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Improvement of Bone Scintigraphy Image Using Image Texture Analysis

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Abstract

Image enhancement allows the observer to see details in images that may not be immediately observable in the original image. Image enhancement is the transformation or mapping of one image to another. Undesirable effects accompany the enhancement of certain features in images. We proposed that to achieve maximum image quality after denoising using local adaptive Gaussian Scale Mixture model and median Filter were presented, which accomplishes nonlinearities from scattering a new nonlinear approach for contrast enhancement of bones in bone scan images using both Gamma Correction and negative transform methods. The usual assumption of a distribution of Gama and Poisson statistics only lead to overestimation of the noise variance in regions of low intensity but to underestimation in regions of high intensity and therefore to non-optimal results. The contrast enhancement results were obtained and evaluated using MatLab program in nuclear medicine images of the bones. The optimal number of bins, in particular the number of gray-levels, is chosen automatically using entropy and average distance between the histogram of the original gray-level distribution and the contrast enhancement function's curve.

1. Introduction

A bone scan or bone scintigraphy is a nuclear scanning test to find certain abnormalities in bone. It is primarily used to help diagnose a number of conditions relating to bones, including: cancer of the bone or cancers that have spread (metastasized) to the bone, locating some sources of bone inflammation (e.g. bone pain such as lower back pain due to a fracture), the diagnosis of fractures that may not be visible in traditional X-ray images, and the detection of damage to bones due to certain infections and other problems. Nuclear medicine bone scans are one of a number of methods of bone imaging, all of which are used to visually detect bone abnormalities [1], [2], [3]. Such imaging studies include magnetic resonance imaging (MRI), X-ray computed tomography (CT) and in the case of 'bone scans' nuclear medicine. However, a nuclear bone scan is a functional test: it measures an aspect of bone metabolism or bone remodeling, which most other imaging techniques cannot. The nuclear bone scan competes with the FDG-PET scan in seeing abnormal metabolism in bones, but it is considerably less expensive. Nuclear bone scans are not to be confused with the

completely different test often termed a "bone density scan," DEXA or DXA, which is a low-exposure X-ray test measuring bone density to look for osteoporosis and other diseases where bones lose mass, without any bone-rebuilding activity [4], [5], [6]. The nuclear medicine scan technique is sensitive to areas of unusual bone-rebuilding activity because the radiopharmaceutical is taken up by osteoblast cells that build bone. The technique therefore is sensitive to fractures and bone reaction to infections and bone tumors, including tumor metastases to bones, because all these pathologies trigger osteoblast activity. The bone scan is not sensitive to osteoporosis or multiple myeloma bones; therefore, other techniques must be used to assess bone abnormalities from these diseases. In the nuclear medicine technique, the patient is injected (usually into a vein in the arm or hand, occasionally the foot) with a small amount of radioactive material such as 740 MBq of technetium-99m-MDP and then scanned with a gamma camera, a device sensitive to the radiation emitted by the injected material. Two-dimensional projections of scintigraphy may be enough, but in order to view small lesions (less than 1cm) especially in the spine, single photon emission computed tomography (SPECT) imaging technique might be required. In the United States, most insurance companies require separate authorization for SPECT imaging. A disruption of bone turnover by a pathologic process approximately 5 to 15% from normal can be detected by bone scintigraphy. Specificity of bone scintigraphy can be increased by performing an indium 111-labeled white blood cell test combined with a technetium-99m-MDP injection. The bones localize about half of the radioactive material. The more active the bone turnover, the more radioactive material will be seen. Some tumors, fractures and infections show up as areas of increased uptake. Others can cause decreased uptake of radioactive material. Not all tumors are easily seen on the bone scan. Some lesions, especially lytic (destructive) ones, require positron emission tomography (PET) for visualization. About half of the radioactive material leaves the body through the kidneys and bladder in urine. Anyone having a study should empty their bladder immediately before images are taken. In evaluating for tumors, the patient injects with the radioisotope and returns in 2–3 hours for imaging. Image acquisition takes from 30 to 70 minutes, depending if SPECT images are required. If the physician wants to evaluate for osteomyelitis (bone infection) or fractures, then a Three Phase/Triphasic Bone Scan is performed where 20–30 minutes of images (1st and 2nd phases) are taken during the initial injection. The patient then returns in 2–3 hours for additional images (3rd Phase). Sometimes late images are taken at 24 hours after injection. The three-phase bone scan detects different types of pathology in the bone. The first phase is also known as the nuclear angiogram or the flow phase. During this phase, serial scans are taken during the first 2 to 5 seconds after

