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The Basics of the Radon transform for medical and quantum state tomography

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This work provides an accessible introduction to the computational aspects of the Radon transformation, nowadays routinely used to reconstruct the 3D distribution of scatterers from the sequence of their 2D integral projections. The focus will be only on the parallel-beam projections, which directly correlate to a real-world application of X-ray absorption tomography, where measurements of the attenuation of the radiation intensity passing through the specimen at different angles were used to reconstruct a medical tomographic image.

For simplicity, the Radon transform, the inverse Radon transform, and their relationship with the spatial Fourier transform will be introduced by analysis of the 2D medical phantom image of a human head. In this setting, the original grayscale image, represented by a square matrix, can be considered a cross-section through the specimen, with the image's light intensities representing the density of the absorbers. We shall briefly mention how to accomplish the image reconstruction tasks easily and computationally efficiently using Matlab's Image Processing Toolbox [1].

In the end, we shall review the use of tomography techniques for reconstructing the quantum state in the phase space using only measurements of the momentum probability distribution done on an ensemble of identically prepared states using homodyne tomography [2] in the case of bosons and quantum beam tomography in the case of fermions [3].

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