Implementation of JPEG2000 Algorithm for Gray scale and Colour Images

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Abstract: **In recent years, the increasing demand for multimedia products has a significant contribution to the insufficient network bandwidth and storage space, therefore innovative data compression techniques are being explored day to day so as to eliminate all forms of redundancies. To address this need in the specific area of still image encoding, a new JPEG2000 standard is currently being developed. It offers a wide range of functionalities such as lossless and lossy coding, embedded lossy to lossless coding, progression by resolution and quality, high compression efficiency and error resilience. Discrete wavelet transform, one of the most frequently used mathematical tools related to signal representation is mainly employed in image compression applications. The general procedure for image compression with wavelets including the tiling, Wavelet decomposition of choice, level shifting, quantization and arithmetic encoding operations in the encoding phase followed by reverse operations for decoding.**

Keywords: **code blocks, jpeg2000,tiling, ,PSNR and MSE**

I.INTRODUCTION

Digital Image compression encodes the original image with few bits and is useful for high resolution images as well as colour images since they are large in size. When a photo is taken from a digital camera or a graphic is scanned to form a digital image, substantial storage space is required to save it in a file. Also, it is time consuming to transmit it from one place to another because of the large file size. Therefore, the amount of data in the image file must be reduced. This process is called "image compression" [1]. The objective of image compression is to reduce the redundancy of the image and to store or transmit data in the most efficient form. Image compression mainly reduces the size of parent image for transmission in low bandwidth channel and further ensures less amount of deviation or error between the decoded image and the original image.

Image compression is mainly of two types Lossless Image compression and lossy Image compression, Lossless compression algorithms reduce file size while preserving a perfect copy of the original uncompressed image. Lossless compression generally results in larger files than lossy compression. Lossless compression is preferred for archival purposes and often for medical imaging, technical drawings, clip art, or comics etc. Lossy Image compression algorithms preserve a representation of original uncompressed image which may not be a perfect replica of the original image. Most of the lossy compression algorithms allow for variable compression rates to trade

image quality for file size. Lossy compression methods, especially when used at low bitrates,   introduce compression artifacts.. Lossy compression methods   are especially suitable   for natural images in applications where minor loss of fidelity is acceptable for achieving substantial reduction in bit rate.

Both the lossy as well as lossless Image compression techniques have their applications in the areas of Televideo conferencing, Remote sensing (satellite imagery). Document and medical imaging, Facsimile transmission (FAX), Control of remotely piloted vehicles in military space.
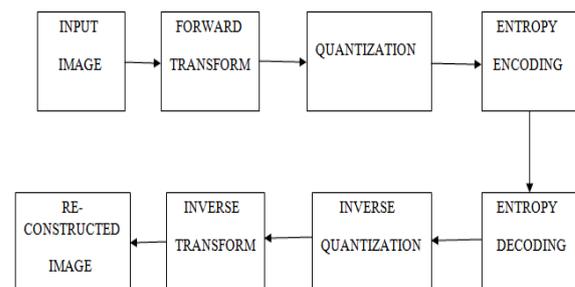

Fig.1.Basic block diagram for image compression

This paper is outlined as follows: In section 2 different compression methodologies are discussed, while the proposed JPEG 2000 based compression is elaborated in section 3, while the experimental analysis and results are explained in section 4 followed by conclusion in section 5.

II.COMPRESSION METHODOLOGIES

Digital Images are compressed through usage of various standards based techniques and algorithms. The lossless compression techniques are used in places where the quality of   accuracy of   image   is of extreme importance, like for example in case of technical drawings and medical images etc. Lossy compression technique produces a minor loss of quality that is almost invisible and hard to identify. Exclusive number of traditional conventional based techniques and new soft core based techniques of compression employing neural networks of multiple architectures are being explored in the present day scenario. Few of them are explained as under:

2.1 Discrete Wavelet Transform:
Discrete wavelet transformation is one of the most popular candidates for the time frequency- transformations. Wavelet transform based image compression methods   are

adequate for representing transients, such as percussion sounds in audio, or high - frequency components in two – dimensional images, for example an image of stars on a night sky, Which means that the transient elements of a data signal can be represented by a smaller amount of information than would be the case with the usage of some other transform, like the most common wide spread discrete cosine transform [3].

