Development of methods for analysis and reconstruction of nuclear medicine images

Implementation of the medical Physics, Oncology & Nuclear medicine research image platform at Sahlgrenska Academy

Tobias Rydén

Department of radiation physics
Institute of clinical sciences
Sahlgrenska Academy at University of Gothenburg

ABSTRACT

This thesis presents four novel algorithms for processing and analysis of nuclear medicine images. In addition, the novel research image platform where these four algorithms have been implemented, together with most established algorithms for image processing and analysis, are shortly described. The majority of the algorithms in the image platform are executed on the graphics processing unit (GPU), which enable fast parallel execution of the scripts.

The four novel algorithms have been constructed for analysis of nuclear medicine images of patients with neuroendocrine tumours, who has either been diagnosed or treated with the somatostatin analogues 111In-octreotide and 177Lu-octreotate, respectively. The first algorithm was constructed for analysis of two planar image methods for kidney dosimetry. The results of the analysis showed that it is most challenging to find a region of interest (ROI) that resembles the true activity in the over- and underlying tissue of the kidney. Nevertheless, in this paper we propose that a ROI surrounding the kidney might be preferable over small ROIs. Furthermore, due to the high influence of background activity in the anterior image it seems to be favourable to perform the dosimetry on the posterior image instead of using the geometric mean value of the anterior and posterior images. The second algorithm was constructed for obtaining good estimates of the bone marrow doses from planar images. The algorithm generated estimates of the absorbed dose to bone marrow that were in agreement with earlier estimates. In addition, the obtained absorbed doses correlated to haematological response. The third algorithm was constructed for improved diagnosis of liver tumours. The methodology was based on a statistical approach for separating livers with tumour involvement from livers without tumour involvement. The method showed promising results in a retrospective study where an increased number of patients with liver tumour involvement could be diagnosed. Finally, a new Monte Carlo-based single photon emission computed tomography reconstruction algorithm was constructed. Since the code is executed on the GPU the tremendous number of photon emission and scattering is rapidly simulated in parallel. Thereby, the simulation time for the reconstruction is only a few minutes. In phantom measurement this reconstruction method was superior to the conventional and the state-of-the-art methods used for reconstruction of clinical images.

Keywords: SPECT reconstruction, Image analysis, Monte Carlo, Dosimetry, Nuclear medicine, Radionuclide therapy

ISBN: 978-91-628-9937-0 (printed)
ISBN: 978-91-628-9938-7 (e-publication, pdf)
http://hdl.handle.net/2077/44923

Development of methods for analysis and reconstruction of nuclear medicine images

Implementation of the medical Physics, Oncology & Nuclear medicine research image platform at Sahlgrenska Academy

Akademisk avhandling

som för avläggande av medicine doktorsexamen
vid Sahlgrenska akademien, Göteborgs universitet,
kommer att offentligen försvaras i Hörsal Arvid Carlsson,
Academicum, Medicinaregatan 3, fredagen den 11 november kl.09.00

av

Tobias Rydén

Fakultetsopponent: Professor Mark Lubberink,
Uppsala universitet, Uppsala
Avhandlingen baseras på följande arbeten:

I. **Magnander* T**, Svensson J, Båth M, Gjertsson P, Bernhardt P. Improved planar kidney activity concentration estimate by the posterior view method in ^{177}Lu-DOTATATE treatments. Radiat. Prot. Dosimetry 2016;169(1-4):259-266. (Open access)

II. Svensson J, **Rydén T**, Hagmarker L, Hemmingsson J, Wängberg B, Bernhardt P. A novel planar image based method for bone marrow dosimetry in ^{177}Lu-DOTATATE treatments correlates with haematological toxicity. EJNMMI Physics, 3(1), 1-12. (Open access)

III. **Magnander* T**, Wikberg E, Svensson J, Gjertsson P, Wängberg B, Båth M, Bernhardt P. A novel statistical analysis method to improve the detection of hepatic foci of ^{111}In-octreotide in SPECT/CT imaging. EJNMMI Phys. 2016;3(1):1. (Open access)

IV. **Rydén T**, Heydorn-Lagerlöf J, Hemmingsson J, Svensson J, Båth M, Gjertsson P, Bernhardt P. Fast GPU based Monte Carlo code for SPECT/CT reconstructions generates improved quality of ^{177}Lu images. Manuscript.

*Magnander was the author's name until 2016

UNIVERSITY OF GOTHENBURG

Göteborg, 2016