injection of the Technetium-99m-MDP. This phase typically shows perfusion to a lesion. Cellulitis shows up more in phase 1 and phase 2 scan, but not in phase 3. Pathology that is more moderate to severe will show more in the first two phases. Pathology that is chronic or partially treated will be more pronounced in the third phase of a triphasic scan [9], [10], [11]. The second phase image, also known as the blood pool image, is obtained 5 minutes after injection. This shows the relative vascularity to the area. Areas with moderate to severe inflammation have dilated capillaries, which is where the blood flow is stagnant and the radioisotope can "pool". This phase shows areas of intense or acute inflammation more definitively compared with the third phase [12], [13], [14]. The third phase, delayed phase, is obtained 3 hours after the injection, when the majority of the radioisotope has been metabolized. This phase best shows the amount of bone turnover associated with a lesion. A typical radiation dosage obtained during a bone scan is 6.3 mSv. These techniques give medical images where they are analyzed and enhanced by image processing (Image processing is the study of any algorithm that takes an image as input and returns an image as output) image processing gives Image enhancement, noise removal, restoration, feature detection, compression and image analysis give Segmentation, image registration, matching [15], [16].

2. Materials and Methods

For bone scan scintigraphy each film was scanned using a digitizer scanner then treated by using an image-processing program (MatLab), where the enhancement and contrast of the image were 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 of the original CT scan. The Fourier transform is a representation of an image as a sum of complex exponentials of varying magnitudes, frequencies, and phases. The Fourier transform plays a critical role in a broad range of image processing applications, including enhancement, analysis, restoration, and compression.

3. The Results

3.1. Negative Transform Technique

To use Photographic Negative, use MATLAB function called `imcomplement`. With this transformation, the true black becomes true white and vice versa. It is suitable when the black areas are dominant in size. Below are the codes that implement photographic negative and example of photographic negative images.

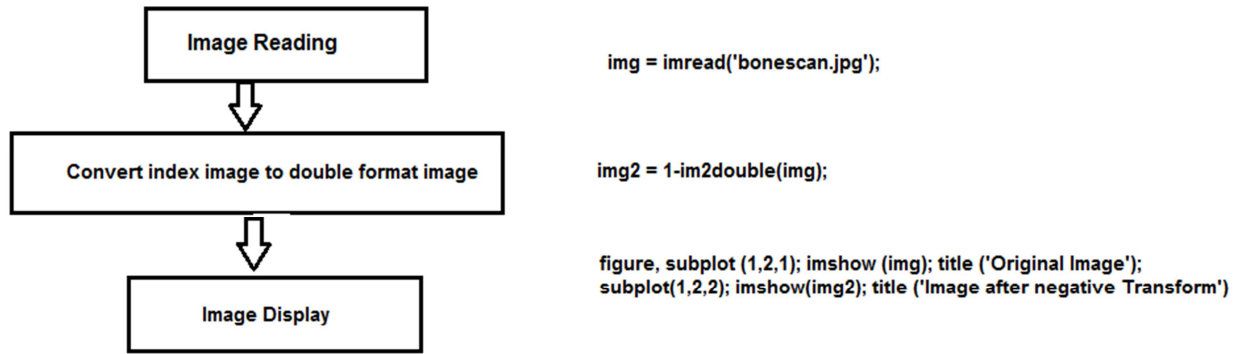


Figure 1. Shows negative transform.

