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Full Length Research Paper

Fine tuning and alignment of the Large Field of View (LFOV) gamma camera board

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Abstract

Processor boards alignment, fine tuning and quality control have been carried out on the Siemens large field of view (LFOV) Gamma Camera at Nuclear Medicine Centre at Korle-Bu Teaching Hospital (KBTH) after a damaged power supply board was restored. The input voltages i.e. various low and high voltage values were checked after the restoration to be +14.995V, -14.998, +12.001V, 12.000V, +5.000V,-5.001V, -100.000V, 200.000V which were within the standard range.. The integral uniformity for the central field of view (CFOV) after the fine tuning and alignment was found to be 1.64% whiles the integral uniformity for useful field of view (UFOV) was 1.67%. The differential uniformity for the CFOV was 1.13% while that of the UFOV was 1.26%. The integral and differential uniformities values for CFOV and UFOV were found to be within the acceptable test range of 1% to 4% which conformed to the standard set by NEMA, the manufacturers of the camera. Therefore the performance of the gamma camera after the restoration is good and would not affect interpretations of clinical studies.

Keywords: Alignment, central field, differential uniformity, gamma camera, integral uniformity, tuning.

INTRODUCTION

The refurbished Siemens Large Field of View (LFOV) Gamma Camera was donated by International Atomic Energy MEDX. INC in 1990 and the Engineering Services Centre (ESC) of Ghana Atomic Energy Commission was mandated to carry out maintenance service when necessary. The facility is used for nuclear medicine imaging. (Diagnosis of biological abnormal growth in human being e.g. tumour cancers). The acquired image is compared with a standard image (Tao, 2011). Nuclear medicine imaging is a non-invasive imaging technique which uses radioisotopes to image biological process within the body (National Electrical Manufacturers Association (NEMA) Performance Measurements of Scintillation Cameras, 2001; Workshop manual for computer-interfaced scintillation camera quality assurance, September 1986). Fine tuning, boards' alignment and quality control is usually done by ESC to ensure high standards of efficiency and reliability in the usage of the gamma camera. There were different uniformity parameters measured after fine tuning and quality control uniformity these are integral and differential uniformities. They were calculated for both the central field of view (CFOV) and useful field of view (UFOV) of the gamma camera. The standard integral uniformity has typical values between 1% to 4%. Differential uniformity values of less than 4% are obtained after uniformity correction (fine tuning) (Workshop manual for computer-interfaced scintillation camera quality

19,18,12,13,20,26,25,18,19,18,12,13,20,26
25,17,11,6,7,8,14,21,27,32,31,30,24,17,18,12,13,20,26,25,18,
19,16,10,5,1,2,3,4,9,15,22,28,33,
37,36,35,34,29,23,16,19,18,12,13,20,26,25,17,
11,6,7,8,14,21,27,32,31,30,24,16,10,5,1,2,3,
4,9,15,22,28,33,37,36,35,34,29,23.

Figure 1. PMT arrangement.

assurance, Provide year; Graham, 1995; Natarajan and Wagner, 1969; Bruno et al., 1970). When the value for differential uniformity exceeds 4% there would be the need to carry out maintenance service on the gamma camera. The values of differential uniformity in the range of 1% to 4% and the values of integral uniformity in the range of 1% to 4% after the restoration is an indication that the system is working well. This work seeks to check and ensure that the differential and integral uniformities are maintained within the accepted range for proper nuclear medicine imaging.
Methods

MATERIALS AND METHODS

The type of gamma camera with the faulty power supply board which was rectified is the Siemens large field of view (LFOV) Gamma Camera installed at the National Centre for Radiotherapy and Nuclear Medicine Unit (NCRNM) of KBTH. A flood source and collimated point source of Tc-99m (technetium) of activity ranging from 20-200µC, was used when the camera was being aligned, fine-tuned and data acquisition was carried out.

