iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** VII **Month of publication:** July 2015

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Perceptual Colour Image Compression

Anish Kumar K[1], Sreeleja N Unnithan[2]
[1,2]Electronics and Communication Department, Calicut University

Abstract— Perceptual coding technique discriminate the signal components which are detected and not detected by the human eye. There are a number of well accepted perceptual factors which influence the visibility of distortions in an image. This factors are used in the image compression schemes to obtain a better visual quality compressed image with improved compression. A perceptual compression of RGB colour image employing DWT is done here, which uses Contrast Sensitivity Function curve as the perceptual factor at the quantization stage. Initially RGB colour image is mapped to YCbCr component by irreversible component transformation and then DWT is applied to each component separately. Quantization is done to each component. Quantization step required for luminance component is determined by using Contrast Sensitivity Function curve. Huffman and Run-length encoding is done to the quantized components to achieve further compression. Thus by adopting the properties of the Human Visual System at the quantization stage of the compression a better visible quality compressed image can be obtained.

Keywords— Contrast Sensitivity Function (CSF), Discrete Wavelet Transformation (DWT), Human Visual System(HVS), Huffman encoding, RLE.

I. INTRODUCTION

The space requirements and the image transmission problem have led to a strong demand for a good image compression technique that maximizes compression while maintaining quality. Compression can be achieved by removing unnecessary information about the images. Every image compression technique undergoes the process of domain transformation, quantization and the coding. Compression can restore the exact information (Lossless methods) or introduce a little distortion (lossy methods). Lossless compression technique aims at the exact reconstruction of the original images. This can be done if only redundant information is discarded. They have weak compression ratio but benefit from an exact reconstruction of the image. The purpose of lossy image compression is to minimize the number of bits needed to represent an image without introducing higher degradation [1]-[2].Compression can also be classified into predictive coding and transform coding. In predictive coding, information already sent or available is used to predict future values, and the difference is coded. Since this is done in the image or spatial domain, it is relatively simple to implement and is readily adapted to local image characteristics. Differential Pulse Code Modulation (DPCM) is one particular example of predictive coding. Transform coding, on the other hand, first transforms the image from its spatial domain representation to a different type of representation using some well known transform and then codes the transformed values (coefficients). This method provides greater data compression compared to predictive methods, although at the expense of greater computation. Transform coding such as JPEG and JPEG2000 are examples of lossy processing methods. When the receiver is human eye, lossy data is allowed, because human eye can tolerate some imperfection in information [3].

A linear transformation is applied to minimize redundancy in the images since it can decorrelate pixel values in the transform domain. The DWT is used to decompose an image into several subbands, each having different spatial frequency and orientation. A colour image which has three colour components (red, green, and blue) is typically transformed to an image with one luminance component (Y) and two chrominance components (Cb and Cr) for improved compression performance. Each component is then independently transformed to the wavelet domain by the DWT.

The main objective of the image compression is to achieve high compression ratio retaining the visual quality of the image. It implies a distinction between the visible and invisible information contained in an image. This distinction is done by the exploitation of a human visual model incorporated within the compressive process, precisely at the quantization stage. The key element of such a model is the Contrast Sensitivity Function (CSF). This function describes the human visual sensitivity to different spatial frequencies by varying their contrast. The exploitation of the CSF at the quantization phase improves the visual quality of the compression significantly. Once the compression is done, the compression achieved can be measured from the compression ratio(CR) and the quality of the reconstructed image is calculated from the mathematical quality metric peak signal to noise ratio(PSNR)[4].Compression ratio is the ratio between the original image and the compressed bits.

This paper is organized as follows: Section II explains the HVS , Contrast sensitivity function and its relation to DWT subbands,

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Section III discusses the compression scheme and section IV the simulation results. Finally, the conclusions are briefed in Section V.

