

Augmentation of X-Rays Images using Pixel Intensity Values Adjustments

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Abstract: *X-Ray images are very popular as a first tool for diagnosis. Automating the process of analysis of such images is important in order to help physician procedures. In this practice, teeth segmentation from the radiographic images and feature extraction are essential steps. The main objective of this study was to study correction preprocessing of x-rays images using local adaptive filters in order to evaluate contrast enhancement pattern in different x-rays images such as grey color and to evaluate the usage of new nonlinear approach for contrast enhancement of soft tissues in x-rays images. The data analyzed by using MatLab program to enhance the contrast within the soft tissues, the gray levels in both enhanced and unenhanced images and noise variance. The main techniques of enhancement used in this study were Contrast enhancement filtering and Deblurring Images Using the Blind Deconvolution Algorithm. In this paper, 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.*

Keywords: Augmentation, x-rays, Pixel Intensity values, Matlab.

1. Introduction

There are three basic means by which radiologic images are produced: transmission of energy, reflection of energy, and emission of energy. The so-called x-ray or radiograph is produced by the transmission of energy. A beam of high-energy photons is passed through the body, some of which are attenuated or blocked when they strike subatomic particles. The higher the atomic weight of the substance through which the photons are passing, the "denser" it appears to photons, and the more likely they are to be blocked, or attenuated. In decreasing order of density, the principal densities visible in a radiograph are metal, bone, water (including soft tissues such as muscle), fat, and air. Of course, even though muscle is denser than fat, the x-ray beam would be more attenuated by passing through a meter of fat than a centimeter of muscle. Both density and thickness, then, are factors to take into account in assessing the degree of opacification noted on a radiograph. Radiographs were initially referred to as "skiagraphs," from the Greek for "shadow pictures," because they represent recordings of the shadows cast by anatomic structures as photons pass through the body. The principal transmission modalities include plain radiography, such as chest radiographs and abdominal radiographs, fluoroscopy, and CT. Plain radiography may be conceptualized as a snapshot: it provides a static view of anatomic structure obtained in a fraction of a second. Fluoroscopy represents a kind of "movie," or moving picture, in which continuous detection and display of the pattern of photon transmission enables the visualization of dynamic processes in real time. CT gathers transmission data from multiple perspectives and employs a mathematical algorithm (the Fourier transform) to reconstruct an image of the slice of tissue through which the x-ray beams passed. The multidetector CT scanners being manufactured now make it possible to acquire multiple "slices" at once in a continuous

fashion. In each case, the contrast in the image is a reflection of the attenuation of the x-ray beam by the tissues through which it passes. From a physical point of view, an image exhibits two crucial characteristics, contrast and detail. The level of contrast between a structure and its background must be at least several percent if it is to be detected by the human eye. Through image postprocessing, rendered possible by computed radiography and digital radiography, it is often possible to adjust and optimize the level of contrast in an image and to perform such manipulations as edge enhancement. The maximum detail detectable by the unaided human eye is 10 line pairs per millimeter. Each radiologic modality has a characteristic range of detail or spatial resolution. In decreasing order, they are plain radiography, fluoroscopy, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and nuclear medicine. Under ideal conditions, the detail captured by plain radiography is so high that magnification enhances detail, as in the detection of microcalcifications in mammography. The term noise refers to a variety of factors that detract from the information contained in an image. Some amount of noise is inherent in every modality, but additional noise may be added by the techniques used to generate or view the image. For example, ambient light in the viewing room decreases the signal-to-noise ratio; when the overhead lights in the viewing room are turned on, many of the photons striking the observer's retina no longer carry diagnostic information. In contrast, when the overhead lights are dimmed and the only source of light is a computer monitor or the view box on which a film is mounted, the signal-to-noise ratio is maximized. Radiologists work in darkened rooms not because they fear the sun, but because they are attempting to maximize the signal-to-noise ratio.

