Performance Assessment of a Digital Mammography System

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Personal Details
I completed the Technician Diploma in Applied Sciences (Physics Option) in 2002 in DIT Kevin Street. I then transferred into the Degree in Applied Science, Physics & Physics Technology option. I studied nuclear physics, biophysics, acoustics and fluid dynamics as part of the course in my final year. Throughout my years in DIT I have kept a part-time job in a pharmacy. This involved working Saturdays and holidays. My hobbies include going to the cinema, music, travelling and socialising.

Project Summary
Radiologists use X-rays to produce medical images of the human body. Firstly X-rays are produced in an X-ray tube. The cathode provides a supply of electrons; these electrons strike the anode causing them to decelerate rapidly. The electrons interact with the target atoms in the anode and X-rays are produced.

When X-rays pass through a human body several interactions can occur; elastic scattering, the photoelectric effect and Compton scattering. Elastic scattering occurs when an electron takes up energies of vibration when they pass close to an atom. Only a certain amount of elastic scattering occurs at all X-ray energies and it never counts for more than 10% of the total interaction process in diagnostic radiology.

The photoelectric effect is the most important interaction, from a diagnostic point of view, between X-rays and bound electrons. In this process the incoming photon is completely absorbed and an electron is dislodged from its orbit around a nucleus. The photoelectric effect depends on the atomic mass $Z$ of the tissue it passes through. In mammography soft tissue and cancerous tissue are very similar but their atomic number differs, therefore the photoelectric effect is the most important interaction in mammography.

The Compton Effect involves the interaction with unbound electrons. It is also known as inelastic scattering. It is the most important effect in radiology that involves unbound electrons. The photons interact with unbound electrons in a billiard ball type collision.

Mammography is a specific type of imaging that uses a low-dose X-ray system for examining the breast. Early detection of breast cancer leads to successful treatment. Mammography plays a very important part in early detection of breast cancer because it can show changes in the breast up to two years before a patient or doctor can feel them. There are two types of mammography systems, standard mammography and the new digital mammography system.

In standard mammography the breast is positioned on a special film cassette and then gently compressed with a paddle. This compression flattens the breast so that the maximum amount of tissue can be imaged and examined. X-rays are radiated through the compressed breast and onto a film cassette positioned under the breast. The X-rays hit a special phosphor coating inside the cassette. This phosphor glows in proportion

Figure 1. (a) The process of standard mammography, (b) The process of digital mammography.
to the intensity of the X-ray beams hitting it, thus exposing the film with an image of the internal structures of the breast. Highly sensitive film and special X-rays are used for mammography to create the highest quality images at the lowest exposure. The resulting “exposed film” inside the cassette is then developed in a dark room much like a regular photograph is developed.

As the X-rays pass through the breast, they are attenuated (weakened) by the different tissue densities they encounter. Fat is very dense and absorbs or attenuates a great deal of the X-rays. The connective tissue around the breast ducts and fat is less dense and attenuates or absorbs far less X-ray energy.

Digital mammography is similar to standard mammography in that X-rays are used to produce detailed images of the breast, but the image is recorded by means of an electronic digital detector instead of the film (see figure 1). This electronic image can be displayed on a video monitor like a TV or printed onto film. This is similar to digital cameras that produce a digital picture that can be displayed on a computer screen or printed on paper. The radiologist can manipulate the digital mammogram electronically to magnify an area, change contrast, or alter the brightness.

The aim of this project was to carry out quality control tests on a new €500,000 digital mammography system in Beaumont hospital, the Senographe 2000D (see figure 2) in order to make sure that the system was working to a high standard. The tests carried out were on the performance of the X-ray tube accuracy and reproducibility. This was to ensure that the peak voltage at which the tube was operating was accurate and could be reproduced. The Half-Value Layer (HVL) of the system was also measured.

The HVL measures the amount of aluminium required to reduce the original X-ray beam to half its original value. The Mean Glandular Dose (MGD) was also measured; this is the average amount of radiation received by the radiation sensitive tissue in the breast.

From this project it was concluded that the peak voltage accuracy and reproducibility were within the allowed parameters. The HVL results were within the acceptable limits. The calculated MGD values were also found to be acceptable.