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An Effective Technique To Compress Images Through Hybrid Wavelet-Ridgelet Transformation

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Abstract

In recent days, images play a vital role in a wide range of applications. Some of the significant application fields such as medical, education, surveillance also utilize images. Images are of large size and hence they are difficult to transmit and store. Images need compression for effective transmission and storage. A wide of range of compression techniques are available in the literature. Some of the techniques only compress the images by minimizing the size on disk without loss of data. In this paper, a hybrid compression technique comprised of wavelet and ridgelet methods is used for compressing images. Initially, the image is denoised with a filter and then the denoised image is transformed utilizing Discrete Wavelet Transform (DWT). After that, Finite Ridgelet Transform (FRT) is employed on the obtained wavelet coefficients, and the compressed image of reduced size is obtained. For decompression the Inverse FRT is employed subsequent to the inverse DWT process and the original image is obtained without loss of data.

Keywords:- compression, decompression, Gaussian Filter, Discrete Wavelet Transform (DWT), Finite Ridgelet Transform (FRT)

1. INTRODUCTION

Digital images have emerged as a significant source of knowledge in the contemporary world of communication systems [1]. A single image can replace thousands of words of information as stated by the phrase “a picture is worth thousand words” [2]. Internet, police department, medical images, digital libraries etc., are some of the several applications which use images [5]. The bit rate of a digital system is calculated by multiplying the sampling rate with the number of bits in each sample. Redundancy is the difference between the information rate of a signal and its bit rate [4].

Compression of the image data can be achieved by removing the redundancy. Spatial Redundancy i.e. correlation between neighboring pixel values and Spectral Redundancy i.e. correlation between different color planes or spectral bands are the two types of redundancies that exist in still Images [5]. Eliminating this redundancy is the basic idea behind compression systems [4]. The process that achieves data reduction without losing the image information is termed as image compression. Specified channel bandwidths or storage needs and maintaining the highest possible quality are the important components to compress data [6]

Lossy and lossless are two types of compression techniques [7]. An exact reconstruction of the original signal can be obtained using methods from the lossless family; however they do not realize low data rates. Conversely, an exact reconstruction is not achieved by lossy methods; however higher compression ratios can be achieved [8]. Selection of the compression method, lossy or lossless is application dependant [7]. A smaller number of bits are required for the representation of the coded image compared to that required for the representation of the original image and this reduces the communication time or the used storage space [9]. Old methods of compression like Fourier Transform, Hadamard and Cosine Transform etc., do not satisfy these requirements because huge mean square error occurs between the original and the reconstructed images. The purpose is very efficiently served by the wavelet transform approach [10].

Multiresolution theory is a powerful approach for wavelets based signal processing and analysis [11]. Data is transformed into diverse frequency components, signifying each component with a resolution that corresponds to its scale by the mathematical function namely wavelets that are defined over a finite interval and have an average value of zero [12]. Wavelets are employed to diverse factors of imaging informatics, such as image compression. A major application area for wavelets is image compression. Compression can also be achieved on the wavelet coefficients, because the original image can be signified by a linear relationship of the wavelet basis functions [13]. A set of sub images with different resolutions matching different frequency bands is obtained by decomposing the image using the wavelet transform [14] [15]. Another transformation that can be utilized is Ridgelet. Wavelets are excellent at signifying point singularities and ridgelets signify line singularities [16]. Functions on continuous spaces that have certain discontinuities along lines can be represented in multiple scales using the Ridgelet transform [17].

In this paper, we propose a hybrid technique which is a wavelet- ridgelet combination for the compression of images. Initially, the input image which is in the RGB colorspace is converted to the grayscale image for compression. After that the grayscale image is denoised by processing using a Gaussian filter, because the noise may degrade the quality of the image. After that the denoised image is transformed using DWT and then using FRT to acquire the compressed image. Subsequent to this process the decompressed image is obtained by applying inverse FRT and inverse DWT in succession on the transformed image. As a result of this process the decompressed image is obtained. The rest of the paper is organized as follows section 2 presents a brief review of some of the existing works in image compression. The proposed mechanism to compress the image using hybrid technique is detailed in section 3. Section 4 describes the results and discussion. Finally, the conclusions are summed up in section 5.

