



Effect of Wavelet Based Image Compression Methods on Enhanced Medical Imagery

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Abstract— The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers, or to provide better input for other automated image processing techniques. Histogram equalization is one of the well known image enhancement technique. It became a popular technique for contrast enhancement because it is simple and effective approach. The basic idea of Histogram Equalization method is to remap the gray levels of an image. We can analyse the influence of gamma correction in digital colour image obtained from cameras using computer vision algorithms. In order to obtain linear light signals either the camera has to be configured linear by using the gamma switch (if available) or by removing analytically nonlinearity using the inverse operation (gamma re-correction). Image compression is advantageous to reduce substantial storage and for transmission resources. Thus image compression in signal and image processing is providing great improvement in performance with the use of wavelet based compression methods. In this paper Comparison of different quality assessment metrics for the enhancement and compression techniques are carried out. This comparison is done on the basis of subjective and objective parameters. Subjective parameter is visual quality and objective parameters are Peak signal-to- noise ratio (PSNR), Compression Ratio (CR), Mean square error (MSE), L2-norm ratio, Bits per pixel (BPP) and Maximum error.

Keywords—Histogram Equalization, CLAHE, Gamma Correction, and Wavelet Compression.

I. INTRODUCTION

Medical image enhancement technologies have become popular since advanced medical equipments were in use. Enhanced images are desired by a surgeon to assist diagnosis and interpretation as the medical image qualities of X-ray, CT scan and MRI are often deteriorated by noise during acquisition and illumination conditions. Image quality enhancement algorithms are developed to improve the visual appearance of an image by the increment of contrast, adjustment of brightness, and enhancing visually important features. Image enhancement is very important pre processing stage in most image processing applications.

The nonlinear effects are not consistent across all regions of the image. In other words, the value of gamma may change from one region to another. For example, it is possible that a scene contains a large dynamic illumination range that an imaging device cannot capture adequately. Thus, especially in very dark or bright regions of the image, some details may become clustered together within a small intensity range. Hence a local enhancement process adjusts the image quality in different regions in such a way that the human viewers grasp these details. Basically there are two categories of image enhancement methods : spatial domain methods and frequency domain methods. The spatial domain methods such as: Histogram Equalization[1], Gamma Correction[2] operate on image pixels directly. The frequency domain methods such as: Un sharp masking, combining nonlinear Low pass and High pass filters, Homomorphic filter directly operate on the frequency of signal. As mentioned above, imaging devices apply the power law transformation on each pixel of the image; hence gamma correction is required to enhance the image. Multimedia data like graphics, audio and video, requires considerable storage capacity and transmission bandwidths. Despite rapid progress in mass-storage density, processor speeds, and digital communication system performances, demand for data storage capacity data-transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia based web application has not only sustained the need for more efficient ways to encode signals and images but has also made compression of such signals common to storage and communication technologies.

A variety of powerful and sophisticated wavelet-based compression schemes [3] on image compression have been developed and implemented[4] . Because of the many advantages, the top contenders in the JPEG-2000 standard are all wavelet based. The wavelet transform has been successfully used in image coding since it allows localization in both the spatial and frequency domains . Coders can then exploit the characteristics of the wavelet coefficients to achieve better efficiency. Wavelet compression allows the integration of various compression techniques into one algorithm. Wavelet-

based image coding techniques are Embedded Zero Tree Wavelet(EZW)[5], Set-Partitioning In Hierarchical Trees (SPIHT)[6], Spatial-Orientation Tree Wavelet (STW),Wavelet Difference Reduction(WDR), Adaptively Scanned Wavelet Difference Reduction (ASWDR)[7]. The next section in this paper has basic literature survey of image enhancement and wavelet based image compression methods. In the preceding section proposed method to enhance and compress the medical imagery is described. The later sections present experimental results, statistical analysis of results, finally the paper is concluded.

II. BACKGROUND

We present some background on topics of image enhancement and image compression which includes Contrast Limited Adaptive Histogram Equalisation (CLAHE), Gamma Correction, and wavelet based image compression before to the details of the proposed method.

