Image Compression Algorithm Using Wavelet Packet Tree on Human Perception

Prof G. K. Kharate, K.K.Wagh Institute of Engineering Education and Research, Nashik – 422003, (MH) India and Dr. A. A. Ghatol, Vice-Chancellor, Dr. Babasaheb Ambedkar Technological University, Raigad (MH), India and Dr. Mrs. P.P. Rege, Professor, Pune Institute of Engineering and Technology, Pune (MH), India.

Abstract

Recently Discrete Wavelet Transform (DWT) has emerged as popular technique for image compression. DWT has high decorrelation and energy compact efficiency. In wavelet technique, the image is decomposed into approximation, vertical details, horizontal details and diagonal details. The approximation is a low frequency of an image. The most of the natural image has maximum low frequency components. By defining the threshold the high frequency components, which has negligible effect on overall image, are removed from the image. In multilevel wavelet the image is decomposed into multiple levels and the high frequency component is separated out. We suggest the new technique to calculate the threshold on the basis of human perception and construct the wavelet packet. This paper includes the experimental results and proposed algorithm. Proposed algorithm could give high compression ratio with good quality of image.

Keyword: adaptive, Human Visual perception, irrelevancy, redundancy, Wavelet.

Introduction

Compression of digital image has been a topic of research from many years' and a number of image compression standards have been created for different applications. The role of compression is to reduce bandwidth requirements for storage of all forms of data. Even though the new technology provides high-speed digital communications and large memories, the image compression still has major importance. Recently digital discrete wavelet transform (DWT) based image coding methods have gained popularity during the last decade. This is because of localization properties of wavelets in both time and frequency.

In wavelet technique, the image is decomposed into approximation, vertical details, horizontal details and diagonal details. The approximation is a low frequency component of an image. The most of the natural image has maximum low frequency components and few percentages of high frequency components [1, 3].

The key problem of lossy image compression is to optimize the trade off between a high compression ratio and good quality of the reconstructed image [5, 6, 7]. However, it is difficult to define quantitative parameters to evaluate the quality of the reconstructed image. As the human eye is more sensitive to some spatial frequencies and errors are more annoying in gray areas of the images, it is reasonable to look for a quality assessment, which takes into consideration some features of the human visual perception [4, 7]. More over these features could improve the compression technique itself. If properly used in algorithm to reduce data.

In this paper we suggest novel algorithm for wavelet on the basis of nature of image. At first level of decomposition the high frequency components are removed from the image directly because human visual system is less sensitive to high frequency signal. After second level decomposition as per nature of the image further decomposition takes place.

This paper is organized as follows. In section 2, brief review basic principle of compression is presented, in section 3 wavelet transform is presented, section 4 visual perception, section 5 details of proposed algorithm is presented, section shows experimental details, section 6 conclusion.

The key problem of lossy image compression is to optimize the trade off between a high compression ration and good quality of reconstructed image [7]. However it is difficult to define a quantitative parameter to evaluate the quality of the reconstructed image. As the human eyes are more sensitive to some special frequencies and errors are more annoying in gray areas of the image, it is responsible to look for a quality assessment which takes into consideration some futures of the human visual perception [7] moreover these futures could improve the compression technique itself if properly used in the algorithm to reduce data.

Basic Principle of Image Compression

A common characteristic of most of images is that the neighboring pixels are correlated, that is, image contains the redundant information. Therefore most important task is to find a less correlated representation of image. The fundamental components of compression are reduction of redundancy and irrelevancy. Redundancy reduction aims at removing duplication from the image. Irrelevancy reduction omits parts of the signal that will not be noticed by the signal receiver namely the human visual system (HVS). In general, three types of redundancies can be identified: Spatial redundancy, Spectral redundancy and temporal redundancy. In still image, the compression is achieved by removing spatial redundancy and Spectral redundancy. The lossless and lossy are the two types of compression techniques. In lossless method, the original signal is perfectly constructed. Lossless methods rely on the model of probability of the data string to reduce the data volume by using customized representation of the information content. Applications include program file or text where the data must be preserved exactly. In lossy compression, methods are applied which extract the essential information from the original and discard the remainder. The extracted information is coded compactly. The compression ratio for the lossy technique is much more higher than the lossless technique.

Wavelet Transform

Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. The basic idea of the wavelet transform is to represent any arbitrary signal 'S' as a superposition of a set of such wavelets or basis functions. These basis functions are obtained from a single photo type wavelet called the mother wavelet by dilation (scaling) and translation (shifts).

