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Performance Analysis of Fuzzified JPEG2k Color Image Compression using RBG Color Model

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Abstract: *Rapid growth in modern communication demands the direct transmission and storage of Multichannel images ie. Color images. This arises the need of effective and standardized Multichannel image compression technique. The aim of this paper is to develop and implement an algorithm for compression of multichannel image ie color images as well as to speed up the compression of multichannel images with high compression. This paper presents a method of implementation of available JPEG2k technique for multichannel (ie. Color) image compression using, fuzzified JPEG2k with RGB Color Model. The proposed algorithm first divides the multichannel image into its consecutive single channel components, and then single channel JPEG2k image compression is applied over each single channel component separately followed by image fuzzification. This leads to the effective solution of the development of multichannel image compression.*

Image compression using JPEG2k is based on discrete wavelet transform. In wavelet transform level of decomposition is a very important parameter, because it plays a crucial role during compression processes. Hence to deploy this dependency, a complete performance analysis of fuzzified JPEG2k for image compression is presented in this paper.

Keywords: *Discrete Wavelet transform, JPEG2K, color image compression, RGB color model, Fuzzy image processing.*

1. Introduction

Image compression addresses the problem of reducing the amount of data required to represent a digital image .The underlying basis of the reduction process is the removal of redundant data. From a mathematical viewpoint, this is a process of transforming a 2-D pixel array into a statistically uncorrelated data set .The transformation is applied prior to storage or transmission of the image [1].

Currently image compression is recognized as an "enabling technology". In addition to the areas just mentioned, image compression is the natural technology for handling the increased spatial resolution of today's imaging sensors and evolving broadcast television standards. Furthermore image compression plays a major role in many important and diverse applications, including tele-video-conferencing, remote sensing (the use of satellite imagery for weather and other earth resource applications), document and medical imaging facsimile transmission (FAX) [2],[3], and the control of remotely piloted vehicles in military, space and hazardous waste management applications.

2. Image Compression using Discrete Wavelet Transform

Wavelet Transform has become an important method for image compression. Wavelet based coding provides substantial improvement in picture quality at high compression ratios mainly due to better energy compaction property of wavelet transforms.

Wavelet transform partitions a signal into a set of functions called wavelets. Wavelets are obtained from a single prototype wavelet called mother wavelet by dilations and shifting. The wavelet transform is computed separately for different segments of the time-domain signal at different frequencies.

2.1 Sub Band Coding

A signal is passed through a series of filters to calculate DWT. Procedure starts by passing this signal sequence through a half band digital low pass filter with impulse response h(n).Filtering of a signal is numerically equal to convolution of the tile signal with impulse response of the filter.

$$x[n] * h[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k] \quad (1)$$

A half band low pass filter removes all frequencies that are above half of the highest frequency in the tile signal. Then the signal is passed through high pass filter. The two filters are related to each other as

$$h[L-1-n]=(-1)^n g(n) \quad (2)$$

Filters satisfying this condition are known as quardature mirror filters. After filtering half of the samples can be eliminated since the signal now has the highest frequency as half of the original frequency. The signal can therefore be sub sampled by 2, simply by discarding every other sample. This constitutes 1 level of decomposition and can mathematically be expressed as

$$y_1[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k]$$

$$y_2[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n+1-k] \quad (3)$$

Where y1[n] and y2[n] are the outputs of low pass and high pass filters, respectively after sub sampling by 2. This decomposition halves the time resolution since only half the number of sample now characterizes the whole signal. Frequency resolution has doubled because each output has half the frequency band of the input. This process is called as sub band coding. It can be repeated further to increase the frequency resolution as shown by the filter bank.

2.2 Compression steps

1. Digitize the source image into a signal s, which is a string of numbers.

2. Decompose the signal into a sequence of wavelet coefficients w.

3. Use threshold to modify the wavelet coefficients from w to w'.

4. Use quantization to convert w' to a sequence q.

5. Entropy encoding is applied to convert q into a sequence e.

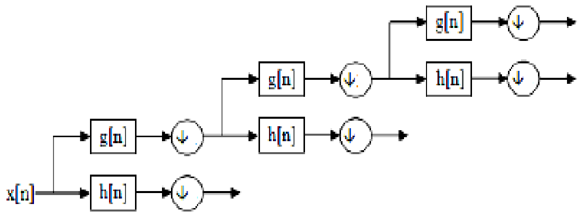

Figure (1) *Filter Bank*

2.2.1 Digitation

The image is digitized first. The digitized image can be characterized by its intensity levels, or scales of gray which range from 0(black) to 255(white), and its resolution, or how many pixels per square inch [9].

