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Enhanced Image by Wavelet Based Compression Method

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***Abstract:** The aim of image enhancement is to improve the perception of information in images for human viewers, to provide better input for other automated image processing techniques. Histogram equalization is one of the well known and popular technique for better contrast and image enhancement. The basic idea of Histogram Equalization method is to remap the gray levels of an image. We can analyse the influence of gamma correction of digital colour cameras on computer vision algorithms. Image compression is advantageous to reduce substantial storage and transmission resources. By using wavelet based compression methods, signal and image processing are improved in performance. In this paper, the comparison of different quality assessment metrics for the enhancement and compression techniques will be carried out. This comparison will be 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, Gamma Correction, Wavelet and Medical Image Compression**

Introduction

Medical image enhancement technologies have become popular since advanced medical equipments were used in the medical field. Enhanced images are desired by a surgeon to assist diagnosis and interpretation because medical image qualities are often deteriorated by noise during acquiring and illumination condition. 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 is not able to adequately capture. 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. There are two categories of image enhancement methods: spatial domain methods and frequency domain methods. The spatial domain methods operate on image pixels directly, such as: histogram equalization[1], gamma correction[2]. The frequency domain methods directly operate on the frequency domain such as: unsharp masking, combining nonlinear low pass and high pass filters, homomorphic filter. As mentioned above, imaging devices apply the power low 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 bandwidth. Despite rapid progress in mass-storage density, processor speeds, and digital communication system performance, 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 applications has not only sustained the need for more efficient ways to encode signals and images but has made compression of such signals common to storage and communication technology.

A variety of powerful and sophisticated wavelet-based compression schemes[3] for 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 compression algorithms. The wavelet transform has been successfully used in image coding since it allows localization in both the space 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 include 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].

This paper presents the literature survey of image enhancement and wavelet based image compression methods, proposed method, experimental results, statistical analysis of results. Also, we present some background topics of image enhancement and image compression which include 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 have proposed the following CLAHE, gamma correction techniques to enhance the medical images.

B. Contrast Limited Adaptive Histogram Equalization (CLAHE)

Contrast Limited Adaptive Histogram Equalization 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 is, in the simplest cases, defined by the following power-law expression. Power-law transformations have the basic form

$S = r c^{\gamma}$ ………… (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.

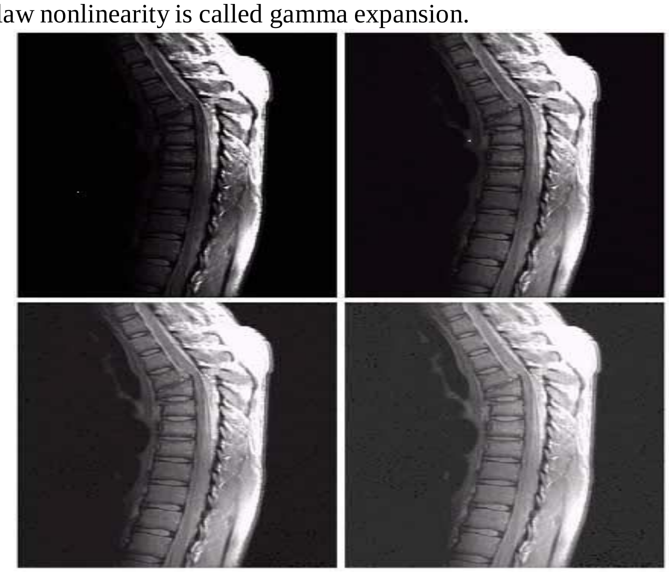

Fig 1. (a) MRI image of fractured human spine (b)-(d) Results of applying transformation in equation with c=1 and γ =0.4, 0.6 and 0.3 respectively.

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 [9].

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 .Because of Many advantages of wavelet based image compression as listed below, the top contenders in the JPEG-2000 standard are all wavelet-based compression algorithms.