The discrete wavelet transform for one-dimensional signal can be defined as follows.

$$c(a,b)=\int_R s(t)\frac{1}{\sqrt{a}}\Psi\frac{(t-b)}{a}dt \qquad (1)$$

The indexes c (a, b) are called wavelet coefficients of signal s(t), a is dilation and b is translation, $\Psi(t)$ is the transforming function, the mother wavelet. It is so called because the wavelet derived from it analyzes signal at different resolutions (1/a). Low frequencies are examined with low temporal resolution while high frequencies with more temporal resolution.

A wavelet transform combines both low pass and high pass filtering in Spectral decomposition of signals.

Orthogonal Discrete Wavelet Transform

In case of orthogonal discrete wavelet transforms (DWT), the image is decomposed into a discrete set of wavelet coefficients using an orthogonal set of basis functions. Haar basis is first orthonormal wavelet basis developed in 1910. Several other orthonormal wavelet bases have been constructed. These bases share the best features of both the Haar basis and Shannon basis; that is, these new base have excellent localization properties both in time and frequency. We will list a few of them here. For example, in 1982, Stromberg constructed bases, which have exponential decay in time and frequency. In 1985, Mayer constructed a base in which $\Psi(\omega)$ is compactly supported in the frequency domain. In 1987, Tchamitchain constructed the first example of biorthogonal wavelet bases. In 1987 and 1988, constructed identical families of orthonormal wavelets bases with exponential decays. In 1989, Daubechies constructed a new family of compact supported wavelets and Coifman constructed a family of symmetrical wavelets.

Proposed Technique

In order to improve the quality of reconstructed image in lossy compression scheme, a possible strategy is used a human perception mechanism to condition the process of data reduction [10]. The human observer is the final user of the compression-decompression algorithms. Human eye is less sensitive for the high frequency signals. Considering this factor algorithm is suggested.

- Initial image is decomposed using the mother wavelet db25,
- High frequency coefficients are directly neglected
- Reconstruct the image from the approximation coefficient cA and define as a image X.
- Further decomposition of image X is taken using the mother wavelet db4.
- The energy of detail coefficients is compared with energy of approximation coefficient. If it is less than 0.1 percent corresponding components are neglected

Threshold is calculated on the basis of human perception and wavelet packet using constructed using threshold entropy. The following parameters are considered to find the threshold.

- Level of decomposition
- Contain of energy
- Type of wavelet use for decomposition

The threshold is adaptive; its value is a function of nature of image.

- For high frequency and low energy component the threshold value is high
- For low frequency and more energy component the threshold value is low.

Experimental Results

We implemented the proposed algorithm. It is tested on standard 256 × 256 colour images; wbarb, woman, leena, wmandril and horizontal, vertical and diagonal line constructed images. Results are observed in terms of percentage of zeros, percentage of energy retained and signal to noise ratio. The best results are presented in paper.