2.2.2 Thresholding

In certain signals, many of the wavelet coefficients are close or equal to zero. Through threshold these coefficients are modified so that the sequence of wavelet coefficients contains long strings of zeros. In hard threshold, a threshold is selected. Any wavelet whose absolute value falls below the tolerance is set to zero with the goal to introduce many zeros without losing a great amount of detail.

2.2.3 Quantization

Quantization converts a sequence of floating numbers w's to a sequence of integer q's. The simplest form is to round to the nearest integer. Another method is to multiply each number in w's by a constant k, and then round to the nearest integer. Quantization is called lossy because it introduces error into the process, since the conversion of w's to q's is not one to one function [9].

2.2.4 Entropy encoding

With this method, a integer sequence q is changed into a shorter sequence, with the numbers in e being 8 bit integers The conversion is made by an entropy encoding table. Strings of zeros are coded by numbers 1 through 100,105 and 106, while the non-zero integers in q are coded by 101 through 104 and 107 through 254.

3. FUZZY DOMAIN

Fuzzy set theory is useful in handling various uncertainties in computer vision and image processing applications. Fuzzy image processing is a collection of different fuzzy approaches to image processing that can understand, represent, and process the image. It has three main stages, namely, image fuzzyfication, modification of membership function values, and defuzzification.

Fuzzy image enhancement is based on gray level mapping into membership function. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image that are farther from the mean [6], [13].

3.1 Fuzzy Image Processing

Fuzzy image processing is not a unique theory. It is a collection of different fuzzy approaches to image processing. It is the collection of all approaches that understand, represent and process the images, their segments and features as fuzzy sets. The representation and processing depend on the selected fuzzy technique and on the problem to be solved [3], [4].

The basis for fuzzy logic is the basis for human communication. This observation underpins many of the other statements about fuzzy logic. Because fuzzy logic is built on the structures of qualitative description used in everyday language, fuzzy logic is easy to use. Fuzzy image processing has three main stages: image fuzzyfication, modification of membership values, and, if necessary, image defuzzification. Figure (2) shows the block diagram representation of Fuzzy Image processing.

The fuzzyfication and defuzzification steps are due to the fact that we do not possess fuzzy hardware. Therefore, the coding of image data (fuzzyfication) and decoding of the results (defuzzification) are steps that make possible to process images with fuzzy techniques. The main power of fuzzy image processing is in the middle step (modification of membership values).

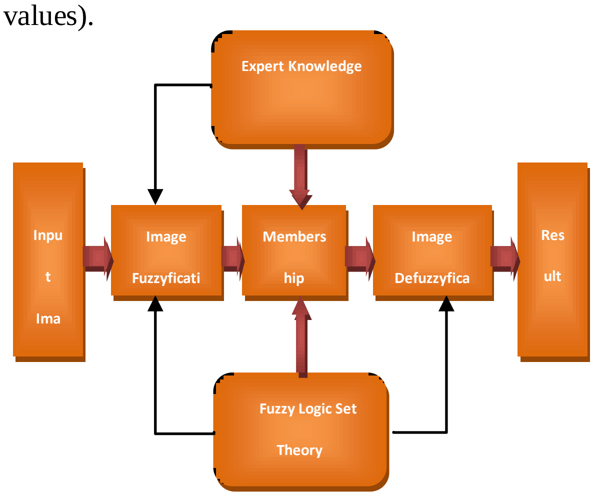

Figure (2) *Fuzzy Image processing.*

After the image data are transformed from gray-level plane to the membership plane (fuzzyfication), appropriate fuzzy techniques modify the membership values [16]. This can be a fuzzy clustering, a fuzzy rule based approach, and a fuzzy integration approach and so on.

4. METHODOLOGY

The proposed algorithm is based on the simple concept that, though the available JPEG2K is a single channel process, but we can convert it to multichannel by just dividing the multichannel image into its consecutive single channel components, and then the use of single channel Fuzzified JPEG2K over the each single channel components separately will leads to the solution of the development of multichannel Fuzzified JPEG2K ie multichannel image compression.

