

Correction Preprocessing Method for Cardiac Scintigraphy Images using Local Adaptive Filters

Eltayeb Wagiallah^{1,2}, Yasir Ahmed², Yousif Mohamed Y. Abdallah³

¹Radiation and Isotopes Center of Khartoum (RICK), Khartoum, Sudan

²Elnileen Medical Center, Khartoum, Sudan

³College of Medical Radiological Science, Sudan University of Science and Technology, Elbaladi Street, Khartoum 1908, Sudan

Abstract: *This study presented an appropriate approach for the robust estimation of noise statistic in cardiac scintigraphy images. To achieve maximum image quality after denoising, a new, low order, local adaptive Gaussian Scale Mixture model is presented, which accomplishes nonlinearities from scattering. State of art methods use multi scale filtering of images to reduce the irrelevant part of information, based on generic estimation of noise. The usual assumption of a distribution of Gaussian and Poisson statistics only lead to overestimation of the noise variance in regions of low intensity (small photon counts), but to underestimation in regions of high intensity and therefore to non-optimal results. The analysis approach is tested on 50 samples from a database of 50 cardiac images and the results are cross validated by medical experts. In this study, prominent constraints are firstly preservation of image's overall look; secondly preservation of the diagnostic content in the image and thirdly detection of small low contrast details in diagnostic content of the image. As shown in previously, state of the art methods provide non-convincing results. The new approach is funded on an attempt to interpret the problem from the view of blind source separation (BSS), thus to see the cardiac image as a simple mixture of (unwanted) background information, diagnostic information and noise.*

Keywords: Nuclear medicine, image processing, cardiac scintigraphy.

1. Introduction

Nuclear Medicine is the section of science that utilizes the properties of radiopharmaceuticals in order to derive clinical information of the human physiology and biochemistry. The radiopharmaceutical follows its physiological pathway and it is concentrated on specific organs and tissues for short periods of time. Then, the patient is positioned under nuclear medicine equipment which can detect the radiation emitted by the human body resulting in images of the bio-distribution of the radiopharmaceutical. In Nuclear Medicine, there are two main methods of patient imaging, the imaging with Planar Imaging, Dynamic Imaging or SPECT and the PET. During the last decade, hybrid systems have been developed integrating the CT technique with either SPECT or PET resulting in SPECT/CT and PET/CT respectively. This chapter will concentrate on the implementation of MatLab code in gamma camera planar imaging, SPECT and SPECT/CT methods [1].

The gamma camera is composed of a collimator, a scintillator crystal usually made of NaI (or CsI), the photomultiplier tubes, the electronic circuits and a computer equipped with the suitable software to depict the nuclear medicine examinations. In planar imaging, the patient, having being delivered with the suitable radiopharmaceutical, is sited under the gamma camera head. The gamma camera head remains stable at a fixed position over the patient for a certain period of time, acquiring counts (disintegrations). These will constitute the radiopharmaceutical distribution image. The counts measured in a specific planar projection originate from the whole thickness of patient [2]

In SPECT, the gamma camera head rotates around the patient remaining at well-defined angles and acquiring counts for specific periods of time per angle. What makes SPECT a valuable tool in nuclear medicine is the fact that information in the three dimensions of the patient can be collected in a number of slices with a finite known volume (in voxels). Thus SPECT technique is used to display the radiopharmaceutical distribution in a single slice removing the contribution from the overlying and underlying tissues. In order to obtain the most accurate quantitative data from SPECT images, two issues that have to be resolved are the attenuation correction and the Compton scattering that the photons are undergone until reach and interact with the slice of interest tissues. As an examining organ has certain dimensions, each slice along the axis of the gamma camera has different distance from the detector. Thus, each photon experiences different attenuation. These two phenomena usually lead to distortion of the measured activity concentration [3][4]. The acquired data are processed in order to correct and compensate the undesired effect of these physical phenomena. The projection data of each slice constitute the sinogram. As a result, a series of sinograms is the files acquired. However, this kind of files needs reconstruction in order to get an image with diagnostic value. The most known reconstruction methods are the Filtered Back-Projection (FBP) and the Iterative methods. Advanced techniques of image processing and analysis find widespread use in medicine. In medical applications, image data are used to gather details regarding the process of patient imaging whether it is a disease process or a physiological process. Information provided by medical images has become a vital part of today's patient care. The images generated in medical applications are complex and vary notably from application to application. Nuclear medicine images show characteristic information about the

