Medical Physics and Image Reconstruction
Available Projects

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2025-11-26

- MRI
- CT
- SPECT
- PET

BSc and MSc topics - Mediso Ltd.

Image uncertainty estimation in SPECT reconstruction

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Image uncertainty estimation in SPECT reconstruction

Background:
- SPECT acquisition is inherently noisy (photon noise)
- SPECT reconstruction is an iterative process => noise amplifies during reconstruction

Tasks:
- Estimate the noise of the current iterate during reconstruction
- Compare available, published solutions with proposed new methods
- Scale toy solutions to real problems

Required skills:
- Statistics (Estimation Theory)
- Python (with focus on scientific computation)
- Numerical methods

Estimation of spatial resolution of SPECT cameras with complex geometry and trajectory

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Spatial resolution estimation in SPECT

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Background:
- Modern SPECT cameras equipped with MPH apertures have complex projection geometry
- Trajectory of the SPECT heads during acquisition is also more complex for MPH

Tasks:
- Based on geometrical description of the pinholes and the trajectory of the acquisition, estimate the spatial resolution locally in the acquisition FOV

Required skills:
- Monte Carlo gamma photon transport
- GPU programming (C++/CUDA)

AI assisted Monte Carlo simulation of gamma photon transport

AI assisted Monte Carlo photon transport

Background:
- Simulation of gamma photons can be quite slow
- During photon transport, gamma photons travel outside and inside the SPECT head before detection

Tasks:
- Compression of photon paths in SPECT heads with generative AI
- Simulate photon track in SPECT head with OpenGATE
- Train generative neural networks to sample detected photons
- Evaluate the performance of the models

Required skills:
- Pytorch (For training networks)
- C++ for validation in OpenGATE

Modern SPECT reconstruction algorithms

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Modern SPECT reconstruction algorithms

Background:
- SPECT reconstruction is an optimization problem
- Similarly to training neural networks, only first order gradient descent method are feasible

Tasks:
- Implement and compare modern gradient descent variants from
  ML in context of SPECT reconstruction
- Scale toy solutions to real ones

Required skills:
- Python with scientific focus
- Convex optimization

Presented Topics

1. Image uncertainty estimation in SPECT reconstruction
2. Estimation of spatial resolution of SPECT cameras with complex geometry and trajectory
3. AI assisted Monte Carlo simulation of gamma photon transport
4. Modern SPECT reconstruction algorithms

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Further variations are also available:

- python + cuda Monte Carlo reconstruction (half-done)

- Uncertainty-constrained Maximum-Likelihodd estimation

- Dosimetry in Thearnostics (MC + error propagation)

Thank you for your attention!

Do you have any questions?

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