

Problem Statement and Goals

Computed Tomography Image Reconstruction

Qianlin Chen

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Table 1: Revision History

Date	Developer(s)	Change
January 16, 2025	Qianlin Chen	Initial Draft
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1 Problem Statement

1.1 Problem

With the arrival of Computed Tomography (CT) as a diagnostic tool in medical imaging, X-ray imaging underwent a revolution. Tomography is a method of imaging a two- or three-dimensional object from multiple one-dimensional “slices” of the object. In a CT scan, these slices are created by multiple parallel X-ray beams passing through the object at varying angles. The initial and final intensity of each beam is recorded, and the original image is reconstructed using backprojection with this data from multiple slices.

However, significant noise blurs the recreated image, even as the number of backprojections increases. Regardless of the number of directions used for backprojection, it can not perfectly recreate the image using the backprojection formula[Beatty2012]. Therefore, it is necessary to develop techniques to filter out noise created by backprojection and produce a smoother representation of the object. Additionally, different filtering techniques may yield varying reconstruction efficiencies, so selecting an appropriate filter is crucial.

1.2 Inputs and Outputs

1.2.1 Inputs

- Phantom images.

- Sinogram data.
- Projection angles.
- Filter type to be applied during backprojection.

1.2.2 Outputs

- Reconstructed CT images.

1.3 Stakeholders

- Medical Researchers who require advanced imaging tools for studying medical conditions and treatment outcomes.
- Hospital which seeks efficient and accurate imaging technologies.

1.4 Environment

Software

Windows, Linux or Mac OS

2 Goals

High-quality CT Image Reconstruction

The tool should improve the quality of reconstructed CT images through advanced filtering techniques.

Filter Options

The tool should provide high-pass and low-pass filter options to filter different types of noise.

User-Friendly Design

The tool will be intuitive, requiring no additional instructions for users to understand all features.

3 Stretch Goals

Adaptive Filtering

The tool should implement adaptive filters that automatically adjust based on image characteristics.

Real-Time Reconstruction

The tool should support real-time image reconstruction during the scanning process, enabling faster diagnostics.

4 Challenge Level and Extras

The main challenge lies in the integration of domain knowledge from the medical and mathematical fields. Understanding the principles of medical imaging, including tomography and the Radon transform, as well as mastering the associated mathematical concepts, requires additional effort.

Testing poses another difficulty in this project. For functional testing, the lack of access to high-quality datasets limits the ability to evaluate the accuracy and effectiveness of the reconstruction process. For usability testing, reaching potential users, such as researchers in medical imaging or related fields, is difficult due to their limited availability.

The expected challenge level for this project is general. While it requires medical and mathematical knowledge, many research resources are available online. The CT image reconstruction process is well-documented and feasible for implementation. This project is appropriate for graduate-level study, combining computer science with interdisciplinary applications.