II. CSF AND DWT

A. CSF

Human visual system (HVS) research offers mathematical models of how humans see the world around them. For example, models have been developed to characterize human's sensitivity to brightness and colour. One of the most important property of the HVS system is that the sensitivity reduces to the high frequency spacial structures. The contrast sensitivity function (CSF) describes human's sensitivity to spatial frequencies [6].A model of the CSF for luminance (or greyscale) images is given by[7]

$$CSF(f) = 2.6(0.0192 + .114f)e^{-(.114f)^{1.1}} \quad (1)$$

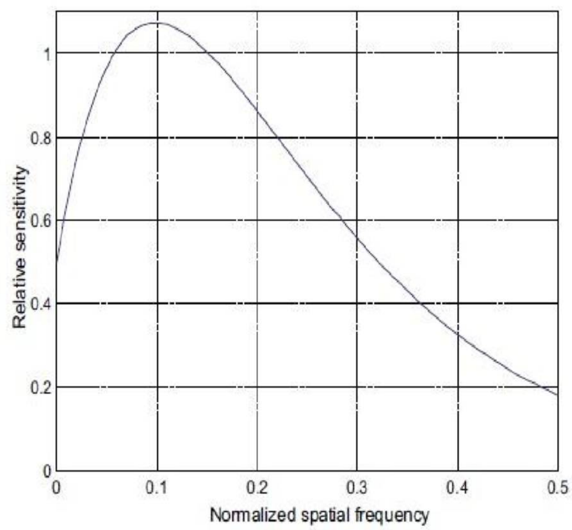

Fig.1 Luminance Constrast Sensitivity Function.

Fig.1 depicts the CSF curve, it characterizes luminance sensitivity of the HVS as a function of normalized spatial frequency. The CSF is a band pass filter: the HVS is most sensitive to middle spatial frequencies, and less sensitive to very low and very high frequencies.

B. DWT

Wavelets are signals which are local in time and scale and generally have an irregular shape. A wavelet is a waveform of effectively limited duration that has an average value of zero. The term wavelet comes from the fact that they integrate to zero, they wave up and down across the axis. Many wavelets also display orthogonality which is a property ideal for compact signal representation .This property ensures that data is not over represented. A signal can be decomposed into many shifted and scaled representations of the original mother wavelet.[7][8]

Discrete Wavelet transforms (DWT) converts spatial domain information to frequency domain information. The DWT is computed by passing the image signal through successive low pass and high pass filters. When a signal passes through the filters, it is separated into two bands. The low pass filter, which corresponds to an averaging operation, extracts the coarse information of the signal. The high pass filter, which corresponds to a differencing operation, extracts the detail information of the signal. The output of the filtering operations is then decimated by two. A 2-dimensional transform can be carried out by performing two separate one-dimensional transforms. First, the image is filtered along the x direction and decimated by two. Then, it is followed by filtering the sub-image along the y-direction and decimated by two. Finally the image is splitted into four bands denoted by LL, HL, LH and HH after one-level decomposition. Figure 2 shows a single-level 2-D wavelet decomposition, in which four wavelet sub bands are generated from the input image and labelled as LL, LH, HL, and HH, respectively, where L means low pass filtering and H means high pass[9].Further decompositions can be achieved by acting upon the LL sub band successively and the resultant image is split into multiple bands. A 5 level DWT of an image results into 16 frequency sub bands. Fig 3. shows the layout of the 5 level DWT image.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