A. Image Enhancement

Image enhancement is the simplest and most appealing areas of digital image processing. Basically, the main idea behind enhancement techniques is to bring out detail that is obscured, or simply to highlight certain features of interest in an image. We look into the following CLAHE, Gamma Correction techniques to enhance the medical images.

B. Contrast Limited Adaptive Histogram Equalization (CLAHE)

Histogram Equalization works on the entire image, but CLAHE [8] operates on small regions in the image, called tiles. Each tile's contrast is enhanced, so that the histogram of the output region approximately matches a specified histogram. The neighbouring tiles are then combined using bilinear interpolation to eliminate artificially induced boundaries. CLAHE differs from ordinary adaptive histogram equalization in its contrast limiting. This feature can also be applied to global histogram equalization, giving rise to contrast limited histogram equalization, which is rarely used in practice. In the case of contrast limited histogram equalization, the contrast limiting procedure has to be applied for each neighbourhood from which a transformation function is derived. Contrast limited histogram equalization was developed to prevent the over amplification of noise, which is a problem in adaptive histogram equalization.

C. Gamma correction

Gamma correction, gamma nonlinearity, gamma encoding, or often simply gamma, is the name of a nonlinear operation used to code and decode luminance or tri stimulus values in video or still image systems. Gamma correction [9] is, in the simplest cases, defined by the following power-law expression. Power-law transformations have the basic form

$$S = c r^\gamma \dots\dots\dots(1)$$

Where c and r are positive constants.

A gamma value $\gamma < 1$ is sometimes called an encoding gamma, and the process of encoding with this compressive power-law nonlinearity is called gamma compression, conversely a gamma value $\gamma > 1$ is called a decoding gamma the expansive power-law nonlinearity is called gamma expansion.

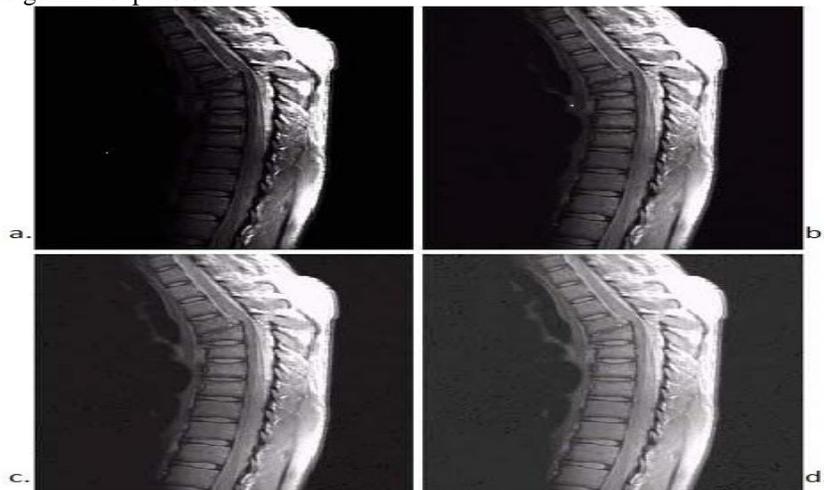


Figure 1(a). MRI image of fractured human spine (b)-(d) Results of applying transformation in equation with c=1 and $\gamma = 0.4, 0.6$ and 0.3 respectively.

D. Compression

Image compression can be defined as the reduction of the amount of data required to represent a digital image by removing the redundant data. It involves reducing the size of image data files, while retaining necessary information. Wavelet is a mathematical function that divides the data into different frequency components, then fits each component with a resolution suitable for its scale [10].

A variety of sophisticated wavelet-based image coding schemes are Embedded Zero tree Wavelet (EZW), Spatial-orientation Tree Wavelet (STW), Set-Partitioning in Hierarchical Trees (SPIHT), Wavelet Difference Reduction(WDR) and Adaptively Scanned Wavelet Difference Reduction (ASWDR) etc.

- Wavelet coding schemes at higher compression avoid blocking artifacts
- They are better matched to the HVS (Human Visual System) characteristics.
- Compression with wavelets is scalable Wavelet compression is very efficient at low bit rates.
- Wavelets provide an efficient decomposition of signals prior to compression.