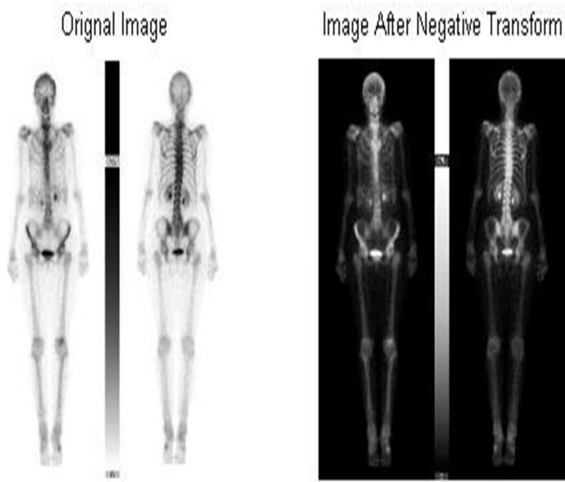


Figure 2. Shows negative transform.

3.2. Gamma Correction Technique

Use the Gamma Correction block to apply or remove gamma correction from an image or video stream. For input signals normalized between 0 and 1, the block performs gamma correction as defined by the following equations. For integers and fixed-point data types, these equations are generalized by applying scaling and offset values specific to the data type

$$S_{LS} = \frac{1}{B_p \left(\frac{1}{\gamma-1} \right)^{-\gamma B_p + B_p}}$$

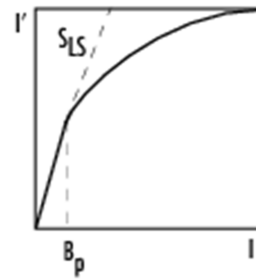
$$F_s = \frac{\gamma^{S_{LS}}}{B_p \left(\frac{1}{\gamma-1} \right)}$$

$$C_o = F_s B_p^{1/\gamma} - S_{LS} B_p$$

$$I' = \begin{cases} S_{LS} I, & I \leq B_p \\ F_s I^{1/\gamma} - C_o, & I > B_p \end{cases}$$

SLS is the slope of the straight-line segment. BP is the break point of the straight-line segment, which corresponds to the Break point parameter. FS is the slope-matching factor, which matches the slope of the linear segment to the slope of

the power function segment. CO is the segment offset, which ensures that the linear segment and the power function segments connect. The following diagram illustrates some of these parameters.



For normalized input signals, the block removes gamma correction, which linearizes the input video stream, as defined by the following equation:

$$I' = \begin{cases} I/S_{SL}, & I \leq B_p \\ \left(\frac{I - C_o}{F_s} \right)^\gamma, & I > B_p \end{cases}$$

To use Gamma Transformation, use MATLAB function called imadjust. The syntax of this function is:

J = imadjust (f, [low_in high_in], [low_out high_out], gamma)

where:

f = input image [low_in high_in], [low_out high_out] = for clipping

gamma = controls the curve.

Values for low_in, high_in, low_out, and high_out must be between 0 and 1. Values below low_in are clipped to low_out and values above high_in are clipped to high_out. For the example below, we will use empty matrix ([]) to specify the default of [0 1]. Gamma specifies the shape of the curve describing the relationship between the values in J and f. If gamma is less than 1, the mapping is weighted toward higher (brighter) output values. If gamma is greater than 1, the mapping is weighted toward lower (darker) output values. By default, gamma is set to 1 (linear mapping). Below are the

codes that implements gamma transformation and example of gamma transformation images. The following plots the

gamma transformations with varying gamma (Fig. 3).

