Comparative Analysis of Color Image Compression using Fuzzified Discrete Wavelet Transform and Normal Discrete Wavelet Transform with Nonlinear Membership Functions

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Abstract

The most important problem in the communication of images through any channel is the huge amount of data and space taken by the images. The amount of data increased if the image is color image; hence most often the images are compressed before transmission. The most commonly used techniques for image compression are discrete cosine transform based and Discrete Wavelet transform (DWT) based techniques. During the compression process of images the most important things are, the technique used must provide higher compression ratio with less error. In this regard DWT based technique is quite good to provide good compression ratio with less error, but it is still not capable to provide it. This paper presents a comparative analysis of color image compression ability of conventional DWT based technique and Fuzzified DWT based technique. For the development of Fuzzified DWT based color image compression technique nonlinear membership function is used and to facilitate this single channel technique for color image compression RGB color space has been utilized. The incorporation of fuzzy rules generates huge difference in the compression using DWT; because fuzzy logic can able efficiently handle the imprecise situations of image compression.

Kew words: - DWT, Fuzzified DWT, color image compression, RGB color model.

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.

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) 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 offers considerable enhancement in picture superiority at high compression ratios generally due to better energy compaction possessions of wavelet transforms. Wavelet transform partitions a signal into a set of functions called wavelets. Wavelets are attained from a only prototype wavelet called mother wavelet by dilations and shifting. The wavelet transform is calculated separately for diverse sections of the time-domain signal at diverse frequencies.

2.1 SUB BAND CODING

A signal is passed through a series of filters to calculate DWT. Methods initiates by passing this signal sequence through a half band digital low pass filter with impulse response h(n).Filtering of a signal

is mathematically equivalent to convolution of the tile signal with impulse response of the filter.
$x[n] * h[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$…….. (1)

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

$h[L-1-n]=(-1)^n g(n)$………………………..(2)

Filters fulfilling this form are known as quadrature mirror filters. After that filtering one half of the samples can be removed since the signal at the present has the maximum frequency as one half of the original frequency. The signal can so be sub sampled by 2, fundamentally by clearaning every other sample. This represents 1 level of decomposition and can scientifically be expressed as

$y_1[n] = \sum_{k=-\infty}^{\infty} x[k]h[2n-k]$
$y_2[n] = \sum_{k=-\infty}^{\infty} x[k]g[2n+1-k]$…….. (3)

Where $y_1[n]$ and $y_2[n]$ are the yields of low pass and high pass filters, correspondingly after sub sampling by 2. This decomposition halves the time resolution as only one half the amount of sample now characterizes the total signal. Frequency resolution has twice because each production has one half the frequency band of the input. This procedure is called as sub band coding. It can be continual advance to increase the frequency resolution as shown by the filter bank.

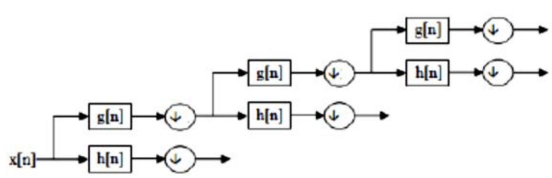

Figure (1) Filter Bank

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.

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.

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. Other technique is to multiply each number in w's by a constant k, and after that round to the nearby integer. Quantization is identified lossy because it begins error into the process, since the alteration of w's to q's is not one to one function.

2.2.4 ENTROPY ENCODING :- By means of this way, a integer sequence q is altered into a shorter sequence, by means of the numbers in e being 8 bit integers The conversion is prepared by an entropy encoding table. Strings of zeros are coded through numbers 1 through 100,105 and 106, although 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 compilation of diverse 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 last one Defuzzyfication.

3.1 FUZZY IMAGE PROCESSING

Fuzzy image processing is not a single theory. It is a set of diverse fuzzy approaches to image processing. It is the set of the entire approaches that recognize, correspond to and process the images, their sectors and features as fuzzy sets. The demonstration and processing depend on the chosen fuzzy system and on the difficulty to be solved. Here is a directory of common observations concerning fuzzy logic:

- Fuzzy logic is theoretically easy to understand.
- Flexibility of fuzzy logic.
- Fuzzy logic is tolerant of vague data.
- Fuzzy logic can be constructed on top of the practice of experts.

