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Spectral/photon-counting computed tomography

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Abstract

For over 100 years, x-rays have played a crucial role in imaging the internal structure of objects nondestructively. e usefulness of x-rays for medical purposes was recognized as soon as Wilhelm C. Röntgen took the famous transmission image of his wife's hand in 1895 (Kevles 1996). For the next 7 decades, the same simple two-dimensional projection method, still known from dental x-rays, for example, remained the state of the art for medical imaging. It was not until the 1970s that x-ray imaging fundamentally changed with the invention of computed tomography (CT) (Ambrose 1973; Hounseld 1973) and the necessary reconstruction algorithms (Cormack 1963, 1964). Hounseld's CT scanner allowed visualization of two-dimensional slices of the human body rather than projection images where all the organs are superimposed and overlapped. e technology was rened quickly over the next 20 years, decreasing scan times and radiation dose and increasing the spatial resolution and the eldof-view size. Medical imaging experienced another boost in the 1990s with the advent of multislice CT scanners. ey allowed acquisition of true three-dimensional data sets and reconstruction of volumetric images in a single scan. Even whole-body scans became possible with clinically acceptable scan times and radiation dose levels. Multislice CT (or MDCT for multidetector CT) is now the state-of-the-art technology for fast, high-resolution, and cost-eective imaging of the human body with a wide range of clinical applications. With gantry rotation times of <0.3 s and detectors with up to 320 rows, it is possible to scan entire organs like the heart in <1 s.

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Fingerprint

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- Tomography — Chemical Compounds
- X rays — Chemical Compounds
- Multidetector Computed Tomography — Medicine & Life Sciences
- Counting — Physics & Astronomy
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Spectral Photon-Counting Computed Tomography (SPCCT) is a promising technology that has shown a number of advantages over conventional X-ray Computed Tomography (CT) in the form of material separation, artefact removal and enhanced image quality. However, due to the increased complexity and non-linearity of the SPCCT governing equations, model-based reconstruction algorithms typically require handcrafted regularisation terms and meticulous tuning of hyperparameters making them impractical to calibrate in variable conditions. Photon-counting computed tomography (PCCT) is an emerging technology in CT imaging, which could represent the next major technological milestone in the field. Briefly, PCCT uses energy-resolving detectors, thereby enabling scanning at multiple en... PCCT readily differentiates between tissue types and contrast agents much like spectral CT. In the future PCCT could offer higher signal-to-noise ratio, better spatial resolution, superior virtual noncontrast imaging, and spectral imaging data much like dual-energy CT currently does. It can also reduce radiation exposure, reduce the amount of contrast agent needed, and lower the amount of CT artifacts. Photon-counting detector-based computed tomography (PCD CT) offers the unique ability to capture X-ray attenuation information at multiple user-defined energy ranges. This is achieved using novel semiconductor technology where X-rays are directly converted to electronic measurements without having to first convert to visible light, as performed conventionally in current clinical CT detectors. In this chapter, we introduce the basic principles of PCD CT, preclinical applications pertaining to neurological imaging, and a case report demonstrating dose efficient high-resolution CT imaging using a whole-body research PCD-CT system. Keywords. Photon-counting detectors Multi-energy CT Electronic noise Ultra-high resolution Artifact reduction. Single-photon emission computed tomography (SPECT) uses similar logistics and technology to PET. The SPECT tracer emits gamma radiation directly, as opposed to PET where the gamma radiation is emitted indirectly. Because SPECT does not use coincidence detection there is decreased resolution.