2. Methods and Materials

Contrast enhancement

The command that implements contrast processing is the `imadjust`. Using this, the contrast in an image can be enhanced or degraded if needed. Moreover, a very useful result can be the inversion of colors, especially in greyscale images, where an object of interest can be efficiently outlined. The general function that implements contrast enhancement is the following:

$$J = \text{imadjust}(I, [low_in \quad high_in], [low_out \quad high_out], gamma);$$

While the function for color inversion is the following:

$$J = \text{imadjust}(I, [0 \quad 1], [1 \quad 0], gamma); \text{ or } J = \text{imcomplement}(I);$$

Suppose that J , is the new image, I , is the initial image and γ factor depicts the shape of the curve that describes the relationship between the values of I and J . If the γ factor is omitted, it is considered to be 1.

Filtering in MatLab

Using Image Processing Toolbox design and filters for image data was implemented.

Special filter:

For linear filtering, MatLab provides the `fspecial` command to generate some predefined common 2D filters. `fspecial` creates Gaussian filters using as following equation:

$$h_g(n_1, n_2) = e^{-(n_1^2 + n_2^2) / (2\sigma^2)}$$

$$h(n_1, n_2) = \frac{h_g(n_1, n_2)}{\sum_{n_1} \sum_{n_2} h_g}$$

`fspecial` creates Laplacian filters using:

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2}$$

$$\nabla^2 = \frac{4}{(\alpha + 1)} \begin{bmatrix} \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4} \\ \frac{1-\alpha}{4} & -1 & \frac{1-\alpha}{4} \\ \frac{\alpha}{4} & \frac{1-\alpha}{4} & \frac{\alpha}{4} \end{bmatrix}$$

`fspecial` creates Laplacian of Gaussian (LoG) filters using:

$$h_g(n_1, n_2) = e^{-(n_1^2 + n_2^2) / (2\sigma^2)}$$

$$h(n_1, n_2) = \frac{(n_1^2 + n_2^2 - 2\sigma^2) h_g(n_1, n_2)}{2\pi\sigma^6 \sum_{n_1} \sum_{n_2} h_g}$$

Equation above describe the commands' package that can be used for the application of the mean (average) filter in a

SPECT slice for different convolution kernel sizes (for 3×3 , 9×9 , 25×25 average filter).

3. Image Segmentation

The image segmentation describes the process through which an image is divided into constituent parts, regions or objects in order to isolate and study separately areas of special interest. This process assists in detecting critical parts of a nuclear medicine image that are not easily displayed in the original image.

4. 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 medical images of several modalities, such as Computed Radiology, Computed Tomography (CT), 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.

5. Contrast Enhancement

The command that implements contrast processing is the `imadjust`. The general function that implements contrast enhancement is the following:

$$RGB1 = \text{imread}('bonescan.jpg'); \text{ Fig.1}$$

Original Image



Figure 1: Original bone scan image

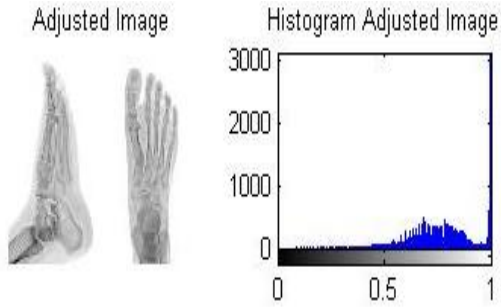


Figure 2: Shows bone scan image after adjustment filtering in MatLab

Using Image Processing Toolbox design and filters for image data was implemented.

Fspecial Filter

For linear filtering, MatLab provides the fspecial command to generate some predefined common 2D filters. $h = \text{fspecial}(\text{type})$ creates a two-dimensional filter h of the specified type. Fspecial returns h as a correlation kernel, which is the appropriate form to use with imfilter Fig.3.