The basis for fuzzy logic is the basis for human communication. This examination underpins a lot of the other reports about fuzzy logic. Since fuzzy logic is constructed on the structures of qualitative explanation 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, third stage is image Defuzzyfication. Figure (2) shows the block diagram representation of Fuzzy Image processing.

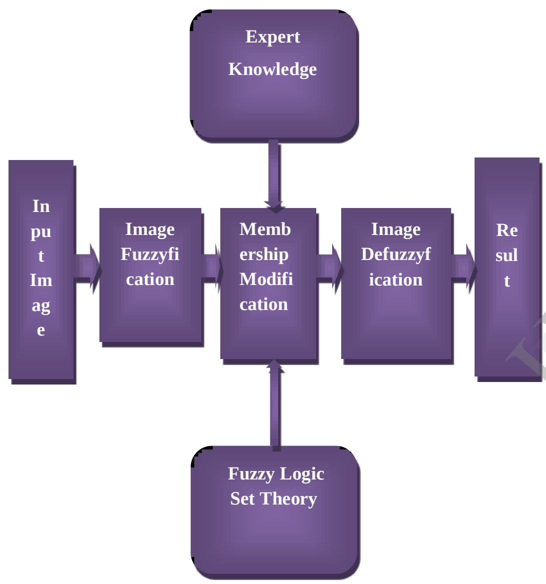

Figure (2):- Fuzzy Image processing.

The Fuzzyfication and Defuzzyfication 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 (Defuzzyfication) are steps that make possible to process images with fuzzy techniques. The most important property of fuzzy image processing is in the middle step (modification of membership values).After the image information is distorted from gray-level plane to the membership plane (Fuzzyfication), suitable fuzzy techniques change the membership values. Result can be the clustering, a rule based approach, and an integration approach and so on of fuzzy.

4. METHODOLOGY

The algorithm is based on the simple concept that, though the available DWT 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 DWT over the each single channel components separately will leads to the solution of the development of multichannel DWT i.e. Color image compression.

a. Methodology of the DWT based Color Image: - Compression is discussed below step by step with the help of flow graph shown in the figure (1).

