Reconstruction algorithms for multi-spectral X-ray CT imaging

Project for Bachelor Thesis
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1 Background

Multi-spectral X-ray CT is an imaging modality that is used in medical applications as well as in security scanners. A polycromatic X-ray source illuminates the object of interest and absorption is measured in different bands of the spectrum. Recent advances in photon counting detectors make simultaneous measurements in different energy bins possible and thus reducing scan times as well as radiation exposure, thus leading to increased interest for medical applications. The inversion problem in multi-spectral CT consists in determining the distribution of different substances in the sample from the absorption measurements in different angels and in certain wavelength intervals. While in conventional CT imaging the (linear) Radon transform can be inverted, one step inversion in multi spectral CT typically leads to a non-linear inversion problem.

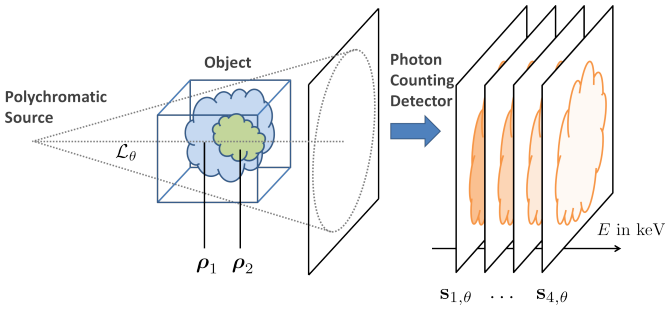

Figure 1.1: Principle of measurement, taken from [3]

We studied the application of block coordinate descent methods to the reconstruction problem of multi-spectral CT imaging in [4]. We believe that this strategy can improve the performance of other iterative algorithms used in the field. Recently a french group performed an extensive comparison of different reconstruction methods on simple phantoms [2]. Their code is available on github. On the other hand measured datasets for scanning of (simulated) baggage are available (compare [1]).

2 Aims of the bachelor thesis

Since multi-spectra X-ray CT is a broad field of recently very active research, there are various possible directions for performing a Bachelor Thesis. Examples are:

- ⇨ Analysis: Does one step inversion of multi-spectral CT imaging satisfy a so called "tangential cone condition", necessary for convergence of iterative regularization methods.
- ⇨ Scientific Computing: Implement coordinate descent strategy in existing optimization algorithms and verify if this leads to acceleration.
- ⇨ Application: Test algorithms on data set from baggage scanning and explore different segmentation strategies.

The precise topic will be fixed depending on the specific interest of the corresponding student. If desired, the field is wide enough to merit also a continuation in the form of a Masters Thesis.

References

[1] J. Kehres-A. B. Dahl C. Kehl, W. Mustafa and U. L. Olsen. Multi-spectral imaging via computed tomography (music) - comparing unsupervised spectral segmentations for material differentiation. Preprint 2018, `https://arxiv.org/abs/1810.11823`. Data available at `http://easi-cil.compute.dtu.dk/index.php/datasets/music/`.

[2] S. Si-Mohamed L. Boussel C. Mory1, B. Sixou and S. Rit. Comparison of five one-step reconstruction algorithms for spectral ct. *Physics in Medicine & Biology*, 63(23):235001, 2018. Code available at `https://github.com/SimonRit/OneStepSpectralCT`.

[3] B. Sixou-S. Rit N. Ducros, J.F.P.J. Abascal and F. Peyrin. Regularization of nonlinear decomposition of spectral x-ray projection images. *Medical Physics*, 44(9):e174–e187, 2017.

[4] L. Neumann S. Rabanser and M. Haltmeier. Analysis of the block coordinate descent method for linear ill-posed problems. Preprint 2019, `https://arxiv.org/abs/1902.04794`.