-ray sensors as well as high-intensity X-ray sources.

In our presentation we discuss different approaches for measuring a 3-D tomographic volume of objects, which are very heavy and thus difficult to move in arbitrary directions. We evaluated three different geometrical principles for data acquisition: tomosynthesis, limited angle CT, and region of interest CT. In addition, the physical aspects of transmission measurements were optimized: the distance of the linear accelerator’s focus to the rotational axis, the spatial resolution in dependency on the pixel pitch of a linear detector array with 10.000 elements, and the collimation and alignment of the X-ray fan.

Furthermore, we show first 3-D measurements of large objects as for instance a 20’-container packed with various typical goods as well as simulated threats like a bomb mock-up. We compare simulated data with real measurements at X-ray energies up to 9 MeV.

Finally, we show various examples of NDT applications with the aim of inspection of heavy machinery.