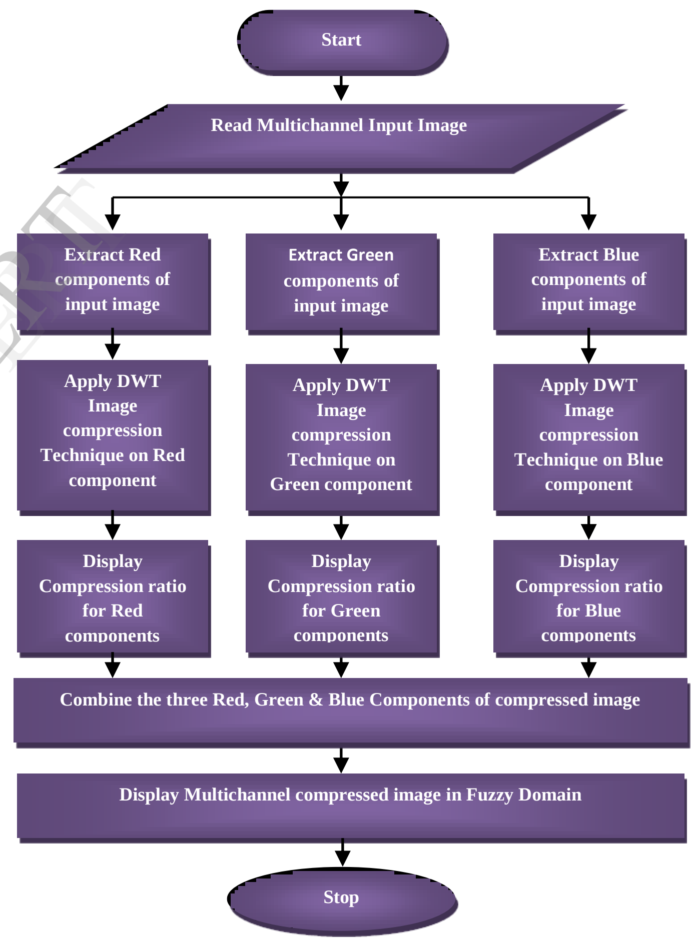

Figure (3):- Algorithm of DWT based Color Image Compression

b. Methodology of Fuzzified DWT based Color Image Compression

Fuzzy logic is the most efficient rule base system to handle the vague and imprecise situations, in case of image based operations most of the time the situations are imperfect and vague. Hence to efficiently generate higher compression ratio DWT technique can be combined with fuzzy rule base. The algorithm for Fuzzified DWT based image compression is shown in figure (2), with the help of flow chart.

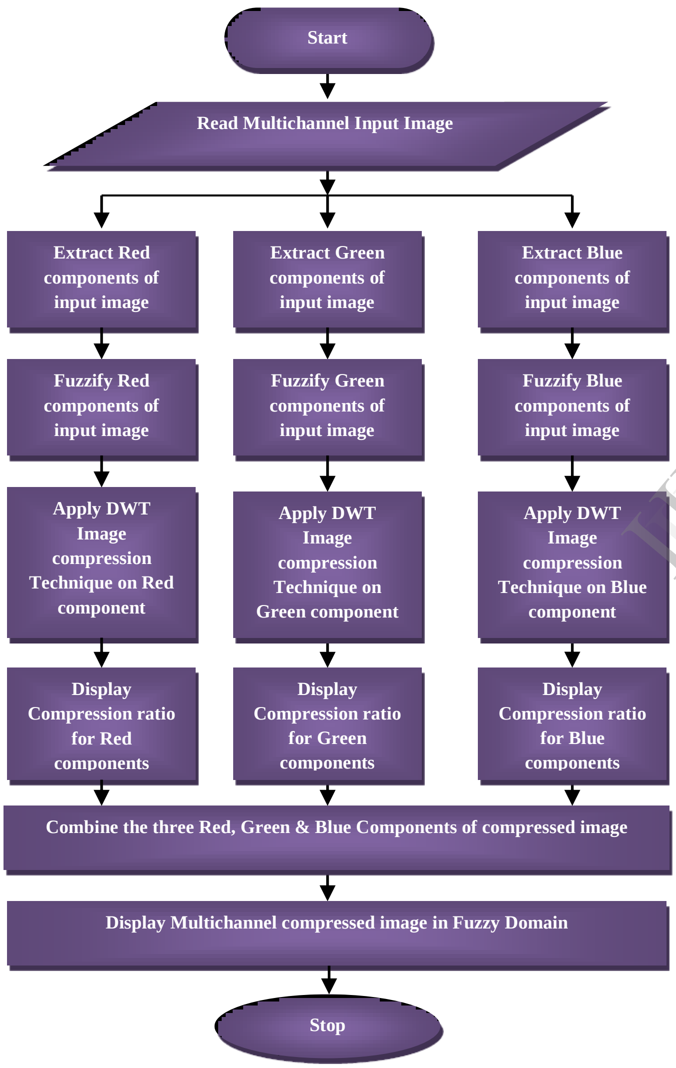

Figure (4) Algorithm of Fuzzified DWT (FDWT) based Color Image Compression

5. RESULT & DISCUSSION

The algorithm has been successfully developed and implemented in MATLB to develop an efficient color image compression. Now we will show & discuss the various results obtained from the two developed algorithms. 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 color images has been used. These images are shown in figure (5.1), figure (6.1) and figure (7.1). To compare the results obtained from the developed algorithm two most important image compression parameters used are,

1) Compression Ratio (CR).
2) Mean Square Error (MSE).

