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Physical Principles to Translate from Phase Contrast Imaging to Absorption Contrast Imaging

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Artificial Intelligence (AI) classification as a methodology and approach to identify Tuberculosis (TB) in patients has become a topic of increasing interest in the past few decades. This is in large part due to the increasing demand for faster methods of detecting TB to reduce spread. However, such methodologies require large datasets so that algorithms can learn the manifestations of TB in the lung. Some of these datasets are private due to patient confidentiality, and the publicly available ones are limited in number. The AI industry has exhausted publicly available chest X-ray (CXR) scans and now look for alternate methods to further develop research in the field. The study focuses on developing methods to translate 3D information on effective electron density from Hierarchical Phase Contrast tomography (HiP-CT) of a human lung to 3D segmented images based on differentiated effective atomic number and mass density. The purpose of this methodology is to create a digital phantom as a synthetic model of a human lung where pathologies of the various stages of TB can be inserted. Monte Carlo modeling of X-ray radiography can then be performed on sets of such digital phantoms to produce a library of 2D conventional X-ray radiographs labeled with details of the occurrence of TB pathologies. This synthetic data set can be used to train an AI classifier.

The study will leverage HiP-CT scans produced by the European Synchrotron Research Facility (ESRF) beamline BM18. These are high-resolution 3D scans (~20μm) of complete human organs. To create a synthetic dataset, the Geant4 toolkit will be used to simulate the properties and physiological conditions of a lung. This information is gathered from the HiP-CT images; to understand the material properties of the HiP-CT images, the phase shift (δ) and the effective mass densities (ρ_{eff}) of the organic materials within the lung must be known. Thus, this research builds on the derivation of equations and the calculation of these parameters as inputs for simulation.

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