physiological properties of the structures-organs. In order to have high quality medical images for reliable diagnosis, the processing of image is necessary. The scope of image processing and analysis applied to medical applications is to improve the quality of the acquired image and extract quantitative information from medical image data in an efficient and accurate way. MatLab (Matrix Laboratory) is a high performance interactive software package for scientific and engineering computation developed by MathWorks (Mathworks Inc., 2009). MatLab allows matrix computation, implementation of algorithms, simulation, plotting of functions and data, signal and image processing by the Image Processing Toolbox. It enables quantitative analysis and visualization of nuclear medical images of several modalities, such as Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET) or a hybrid system (SPECT/CT) where a Computed Tomography system (CT) is incorporated to the SPECT system[5][6].

2. Methods and Materials

For cardiac scintigraphy images each film scanned using digitizer scanner then treat by using image processing program (MatLab), where the enhancement and contrast of the image was determined. The scanned image was saved in a TIFF file format to preserve the quality of the image. The data analyzed used to enhance the contrast within the soft tissues, the gray levels which can be redistributed both linearly and nonlinearly using the gray level frequencies and noise estimation of the original cardiac scintigraphy images.

In Figure 1 explains the block diagram about the flow proposed research paper. Researchers use in this study a method for image preprocessing of X-ray radiographic images step by step process. This flow diagram explains the flow of work. Collecting the X-ray images from Govt. Hospitals and converting this image RGB into Gray color.

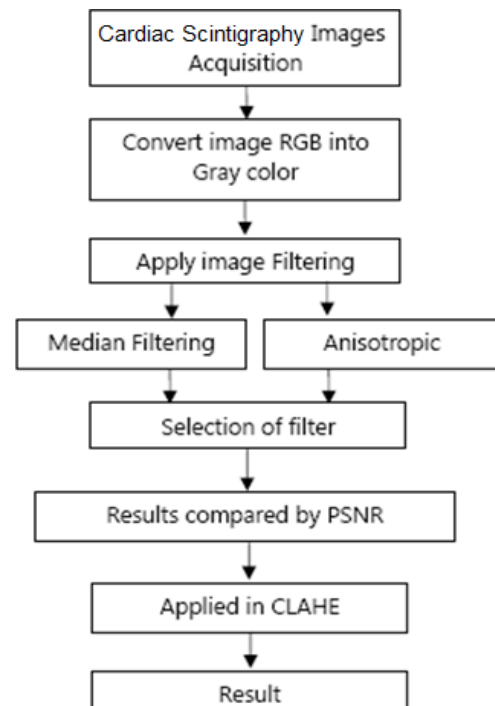


Figure 1: Flow chart of image analysis

Panoramic images were filtered by two different filtering algorithms. The filtering algorithms are used for anisotropic filtering and median filtering algorithm. The output results were compared in PSNR and MSE values. The output of filtering image applied for Image enhancement. That given image improves the subjective quality of contrast, noise reduction and edge sharpening. The targets for image enhancing are better contrast, sharpness of detail and visibility of features. Several algorithms are Histogram Equalization (CLAHE). Here researchers applied contrast limited adaptive histogram equalization algorithm. The best PSNR value of X-ray image output is given into input of Contrast Limited Adaptive Histogram Equalization (CLAHE).

3. The Results

MatLab allows matrix computation, implementation of algorithms, simulation, plotting of functions and data, signal and image processing by the Image Processing Toolbox. It enables quantitative analysis and visualization of nuclear medical images of several modalities, such as Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET) or a hybrid system (SPECT/CT) where a Computed Tomography system (CT) is incorporated to the SPECT system. The main objective of this study was to enhance of SPECT images using Filtering Technique in order to evaluate contrast enhancement pattern in different SPECT images such as grey color and to evaluate the usage of new nonlinear approach for contrast enhancement of soft tissues in SPECT images.

This was an experimental study deals with propose a new approach for independently identically Distributes (IID) noise in cardiac images and reduction of the redundancy in the image data using image processing technique (MatLab

version R2009a). In addition to highlight the role of the proposed approach (noise variance) by preservation of the image's overall look, preservation of the diagnostic content in the image and detection of small and low contrast details in the diagnostic content of the image and to highlight the role of using image processing technique in Radiology.