Alignment of LFOV of the gamma camera

Tc-99m (technetium) flood source was positioned under NaI (sodium iodide) detector to check for flood uniformity. The cold and hot spots were seen on the resulting image showing non-uniformity hence the need for processor boards' alignment, fine tuning and quality control of the camera. It was ensured that the room that housed the camera was air- conditioned to operating temperature of 15 ºC to 17ºC and 30 minutes operation time was allowed before all adjustments were carried out. The various boards were aligned to zero offset voltages using their respective pots. The low voltages supplies were all adjusted to their respective values as specified in the maintenance manual. Timing boards: Pile up, display control, the integrator amplifiers and control boards were adjusted to obtain their respective processor signal timing values. The analyser one board energy and window levels were also set for Tc-99m.Thus the energy window level was set to 140keV with the upper and lower window levels set to 154KeV and 126KeV respectively. After the alignment, fine tuning of the PMT was carried out.

Fine tuning of the Photo Multiplier Tubes (PMT)

During the fine tuning, the head of the camera was pointed up by rotating the tube (not the yoke). The analyser was set one level for 1 - 40. Tc-99m source was placed to obtain a flood of 20k to 30K counts per second. Switch S1 was set on and switch S13 which is in the A scope was adjusted to be in tune with S1.

The detector high voltage was adjusted to the center of the meter. The collimated Tc-99m point source that gives 5k to 20k counts per second was placed over the tube 19. The tuning box was also adjusted to the center of the meter. The source was moved to each of 37 PMTs in the order of arrangement shown in Figure 1 above.

The corresponding adjustments on the tune box were done to center in the neighbourhood of +2.5 divisions ofthe meter. Any tube that was off center by more than ±5 division on meter was adjusted to ±4 which lie within the stated required range. S1 and S13 were set from off tune to normal.

Calculation of uniform and differential uniformities

Formulas for calculating integral uniformity and differential uniformity are respectively shown in the equations 1 and 2 below. Suppose the maximum (max) and minimum (min) counts in the pixels lying within the UFOV and the CFOV. The integral uniformity IU is then given:

$$IU = \pm 100\% \left[\frac{\max - \min}{\max + \min} \right] \quad (1)$$

Assuming in each row or column of pixels in the x and y directions within the UFOV and the CFOV the maximum count difference in any 6 contiguous pixels are determined and the highest value of the maximum count difference in the sets of rows and columns is determined.

