Hyperspectral CT Reconstruction & Material Segmentation

1. General Info

Project Title: Hyperspectral CT Reconstruction & Material Segmentation

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2. Project Abstract

Novel Computed Tomography Devices allows the user to choose a wide range of energy levels for imaging enabling the acquisition of hyperspectral measurements that can improve reconstruction quality and allow for the identification of different materials leveraging their photon-matter interaction characteristics. The goal of this project is to build a prototyping pipeline for testing different hyperspectral reconstruction and segmentation approaches leveraging public data and/or simulated data. The overall research goal is to identify a minimal wavelength set to segment a novel object based on a database of known materials.

3. Background and Motivation

The reconstruction of objects made up of complex shapes and different materials is challenging as the different materials have varying absorption and transmission properties. Leveraging multiple measurements of different wavelengths can provide additional information about the material parameters and therefore help the reconstruction and identification of materials within an object. Hyperspectral measurements contain a large number of measurements over a wide band of energies. In this project we want to evaluate state-of-the-art methods based on their reconstruction and segmentation accuracies.

4. Technical Prerequisites

- Experience in 3D Computer Vision
- Experience in Machine Learning
- Python/C++/CUDA Programming

5. Benefits:

- Learn about 3d reconstruction
- Learn about material properties and simulation
- Learn about 3d segmentation

6. Students' Tasks Description

Students' tasks would be the following:

- Design a prototyping framework for hyperspectral CT processing
- Implement at least one method for hyperspectral CT reconstruction
- Implement at least two methods for hyperspectral material segmentation
  - One unsupervised method
  - One decomposition/unmixing method with known material spectra

7. Work-packages and Time-plan:

	Description	#Students	From	To
WP1	Literature, code & data review			
WP2	Design prototyping framework			
WP3	Implement CT Reconstruction			
M1	Intermediate Presentation			
WP4	Implement Unsupervised Material Segmentation			
WP5	Implement Unmixing Material Segmentation			
WP6	Evaluation of all implemented methods			
M2	Final Presentation			

References

1. So, A., & Nicolaou, S. (2021). Spectral computed tomography: fundamental principles and recent developments. *Korean Journal of Radiology*, *22*(1), 86.
2. Mory, C., Sixou, B., Si-Mohamed, S., Boussel, L., & Rit, S. (2018). Comparison of five one-step reconstruction algorithms for spectral CT. *Physics in Medicine & Biology*, *63*(23), 235001.
3. Kehl, C., Mustafa, W., Kehres, J., Dahl, A. B., & Olsen, U. L. (2018). Multi-Spectral Imaging via Computed Tomography (MUSIC)-Comparing Unsupervised Spectral Segmentations for Material Differentiation. *arXiv preprint arXiv:1810.11823*.
   Code: https://github.com/CKehl/MECT
   Dataset: http://easi-cil.compute.dtu.dk/index.php/datasets/music/
4. Zeegers, M. T., Kadu, A., van Leeuwen, T., & Batenburg, K. J. (2022). ADJUST: a dictionary-based joint reconstruction and unmixing method for spectral tomography. *Inverse problems*, *38*(12), 125002.
5. Wu, W., Yu, H., Chen, P., Luo, F., Liu, F., Wang, Q., ... & Yu, H. (2020). Dictionary learning based image-domain material decomposition for spectral CT. *Physics in Medicine & Biology*, *65*(24), 245006.
6. Fredette, N. R., Kavuri, A., & Das, M. (2019). Multi-step material decomposition for spectral computed tomography. *Physics in Medicine & Biology*, *64*(14), 145001.
7. Hohweiller, T., Ducros, N., Peyrin, F., & Sixou, B. (2018, September). An admm algorithm for constrained material decomposition in spectral ct. In *2018 26th European Signal Processing Conference (EUSIPCO)* (pp. 71-75). IEEE.