3.1 Median filter

The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. (If the neighborhood under consideration contains an even number of pixels, the average of the two middle pixel values is used.) Figure 2 illustrates an example calculation.

80	81	79	79	79	80
80	81	79	79	79	80
80	81	79	79	79	80
79	79	77	77	78	78
79	79	79	79	80	80
79	79	80	80	81	81

Figure 2: Sample matrix value taken from figure 1

Neighborhood values: 77,77,79,79,79,79,79,79,81
Median Value is: 79

Figure 4-5 calculating the median value of a pixel neighborhood. As can be seen, the central pixel value of 81 is rather unrepresentative of the surrounding pixels and is replaced with the median value: 79. A 3×3 square neighborhood is used here larger neighborhoods will produce more severe smoothing. Anisotropic Filtering and Median Filtering algorithms are applied in ten different X-ray images and calculated the equivalent MSE and PSNR values. The original picture fig.3 RGP is changed into GRAY color fig.4. This gray color image applied into anisotropic filtering method the output is in fig.4.

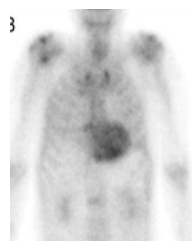


Figure 3: Shows the original of cardiac scintigraphy

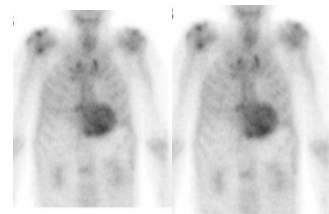


Figure 4: A and B shows median 5 and median 25 for image 4 respectively.

4. Stretchlim Technique

A two-element vector of pixel values that specify lower and upper limits that could be used for contrast stretching image I. By default, values in LOW_HIGH specify the bottom 1% and the top 1% of all pixel values. The gray values returned can be used by the imadjust function to increase the contrast of an image fig.5.

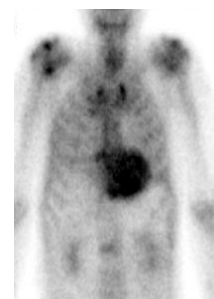


Figure 5: Shows Stretchlim technique

5. Image Addition Technique

Add two images or add constant to image
 $Z = \text{imadd}(X,Y)$ adds each element in array X with the corresponding element in array Y and returns the sum in the corresponding element of the output array Z. X and Y are real, nonsparse numeric arrays with the same size and class, or Y is a scalar double. Z has the same size and class as X, unless X is logical, in which case Z is double. If X and Y are integer arrays, elements in the output that exceed the range of the integer type are truncated, and fractional values are rounded

5.1 Contrast enhancement

The command that implements contrast processing is the imadjust. The general function that implements contrast enhancement is the following (figure 5):

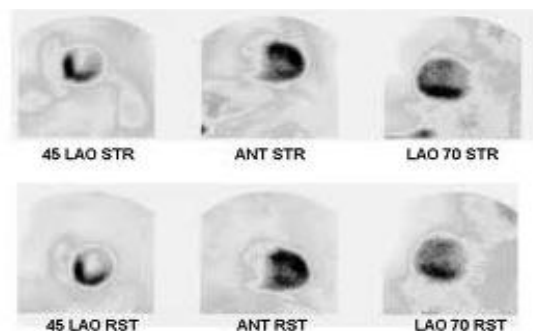


Figure 1: Shows Original cardiac scintigraphy image

```
RGB2=imadjust(RGB1,[.2,.3,0;.6,.7 1],[.]);
imshow(RGB1), figure, imshow(RGB2)
```

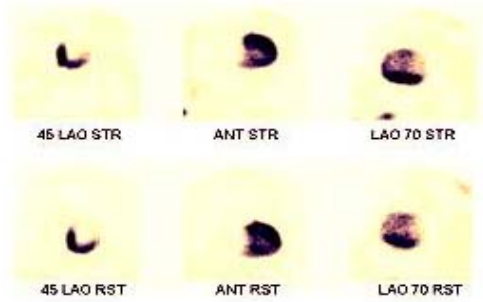


Figure 2: Shows bone scan image after adjustment

5.2 Removing Noise by Wiener filter

The `wiener2` function applies a Wiener filter (a type of linear filter) to an image adaptively, tailoring itself to the local image variance. Where the variance is large, `wiener2` performs little smoothing. Where the variance is small, `wiener2` performs more smoothing. This approach often produces better results than linear filtering. The adaptive filter is more selective than a comparable linear filter, preserving edges and other high-frequency parts of an image. In addition, there are no design tasks; the `wiener2` function handles all preliminary computations and implements the filter for an input image. `wiener2`, however, does require more computation time than linear filtering. `Wiener2` works best when the noise is constant-power ("white") additive noise, such as Gaussian noise. The example below applies `wiener2` to an image of Saturn that has had Gaussian noise added.

