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Factors Affecting Image Quality For Optimal Radiodiagnosis

Research Article

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Abstract

The discovery of X-rays and the ability to view, non-invasively, the human body has greatly facilitated the work of professionals in diagnosis of diseases.
It is necessary to adopt optimisation strategies to maximise the benefits (image quality) and minimise risk (dose to the patient) in radiological facilities as well as focus on image quality. The implementation of optimisation strategies involves an understanding of images acquisition process and value of the various parameters and their impact in image quality. The objective of this review was to analyse the role of different viewing parameters used in radio diagnosis.
The relationship between the quality parameters of digital radiographic images including resolution (spatial resolution and contrast resolution), noise, and artefacts and optimising image quality parameters in regard to radiation dose is a challenge. Therefore each evaluation method should be utilised and employed according to its aptitudes to improve image quality and imaging process.

Introduction

The discovery of X-rays and the ability to view, non-invasively, the human body has greatly facilitated the work of professionals in diagnosis of diseases. Image quality can be defined as the attribute of the image that influences the clinician's certainty to perceive the appropriate diagnostic features from the image visually [1]. It is necessary to adopt optimisation strategies to maximise the benefits (image quality) and minimise risk (dose to the patient) in radiological facilities as well as focus on image quality. The implementation of optimisation strategies involves an understanding of images acquisition process and value of the various parameters and their impact in image quality. Digital images have vital advantages in health services. Image quality has been improved and patient radiation dose reduced by the introduction of digital imaging systems including computed and digital radiography [2]. There are several parameters that characterise the quality of digital images such as resolution, noise, and artefacts are the main parameters of image quality [3, 4], [Figure 1]. Some studies include blur factors which relate so far to the spatial resolution. The aim and objective of this study was to analyse the role of different viewing parameters used in radio diagnosis.

Image Quality Parameters

Spatial Resolution: Spatial resolution refers to the imaging system's ability to distinguish and detect the adjacent structures separate from each other. A bar pattern containing alternate radiodense bars and radiolucent spaces of equal width can be imaged to get the subjective measurement of spatial resolution in units of line pairs per millimetre. Maximum spatial resolution is defined by the size of the pixel and the spacing between them. Spatial resolution is influenced by blur factors, processing of image, magnification, X-ray focal spot size, detector resolution, patient motion. A limiting system spatial resolution of 2.5 mm or higher is essential for digital radiographs [5]. Spatial resolution is affected by four blur factors, namely subject blur, geometric blur, motion blur, and receptor blur [6].

Noise Sources: The statistical variation or fluctuation of value

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from pixel to pixel produces noise. It is appreciated as a grainy appearance of the image and is often considered as un-useful information. The noise power spectrum is the best metric of noise that measures the spatial frequency content of the noise and controlling exposure factors is the best way to reduce quantum noise [7]. Noise images can be related as to the number of x-ray particles that are stagged in each pixel or in a small area of an image. Goldman had categorised the noise into Quantum noise, electronic or detector noise and computational or quantisation noise [3].

Contrast Resolution Elements: Contrast resolution refers to the ability of an imaging system to discriminate objects with small density differences and/or differentiate small attenuation variety on the image [5]. These elements are generated by the differential attenuation of x-rays using different tissues and it is directly proportional to the tissue thickness, density and number. The first step of digitisation affects the spatial resolution whereas the second step quantisation in signal intensity influences the gray-scale depth or contrast resolution. Contrast resolution is altered by tube collimation, number of photons, noise, scatter radiation, beam filtration, detector properties and algorithmic reconstruction used. Image contrast depends on subject, detector and displayed contrast.

Signal To Noise Ratio (SNR): This combines the effects of contrast, resolution and noise. Higher the signal and lower the noise, image quality is better.