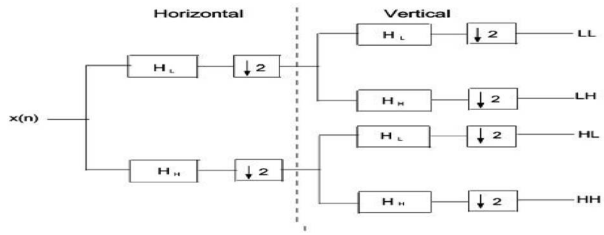

Fig 2. Structure of a single-level 2-D subband decomposition system

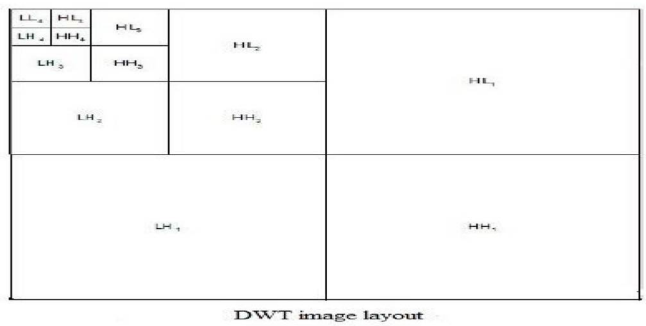

Fig 3. Layout of DWT image.

III. COMPRESSION SCHEME

The compression by Discrete Wavelet Transforms (DWT) is accomplished with a quantization and an entropy encoder. The RGB colour image is first converted into an image with one luminance component (Y) and two chrominance components (Cb and Cr) by the irreversible colour transform (ICT).Then a 5 level DWT is applied to each components individually. The wavelet used in this work is Daubechies. When an image has been processed with the DWT, the total number of transform coefficients is equal to the number of samples in the original image, but the important visual information is concentrated in a few coefficients. To reduce the number of bits needed to represent the transform, all the subbands are quantized. To the two chrominance components quantization value is determined by the statistical modelling of the quantization distortion[5].

For the luminance component quantization is done by considering the Contrast sensitivity function. The quantization factors are inversely proportional to the sensitivity average of the HVS on the frequency band related to each subband of the wavelet transform. Indeed, every subband of the wavelet transform occupies an interval on the spatial frequencies. Therefore, we compute the average of the CSF on every interval of the spatial frequency. A band-average CSF mask gets its weights directly from the CSF curve in the normalized spatial frequency domain. For a five level wavelet decomposition of the image, the band average CSF mask is a 6-weight mask. Each CSF weight is computed as the average of the CSF curve in its corresponding frequency band. Then the CSF quantization value is the inverses of these weights. Then they are normalized so that the smallest of these factors is equal to 1.Quantization of the coefficients are done using a dead-zone quantizer. The coefficients which are less than the quantization value are replaced by zero and the remaining are quantized based on the formula

$$qj(m,n) = sign(yj(m,n))\left(\frac{Wj(m,n)}{\Delta j}\right) \qquad (2)$$

where $W_j(m,n)$ is a DWT coefficient of pixel position m,n in subband j and Δ_j is the quantization value for the subband j. Quantization value for the luminance components and the chrominance components are given in the table I.

Subband	Y	Cb	Cr
HH1	7.655	24.72	15.49
HL1	7.655	14.50	6.35
LH1	7.655	14.50	6.35
HH2	1.165	14.77	7.40
HL2	1.165	6.36	2.60
LH2	1.165	6.36	2.60

HH3	1.09	11.55	2.57
HL3	1.09	4.03	1.23
LH3	1.09	4.03	1.23
HH4	1	4.93	1.25
HL4	1	3.26	.69
LH4	1	3.26	.69
HH5	1.322	1.05	.56
HL5	1.322	1.05	.58
LH5	1.322	1.05	.58

Table I. Quantization values for YCbCr components.

After the quantization applied to each of the subbands of luminance and chrominance components an entropy coding is done. The coding adopted here is huffman coding which is a lossless coding technique. Huffman coding codes the pixels based on the probability of its occurrence. It is a variable length code whose length is inversely proportional to the frequency of occurrence of coefficients. Huffman coding consist of two passes, first pass accumulates the coefficient frequency and generate codebook. Second pass does compression with the codebook. The DWT subbands are divided into different blocks of size 16*16 and then to the each block of coefficients huffman coding is done.

