Implementation of a Proficient Multichannel Image Codec System Using Non-Linear Fuzzyfied Discrete Wavelet Transform

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Abstract- **The brisk expansion of advanced imaging applications, together with desktop publishing, multimedia, teleconferencing, and high definition television (is that they have some unnecessary information. Image compression HDTV) has amplified the necessitate for valuable and standardized image codec techniques. Among the emerging standards JPEG and JPEG2K are for compression of still images. A universal feature of most images is crucial to reduce the number of bits needed to represent an image by removing the redundancies as much as possible. One of the most important techniques frequently used for still image compression in the present scenario is JPEG 2000(JPEG2K). The JPEG2000 is a single channel image compression technique, hence not able to compress the multichannel images. But in the present era most of the still images are the multichannel like RGB images. However there are some techniques available for color image compression based on JPEG2K, but this field is still open for development of efficient image compression techniques for color images. This paper presents a new method of implementation of available wavelet transform based image compression technique for color image compression using fuzzyfied discrete wavelet transform. Zadah in his first paper on fuzzy, discussed that fuzzy logic is an efficient tool for handling imprecise and vague situations, hence fusion of fuzzy rule base with discrete wavelet transform is the Efficient way to achieve higher compression ratio with less error.**

Kew words: - Discrete Wavelet transform, 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 [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.

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

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

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

Filters satisfying this condition are known as quadrature 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

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

Where y_1 [n] and y_2 [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.

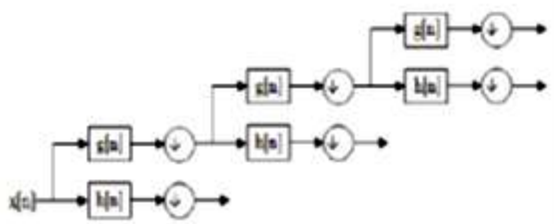

Figure (1) Filter Bank

2.2 COMPRESSION STEPS [9]:

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 [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 Defuzzyfication.

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]. Here is a list of general observations about fuzzy logic:

- Fuzzy logic is conceptually easy to understand.
- Fuzzy logic is flexible.
- Fuzzy logic is tolerant of imprecise data.
- Fuzzy logic can be built on top of the experience of experts.

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 [36], [37]. Fuzzy image processing has three main stages: image Fuzzyfication, modification of membership values, and, if necessary, image Defuzzyfication. Figure (2) shows the block diagram representation of Fuzzy Image processing.

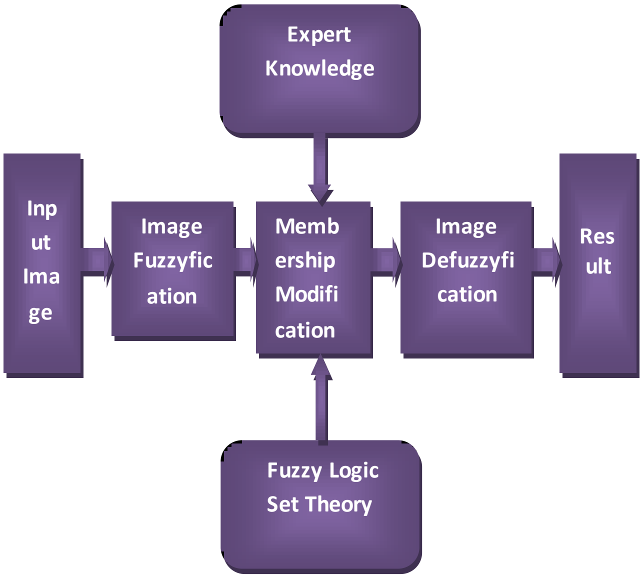

Figure (2):- Fuzzy Image processing.

The Fuzzification 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 main power of fuzzy image processing is in the middle step (modification of membership values).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

In the past, the image compression techniques were mostly based on the single channel image compression, but now the technology is looking for multichannel image compression. To overcome this problem this paper proposed a novel algorithm for multichannel image compression using Fuzzyfied discrete wavelet transform (FDWT). The implementation the algorithm is based on the MATLAB.

The proposed 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 FDWT [1] over the each single channel components separately will leads to the solution of the development of multichannel FDWT 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).

