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Algorithm for Automatic Placement of ROI'S and Calculation of Contrast Recovery and Background Variability in Nema-IQ Phantom

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Abstract: The present work deals with A new approach for the automation tool for the analysis and evaluation of images as per the requirements of NEMA standards so that change in orientation of spheres in the phantom can be well taken care of. This tool supports automatic segmentation of lesions in the phantom images, calculation of Background Variability & Contrast Recovery for various orientations of spheres.

Keywords: Automation tool, NEMA standards, automatic segmentation of lesions in the phantom images.

I. INTRODUCTION

The number of new cases of malignancy is 448.7 for every 100,000 men and women for every year. The number of deaths is 168.5 for every 100,000 men and women every year. Oncology remains by far the largest application of PET scanning, mostly in the staging/restaging phase, also in the diagnostic process. PET is utilized for malignancy analysis of solitary pulmonary nodules (SPNs), for which there is confirmation of demonstrative viability up to indicative applications in light of the presence of a pre-test probability and a likelihood proportion, permitting the calculation of posttest probability.

Positron emission tomography (PET) is one of the advanced nuclear medicine imaging modality available. It is a well-established diagnostic modality that is extensively used in oncology for tumor diagnosis, staging, radiotherapy planning and monitoring, as well as cardiology for myocardial viability and perfusion, and neurology for perfusion and neuro-receptor imaging. These scanners allow high contrast biochemical PET images on high resolution anatomical CT images.

There are certain need to be done with quality assurance and acceptance testing for the assessment of PET scanner performance. One of the popular standards for PET performance is run by NEMA (National Electrical Manufacturers Association). One of the tests for quality assurance is related to image quality measurement using NEMA IQ phantom.

This test involves acquisition of the phantom data and analysis over reconstructed images. The reported parameters from this test include image contrast and SNRs for hot and cold lesions, lesions, residual error in lung, and variability in background. An automatic tool is used to generate the report by using reconstructed PET images. However, sometimes if there is deviation in sphere locations of the phantom from the desired position then tool fails to produce the output.

The present work deals with A new approach for the automation tool for the analysis and evaluation of images as per the requirements of NEMA standards so that change in orientation of spheres in the phantom can be well taken care of. This tool supports automatic segmentation of lesions in the phantom images, calculation of Background Variability & Contrast Recovery for various orientations of spheres.

The image quality tool with new approach has been extensively verified on multiple datasets for automatic ROI placements and Standard deviations, Mean calculations.

The results obtained by the newly developed tool were also verified by comparing the results of the Existing tool. The Background Variability & Contrast Recovery values are found to be matching in case of correct orientation of spheres.

This NEMA Image Quality tool is giving good result in case of various orientation of phantom sphere and reduces errors in the placements of the ROI and calculation of Background Variability & Contrast Recovery when compared with old approach.

The New approach increases accuracy involved in calculation of Background Variability & Contrast Recovery values reduce time required to obtain the quantitative measures during image analysis. The new

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approach can easily be extended to automatic segmentation of spheres in other phantoms and patient studies.

II. NEMA IMAGE QUALITY ANALYSIS

One transverse slice shall be used in the image quality analysis. A transverse reconstructed image centered on the cold and hot spheres is used in the analysis.

The appropriate slice is determined by viewing the individual slices and selecting the transverse image in which the hot and cold spheres are visualized with the highest contrast. The same slice is used for all spheres.

Circular ROIs are drawn on each hot and cold sphere. The diameter of the ROI's have a diameter that is as close as possible to the inner diameter of the sphere that is measured.

The ROI analysis tool is taken into account partial pixels and permit movement of the ROI in increments of 1 mm or less.

Regions of interest of the same sizes as the ROIs drawn on the hot and cold spheres is drawn in the background of the phantom on the slice centered on the spheres.

Twelve 17 mm diameter ROIs is drawn throughout the background at a distance of 15 mm from the edge of the phantom but no closer than 15 mm to any sphere.

ROIs of the same sizes as the smaller spheres (10, 13, 17, 22 and 28 mm) are drawn concentric to each of the 17 mm ROIs on the background region.

The same set of background ROIs are drawn on the slices as close as possible to +2 cm, +1 cm, –1 cm and –2 cm on either side of the central slice.

A total of 60 background ROIs of each size, 12 ROIs on each of five slices, shall be drawn. The average counts in each background ROI is recorded. The per cent contrast $Q_{h,j}$ for each hot sphere j is calculated as:

$$Q_{h,j}=100*\{[C_{H,j} - C_{b,j})/C_{b,j}]/[(A_h - A_b)/A_b]\}$$

Where,$C_{H,j}$ is the average number of counts in the ROI for sphere j, $C_{b,j}$ is the average of the background ROI counts for sphere j, A_h is the radioactivity concentration in the hot spheres and A_b is the radioactivity concentration in the background.

The percent contrast$Q_{c,j}$ for each cold sphere j is computed as:

$$Q_{c,j} = 100 * [\frac{C_{b,j} - C_{c,j}}{C_{b,j}}]$$

Where$C_{c,j}$ is the average number of counts in the ROI for sphere j and $C_{b,j}$ is the average number of background ROI counts for sphere j.