Figure 3: Shows original shoulder x-rays image

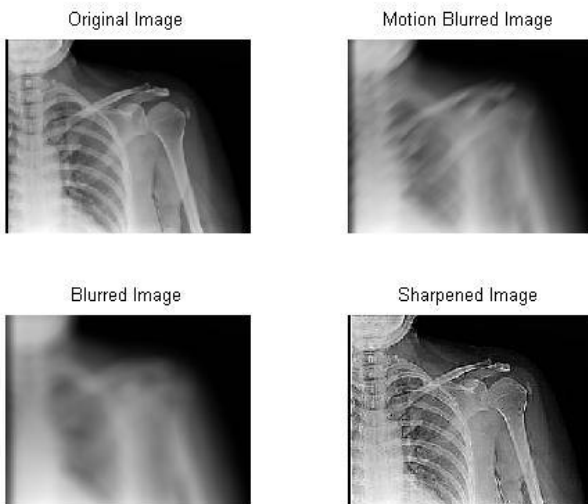


Figure 4: Shows Fspecial filter

Convolution kernel filter



Figure 5: Shows Original Image



Figure 6: Shows $[3 \ 3]$ fspecial filter of figure 3-5



Figure 7: Shows $[9 \ 9]$ fspecial filter of figure 3-5



Figure 8: Shows $[25 \ 25]$ fspecial filter of figure 3-5

Removal impulse noise from x-rays images

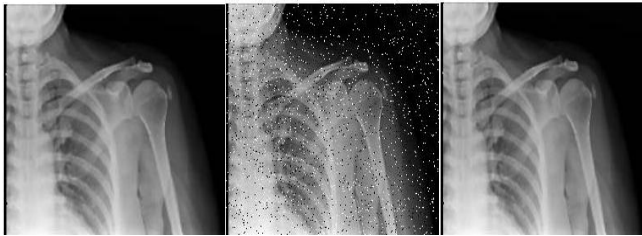


Figure 9: Impulse noise elimination by median filter. (a) Original image (b) the image with impulse noise (c) the image on which the noise is suppressed with the median filter. [(a) to (c) from left to right]

Removing Noise By Adaptive Filtering

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 truecolor image, the example converts it to grayscale.
- 2) The example then add Gaussian noise to the image and then displays the image. Because the image is quite large, the figure only shows a portion of the image.

Gaussian Noise



Figure 10: Portion of the Image with Added Gaussian Noise

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

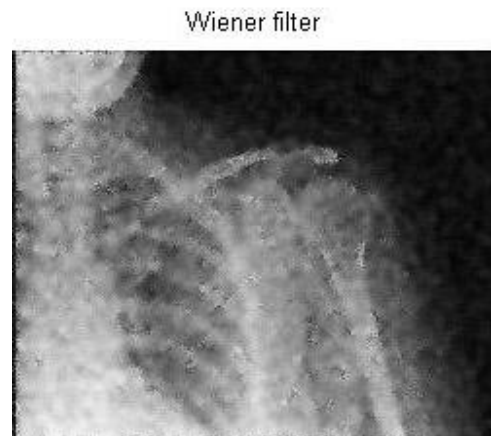


Figure 11: Shows Portion of the Image with Noise Removed by Wiener Filter

6. Conclusion

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. This study conducted in College of Medical Radiological Science, Sudan University of Science and Technology and Elnileen Medical Center. The main objective of this study was to study the enhancement of SPECT images using filtering technique. 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. The data analyzed by using MatLab program to enhance the contrast within the soft tissues, the gray levels in both enhanced and unenhanced images and noise variance. The main techniques of enhancement used in this study was For linear filtering, MatLab provides the fspecial command to generate some predefined common 2D filters. $h = \text{fspecial}(\text{type})$ creates a two-dimensional filter h of the specified type. fspecial returns h as a correlation kernel, which is the appropriate form to use with imfilter. The results of this technique agreed the results of Robiul et al, (2011), Nasrul et al, (2012), Gupta et al, (2012) and Smriti et al, (2012) who used non-linear filtering based methods to enhance the nuclear medicine images. The another technique was Convolution kernel filter. Filtering is a technique for modifying or enhancing an image. For example, researchers can filter an image to emphasize certain features or remove other features. Image processing operations implemented with filtering include smoothing, sharpening, and edge

enhancement. Filtering is a neighborhood operation, in which the value of any given pixel in the output image is determined by applying some algorithm to the values of the pixels in the neighborhood of the corresponding input pixel. A pixel's neighborhood is some set of pixels, defined by their locations relative to that pixel. Linear filtering is filtering in which the value of an output pixel is a linear combination of the values of the pixels in the input pixel's neighborhood. Luqman et al, (2011) stated in their study of enhancement of bone fracture image using filtering techniques that the Blind Deconvolution Algorithm is a better technique in reducing the speckle and noise without fully eliminating the image edges.

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Author Profile



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