Sirius: Simulating X-Ray Images Through Computational Mathematics

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This research investigates, from a mathematical and computational perspective, the process of image formation and reconstruction through Computed Tomography (CT), using algorithms implemented in Python. By leveraging the Radon Transform and filtered backprojection techniques, a custom code was developed to simulate the acquisition of two-dimensional tomographic data and reconstruct high-fidelity three-dimensional images from these simulated inputs. Inspired by cutting-edge technologies such as the Sirius particle accelerator (LNLS), which employs X-rays for high-precision scientific analyses, the project adopts an approach based on the simultaneous rotation of the sample and the detector. This allows for the mathematical manipulation of projections as matrices and vectors, enabling an efficient and accessible computational model that brings the real imaging process closer to virtual simulation. The research integrates knowledge from Physics, Mathematics, and Computer Science to understand the physical principles of CT and translate them into computational models. The implementation of the code enables accurate reconstruction of samples, as demonstrated in tests using 3D-printed objects, revealing internal and structural details. Moreover, the model presents potential for expansion into various scientific and technological contexts, such as medical imaging diagnostics, nanomaterial studies, geosciences, and materials engineering. More than a theoretical proposal, this work delivers a functional computational tool that can serve as a foundation for future research and contribute to the democratization of access to CT studies through digital simulation.

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