Artifacts: Image features that mask or mimic clinical features are called artifacts. They are caused by image acquisition or object artefacts, hardware artifacts and software artefacts. Artifacts lead to poor image quality due to unequal magnification, non-uniform image due to detector problems, bad detector elements, aliasing, and improper use of grids.

Evaluation Methods For Image Quality

The quality of image and the ability of the interpreter are the two main factors that gives a accurate image interpretation and better utility of radiologic images.

Good image quality is an important factor that allows the radiologists to interpret the image most accurately, correctly and timely [8]. The different methods that are used to measure the quality parameters are modulation transfer factor, noise, SNR and detection quantum efficiency (Physical methods); rose model, contrast detail analysis and subjective assessment of physical parameters (Psychophysical methods); receiver operating curve and visual grading characteristic (Clinical performance methods) [9, 10], [Figure 2].

Modulation Transfer Factor And Detection Quantum

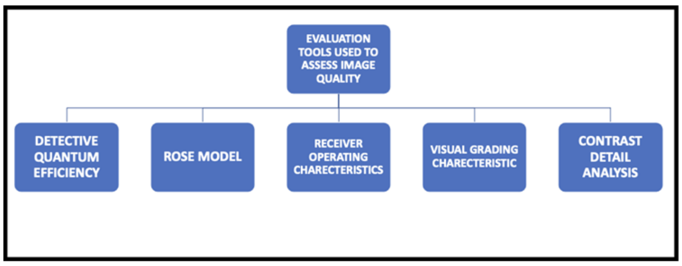
Efficiency: This evaluation method mainly focuses on the "image receptor" performance thereby to assess image quality of certain imaging systems. The measurement parameters of detection quantum efficiency are modulation transfer function and noise power spectrum of the system. The MTF describes a system with the ability to reproduce and preserve the information of spatial frequency contained in the incident x-ray signal. The NPS describes the frequency content of the noise in the spatial frequencies of the system image [4, 11]. The main drawbacks of this include time consuming, they do not provide description of all components in the imaging process.

Rose Model: It is another tool used to evaluate image quality of digital radiographic images. Quantum efficiency is used in this method to evaluate the performance of imaging systems using the sound to noise ratio. SNR is calculated to measure image quality as it describes noise and resolution characteristics of image and human visual systems. The drawbacks include that the size of the object are not considered in SNR measurements and noise description is subjective to the observers [12].

Contrast Detail Analysis (CDA): This is one of the widely used subjective evaluation tool to evaluate image quality and it provides quantitative evaluations of low contrast and even small detailed measurement of medical images [11, 13]. Contrast detail analysis

Figure 1. Different Image Quality Parameters.

Figure 2. Various Evaluation Tools Used To Assess Image Quality.



is an approach to describe the image quality in terms of detail and contrast (varying depth). Hence, larger objects can have lower contrast than the smaller objects for the same detectability performance. A study done by De Crop et al [14] using chest radiographs have further proved that CDA is the most relevant method for image quality optimisation and can be used to compare and contrast the image quality of different systems.

Receiver Operating Characteristics Analysis (ROC): ROC method is used to evaluate imaging performance of the imaging systems and is a task based method with human observers. This method measures the sensitivity and specificity to evaluate and assess the accuracy of diagnostic imaging systems.

The sensitivity measures the probability that a patient who actually has the disease is determined as having a disease by image interpreters. On the other hand, the specificity measures the probability that the patient who truly does not have the disease is determined as not having the disease by image interpreters [11]. There are several types of ROC analysis methods such as ROC curve, multiple-reader multiple-case and free response ROC analysis. ROC method is gold standard for image quality evaluation mainly during comparison of different imaging modalities in terms of detectability of a specific pathology. VISUAL GRADING CHARACTERISTIC(VGC): VGC is common clinical based evaluation method of image quality. It is based on the ability to detect and perceive pathology and correlating with the anatomical demonstration. VGC is performed by relative grading and absolute grading. The drawbacks of this method include false positive fractions of less clinical relevance [14].

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