II. Related Researches: A Review

A handful of recent researches are available in the literature. Picture archiving and communication systems have been utilized for storing majority of the image data in hospitals in digital form With the widespread digitization of data and the rising use of telemedicine, the requirement for data storage and bandwidth requirements have been rising and lossy compression techniques have become important. In literature, the triumphant use of the wavelet transform in the field of image compression has been widely studied. For medical image compression, the functioning of Bi-orthogonal spline wavelet as an efficient mode has been investigated by Loganathan *et al* [18]. An experimental setup to evaluate the effectiveness of medical image compression by means of bi-orthogonal wavelet has been executed. The result of the experimental set up for several reconstruction and decomposition values has obtained a quite stable compression ratio.

Mansi Kambli *et al.* [19] have proposed a framework which is a Modified Set Partitioning in Hierarchical Tree with Run Length Encoding for fingerprint image compression. Their Proposed method is superior because lots of images associated to the fingerprint image have been retrieved. Their proposed method has been shown to execute well in compression and decompression by a test conducted on an image database of grayscale bitmap images. The picture quality of fingerprint images has been determined using both Peak Signal to noise ratio and Mean Square Error.

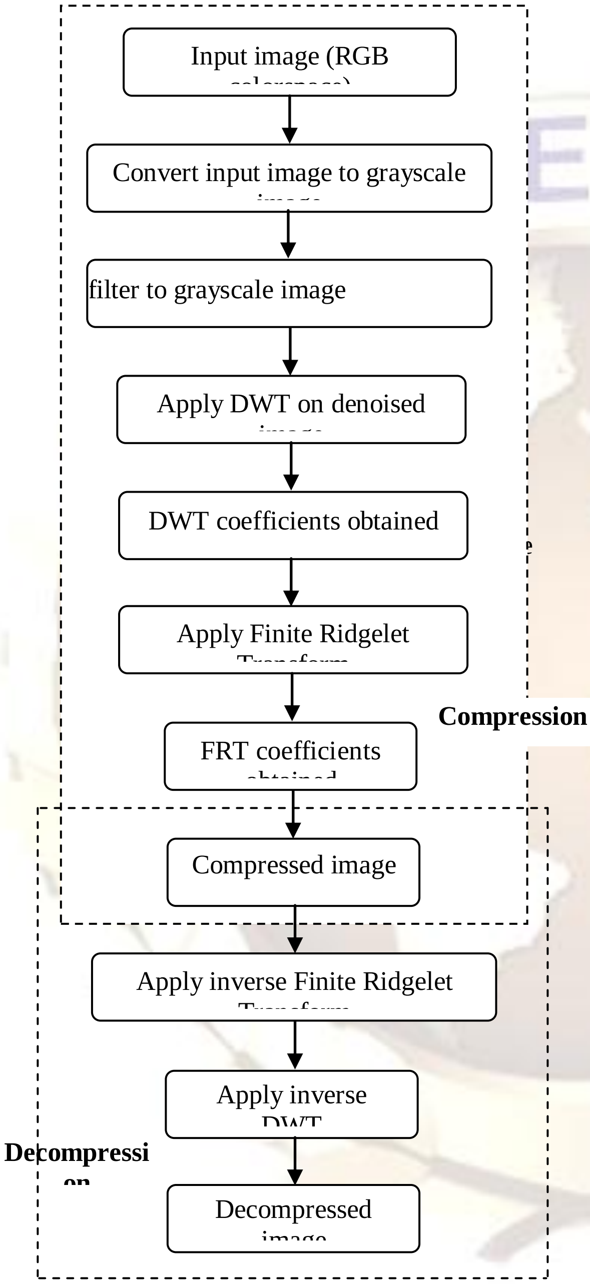
Ming-Shing Hsieh [20] has proposed a DWT-based watermarking technique to embed signatures in images for confirming the owner identification and reducing unauthorized copying. They have included a fuzzy inference filter to select the larger entropy of coefficients to embed watermarks. Unlike most prior watermarking frameworks which entrench watermarks in the greater coefficients of inner coarser subbands, their proposed technique has been based on exploiting a context model and fuzzy inference filter for embedding watermarks in the greater-entropy coefficients of coarser DWT subbands. Transparency and robustness to the common image-processing attacks for example smoothing, sharpening, and JPEG compression, have been achieved in their proposed techniques by permitting insertion of adaptive casting degree of watermarks. The approach has not required the original host image to get back the watermarks from the watermarked image. Their schemes have been shown to offer excellent outcomes in both image transparency and robustness.

The transform selected for image compression must obtain a resultant data set that is smaller than the source data set in terms of size. Wavelet transforms and wavelet packet transform have materialized as well-liked techniques for continuous and discrete time cases. Tripatjot Singh *et al* [21] have attempted to find out the most excellent wavelet for compressing the still image at a particular decomposition level using wavelet transforms and wavelet packet transforms. For decomposition level 2, Compression Ratio (CR) and Energy Ratio (ER) have been decided for dissimilar wavelets at different threshold values ranging from 5 to 100.