III. FLOWCHART FOR NEMA IMAGE QUALITY ANALYSIS

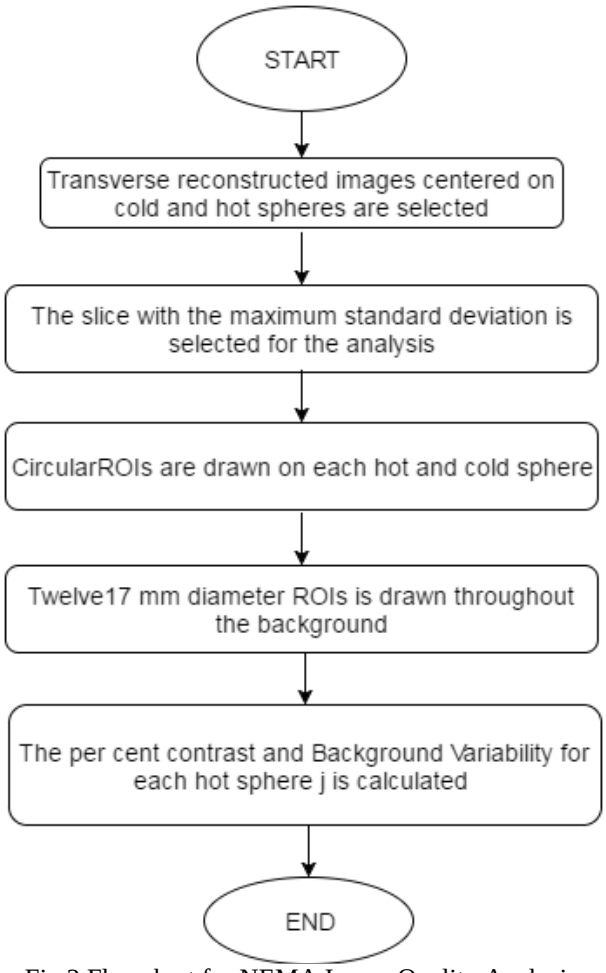

Fig 2 Flowchart for NEMA Image Quality Analysis

Algorithm for automatic placement of ROI's in NEMA tool:

Identification of base slice. Base slice is the slice which contains all the six spheres with high contrast. The base slice is identified as the slice with the maximum standard deviation. The base slice is used in the analysis of all other spheres.

Pre-process the base slice by Gaussian filter. The diameters of the spheres are calculated using region properties and are found to be 10,13,17,22,28,37 mm with an error approximation of 0.5%.

The ROI's are drawn on the spheres of 10, 13, 17, 22, 28, 37 mm diameters.

Background variability and Contrast Recovery is calculated.

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Flowchart for Automatic Placement Of ROI's On The Spheres in NEMA Tool:

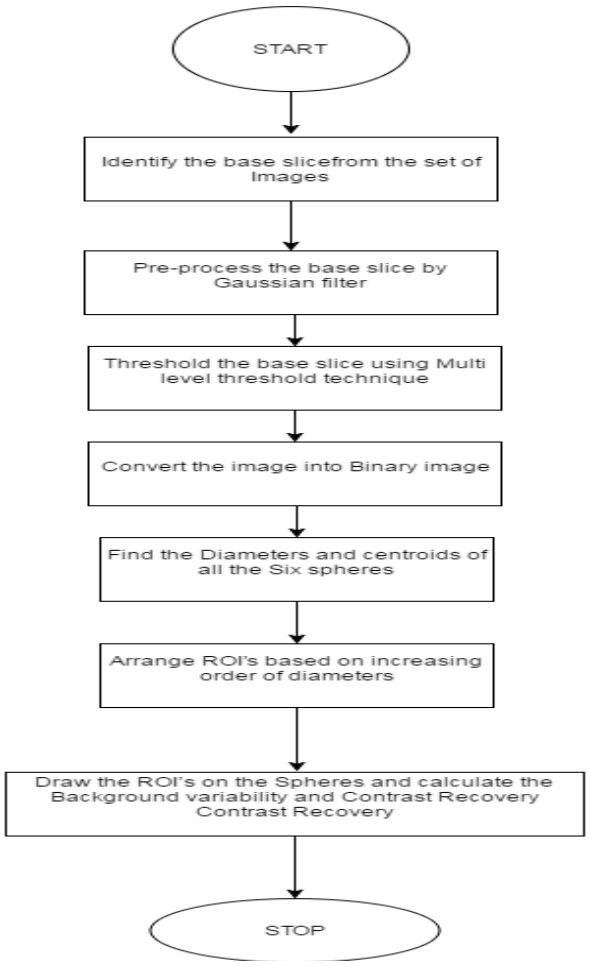

Fig 3: Flowchart for Automatic Placement Of ROI's in NEMA-IQ Tool

IV. RESULTS

The proposed algorithm has also been tested with right alignment and right activity concentration and the values obtained are as per our expectations. The results are shown in Figure 4 corresponding contrast recovery values are listed in table 1

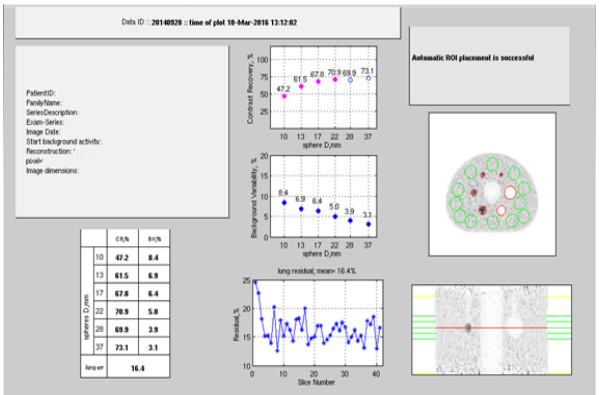

Fig 4. Image Quality tool results

Table 1 Contrast Recovery and Background Variability calculated from the newly developed tool

SL NO	Sphere Radius	Contrast Recovery	Background Variability
1	10	47.6	8.4
2	13	61.5	7.0
3	17	67.3	6.5
4	22	70.6	5.0
5	28	69.9	3.9
6	37	73.1	2.9

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