Göteborg, 2022

Effects of nonlinear noise reduction algorithms on image quality in computed tomography systems

Evaluations using human observers and methods for assessing distortion

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligen försvaras i hörsal Arvid Carlsson, Medicinaregatan 3, Göteborg fredagen den 2 december 2022, klockan 13:00

av Joel Larsson

Fakultetsopponent: Erik Tesselaar, Docent

Medicinsk strålningsfysik, Linköpings universitet, Linköping, Sverige

Avhandlingen baseras på följande delarbeten

I. Larsson J., Båth M., Ledenius K., Thilander-Klang A. *The effect of adaptive statistical iterative reconstruction on the assessment of diagnostic image quality and visualisation of anatomical structures in paediatric cerebral CT examinations.* Radiation Protection Dosimetry 2016; 169(1-4): 115–122

II. Larsson J., Båth M., Ledenius K., Caisander H., Thilander-Klang A. *Assessment of clinical image quality in paediatric abdominal CT examinations – dependency on the level of adaptive statistical iterative reconstruction (ASiR) and the type of convolution kernel.* Radiation Protection Dosimetry 2016; 169(1-4): 123–129

III. Larsson J., Båth M., Thilander-Klang A. *Frequency response and distortion properties of reconstruction algorithms in computed tomography.* Radiation Protection Dosimetry 2021; 195(3-4): 416–425

IV. Larsson J., Båth M., Thilander-Klang A. *Visualization of the distortion induced by nonlinear noise reduction in computed tomography*. Submitted

SAHLGRENSKA AKADEMIN
INSTITUTIONEN FÖR KLINISKA VETENSKAPER

GÖTEBORGS UNIVERSITET

Göteborg, 2022

Effects of nonlinear noise reduction algorithms on image quality in computed tomography systems

Evaluations using human observers and methods for assessing distortion

Joel Larsson

Ämnesområdet medicinsk strålningsvetenskap, Institutionen för kliniska vetenskaper, Sahlgrenska akademin, Göteborgs universitet, Sverige, 22.

Abstract

Many conventional radiological examinations have during the past decades been replaced by examinations performed on computed tomography (CT) systems. One reason is that a CT system, in contrast to a conventional X-ray system, depicts slices of the body so that anatomical structures to a lesser extent risk to obscure the potential pathology. This extra diagnostic information may increase the absorbed dose for patients, because the noise in CT examinations acquired at the same absorbed dose as conventional radiographs would have instead risked obscuring the pathology. Hence, if the noise in the CT images could be reduced by a mathematical algorithm a reduction in absorbed dose may also be possible. Traditionally, noise is reduced using linear convolution kernels, which weights the content of the CT image such that distinct variations are reduced. Concurrently, sharp edges in the image are smoothed out (the resolution is reduced), as sharp edges and noise are described by the same type of image content. Hence, the amount of noise reduction and consequently dose reduction will be limited by the required image resolution for the diagnostic task. In contrast to a linear algorithm, a nonlinear noise reduction algorithm is intended to reduce noise while keeping or increasing the image resolution. Hence, the image quality brought about by such an algorithm may depend on the content of the image including the noise level, which will make prediction of image quality in patients more difficult than for a linear algorithm. Further, nonlinear algorithms tend to distort the image. The impression of the image content may potentially be changed and aggravate the diagnostic assessment. Thus, the overall aim of the thesis was to investigate the effects of nonlinear noise reduction algorithms in CT imaging to help understand how to assess and predict image quality and how to perform a safe dose reduction for such a system.

Keywords: Computed Tomography, Nonlinear noise reduction, Visual grading, Distortion analysis

ISBN: 978-91-8069-007-2 (TRYCK)
ISBN: 978-91-8069-008-9 (PDF)

http://hdl.handle.net/2077/72574