PROPOSED WORK

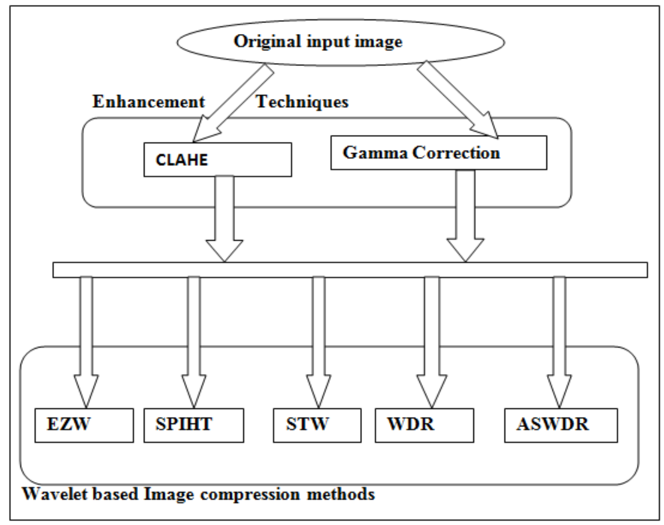

Fig . 2 Block Diagram of Proposed work

The proposed method is used to enhance and compress the medical image. 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.

Experimental Results

Here we can use some medical image modalities like MRI, CT scan, ECG etc. For example here we are using an image which is X-Ray of a shoulder of a patient. Fig. 3.(a, b, c, d, e) shows experimental results. **Fig. 3.a** is original image, **Fig.3.b** is enhanced image via CLAHE, **Fig.3.c** is enhanced image via Gamma Correction, **Fig.3.d** is Gamma-corrected compressed image and **Fig.3.e** is CLAHE Compressed image.

Statistical Analysis

The Performance of the proposed method was evaluated using quality metrics like Compression Ratio (CR), and Peak signal to Noise Ratio (PSNR) [10], Bits per pixel (BPP), L2-norm.ratio, Maximum error, Mean square error.

(1). **MSE** $= \sum_{i=1}^{x}\sum_{j=1}^{y} \frac{\left(\left|A_{ij} - B_{ij}\right|\right)}{x * y}$ …………. (2)

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

MSE: Mean-Square error; x: width of image, y: height.
x*y: number of pixels (or quantities).

$$\textbf{PSNR (dB)} = 10 \log \frac{255^2}{MSE}$$

(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)

$$C_R = (U_{size}) / (C_{size}). \quad \ldots\ldots\ldots (4)$$

$$\text{Where } U_{size} = M*N*K \quad \ldots\ldots\ldots\ldots\ldots (5)$$

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

(4). Bits per pixel (BPP): BPP can be defined as

BPP = (number of encoded bits) / (m*n) …………. **(6)**

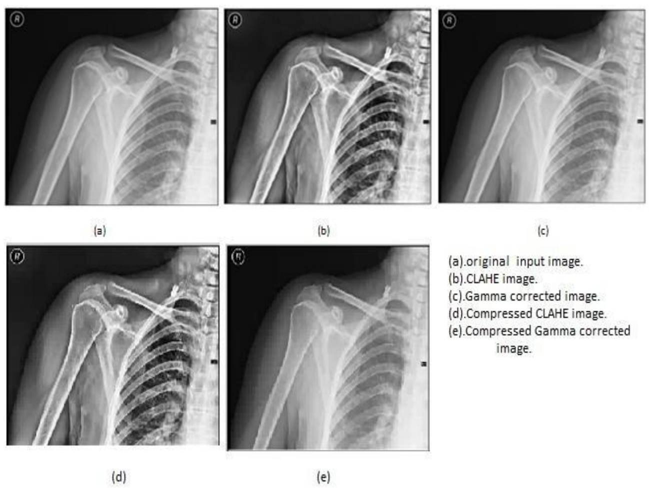

Fig 3. Experimental Results for a X-Ray image.

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

By observing all of the above quality assessment metrics for “X-Ray of Lungs” 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 (Compression Ratio), Maximum Error, and “wavelet difference reduction(WDR)” will give good results in case of L2-norm ratio and Bits Per Pixel.

Conclusions

The proposed algorithm is effective in improving visual appearance of an image. It gives better results in substantial storage and transmission resources to all the researchers in their work.

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