Because of Many advantages of wavelet based image compressions [11] as listed above , the top contenders in the JPEG-2000 standard are all wavelet-based compression algorithms.

II. PROPOSED WORK

The proposed method is used to enhance and compress the medical image. Here we use the Contrast limited adaptive Histogram Equalization (CLAHE) and Gamma -Correction to enhance the medical images, and Wavelet based Compression algorithms to compress the Enhanced medical image.

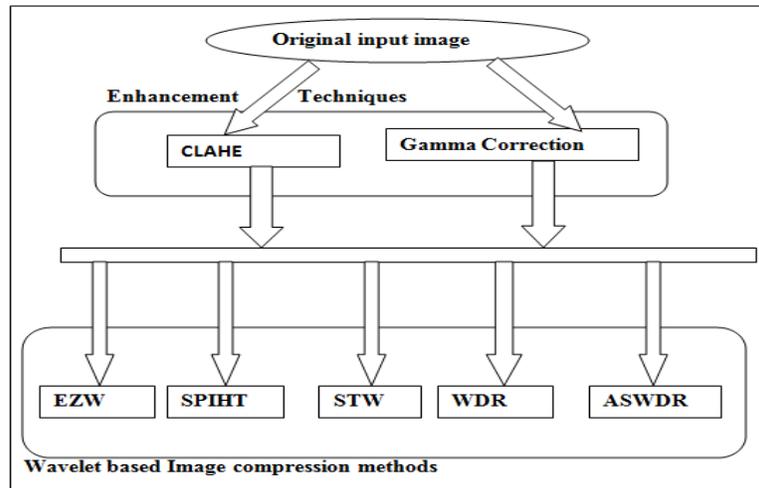


Figure 2. Block Diagram of Proposed work

We take an original image, on that image we apply CLAHE and Gamma-correction enhancement techniques. Then we apply some wavelet based compression techniques on those enhanced images. Finally we get enhanced & compressed image as an output image.

IV. EXPERIMENTAL RESULTS & ANALYSIS

We can use some medical image modalities like X-ray, MRI, CT scan, ECG etc. Here we are using an X-ray image of a shoulder of a patient. Fig.3 shows the results obtained during the processing with different techniques. Figure 3. (a) is original image, Figure 3.(b) is enhanced image obtained after CLAHE algorithm, Figure 3.(c) is enhanced image using Gamma Correction, Figure 3.(d) is CLAHE compressed image and Figure 3.(e) is Gamma-corrected compressed image.

