Problem Statement and Goals
Computed Tomography Image Reconstruction

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January 17, 2025

Table 1: Revision History

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

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 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 cannot perfectly recreate the image using the backprojection formula. 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 in degrees.
- Filter type to be applied during backprojection.

1.2.2 Outputs

- Reconstructed CT images.

1.3 Stakeholders

- Researchers
- Hospital

1.4 Environment

Software Windows, Linux or Mac OS

2 Goals

Image Quality Enhancement
The quality of reconstructed images will improve through advanced filtering techniques.

Filter Options
High-pass and low-pass filters will be available to enhance flexibility and optimize reconstruction.

User-Friendly Design
The application will be intuitive, requiring no additional instructions for users to understand all features.

3 Stretch Goals

Adaptive Filtering
Implement adaptive filters that automatically adjust based on the image characteristics, reducing manual intervention.

Real-Time Reconstruction
Develop functionality for real-time image reconstruction during the scanning process, enabling faster diagnostics.

4 Challenge Level and Extras

The primary challenge of this project 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 significant learning and effort.
While coding is not a challenge, testing poses another difficulty due to limited access to high-quality data, which could impact the evaluation of reconstruction accuracy and filter performance. Addressing these issues will demand innovative approaches, such as using simulated data or augmenting limited datasets.

[State your expected challenge level (advanced, general or basic). The challenge can come through the required domain knowledge, the implementation or something else. Usually the greater the novelty of a project the greater its challenge level. You should include your rationale for the selected level. Approval of the level will be part of the discussion with the instructor for approving the project. The challenge level, with the approval (or request) of the instructor, can be modified over the course of the term. —SS]

[Teams may wish to include extras as either potential bonus grades, or to make up for a less advanced challenge level. Potential extras include usability testing, code walkthroughs, user documentation, formal proof, GenderMag personas, Design Thinking, etc. Normally the maximum number of extras will be two. Approval of the extras will be part of the discussion with the instructor for approving the project. The extras, with the approval (or request) of the instructor, can be modified over the course of the term. —SS]

Appendix — Reflection

[Not required for CAS 741 —SS]

The purpose of reflection questions is to give you a chance to assess your own learning and that of your group as a whole, and to find ways to improve in the future. Reflection is an important part of the learning process. Reflection is also an essential component of a successful software development process.

Reflections are most interesting and useful when they're honest, even if the stories they tell are imperfect. You will be marked based on your depth of thought and analysis, and not based on the content of the reflections themselves. Thus, for full marks we encourage you to answer openly and honestly and to avoid simply writing "what you think the evaluator wants to hear."

Please answer the following questions. Some questions can be answered on the team level, but where appropriate, each team member should write their own response:

1. What went well while writing this deliverable?
2. What pain points did you experience during this deliverable, and how did you resolve them?
3. How did you and your team adjust the scope of your goals to ensure they are suitable for a Capstone project (not overly ambitious but also of appropriate complexity for a senior design project)?