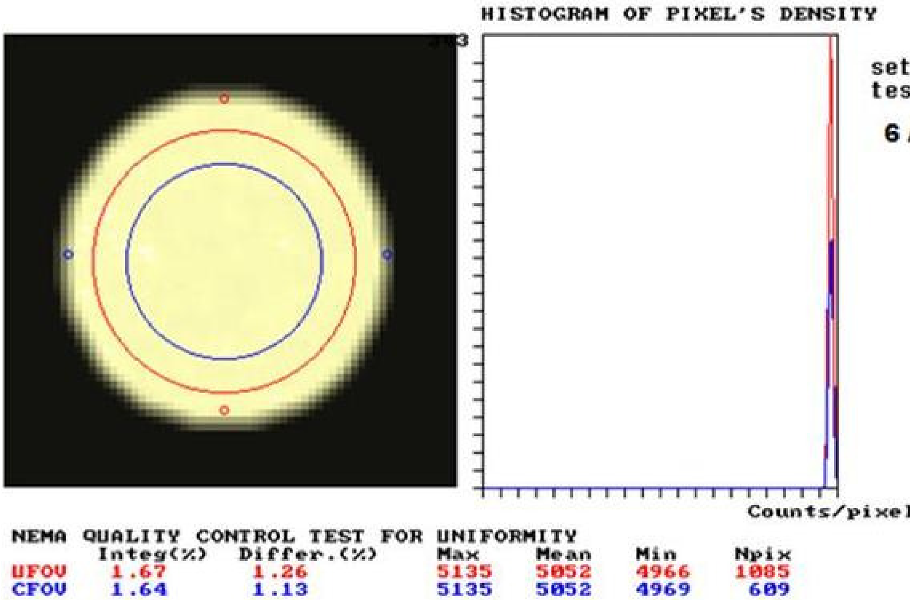

Figure 2. Quality control for test uniformity

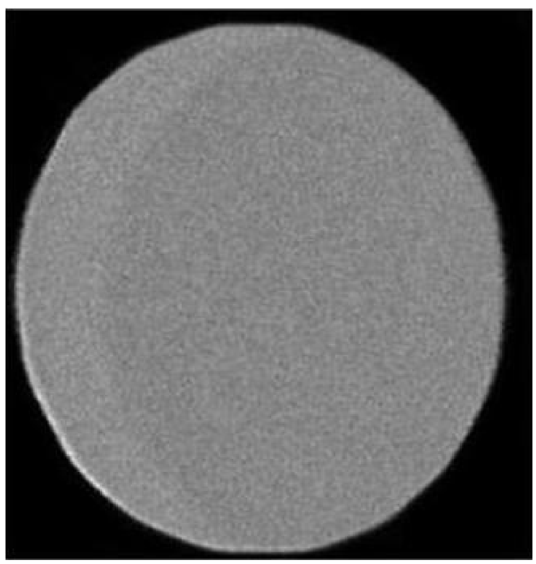

Figure 3. Image from confirmatory flood uniformity test

The differential uniformity, DU is then given by:

$$DU = \pm 100\% \left[\frac{hi - low}{hi + low} \right] \text{.......................................} (2)$$

Where High and Low are the pixel counts giving the highest value of the maximum count difference (National Electrical Manufacturers Association (NEMA) Performance Measurements of Scintillation Cameras, 2001; International Atomic Energy Agency, Vienna, 1984).

Configuration and standardization of acquisition computer for clinical studies

Medic view software is a special program installed on a computer dedicated for the data acquisition. The acquisition computer interfaced to the camera was used to acquire 20,000.000 counts. At the end of 20,000,000 counts the acquired image was saved. The ring collimator and phantom were then put under the detector. Static uniformity correction matrix test was performed. At this stage, the camera is set for medical examination.

RESULTS AND DISCUSSION

The resulting acceptable image which compares with the standard image is shown in Figure 2. From the image it was clear that the camera had uniformity that was free from hot and cold spots and it was within the acceptable range. The integral uniformity for CFOV was 1.64% against the acceptable value of 1% to 4% while the integral uniformity for the UFOV was found to be 1.67% as against the range of 1% to 4% for the acceptance test. The differential uniformity for CFOV value was 1.13% as against acceptance test value of 1% to 4% while that of UFOV was found to be 1.26% against 1% to 4% for the acceptance test. The integral and differential uniformities values can be verified by substituting the data in Figure 2 in equations 1 and 2 above.

System uniformity is the most sensitive parameter that changes in system performance (Graham et al., 2003). The PMT and detectors' performance always affect image uniformity. The PMT and detector are partly electronic and one of the defects of PMT is the appearance of hot and cold spots in the flood image. A number of factors can course either the gain of a PMT or light collector properties of the camera. PMT gain is a strong function of temperature counting rate (i.e. number of event signals per unity time) and the high voltage power supply regulation. The PMTs and their associated electronics tend to become unstable with time. This and other effects such as magnetic field on the gamma camera and sharp temperature variation within can cause the uniformity to change (Graham et al., 2003). Variation in PMT response (and non-linearity in X, Y positioning pulses along the field of view) is the leading cause of deterioration in gamma camera flood uniformity (Saha, 2001) and this occur when the PMT become unstable. Sodium iodide (NaI) located in the detector is a hydroscopic material and if water vapour reaches the crystal it becomes yellow and the light transmission is diminished (Malmin and Caruba, 2008). To enhance uniformity there is also the need to allow detector to warm up and stabilized. The performance/stability of the PMTs, the detector and other electronic components are highly dependent on the electric power supply to the gamma camera. In view of this, when the faulty power supply was repaired, quality control test was carried out and the result showed uniformity (no cold and hot spots) (Siemens Medical Solutions USA, Inc, January 2005; Mediso Medical Imaging Systems, 2004) as shown in flood uniformity test in Figure3 above.

CONCLUSION

Fine tuning, alignment and quality control were done. From the acquired image represented in Figure 2, above, the CFOV and UFOV values compared very well with the corresponding standard values. This result shows that the camera uniformity is good for any clinical imaging.

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