The developed algorithm of the paper is discussed below step by step with the help of flow graph shown in the figure (3).

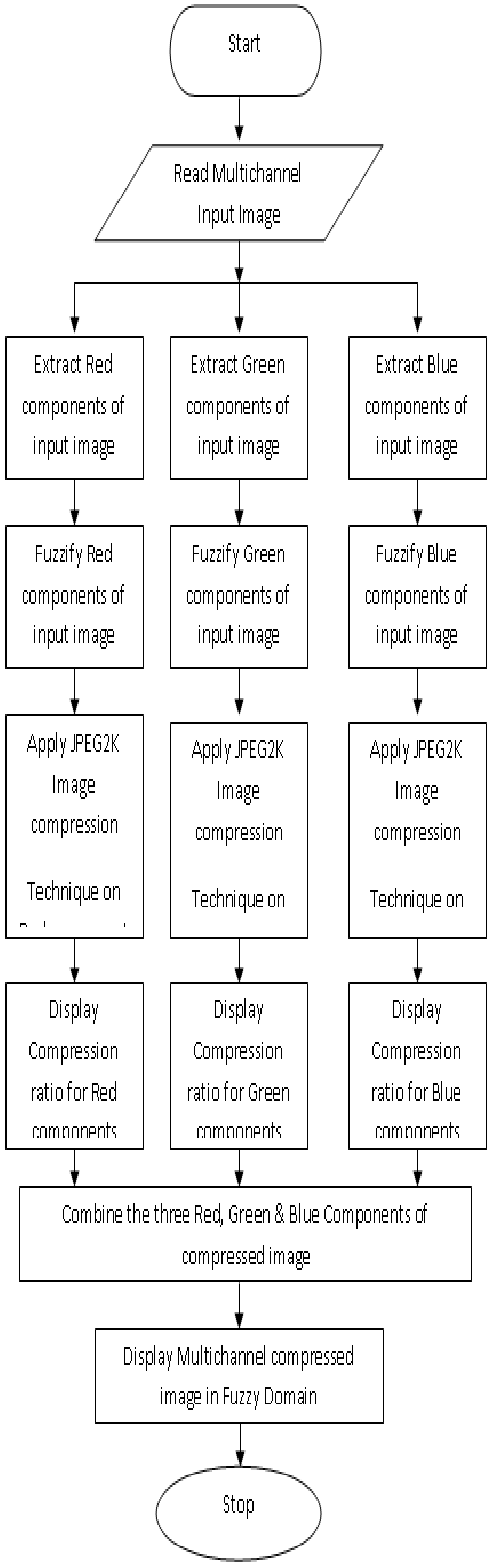

Figure (3) *proposed algorithm.*

5. Result & Discussion

The algorithm has been successfully developed and implemented in MATLB to develop an efficient multichannel image compression. Now we will show & discuss the various results obtained from the developed algorithm. Since it is not possible to evaluate the performance of any algorithm on the basis of single image, hence for the performance evaluation of the developed algorithm three different multichannel images has been used. These images are shown in figure (4), figure (5) and figure (6). To compare the results obtained from the developed algorithm two most important image compression parameters viz, are used.

1. Compression Ratio.
2. Mean Square Error.

To show the compression and decompression process by using developed algorithm on input image ie. autumn.tif. Whose size is 206X345 and memory requirement to store is 71070 bytes shown in figure (4). For the performance evaluation of developed algorithm on compression and decompression processes, the value of parameter N (levels of decomposition) is fixed to 5. The results obtained after the compression and decompression process are shown from figure (4.1) and figure (4.2).

Figure (4) *Input Image (autumn.tif), Size 206X345 and memory requirement to store is 71070 bytes*

Figure (4.1) *Compressed Image (autumn.tif), Size 206X345 and memory requirement to store is 67872 bytes*

Figure (4.2) *Decompressed Image (autumn.tif), Size 206X345 and memory requirement to store is 71070 bytes.*

The compression parameters obtained after input image compression and decompression process are as follows.

