

Probability density-based image reconstruction for proton Computed Tomography

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PROBABILITY DENSITY-BASED IMAGE RECONSTRUCTION FOR PROTON COMPUTED TOMOGRAPHY

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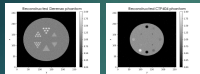
Abstract Proton density-based image reconstruction for proton computed tomography (pCT) is a challenging task due to the limited number of projections and the high energy of the particles. In this paper, we propose a novel method for pCT image reconstruction based on the maximum likelihood estimation (MLE) of the proton density distribution. The proposed method is based on the Monte Carlo simulation of the proton transport and the optimization of the proton density distribution. The proposed method is able to reconstruct the proton density distribution from a limited number of projections. The proposed method is able to reconstruct the proton density distribution from a limited number of projections. The proposed method is able to reconstruct the proton density distribution from a limited number of projections.



METHODOLOGY

The pCT simulation models measure the energy of particles in the path of each path length to obtain measured path length (MPL). During the simulation, the pCT detector measures the MPL of each particle. The MPL is then compared with the simulated MPL to obtain the difference between the measured and simulated MPL. The difference between the measured and simulated MPL is used to reconstruct the proton density distribution. The proposed method is able to reconstruct the proton density distribution from a limited number of projections.

$$MPL = \int_0^L \rho(x) dx$$



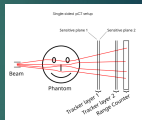
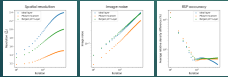
SIMULATIONS WITH THE ALGORITHM

A single-rod detector design with a 256 channel proton beam line configuration. Three different detector sizes are simulated. The detector sizes are compared with the detector size used in the Wigner Research Centre for Physics (Wigner RCF) pCT experiment. The detector sizes are compared with the detector size used in the Wigner RCF pCT experiment. The detector sizes are compared with the detector size used in the Wigner RCF pCT experiment.

Detector size (mm)	Channel	Energy (MeV)	Resolution (mm)	Efficiency (%)
100	128	100	100	100
200	256	100	100	100
300	384	100	100	100

RESULTS

The simulation results show that the proposed method is able to reconstruct the proton density distribution from a limited number of projections. The proposed method is able to reconstruct the proton density distribution from a limited number of projections. The proposed method is able to reconstruct the proton density distribution from a limited number of projections.

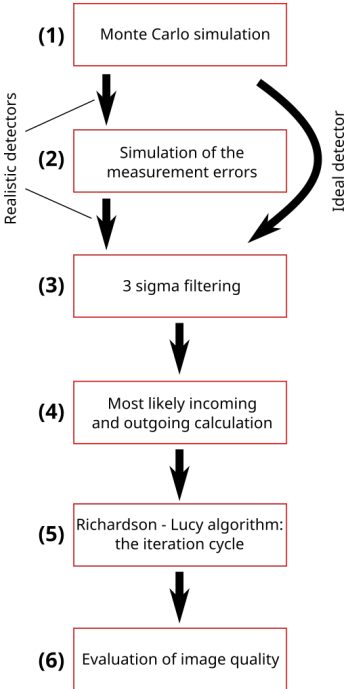
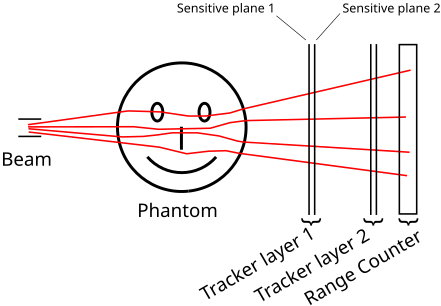


The proposed method is able to reconstruct the proton density distribution from a limited number of projections. The proposed method is able to reconstruct the proton density distribution from a limited number of projections. The proposed method is able to reconstruct the proton density distribution from a limited number of projections.

Novel points:

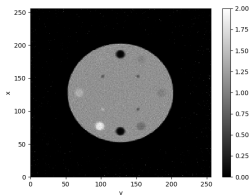
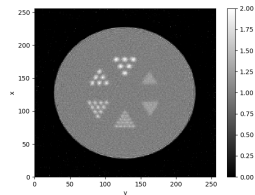
- Richardson – Lucy algorithm (first applied for pCT)
- Probability-density based trajectory model
- Measurement uncertainties in most likely path calculations

Single-sided setup:

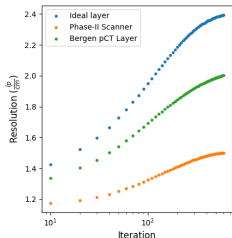


Results:

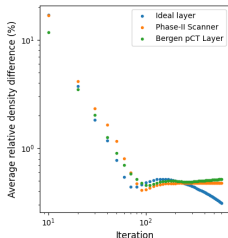
- Spatial resolution ($MTF_{10\%}$):
ideal: 2.4 lp/cm & realistic: 2.0 lp/cm
- Relative stopping power (RSP) accuracy:
0.3 % for ideal & 0.5 % for realistic setup
- Image noise: around 5 % for both cases



Spatial resolution



RSP accuracy



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