PROJECT BME 2018

Fan-beam tomographic image reconstruction algorithm

Reconstruction of a tomographic image from projections:
Receive projections with "fan-beam" geometry

The aim of this project is the effect various parameters of tomographic image reconstruction from projections, which stimulate clinical conditions in modern Computed Tomography Systems (CT) imaging systems with x-rays, on the quality of medical image. Specifically, the following will be studied:

a) the effect of angular sampling (number of projections),
b) the effect of projection sampling,
c) the effect of the reconstruction filter,
d) the effect reconstruction filter cut-off frequency.

MATLAB programming environment
Using the MATLAB programming environment (Image Processing Toolbox), the project will be carried out on CT data (test1- test6.tif). In particular, the following tasks should be used:

- Reading/presentation of two-dimensional cross-sectional image data using a volume normalization function [0,1],
- Extracting sinograms (with fanbeam transformation) for specific values of projections sampling Δr (Sensor Spacing) and angular sampling $\Delta\theta$ (Rotation Increment),
- Use of different projection modification filters (reconstruction filter),
- Use of different filter cut-off frequencies with use of the max frequency (frequency scaling % of maximum frequency),
- Use of ifanbeam function for image reconstruction.

In all case use a non-linear (cubic) method of interpolation.

Quantitative evaluation of the effect of computed tomography reconstruction parameters on CT image quality.

Calculate the following quantitative image quality indices on the original and reconstructed CT images for various values of the above parameters:

a) Calculate the noise in a homogeneous circular region of interest (ROI) of the background
b) Calculate the contrast to noise ratio (CNR) in two circular structures of your choice, corresponding to biological anatomical tissue equivalents.
c) Calculate the "blurring" in the above two circular structures

The above measurements should be made on the basis of measurements of circular ROIs (e.g. imellipse), placed in the background, as well as inside the circular structures. In particular, in the case of circular structures the ROIs are placed inside their limit (50% of their limit), as well as data lines (e.g. improfile) along the

horizontal direction, which run through both the interior and the edge of the circular structures.

In any case the following are required to be displayed:

1. The original image of the cross section to be reconstructed (test1-test6.tif).
2. The regions of interest (ROIs) and data lines (Profiles) selected in the original and reconstructed images to calculate noise, CNR and blurring.
3. Sinograms of the cross-section to be reconstructed for specific combinations of angular sampling [Sensor Spacing (Δr): 0.8^0, 0.5^0 και 0.2^0] and projection sampling [Rotation Increment (Δθ): 3º, 2º και 1º which correspond to 120, 180 and 360 projections].
4. The reconstructed images of the above combinations of angular sampling and projection sampling for a specific projection modification filter (filter: Hanning), with a cut-off frequency of the reconstruction filter (frequency scaling: 95%).
5. The reconstructed images by applying different projection modification filters (filter: Ram-Lak, Cosine και Hamming) with filter cut-off frequency (frequency scaling: 100%), for the optimal combination of angular sampling and projection sampling.
6. The reconstructed images by applying a specific filter of your choice for different cut-off frequency values of the reconstruction filter (frequency scaling: 100%, 90% και 80%), for the optimal combination of angular sampling and projection sampling.

Questions:

i. How do image quality indicators differ: noise, CNR and blurring of structures depending on (a) angular sampling, (b) projection sampling, (c) projection modification filter and (d) filter cut-off frequency? Present the corresponding graphs.
ii. What do you conclude about the effect of the filter type (including cut-off frequency) on the display of structures? What is the optimal combination for the specific 2 structures of your choice?
iii. Which of the above 3 image quality indicators are most affected by the various reconstruction parameters? Who expresses the traceability of structures?