1	Bi (size of input image in bytes)	71070 bytes.
2	Bc (size of compressed image in bytes)	67872 bytes.
3	Bo (size of first decompressed image in bytes)	71070 bytes.
4	Cr (Compression Ratio)	23.1081.
5	M.S.E (Between original & decompressed Image)	11.0090

5.1 Effect of Parameter "N" On Image Compression Using Fuzzified JPEG2k

Up to this stage we have considered the JPEG2k parameter "N" as a constant. Now in this section we will discuss the effect of variation on decomposition levels "N" on the image compression processes, and for that we will show some statistical analysis, like the effect of "N" on compression ratio and Mean Square Error. To examine the effect of variation in N on compression ratio and error, let us again consider input image as shown in Figure (4). Now the resultant compressed and decompressed images for various values of N are shown below form Figure 4.3 to Figure 4.5.

From the Figure 4.3 to Figure 4.5, it has been clear that as we increase the parameter N the visual degradation will increase in resultant reconstructed images at the receiving end. The resultant parameters for image compression on the basis of variations in fuzzified JPEG2k parameter N are recorded in the Table (1).

Figure 4.3 *Decompressed image for N = 2.*

Figure 4.4 *Decompressed image for N = 6.*

Figure 4.5 *Decompressed image for N = 30.*

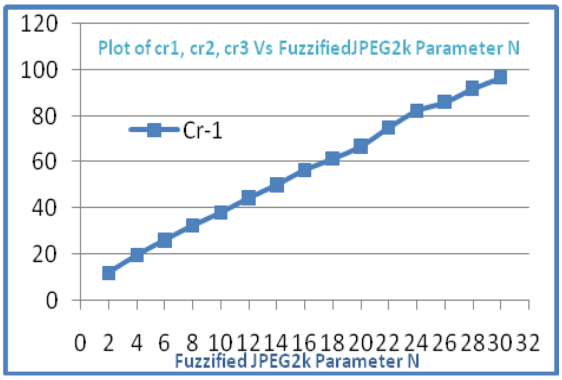

Figure4.6 *Plot of compression ratios Vs Parameter N.*

Table (1). *Effect of Variation in fuzzified JPEG2k Parameter N on Image Compression & Decompression*

S.No.	Parameter "N"	Cr	M.S.E
1	2	12.2026	17.8006
2	4	19.7224	26.6554
3	6	26.2924	32.642
4	8	32.5756	36.8707
5	10	38.1542	38.4482
6	12	44.482	44.1753
7	14	50.2203	46.0266
8	16	56.5856	50.9949
9	18	61.4095	50.2977
10	20	66.8217	59.2806
11	22	74.9056	78.7097
12	24	82.149	66.0126
13	26	85.7914	61.3866
14	28	91.7151	64.5248
15	30	96.3526	65.6618

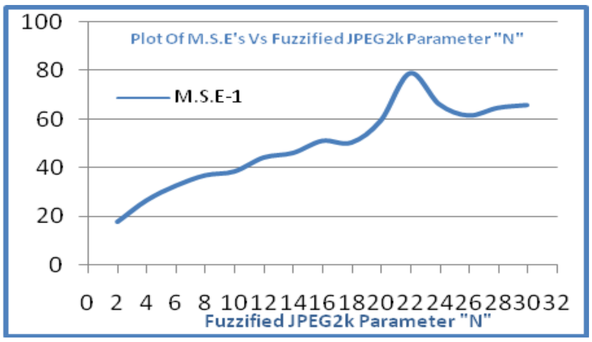

Figure 4.7 *Plot of Mean Square Error Vs Parameter N.*

6. CONCLUSION

In this modern era during transmission and reception, the image storage plays very important and crucial role. In the present scenario the technology development wants fast and efficient result production capability. This paper presented an algorithm for real time multichannel image compression especially for three channel ie. For color images. The developed algorithm is found very efficient for multichannel image compression. During the analysis it is found that, proposed algorithm provides high compression ratio as compare to simple JPEG2k. The advantage of the developed algorithm is, fuzzification performed before using JPEG2k because normal JPEG2k cannot able to handle imperfections presented in the input images. From Table (1) and the plots shown in Figure 4.6 and Figure 4.7, it can be observed that as we increase the value of N, though the compression ratio increases but simultaneously it increases the Mean Square Error also, hence there is a requirement of a suitable range of Fuzzified JPEG parameter N, which can provide high compression ratio with low Mean Square Error. From the Table (1) and plots the suitable range of parameter N for developed algorithm has been found as 4 to 18.

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