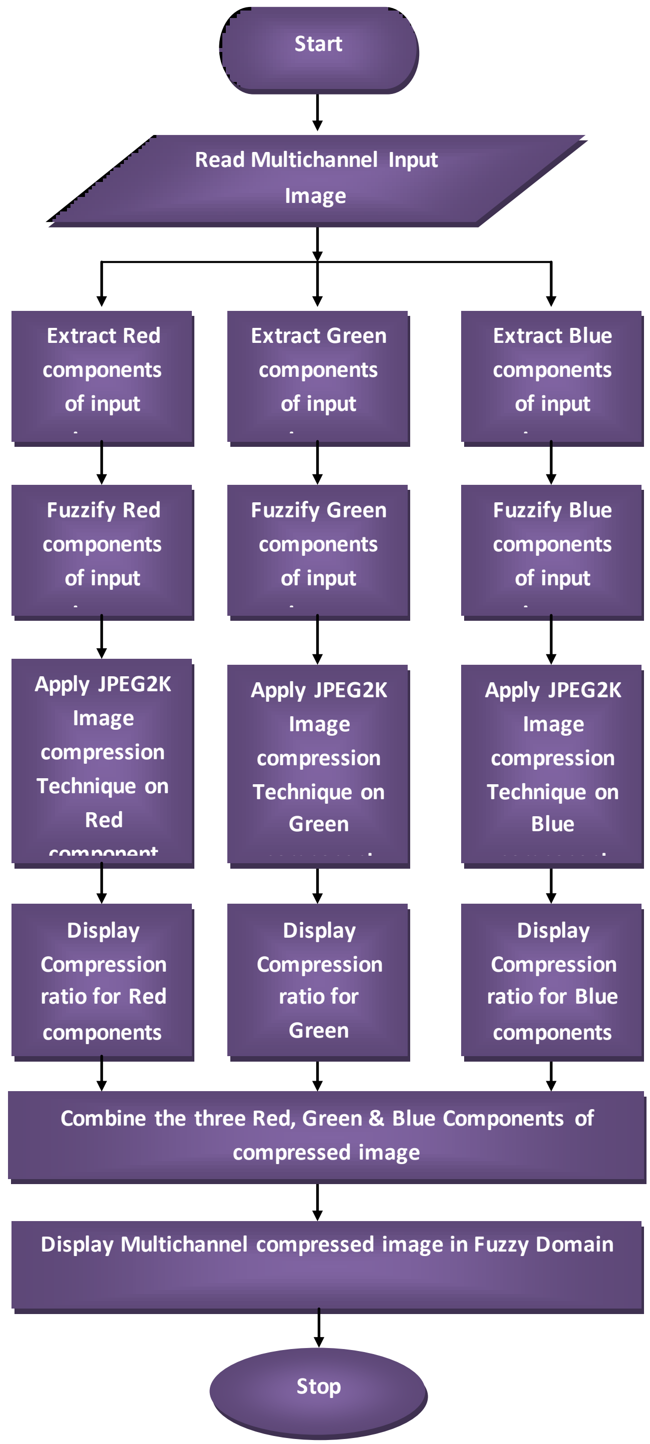

Figure (3):- developed algorithm.

5. RESULT & DISCUSSION

The algorithm has been successfully developed and implemented in MATLB to develop an efficient gray 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 two different gray 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 three most important image compression parameters viz, are used.

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 (4). For the performance evaluation of developed 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 Fuzzyfied discrete wavelet transform (FDWT) are shown from figure (4.1), figure (4.2) and figure (4.3).

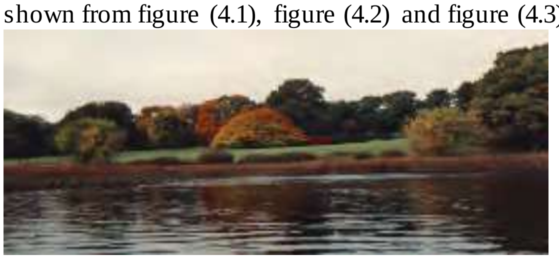

Figure (4.1):- input image.

Figure (4.2):- Output image using (NDWT)

Figure (4.3):- Output image using (FDWT)

The compression parameters obtained after first input image compression and decompression process using NDWT and FDWT are as follows.

S. N.	Parameters	Results for Normal DWT	Results for Fuzzyfied 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 ie. (lena.jpeg), who's Size, is 415X445 and memory requirement to store is 180525 bytes are shown from figure (5.1) to figure (5.3). The compression parameters obtained after Second input image compression and decompression process using normal discrete wavelet transform (NDWT) and Fuzzyfied discrete wavelet transform (FDWT) are as follows.

Figure (5.1):-input image

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

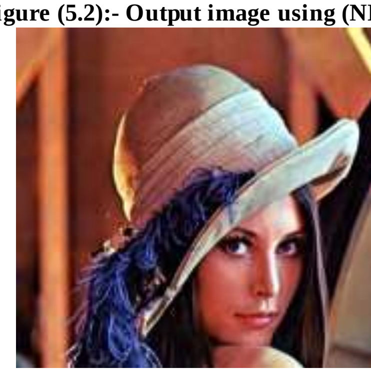

Figure (5.3):- Output image using (FDWT)

S. N.	Parameters	Results for Normal DWT	Results for Fuzzyfied 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 ie. (football.jpeg) Size 256X320 and memory requirement to store is 81920 bytes are shown from figure (6.1) to figure (6.3). The compression parameters obtained after Third input image compression and decompression process using normal discrete wavelet transform (NDWT) and Fuzzyfied 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)

S. N.	Parameters	Results for Normal DWT	Results for Fuzzyfied 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. 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 an algorithm for real time gray image compression.

The developed algorithm is found very efficient for gray image compression. During the analysis it is found that, developed algorithm provides higher compression ratio as compare to normal discrete wavelet transform. In addition to this fuzzyfied discrete wavelet transform based developed 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. The advantage of the developed algorithm is, Fuzzyfication performed before using DWT because normal DWT cannot able to handle imperfections presented in the input images.

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