To accomplish image compression, wavelet-Modified Single Layer Linear Forward Only Counter Propagation Network (MSLLFOCPN) technique has been presented by Narayanan Sreekumar *et al* [22]. Properties of localizing the global spatial and frequency correlation have been inherited by their technique from wavelets. Function approximation and prediction have been achieved using neural networks. As a result of its better performance counter propagation network has been considered and the research has allowed them to suggest a neural network architecture named single layer linear counter propagation network (SLLC). The combination of wavelet and SLLC network has been experimented on many benchmark images and the experimental outcomes have shown improvement in picture quality, compression ratio and approximation or prediction comparable to existing and traditional neural networks.

III. Proposed Method

Nowadays, the impact of images in the real world applications is more. The storage and the transmission of images is the important one nowadays because of its advantages. Hence the compression of images are important while transmission and storage. In this paper we propose a hybrid effective technique to compress the image in an effective manner without losing the data. Let I be the image of RGB colorspace with dimension of $M \times N$ where $0 \le m \le M-1$ $0 \le n \le N-1$ which is to be compressed.



Initially the image I is in RGB colorspace is converted to gray scale image in which the image is to be compressed. The following equation details the conversion process of RGB colorspaced image to the gray scale image.

$$I_{gy} = 0.2989 * I_r + 0.5870 * I_g + 0.1140 * I_b \quad (1)$$

Here I_r, I_g and I_b be the red, green and blue contribution of the image I_{gy} is the gray scale image obtained by the aforesaid equation which is the Craig's formula for RGB to gray color conversion. After the conversion of RGB to gray scale image I_{gy}, it is applied with the Gaussian filter which is applied for the denoising process.

$$f\,(u,v) = e^{\frac{-(u^2+v^2)}{2\sigma^2}} \quad (2)$$

Where

$$f_g(u,v) = \frac{f(u,v)}{\sum_u \sum_v f} \quad (3)$$

The eqn (2) and eqn (3) are the Gaussian filter which may utilized for the denoising process. This Gaussian filter returns a rotationally symmetric Gaussian lowpass filter of size $[u,v]$ with standard deviation sigma (positive). After denoising the image using the Gaussian filter the denoised image I_{de} is obtained. Subsequent to this process, the Discrete Wavelet Transform (DWT) which is discrete 2D wavelet transform. DWT is based on sub-band coding is utilized to defer a fast computation of wavelet transform. DWT reduces the computational time and resources required and it is easy to implement this DWT. The following details the DWT process on the images and the following eqn details the 2D DWT process.

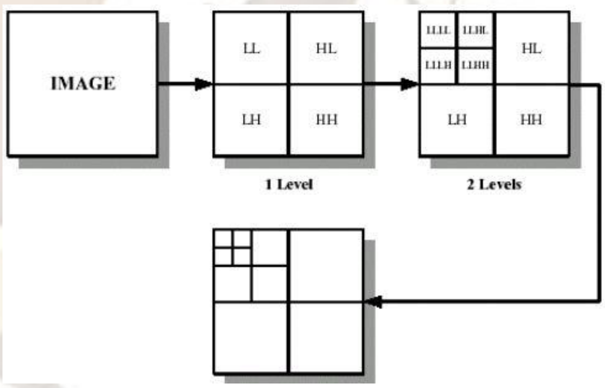


Figure 2 2D DWT for image

$$H_t = \sum_{t=o}^{k-1} I_{de_{2x-t}} * S_t(z) \quad (4)$$

$$L_t = \sum_{t=o}^{k-1} I_{de_{2x-t}} * p_t(z) \quad (5)$$

These are the high pass and low pass coefficients for the 2D DWT transform and the DWT coefficient vector is $\hat{D}_{co}$. Subsequent to this process the finite ridgelet transform is applied on these coefficients.
After obtaining these coefficients the image is then applied with the finite ridgelet transform which is detailed in the steps below

Input: $\hat{D}_{co}$ DWT coefficient vector, number of decomposition level
Output: Ridgelet coefficients, normalized mean value
Steps

1. Resize the vector to $p \times p$ the prime number
2. Compute the mean μ of $\hat{D}_{co}$
3. $\hat{D}_{co} = \hat{D}_{co} - \mu$
4. Normalize the mean value $\mu = p * \mu$
5. Compute the finite radon transform $\hat{r}$
6. Apply wavelet transform on the radon transform $\hat{r}$