To show the compression and decompression process by using developed algorithm on first input image i.e. autumn.tif. Whose size is 206X345 and memory requirement to store is 71070 bytes shown in figure (5.3). For the performance evaluation of algorithm on compression and decompression processes, the value of parameter level of decomposition is fixed to 5. The results obtained after the compression and decompression process using normal discrete wavelet transform (NDWT) and Fuzzified discrete wavelet transform (FDWT) are shown from figure (5.2) and figure (5.3).

Figure (5.1):- input image.

Figure (5.2):- Output image using (NDWT)

Figure (5.3):- Output image using (FDWT)

Table 1:- The compression parameters found after first input image compression and decompression procedure using NDWT and FDWT are as follows.

S. No.	Parameters	Results for Normal DWT	Results for Fuzzified DWT
1	Bi (size of first input image in bytes)	71070 bytes.	71070 bytes.
2	Bc(size of first compressed image in bytes)	47992 bytes.	7620 bytes.
3	Bo (size of first decompressed image in bytes)	71070 bytes.	71070 bytes.
4	Cr1 (Compression Ratio)	8.5317	73.1787
5	M.S.E1(Between original & decompressed Image)	19.0883	34.35

Similarly the results obtained for second input image i.e. (lena.jpeg), whos's Size, is 415X445 and memory requirement to store is 180525 bytes are shown from figure (6.1) to figure (6.3). The compression parameters obtained after Second input image compression and decompression process using normal discrete wavelet transform (NDWT) and Fuzzified discrete wavelet transform (FDWT) are as follows.

Figure (6.1):-input image

Figure (6.2):- Output image using (NDWT)

Figure (6.3):- Output image using (FDWT)

Table 2:- The compression parameters found after second input image compression and decompression procedure using NDWT and FDWT are as follows.

S. N.	Parameters	Results for Normal DWT	Results for Fuzzified DWT
1	Bi (size of first input image in bytes)	180525 bytes.	180525 bytes.
2	Bc (size of first compressed image in bytes)	54624 bytes.	16016 bytes.
3	Bo (size of first decompressed image in bytes)	180525 bytes.	180525 bytes.
4	Cr2 (Compression Ratio)	13.896	95.5320
5	M.S.E2 (Between original & decompressed Image)	30.2527	42.7232

Again the results obtained for Third input image i.e. (football.jpeg) Size 256X320 and memory requirement to store is 81920 bytes are shown from figure (7.1) to figure (7.3). The compression parameters obtained after Third input image compression and decompression process using normal discrete wavelet transform (NDWT) and Fuzzified discrete wavelet transform (FDWT) are as follows.

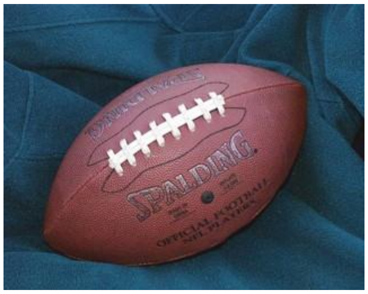

Figure (7.1):- input image

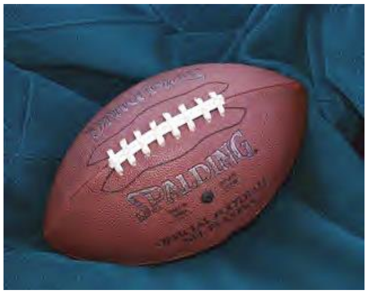

Figure (7.2):- Output image using (NDWT)

Figure (7.3):- Output image using (FDWT)

Table 3:- The compression parameters found after third input image compression and decompression procedure using NDWT and FDWT are as follows:

S.N.	Parameters	Results for Normal DWT	Results for Fuzzified DWT
1	Bi (size of first input image in bytes)	81920 bytes.	81920 bytes.
2	Bc (size of first compressed image in bytes)	59648bytes.	5090 bytes.
3	Bo (size of first decompressed image in bytes)	81920 bytes.	81920 bytes.
4	Cr2 (Compression Ratio)	19.256	130.3596
5	M.S.E2 (Between original & decompressed Image)	33.2644	44.3505

6. COMPARATIVE ANALYSIS

To present the comparative analysis this section provides some statistical analysis on the basis of compression ratio and MSE obtained for both the techniques for all three images. To compare both the techniques let consider second input image. Table (1) shows the different values of parameters obtained for both techniques. Figure (32) and (33) shows plot of Compression ratio and Mean Square Error for both techniques with respect to N.

