Problem Statement and Goals
Computed Tomography Image Reconstruction

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Table 1: Revision History

Date	Developer(s)	Change
January 16, 2025	Qianlin Chen	Initial Draft
...	...	...

1 Problem Statement

The following section highlights the challenges in reconstructing clear CT images during the backprojection process, with a particular focus on selecting appropriate filtering techniques. Addressing these challenges is crucial for developing solutions that improve image clarity and enhance diagnostic accuracy.

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[1].
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[1]. 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[2].

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.

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. Since the project is intended as a tool rather than for research purposes, a user manual is essential to guide users in effectively using the tool.

References

[1] Jen Beatty. "The Radon Transform and the Mathematics of Medical Imaging". In: (2012). Paper 646. URL: https://digitalcommons.colby.edu/honorstheses/646.

[2] Maria Lyra and Agapi Ploussi. "Filtering in SPECT Image Reconstruction". In: *International Journal of Biomedical Imaging* 2011 (2011). PMCID: PMC3132528, pp. 1–11. DOI: 10.1155/2011/693795. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3132528/.