2.2. Discrete Cosine Transform:

A Discrete cosine transform (DCT) expresses a finite sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. DCTs are importantly employed in numerous applications in science and engineering like the lossy compression of audio (e.g. MP3) and images (e.g. JPEG) (where small high–frequency components can be discarded) to the spectral methods of numerical solution of partial differential equations. The use of cosine rather than sine functions is critical in these applications: for compression, it turns out that cosine functions are much more efficient, whereas for differential equations the cosines express a particular choice of boundary conditions.

2.3. JPEG Compression:

JPEG (Joint Photographic Experts Group) is a lossy compression method. JPEG-compressed images are usually stored in the JFIF (JPEG File Interchange Format) file format. The JPEG / JFIF filename extension is JPG or JPEG. Nearly every digital camera can save images in the JPEG/JFIF format, which supports 8-bit gray scale images and 24-bit color images (8 bits each for red, green, and blue).

JPEG applies lossy compression to images, which can result in a significant reduction of the file size. Applications can determine the degree of compression to apply, and the amount of compression affects the visual quality of the result. When not too great, the compression does not noticeably affect or detract from the image quality, but JPEG files suffer generational degradation when repeatedly edited and saved.

2.4. JPEG 2000 Image Compression:

The JPEG2000 international standard represents advances in image compression technology where the image coding system is optimized not only for efficiency but also for scalability and interoperability in network and mobile environments. Digital imaging has become an integral part of the Internet and JPEG2000 is a powerful new tool that provides power capabilities for designers and users of networked imaging applications. With the continual expansion of multimedia and Internet applications, the needs and requirements of the technologies used, grew and evolved. In March 1997 a new call for contributions were launched for the development of a new standard for the compression of still images, the JPEG2000.

JPEG 2000 is a compression standard enabling both lossless and lossy storage. The compression methods used are different from those in standard JFIF / JPEG; they improve the quality and compression ratios, but also require more computational power to process. JPEG 2000

also adds features that are missing in JPEG. It is not nearly as common as JPEG, but it is used currently in professional movie editing and distribution (some digital cinemas, for example, use JPEG 2000 for individual movie frames).Few applications of JPEG 2000 based Image Compression technique include the multimedia Devices (e.g.: digital cameras, 3G mobile phones), Client/server communication (e.g., the Internet, Image database, Video streaming, video server, etc.), Military/surveillance (e.g., HD satellite images, Motion detection, network distribution and storage, etc.) , Medical imagery, esp. the DICOM specifications for medical data interchange and the remote sensing etc.

2.5 Artificial Neural Networks based Image Compression:

The various steps involved in MATLAB modeled neural network based image compression are as enumerated below for achieving better SNR and compression levels [4].

- Read image pixels and perform normalization to range [0-1].
- Divide the image into non-overlapping blocks.
- Perform rasterization of the pixels and apply to the input layer of Neural Network.
- Compute the outputs of hidden layer units by multiplying the input vector by the weight matrix (V).
- Store the outputs in a compressed file after renormalization.
- For more number of image vectors repeat above steps again.

2.6. Image Compression using Vector Quantization:

Vector quantization based image compression algorithms have been extensively investigated for speech and Image signals. Image vector quantization (VQ) includes four stages: vector formation, Training set selection, codebook generation and quantization. The first step is to divide the input image into set of vectors. The Subset of vectors in the set chosen as a training sequence. The codebook of code words is obtained by a 1iterative clustering algorithm. Finally, in quantizing an input vector, closest code words in the codebook is determined and corresponding label of this code word is transmitted.

III.PROPOSED ARCHITECTURE
## 3.1JPEG 2000 Image Compression Encoder:
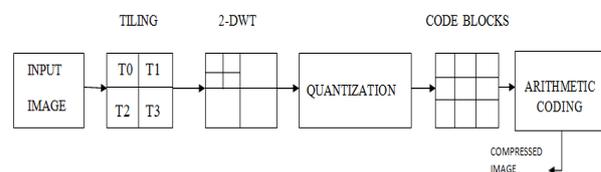
Fig.2.Block diagram of encoder for JPEG 2000 image compression

3.1.1. Tiling:

Tiling partitions the input image into rectangular and non-overlapping tiles of equal size (except possibly for those tiles at the image borders) as shown in figure.2.The tile size is arbitrary and can be as large as the original image itself (i.e., only one tile) or as small as a single pixel. Tiling is particularly useful for

applications where the amount of available memory is limited compared to the image size.[6]

3.1.2. Discrete Wavelet Transform (DWT):

DWT is the discrete variant of the wavelet Transform. Wavelet transform represents a Valid alternative to the cosine transform Wavelet compression is a form of data compression well suited for image compression (sometimes also video compression and audio compression). Notable implementations are JPEG 2000, ECW for still images, the BBC's Dirac, and Ogg Tarkin for video. Mainly, here we use 2-D discrete wavelet Transform on each tile.