In order to achieve further compression, Run-length encoding is done. Run-length encoding (RLE) is a very simple form of data compression in which runs of data (that is, sequences in which the same data value occurs in many consecutive data elements) are stored as a single data value and count, rather than as the original run. This is most useful on data that contains many such runs.

IV. SIMULATION RESULTS

Colour images are compressed using both conventional and proposed CSF quantization method. Since we used 5 level DWT decomposition the original image is decomposed into 16 subbands of different frequencies. The original and 5 level decomposed image of bike is shown in the Fig.4 and fig.5 respectively. The compression ratio and the peak signal to noise ratios are used as the quality metrics to measure the extend of compression. The obtained peak signal to noise ratio and compression ratio in percentage of the reconstructed image using CSF quantization method is 81.86 and 34.49(dB) respectively which is better than the conventional method. The Fig.6 shows the reconstructed image using conventional quantization method and Fig.7 the reconstructed image using proposed method. The results for different images are obtained and compared with the conventional method which is shown in the table II. From the table we can see that the proposed CSF based scheme gives a better PSNR and compression than conventional method.

Subjective analysis of the proposed method is done with 25 people. The reconstructed images of both conventional and proposed methods are shown simultaneously to them and feedback is taken. The proposed method gives better result.

Fig 4. Original image

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

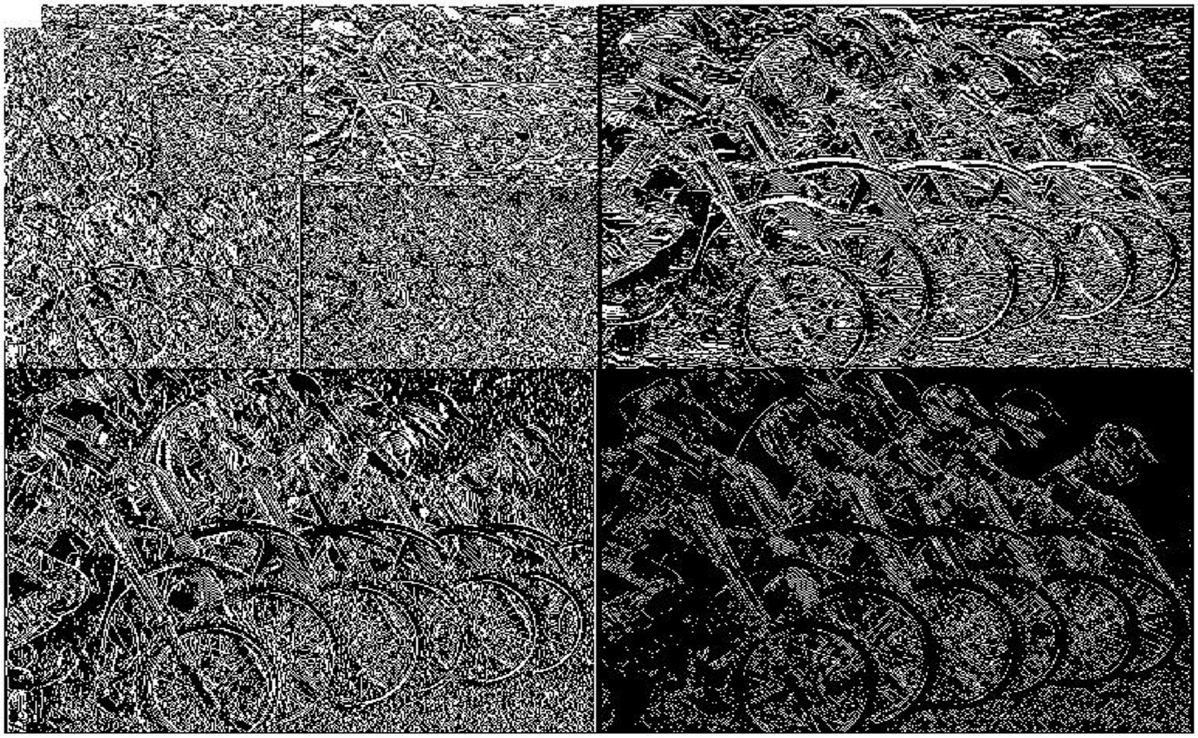

Fig 5. 5 level DWT luminance decomposition

Fig.6. Reconstructed image with conventional quantization method

Volume 3 Issue VII, July 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Fig 7. Reconstructed image with proposed CSF quantization method

