

## **Abstract**

Digital radiographic systems are becoming more and more common in projection radiography. These systems are linear or can be linearized, which makes the use of methods based on linear-systems theory appropriate for evaluating the imaging properties. However, the fact that the systems sample the signal at discrete locations may lead to non-stationarity, which demands adaptation of the evaluation methods since these often assume not only linearity but also stationarity. The work described in this thesis was aimed at investigating methods based on linear-systems theory for evaluating the imaging properties of digital radiographic systems through the application of existing methods and the development of new methods, as well as the assessment of these methods – both in terms of the validity and reliability of the results and their importance regarding the clinical performance of the systems.

A computer program for simulating the modulation transfer function (MTF) of a digital radiographic detector was developed. The program simulates a detector using the sampling distance and sampling aperture, and the spread of signal due to the interaction processes of the incoming photons. The program was used to investigate the effects on the MTF of the design of the system. The program was also used to simulate a measurement of the presampling MTF with the slit method, and it was found that the slit could have a finite width and still give valid results.

A new method of determining the two-dimensional presampling MTF – the aperture mask method – was developed. The method is based on imaging an aperture mask, consisting of an array of cylindrical holes drilled in an attenuating material. The image data are used to construct a finely sampled disk spread function (DSF) which can be Fourier transformed and corrected for the finite size of the holes to obtain the two-dimensional presampling MTF. The method was applied to two computed radiography (CR) systems and was found to be consistent with the established tilted slit method in determining the one-dimensional presampling MTF. The method was used to determine the two-dimensional detective quantum efficiency (DQE) of a CR system.

The imaging properties of two generations of a CCD-based digital radiography (DR) system for chest radiography were analysed in detail through experimental determination of the presampling MTF, the noise power spectrum (NPS), the noise equivalent quanta (NEQ) and the DQE, as well as through modelling of the DQE and the production of quantum accounting diagrams (QADs). It was found that the second generation was substantially improved compared with its predecessor regarding all relevant measures, mainly due to a better system gain. However, modelling showed that both systems suffer from low optical efficiency due to the high degree of demagnification employed, leading to a secondary quantum sink and relatively modest DQE for both systems, especially at low exposures.

A study was conducted to compare the imaging properties, mainly in term of DQE, of digital radiographic systems with the clinical image quality, determined using visual grading analysis (VGA) of important anatomical structures, of chest images produced with the systems. It was found that a system with a low DQE could produce images with a clinical image quality comparable to that of systems with substantially higher DQEs. The results indicate that in chest radiography performed at standard dose (speed class 200), quantum noise and system noise do not dominate the clinical image quality but anatomical structure and image processing.

**Keywords:** linear-systems theory (LST), linear-systems analysis (LSA), digital radiography (DR), computed radiography (CR), digital radiographic systems, detective quantum efficiency (DQE), modulation transfer function (MTF), noise power spectrum (NPS), noise equivalent quanta (NEQ), quantum accounting diagram (QAD), image quality, visual grading analysis (VGA), chest radiography, imaging properties

ISBN 91-628-5651-0