Table 4:- parameter obtained for NDWT and FDWT

S. No.	Parameter "N"	NDWT		FDWT	
		Cr1	M.S.E1	Cr2	M.S.E2
1	2	4.6569	10.142	17.6569	42.134
2	3	14.4561	16.2262	29.4371	42.2106
3	4	22.1118	19.3154	53.1186	42.3742
4	5	25.532	22.7124	95.532	42.7232
5	6	42.1011	28.1553	173.6801	43.1973
6	7	50.1896	32.2347	314.1886	44.0587
7	8	72.0714	42.1043	550.0797	45.5804

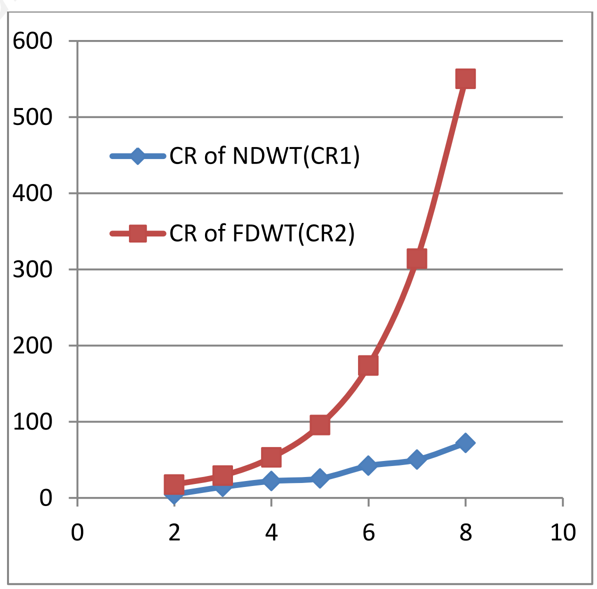

Figure (8):- Plot of compression ratio with respect to N.

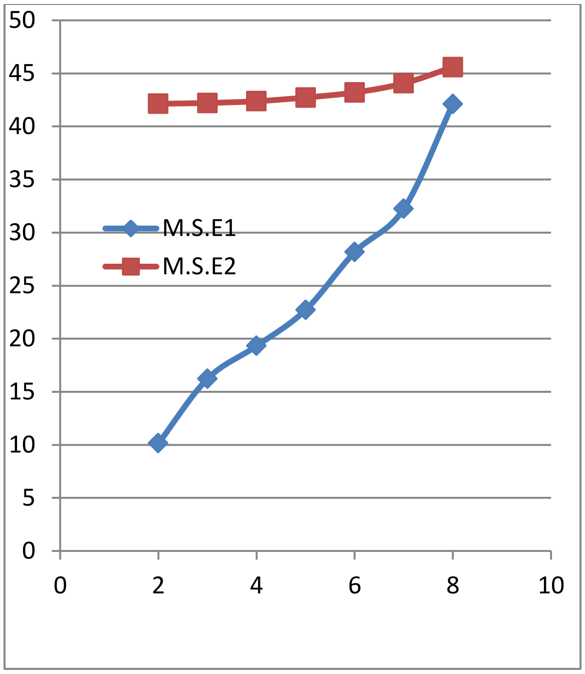

Figure (9):- Plot of Root Mean Square Errors with respect to N.

7. CONCLUSIONS

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 a comparative analysis for Normal DWT based color image compression and Fuzzified DWT based color image compression.

During the analysis it is found that, FDWT image compression technique provides higher compression ratio as compare to normal discrete wavelet transform (NDWT).

In addition to this Fuzzified discrete wavelet transform based image compression technique is also able to keep error between input image and reconstructed image in allowable range, though it is generating slightly higher error but at the same time the compression ratio is much higher than available NDWT technique

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