Images	Conventional scheme		Proposed scheme	
	CR	PSNR	CR	PSNR
Bikes	72.62	33.42	81.86	34.49
Garden	70.20	31.99	78.50	32.83
Tiger	75.68	34.97	85.30	36.39
Bricks	70.76	32.84	80.74	33.60
Fort	77.80	36.03	87.37	37.97
Trees	78.64	38.55	88.29	40.32
Books	80.10	36.54	90.23	37.97

Table II. Shows the CR and PSNR for conventional and proposed method

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

V. CONCLUSION

A colour image compression scheme which adopts CSF at quantization stage of the luminance component is performed here. Huffman and RLE encoding are adopted as a lossless compression scheme to achieve further compression .The PSNR(peak signal to noise ratio) and compression ratios of different reconstructed images are measured for quantitative performance analysis. This method gives a better compression and visual quality than the conventional method which does not uses the HVS.

Thus with the adoption of properties of the human visual system we can improve the visual quality of the reconstructed image. Instead of DWT contourlet transform can be applied to get better result.

VI. ACKNOWLEDGMENT

The author would like to thank all the teaching and non-teaching staffs of Electronics and Communication Department, NSS College of Engineering, Palakkad for their timely guidance and motivation for preparing this paper.

REFERENCES

[1] Mridul Kumar Mathur, A Comparative Study of Various Lossy Image Compression Techniques International journal of engineering research and technology ISSN: 2278- 0181

[2] M. Kaur and G. Kaur, Survey of Lossless and Lossy Image Compression Techniques, International Journal of Advanced Research in Computer Science and Software Engineering, vol. 3, no. 2, pp. 323-326, February 2013.

[3] Sherin Jabbar and Shaiju Panchikkil Lossy compression schemes based on transforms-A literature survey International Journal of Advanced Information Technology (IJAIT) Vol. 2, No.6, December 2012

[4] Michael P. Eckert Andrew P. Bradley, Perceptual quality metrics applied to still image compression Signal Processing 70 (1998)

[5] Han Oh, Ali Bilgin, Senior Member, IEEE, and Michael W. Marcellin, Visually Lossless Encoding for JPEG2000 IEEE transactions on image processing, vol. 22, no. 1,2013

[6] Han oh, Ali Bilgin and Michael W Marcellin Visibility thresholds for quantization distortion in jpeg2000, 2009 IEEE

[7] Fahmi Kammoun, and Mohamed Salim Bouhlel, A Perceptual Image Coding method of High Compression Rate World Academy of Science, Engineering and Technology International Journal of Computer, Information, Systems and Control Engineering Vol:1 No:9, 2007

[8] M. Mozammel Hoque Chowdhury and Amina Khatun, Image Compression Using Discrete Wavelet Transform, IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 4, No 1, July 2012

[9] Zhigang Gao, Member, IEEE, and Yuan F. Zheng, Fellow, IEEE, Quality Constrained Compression Using DWT Based Image Quality Metric, IEEE transactions on circuits and systems for video technology, vol. 18, no. 7, july 2008

[10] Clifford Lui A Study of the JPEG-2000 image Compression Standard Queen's University Kingston, Ontario, Canada May 2001

[11] S. G. Mallat, A theory for multiresolution signal decomposition: The wavelet representation, IEEE Trans. Pattern Anal. Mach. Intell., vol. 11, no. 7, pp. 674-693 , Jul. 1989.