Image Noise Analysis for Medical X-ray Images

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Personal Details
In 2000, I entered the Degree in Applied Sciences and Computers. In first to third year of the course, the subjects involved computers, physics, maths, french and management studies. In my fourth year I decided to continue with computers, physics and french. In third year, I took part in the Socrates program, which meant that I spent six months in France, completing the course work in college there. It was a great experience and really enjoyable.

Project Summary
The aim of this project was to investigate the relationship between subjective and objective image quality assessment in images produced by an X-ray Image Intensifier TV system. Subjective image quality assessment involves determining the number of visible objects of decreasing contrast and/or resolution within test phantoms while objective image quality assessment assesses image quality using mathematical parameters (such as MTF).

In this project, the subjective measure of image quality was Threshold Contrast Detail Detectability (TCDD), which is assessed using the Leeds TO.10 test object. TCDD is related to SNR2 (signal-to-noise ratio squared), which is an objective measurement of image quality but there is as yet no defined link between these two assessments. A measurement of TCDD measurement gives an overall assessment of image quality since it comprises assessments of contrast and resolution (see figure 1). The Leeds TO.10 test object which comprises of an opaque perspex plate, which has 108 discs of different diameter and x-ray attenuation coefficient (contrast) mounted within it. For each of the twelve discs diameters, there are nine contrast levels (discs of different thickness). Each row of the image was viewed separately and the number of discs visible was counted. The corresponding threshold contrast, CT, and area of the disk, A, was taken from a table provided. These values were used to calculate the threshold detection index, HT, of a disk using the formula

\[ H_T(A) = \left[C_T(A)A^2 \right]^{-1} \]

The TCDD was found from plotting a graph of square root detail area against threshold detection index (see figure 3). These TCDD curves were converted into a quality index, Q (Gallacher, BJR, 2003) which distills each graph into a single figure measure of overall image quality with respect to a standard TCDD curve. This project investigated the subjective perception of degradation in image quality (Q) with increasing image noise variance (from \(v=0.01\) to \(v=0.1\)). TO10 images were imported into Matlab where multiplicative noise was added to the images. Multiplicative noise was used as it closely mirrors the noise added in image intensifier TV systems.

To first assess the degradation in image quality post-importation of the images into Matlab, the histogram of the greyscale values was checked

Figure 1. Leeds TO.10 test object.
and compared for both the original and exported image. The original images were in the standard DICOM format, and were viewed using a standard DICOM viewer (OSIRIS). The DIT version of Matlab is not DICOM compliant and so the images were converted into JPEG format.

To investigate whether this transportation affected image quality, a histogram of frequency against greyscale values was created for images pre and post importation. The histogram graphs of the original and exported images are shown in Figure 2. It is clear that the data shows some image quality degradation. To assess whether this degradation was visible, 4 TO10 images pre and post importation into Matlab were scored by 6 observers, and the quality index, Q, calculated for each image was compared pre and post importation using the Student t-test. This statistic indicated that the image visibility was comparable to above the 60% level, which is above the level of acceptability for comparison (Marshall, Phys. Med. Biol., 2001).

The TO10 images with noise added were then compared in the same way by using 6 observers to view 4 TO10 images each with increasing noise level. The quality index, Q, was then calculated for each assessment with increasing noise, and each Q-value was compared to that for the unmodified original image using the student t-test. This indicated that the images with noise variance of 0.01, 0.02, and 0.04 were only comparable to the level of 29%, 17%, and 9% respectively. This indicates that the TCDD measure can discriminate noise increases at a slight level (v=0.01) from an original unmodified image. This is an interesting and encouraging result, which indicates that TCDD is related well to SNR decreases in an image. Further work on a larger scale will need to be conducted to verify and increase the accuracy of this result.

Figure 2. Graph of the histogram of pixel values for the original and exported image.

Figure 3. Graph of the TCDD for the exported image and images of increasing noise.