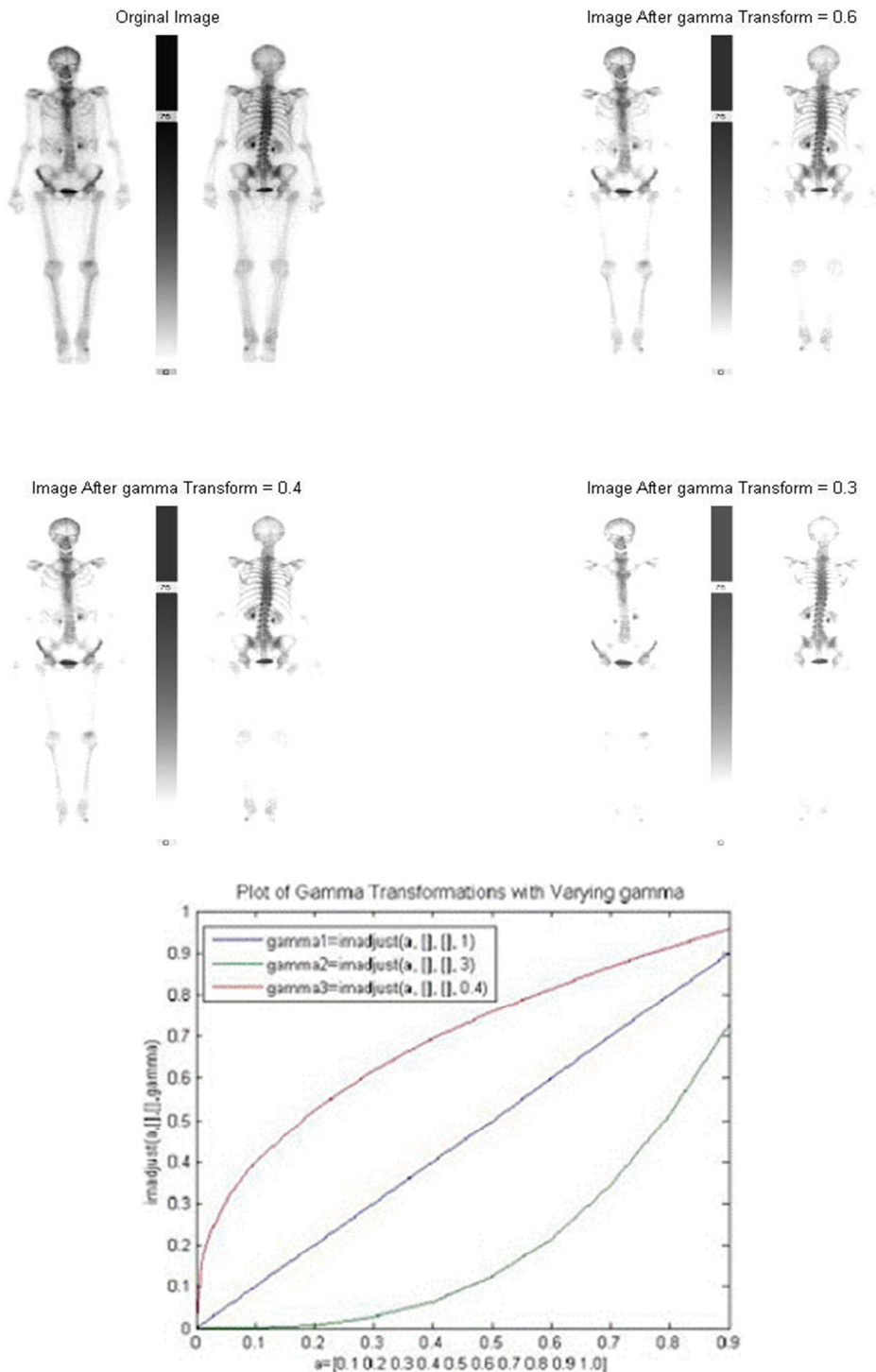


Figure 3. Gamma transform of image a) bone scan scintigraphy b) plot of gamma transformation with varying gamma.

4. Discussion

The main idea of this paper was to study of enhancement in bone scan scintigraphy images using negative transform and gamma correction filtering in order to study improvement of bone scan image and to classify nodules as

cancerous and non-cancerous using Genetic Programming-based Classifier (GPC) technique. Thus the lung bone scan image is subjected to various processing steps and features are extracted for a set of images. Pre-processing 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 pre-processing to remove artefacts 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 neighbours to decide whether 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.). Histogram equalization is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the local contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast without affecting the global contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. Given an image, improve the subjective quality of Contrast, Noise reduction and Edge sharpening. It operates on small pixel regions (tiles), rather than the entire image. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches the specified histogram. The neighboring tiles are then combined using bilinear interpolation in order to eliminate artificially induced boundaries. The contrast, especially in homogeneous areas, can be limited in order to avoid amplifying the noise, which might be present in the image. So conclusion of this research that the new approach is funded on an attempt to interpret the problem from the view of blind source separation (BSS), thus to see the panoramic image as a simple mixture of (unwanted) background information, diagnostic information and noise and filtered it. The detection of the noise is a complex procedure, which is difficult to detect by naked eye so that image analysis should be performed by using powerful image processing. The processing steps include