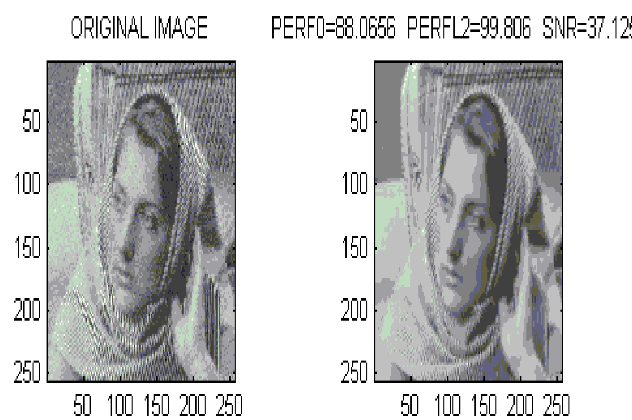

Figure 1 Original Image and result of proposed algorithm

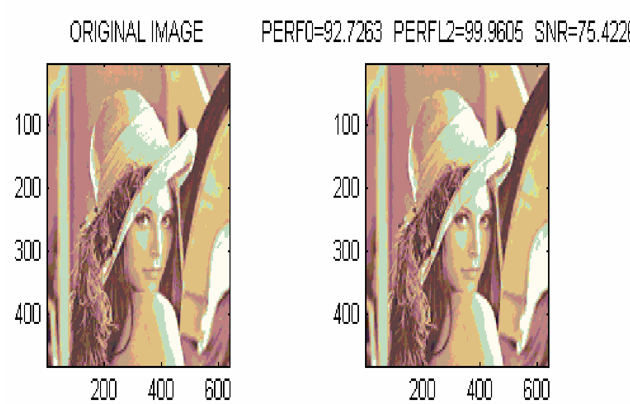

Figure 2 Original Image and result of proposed algorithm

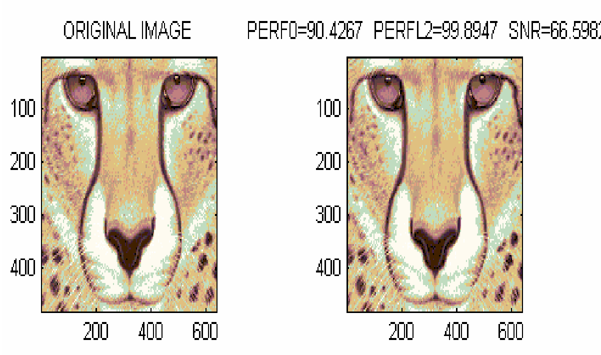

Figure 3 Original Image and result of proposed algorithm

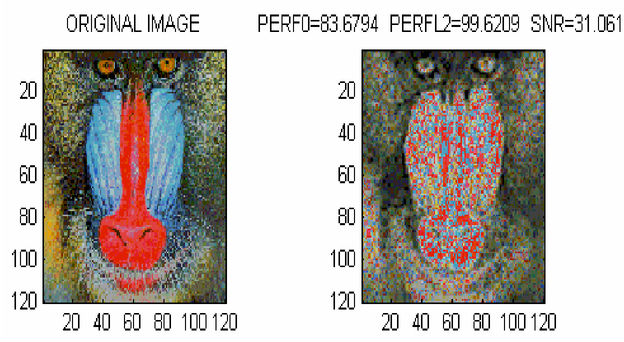

Figure 4 Original Image and result of proposed algorithm

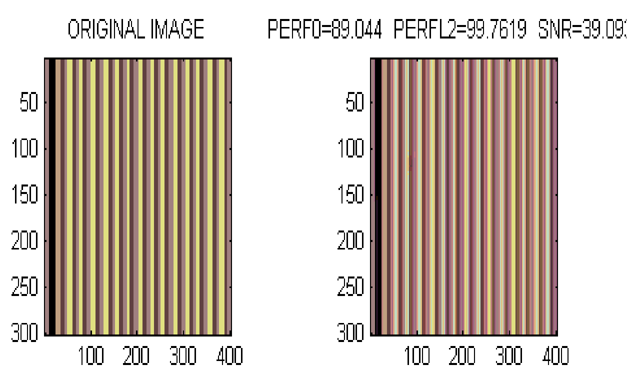

Figure 5 Original Image and result of proposed algorithm

The table shows the comparison of standard decomposition method with proposed results for different images.

Table 1: Comparison with standard methods

Name of The images	Result for standard method		
	Percentage of zeros	Percentage of Energy in retained	SNR in db
wbarb	89.58	99.00	51.92
woman	82.39	99.55	51.27
mandrilla	65.28	99.42	49.94
lena	91.19	99.93	72.89
chitta	88.56	99.87	65.34
horizantal	91.44	99.96	80.73
vertical	85.99	99.84	63.16
diagonal	82.77	99.96	78.18

Table 2: Results of methods

Name of The images	Result for Proposed method		
	Percentage of zeros	Percentage of Energy in retained	SNR in db
wbarb	90.97	99.81	43.37
woman	88.06	99.80	37.12
mandrilla	83.67	99.62	31.06
lena	92.72	99.96	75.42
chitta	90.42	99.89	66.59
horizantal	92.46	99.94	46.90
vertical	89.04	99.76	39.09
Diagonal	85.35	99.94	41.63

Conclusion

In this paper new algorithm based on irrelevant and redundancy reduction has been presented; input image is first decomposed using db_{25} and high frequency components are neglected. On the basis of energy content some of the components are directly neglected and quantization of other components based on adaptive threshold takes place. From the result it is observed that by using the defined algorithm the percentage of zero is increased 4 to 5 percent with comparable quality.

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Author Biography

G. K. Kharate is postgraduate in Electronics Engineering. He is working as a Professor and Head of Information Technology Department at Karmaveer Kakasaheb Wagh Institute of Engineering Education & Research, Nashik,(MH, India)since 1987. Currently he is perusing his Ph.D. programme at University of Pune in area of Image Compression. He is a Chairman of Board of Studies of Electronics in University Pune. He has presented and published more than 10 papers in National/ International Conferences/ Seminars and Journals. He has authored various books in the field of Electronics Engineering.