ABSTRACT

The X-ray attenuation coefficients for materials are important in almost all fields in which the interaction of X-rays with matter is studied. For example, the attenuation coefficients (μ) of unknown materials when exposing it to an X-ray of a known energy can also help to identify the substance and shows the potential of choosing the materials to create a phantom which can be used to measure the image quality of the X-ray imaging system. The main aim of this study was to improve a method to measure and evaluate the spatial resolution of the computed tomography (CT) based on the newly designed phantom. This method is well established in CT. However, several methods for measurement of spatial resolution on CT images are available. The improved method requires specific technique and design of the phantom materials. The materials that used in designing the phantom were evaluated by measuring the X-ray linear attenuation coefficient. In general, this project can be divided to three phases.

In the first phase, the X-ray linear attenuation coefficient (μ) was measured for the selected materials which will be used to construct the spatial resolution phantom. These materials were prepared in a step-wedge triangle with 3 mm thickness different. All materials samples were exposed to X-ray with 30 keV and 20 mA parameters using Micro-Digital Radiography. The materials were plastic, Plexiglas, silicone rubber, soap and paraffin wax. Multiple images were captured for each sample. Then it was averaged and calculated with grayscale values by using image process program. The linear attenuation coefficient value was achieved by plotting the log of the X-ray intensity against the varying in thickness. The result as following, Plastic ABS is 0.0284 cm^{-1}, Plexiglas is 0.0436 cm^{-1}, Silicone Rubber is 0.0873 cm^{-1} and Paraffin wax is 0.0237 cm^{-1}. Compared with the results of the literature, the values of (μ) obtained indicates that there is a good agreement, and the method is appropriate to be used as an alternative method for measuring the linear attenuation coefficient of materials.

The second phase of the study aimed to measure the spatial resolution of (CT) imaging system, spatial resolution is the ability of an image to convey details and distinguish between small objects that are close together. The improved method for measuring the spatial resolution of CT images was implemented using phantom images, which is based on the calculation of the full width at half maximum (FWHM) of the line spread function (LSF) that acquired from a function called the edge spread function (ESF). The ESFs data were constructed from the CT image obtained by scanning phantom made of silicone rubber shaped as cylindrical containing different materials. The ESF curves were obtained by a direct fit of a mathematical expression of the ESF profile using MATLAB (R2015b) to the ESF data acquired at the interface between the different materials within the experiment phantom. The results show that the improved method are able to detect spatial resolution between materials with different and/or similar attenuation coefficients, since materials with differences in their attenuation properties very fine details can be imaged, but if they are similar, only larger-scale details and/or particles can be reliably distinguished. The larger the (λ), the smaller the FWHM obtained, and the narrower the LSF. High resolution imaging system was characterized by large values of this resolution parameter. The large value of the resolution parameter (λ) was obtained between paraffin wax and plastic (ABS) materials = 29.96±0.27 mm, and the FWHM of those materials = 0.066±0.009 mm. The smallest value of the (λ) was obtained between Plexiglas and soap materials = 8.86±0.23, and the FWHM = 0.225±0.025 mm, the FWHM results of the other materials were Plexiglas with silicone rubber = 9.06±0.07 mm, soap with silicone rubber = 18.53±0.04 mm, paraffin wax with silicone rubber = 21.31±0.06 mm, and soap with paraffin wax = 9.00±0.08 mm. The proposed methodology can be implemented using signal data from the reconstructed CT image and is not sensitive to the noise introduced by differentiating the ESF to produce the LSF as noted in the previous measurement. In addition, the proposed methodology provides a practical measurement of CT machine spatial resolution.

The third phase of the study aimed to measure the contrast sensitivity of the CT system as one unites; the measurement was performed using the same reconstructed CT image which was utilized in the measurements of the spatial resolution parameter. Histograms for each ROI selected on the CT image was plotted to provide information about each material such as RoI count, mean gray level and standard deviation which were used to calculate the contrast sensitivity.

Keywords: Micro-digital radiography System, Micro- computed tomography system, linear attenuation coefficient, spatial resolution and contrast sensitivity.