Now the FRIT coefficients $\hat{r}$ has been obtained now the compressed image has been obtained. For decompression the image has been applied with the inverse finite ridgelet transform initially the $\hat{r}$ of ridgelet transform coefficient is applied with the inverse FRIT. In the inverse FRIT the $\hat{r}$ is transformed to the radon domain and then the inverse finite radon transform has been obtained for it.

$$\hat{D}_{co} = \hat{D}_{co} + \mu / (sizeof(\hat{r}) - 1) \quad (6)$$

After that the inverse DWT has been applied on the image to obtain the original image of decompressed in size without losing of data. Hence our proposed hybrid technique compresses the image in an effective manner without degrading the image quality.

IV. Results and Discussion

The proposed hybrid technique to compress the image has been implemented in the working platform of MATLAB (version 7.10). Initially the image is converted to the gray scale conversion and then the image is denoised with the Gaussian filter. Then the DWT is applied on the denoised image then the finite ridgelet transform is applied on the obtained coefficients and then the compressed image applied with the inverse ridgelet transform and then the inverse DWT has been applied on the image. The proposed hybrid techniques have been tested on the standard images and the following results are obtained for the proposed method that is shown below.

Figure 3. Original image

Figure 4. DWT applied imag

Figure 5 Decompressed image

Input Image	PSNR for Proposed Method	PSNR for Ridgelet Transform
Lena	38.29281	20.37056
Baboon	33.38936	19.72939
Cameraman	36.07291	15.15914
House	42.09413	18.02169
Barbara	39.71284	19.58824

Table 1. PSNR comparison for proposed hybrid method and the ridgelet transform applied image

Input image	Original size	Decompressed size
Lena	9771	8867
Baboon	16418	13753
Cameraman	10057	9144
House	8089	7549
Barbara	10926	9144

Table 2 Size for original image and the decompressed image comparison

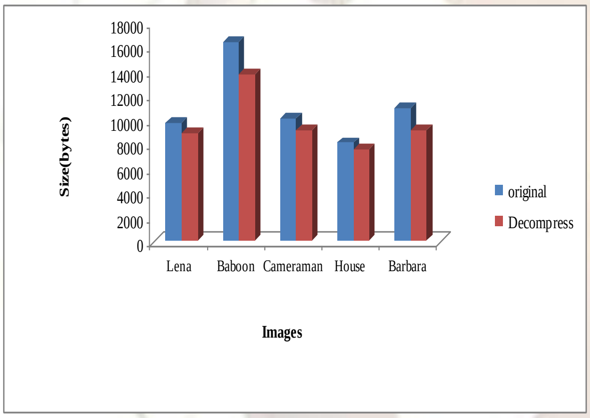
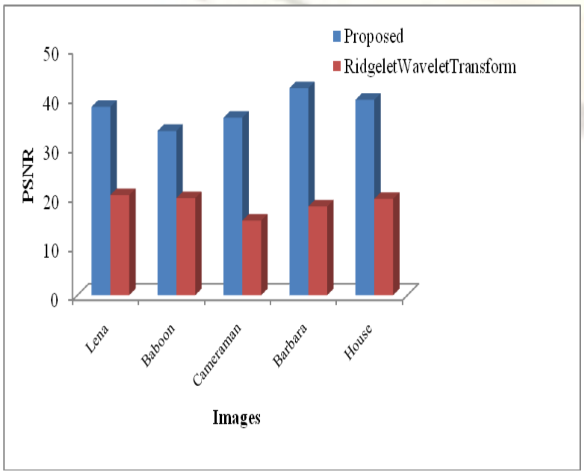


Figure 6 Graph for decompressed image size and original image size of Original and decompressed image



Figurre 7 Graph for proposed PSNR and ridgelet transform PSNR

Figure 3 shows the original image and the image Figure 4 shows the DWT applied image and the figure 4 shows the decompressed image without degrading the quality. Table 1. Shows the PSNR comparison table for the proposed hybrid technique and the ridgelet transform and the corresponding graph is shown in the Figure 7. Table 2 shows the size comparison for the original image and the decompressed image.

V.Conclusion:

In this paper, an effective hybrid technique to compress the image by means of a hybrid combination of wavelet-ridgelet techniques is proposed. Initially, the original RGB colorspaced image is converted to the grayscale image and then the image is denoised using the Gaussian filter. Subsequently, the image is transformed first using DWT and then using FRT. Now the compressed image has been obtained and after that the inverse FRT transform is applied. Then finally, the inverse DWT transform is applied and the decompressed image is obtained.

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