1. Read in an image. Because the image is a true color image, the example converts it to grayscale.

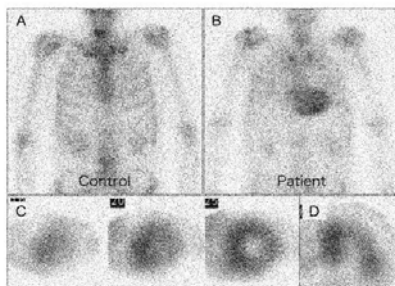


Figure 6: Shows Portion of the Image with Added Gaussian Noise

2. Remove the noise, using the `wiener2` function. Again, the figure only shows a portion of the image

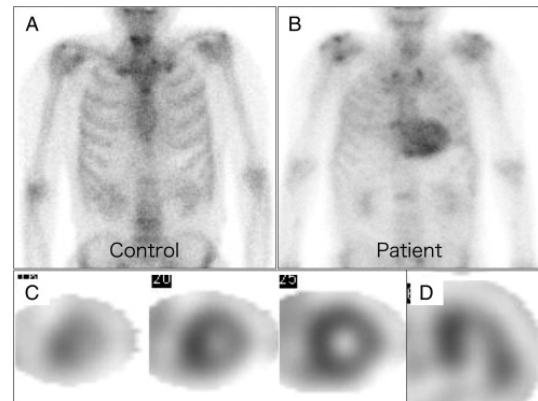


Figure 6: Shows Portion of the Image with Noise Removed by Wiener Filter

6. Conclusion

Preprocessing is to improve their quality of images. If these images are too noisy or blurred they should be filtered and sharpened. In image processing, filters are mainly used to suppress either the high frequencies in the image, i.e. smoothing the images or the low frequencies, i.e. enhancing or detecting edges in the image. Due to various factors the images are in general poor in contrast. Researchers applied image preprocessing to remove artifacts and degradations such as blurring and noise. A variety of smoothing filters have been developed that are not linear. While they cannot, in general, be submitted to Fourier analysis, their properties and domains of application have been studied extensively. For this reason researchers applied anisotropic filtering and median filtering. In study method anisotropic and median filtering algorithms were used. The another filter median used to reduce noise in an image, somewhat like the mean filter (it is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images). The median filter is normally used to reduce noise in an image, somewhat like the mean filter. However, it often does a better job than the mean filter of preserving useful detail in the image. Like the mean filter, the median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. Instead of simply replacing the pixel value with the mean of neighboring pixel values, it replaces it with the median of those values. The median is calculated by first sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value. So conclusion of this research that image processing and analysis applied to nuclear medicine images for diagnosis, improve the acquired image qualitatively as well as offer quantitative information data useful in patient's therapy and care. Advanced techniques of image processing and analysis find widespread use in nuclear medicine. MatLab and Image Processing Toolbox enable both quantitative analysis and visualization of Nuclear Medicine images acquired as planar or angle projected images to reconstruct tomographic (SPECT, PET) slices and 3D volume surface rendering images.

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Author Profile



Eltayeb Wagallah received the B.S. in nuclear medicine technology, Rabat University and M.Sc. in nuclear medicine from College of Medical radiological Science, Sudan University of Science and Technology in 2005 and 2011, respectively. During 2006 up to date, he is staying in nuclear medicine department of

Radiation and Isotopes Center of Khartoum (RICK) and Elnileen Medical Center.

Yasir Ahmed, is consultant cardiologist, he was working in nuclear Sudan Cardiovascular Center and Elnileen Medical Center.



Yousif Mohamed Yousif Abdallah received the B.S., M.Sc. and PhD degrees and M.Sc. in nuclear medicine and Radiotherapy Technology from College of Medical radiological Science, Sudan University of Science and Technology in 2005, 2009 and 2013,

2014, respectively. During 2006 up to date, he is staying in College of Medical radiological Science, Sudan University of Science and Technology. He is now assistant professor, college registrar and Consultant Radiation Therapist.