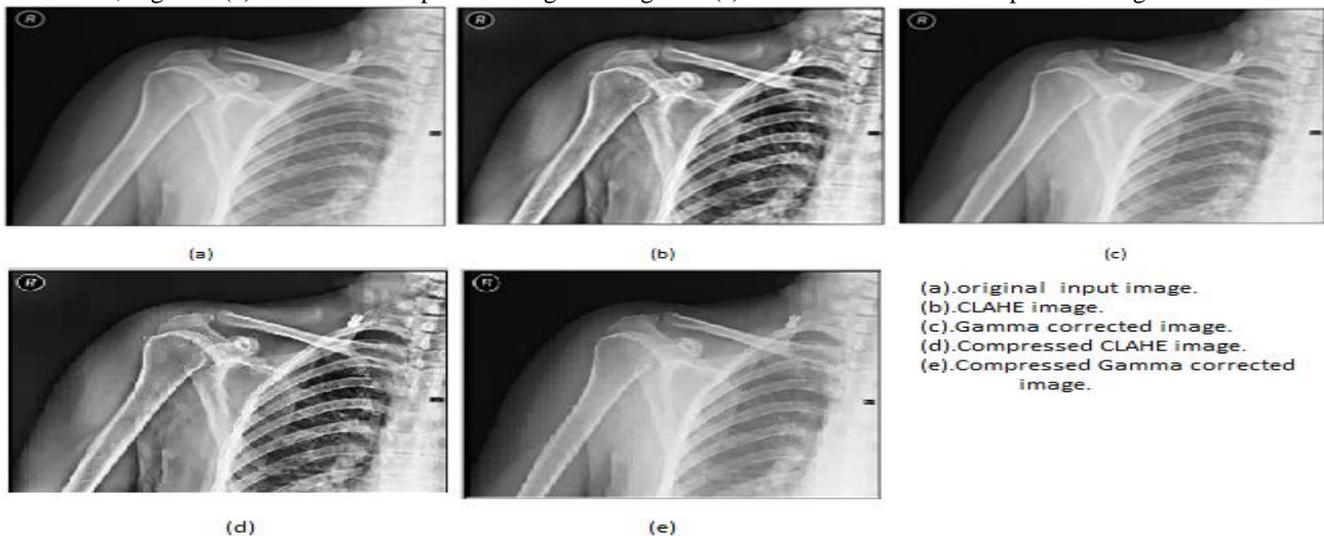


Figure 3.Experimental Results for a X-Ray image. (X-ray image courtesy of [Wikimedia](http://www.wikipedia.org))

The performance of the proposed method was evaluated using quality metrics like Compression Ratio (CR), and Peak Signal to Noise Ratio (PSNR) [12], Bits per pixel(BPP), L2-norm.ratio, Maximum error, Mean Square Error. The metrics are obtained from the following equations.

$$(1). \text{Mean-Square error} = \frac{\sum_{i=1}^x \sum_{j=1}^y (|A_{ij} - B_{ij}|)}{x * y} \dots\dots\dots(2)$$

x: width of image.

y: height.

x*y: number of pixels (or quantities).

(2).The Peak Signal to Noise Ratio (PSNR)is calculated using the formula

$$\text{PSNR (dB)} = 10 * \log (255^2 / \text{MSE}).$$

MSE: Mean Square error.(3)

(3). The ratio of the original (uncompressed) image to the compressed image is referred to as the Compression Ratio

C_R= (Uncompressed image size) / (compressed image size) or represented as

$$C_R = (U_{\text{size}}) / (C_{\text{size}}) \dots\dots\dots(4)$$

Where

$$U_{\text{size}} = m * n * k \dots\dots\dots (5)$$

C_{size}=Size of compressed image file stored.

(4). Bits per pixel (BPP)[12] can be defined as

$$\text{BPP} = (\text{number of encoded bits}) / (m * n).$$

Where n, m is the image size.

$$\dots\dots\dots (6)$$

For the X-ray image the below tables give metrics

Table1: Quality Assessment metrics for Gamma corrected compressed X-Ray image.

Compression method/Parameter	EZW	SPIHT	WDR	ASWDR	STW
MSE	29.35	75.45	31.57	31.57	60.78
Maximum Error	43	121	43	43	104
L2norm	99.92	99.32	99.80	99.80	99.56
PSNR	33.46	29.35	33.14	33.14	30.29
BPP	0.790	0.171	0.865	0.840	0.339
C.R	3.29	0.71	3.61	3.50	1.41

Table2: Quality Assessment metrics for CLAHE compressed X-Ray image.

Compression method/Parameter	EZW	SPIHT	WDR	ASWDR	STW
MSE	67.03	179	72.72	72.72	155.5
Maximum Error	51	100	61	61	95
L2norm	99.82	98.92	99.54	99.54	99.18
PSNR	29.87	25.6	29.51	29.51	26.21
BPP	1.935	0.607	2.243	2.141	0.832
C.R	8.06	2.53	9.35	8.92	3.47

V. CONCLUSIONS

By observing all of the quality assessment metrics for “X-Ray of shoulder” image, we can conclude that between two enhancement methods “Gamma Correction” method will produce better results than “CLAHE” method. Among all the compression methods “Embedded Zero tree Wavelet (EZW)” will give good results in case of Mean Square Error(MSE), Peak Signal to Noise ratio(PSNR), Compression Ratio (CR), Maximum Error, and “Wavelet Difference Reduction(WDR)” will give good results in case of L2-norm ratio and Bits Per Pixel.The proposed algorithm of combining effect of enhancement techniques with the compression techniques is effective and improved visual appearance of an image is obtained. It also gives better results in substantial storage and transmission resources.

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