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Material density and effective atomic number maps of soft tissues via synchrotron radiation spectral CT

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Spectral computed tomography (CT) systems for probing tissue attenuation at different energy levels offer added information to tissue characterization and can help in resolving the ambiguity created when different tissue produce very similar gray levels at a single energy range. Attenuation maps measured at different energy can be used to perform material decomposition and/or compute material characteristic quantities such as material density and effective atomic number. Material decomposition is a procedure in which spectral data is represented in the basis of two known materials and often serves as an intermediate step for ρ/Z_{eff} mapping. The clinical relevance of ρ/Z_{eff} mapping has been demonstrated in terms of better tissue distinction [1], material-specific imaging (e.g., iodine, bone, or calcium), and treatment planning in particle radiation therapy [2]. To this day many algorithms were developed to extract this information from spectral datasets obtained by monochromatic and polychromatic X-ray sources.

In our previous work, we developed two different algorithms to perform material decomposition [3] and an approach to compute ρ and Z_{eff} from said decomposition. The results of this approach are shown in Fig. 1. In the present work, we compared several approaches also published by different authors [4] to extract material density and effective atomic numbers from the spectral CT dataset of various soft tissues obtained at SYRMEP beamline at Elettra Sincrotrone Trieste. The comparison study is performed to find an optimal solution to the state-of-the-art synchrotron radiation breast CT setup currently developed in Trieste. The algorithms were evaluated based on the SNR and the accuracy of extracted ρ and Z_{eff} values.

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[2] Bär E, Lalonde A, Royle G, Lu HM, Bouchard H. The potential of dual-energy CT to reduce proton beam range uncertainties. Medical Physics. 2017;44(6):2332–44.
[3] Vrbaski S, Longo R, Contillo A. From spectral decomposition through SVD to quantitative description of monochromatic CT images: a phantom study. Medical Imaging 2022; doi 10.1117/12.2613130
[4] Niu T, Dong X, Petrongolo M, Zhu L. TU-F-18A-02: Iterative Image-Domain Decomposition for Dual-Energy CT. Medical Physics. 2014;41(6Part27):475–6.

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