3.1.3. Quantization:

Quantization refers to the process of approximating the continuous set of values in the image data with a finite, preferably small, set of values. The input to a quantizer is the original data and the output is always one among a finite number of levels. Quantization is usually the main source for error in the reconstructed image [6].

For each sub-band b; a basic quantizer step size Db is selected by the user and is used to quantize all the coefficients in that sub-band. The choice of Db can be driven by the perceptual importance of each sub-band based on HVS data, or it can be driven by other considerations such as rate control. The quantizer maps a wavelet coefficient yb(u, v) in sub-band b to a quantized index value qb(u, v).

There are two types of quantization: scalar quantization and vector quantization. In scalar quantization, each input symbol is treated in producing the output while in vector quantization the input symbols are clubbed together in groups called vectors, and processed to give the output. This clubbing of data and treating them as a single unit, increases the optimality of the vector quantizer, but at the cost of increased computational complexity.

3.1.4. Code Blocks:

In JPEG2000, each sub-band is encoded independently of the other sub-bands. In addition, JPEG2000 uses a block coding paradigm in the wavelet domain as in the embedded block coding with optimized truncation (EBCOT) algorithm, where each sub-band is partitioned into small rectangular blocks, referred to as code blocks, and each code block is independently encoded. The nominal dimensions of a code block are free parameters specified by the encoder but are subject to be an integer power of two; the total number of coefficients in a code block cannot exceed 4096; and the height of the code block cannot be less than four. The independent encoding of the code blocks has many advantages including localized random access into the image, parallelization, improved cropping and rotation functionality, improved error resilience, efficient rate control, and maximum flexibility in arranging progression orders. It may seem that failing to exploit inter-sub-band redundancies would have a sizable adverse effect on coding efficiency [7].

3.1.5Arithmetic coding:

Arithmetic coding uses a fundamentally different approach from Huffman coding in that the entire sequence of source symbols is mapped into a single codeword which is developed by a recursive interval partitioning using the symbol probabilities, and the final codeword represents a binary fraction that points to the subinterval determined by the sequence [8]. In essence, arithmetic coding provides compression efficiency that comes with Huffman coding of large blocks, but only a single symbol is encoded at a time. This single-symbol encoding structure greatly simplifies probability estimation.

3.2. JPEG 2000 Image Compression Decoder:
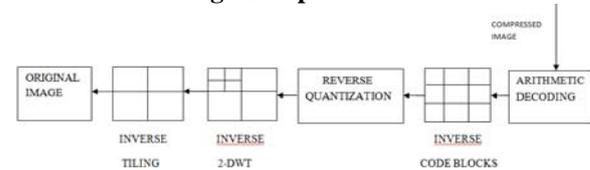
Fig.3.Block diagram of JPEG2000 image compression decoder

3.2.1. Arithmetic Decoding:

Arithmetic decoding is an inverse process of arithmetic encoding which results in the form of code blocks. In order to improve an arithmetic decoder, the method of arithmetically decoding an arithmetically-encoded information signal into an information signal including a serial sequence of n-bit symbols is adapted to decode two subsequent symbols of the information signal in one decoding cycle if the first symbol to be decoded has the most probable symbol value, the idea of the arithmetic decoder is opposite to that of the encoder. In contrast to the encoder, which encodes data to a bit stream in memory, the decoder reads data directly from a file. The arithmetic decoder should be defined very correctly here because it determines how the bit stream must look to be decodable.

3.2.2. Inverse code blocks:

The process of converting the output of arithmetic code into code blocks is simply called inverse code blocks as shown in figure.3.

3.2.3. Reverse quantization:

Assigning each symbol to the pixel values is called reverse quantization. Disclosed is a reverse quantization method that reverse quantizes multiple quantized values as a set, the reverse quantization is performed after all data of code block is received and only if the coefficients were quantized. The reverse quantization can be expressed by the following formulas:

$$Cr = \begin{cases} Cq & if\ q = 0 \\ Cq + 2^{q-1} & if\ q > 0 \end{cases}$$

where q is the quantization step, q = 2l where l is the least significant bit plane of the code block which is already completely processed. Obviously, signs of the coefficients do not alternate during dequantization.