thresholding, morphological operations and feature extraction. By using these steps the nodules are detected and segmented and some features are extracted. The extracted features are tabulated for future classification. Undesirable effects accompany the enhancement of certain features in images. We proposed that to achieve maximum image quality after denoising, a new, low order, local adaptive Gaussian Scale Mixture model and median Filter were presented, which accomplishes nonlinearities from scattering a new nonlinear approach for contrast enhancement of bones in bone scan images using both Gamma Correction and negative transform methods. The usual assumption of a distribution of Gamma and Poisson statistics only lead to overestimation of the noise variance in regions of low intensity but to underestimation in regions of high intensity and therefore to non-optimal results. The contrast enhancement results were obtained and evaluated using MatLab program in nuclear medicine images of the bones. The optimal number of bins, in particular the number of gray-levels, is chosen automatically using entropy and average distance between the histogram of the original gray-level distribution and the contrast enhancement function's curve.

References

- [1] Adelson, E. H., Bergen, J. R.. "The plenoptic function and the elements of early vision", In *Computation Models of Visual Processing*, M. Landy and J. A. Movshon, eds., MIT Press, Cambridge, 1991. pp. 3-20.
- [2] Abdallah Y. M., *Computed verification of Light and radiation Field Size on Coblat-60*, Lambert Publisher Press, Germany, October 2010. Pp. 34-66.
- [3] Abdallah Y. M., Mohamed S. "Automatic Recognition of Leukemia Cells using Texture Analysis Algorithm". *International Journal of Advanced Research (IJAR)*. Vol. 4, No.1, February 2016.
- [4] Abdallah Y. M. "Increasing of Edges Recognition in Cardiac Scintigraphy for Ischemic Patients". *Journal of Biomedical Engineering and Medical Imaging*. Vol. 3. No. 4. January 2016.
- [5] Ball, J., Price, T., "Chesney's radiographic imaging" 6th edition, Blackwell Scientific, Oxford. 1995. Pp 64-112.
- [6] Farr, R., Allisy-Roberts, P., 1997, *Physics for medical imaging*, W. B. Saunders, London.
- [7] Abdallah Y. M., Wagiallah E., Yousef M. M. "Improvement of Nuclear Cardiology Images for Ischemic Patients using Image Processing Techniques". *SMU Medical Journal* Vol. 2, No. 2. July. 2015.
- [8] Abdallah Y. M. "Lungs Detection in Ventilation and Perfusion Scintigraphy using Watershed Transform". *International Journal of Electronics Communication and Computer Engineering (IJECCCE)*, Vol. 2, No. 3. June 2015.
- [9] Abdallah Y. M. "An Accurate Liver Segmentation Method Using Parallel Computing Algorithm". *Journal of Biomedical Engineering and Medical Imaging*. Vol. 3. No. 2. June 2015.

- [10] Abdallah Y. M. "Increasing the Precision of Edges Recognition in Static Renal Scintigraphy". *Indian Journal of Applied Research (IJAR)*. Vol. 4. No. 7. September 2015.
- [11] Yang, J. C., Everett, M., Buehler, C., McMillan, L. "A real-time distributed light field camera", *Proc. Eurographics Rendering Workshop 2002*.
- [12] Abdallah YM. Abdelwahab RI. "Application of Texture Analysis Algorithm for Data Extraction in Dental X-Ray Images". *International Journal of Science and Research*. Volume 3, Issue 8, 2014: P.p.1934-1937.
- [13] Adam MJ, Wilbur DS. "Radiohalogens for imaging and therapy". *Chem Soc Rev* Vol. 34. 2005: P.p 153–63.
- [14] Adelson, E. H., Bergen, J. R. 1991. "The plenoptic function and the elements of early vision", In *Computation Models of Visual Processing*, M. Landy and J. A. Movshon, eds., MIT Press, Cambridge, 1991, pp. 3-20.
- [15] Abdallah Y. M "Application of Analysis Approach in Noise Estimation: Using Image Processing Program". Lambert Academic Publishing. Germany. November 2011: P.p. 232-346.