Backprojection of a conical Radon Transform in Compton scatter tomography

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Introduction and context

Patrimonial and ancient material objets having a flattened geometry, i.e. having a large ratio between the top or bottom area and its thickness, are nowadays difficult to study with classic radiation tomography methods. A Compton Scatter Tomography (CST) approach is then envisaged.

While incoherent (Compton) scattering data is usually considered as noise, it will be treated in this work as the primary phenomenon of the image formation process. In a Compton event, an incident photon of energy E_0 is absorbed by a target electron, who re-emits a secondary photon scattered by an angle ω relative to the direction of the original photon. The scattered photon has an energy $E_\omega < E_0$ and it will be the collected information to perform the in-depth reconstruction, without the need of rotating the system. The energy loss is practically encoding the scattering angle information.

Methods

CST focuses to reconstruct the electron density map of the object. The Conical Radon Transform (CRT), introduced and developed in [1, 2], is used to this goal.

The locus of scattering points of the object having the same detecting site D and the same scattering angle ω, encoded by a measured energy loss $E_0 - E_\omega$ are included in a cone C with apex at D and opening angle ω. The photon flux density recorded at D having an energy E_ω can be modelled with the CRT as a surface integral over the cone C [1].

Additional essential tools are: The Compton formula, that gives us the relationship between the scattering angle ω and the scattered energy E_ω. The Klein-Nishina cross section, giving us the probability of a photon to be Compton scattered into a specific direction.

Results

Inversion of a 2D CRT is stablished in [2] and a backprojection inversion in [1] for a Compton gamma-ray Camera. We will present in this work 2D and 3D reconstructions of simulated patrimonial objects in a different imaging configuration: A synchrotron radiation setup with a monochromatic parallel source and 2D energy detectors. In these first attempts, attenuation and multiple scattering will be neglected.

First results, presented in Figure 1, show the feasibility of the approach where an in-depth analysis can be performed by only considering Compton scattering events without relying on a rotation of the phantom/system relative to the detection setup.

Algorithmic implementation and time complexity of this backprojection method will also be discussed.

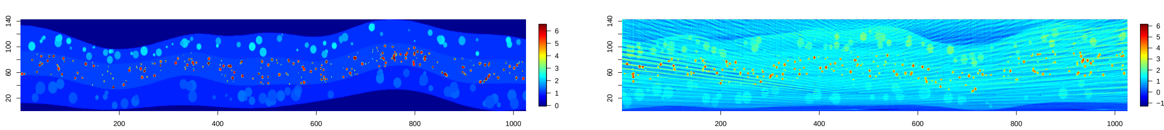

Figure 1: Reconstruction of a stratigraphic phantom by a backprojection of the CRT. Inner grains can be distinguished at the correct depth.

Références

[1] J. Cebeiro, M. Morvidone and M. K. Nguyen, *Back-projection inversion of a conical Radon transform*, Inverse Problems in Science and Engineering, 2015.

[2] M. Morvidone, M. K. Nguyen, T. T. Truong and H. Zaidi, *A novel V-line Radon transform and its imaging applications*, International Journal of Biomedical Imaging, 2010.

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