3.2.4 Inverse Discrete Wavelet Transform:

Once we arrive at our discrete wavelet coefficients, we need a way to reconstruct them back into the original signal (or a modified original signal if we played around with the coefficients). In order to do this, we utilize the process known as the inverse discrete wavelet transform. The DWT coefficients are first upsampled (the approximation and the detail coefficients are handled separately) by placing zeros in between every coefficient, effectively doubling the

lengths of each. These are then convolved with the reconstruction scaling filter for approximation coefficients (the reconstruction scaling filter is simply the original scaling filter that has been flipped left to right) and the reconstruction wavelet filter for the detail coefficients. These results are then added together to arrive at the original signal. After the convolution and addition, to grab the part of the signal we want away from the convolution 'junk', we grab the coefficients from N to the length of the signal + N -1. This will give us our original signal.

IV. RESULTS

For the sake of analysis, we have taken three different RGB (colour) images and performed JPEG2000 encoding operation. Later, the same images are connected to gray scale performed JPEG2000 operations. The three images considered for analysis are 1.flowers, 2.water falls, and 3. Towers. Result images as shown in figures 4, 5&6 are arranged in two rows with three images in each row. Where the top row and bottom row images represents those of gray scale and colour images. Each row of images can be read as input image, two level decomposed tiled image, reconstructed image from left to right.
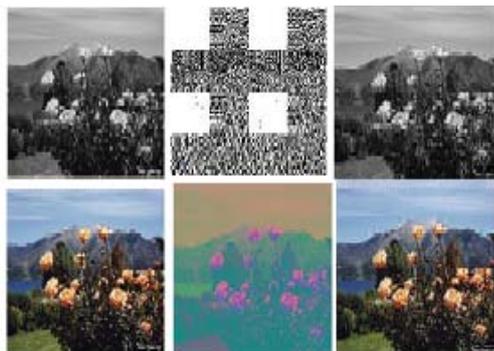

Figure.4 results of flowers image

Table.1 Metrics of flowers image

PARAMETER	GRAY SCALE	COLOR IMAGE
PSNR	15.7948	15.7746
MSR	1.7124e+03	1.7204e+03
MAXERR	236	244
L2RAT	1.0438	1.0453
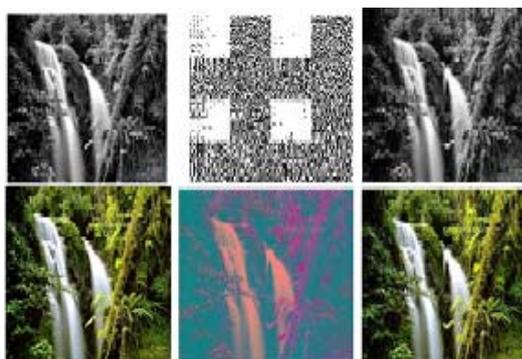
Figure.5 results of waterfalls image

Table.2 Metrics of waterfalls image

PARAMETER	GRAY COLOR	COLOR IMAGE
PSNR	17.0885	13.9210
MSR	1.2713e+03	2.6362e+03
MAXERR	255	250
L2RAT	0.9946	0.9961
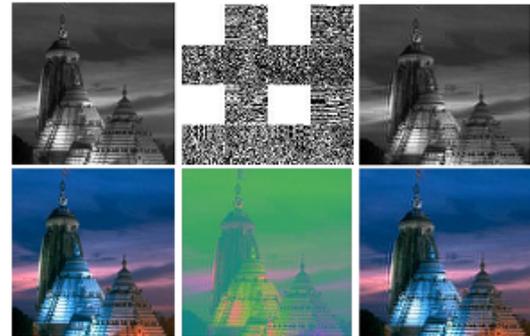
Figure.6 Results of towers image

Table.3 Metrics of towers image

PARAMETER	GRAY COLOR	COLOR IMAGE
PSNR	17.6841	17.0885
MSR	1.1083e+03	1.2713e+03
MAXERR	250	255
L2RAT	0.9830	0.9946

IV. CONCLUSION

The architecture for the image compression has been proposed, which is based on JPEG 2000 standard. It was observed from tables 1, 2&3 that, in case of gray scale images, towers image produced better PSNR of order 17.6841, while the flowers image has the least MSE of order 236.

In case of colour images, towers image produced better PSNR of order 17.0885, while the flowers image has the least MSE of order 244. The proposed architecture can reduce the internal memory size to transmit in a low bandwidth channel. The number of accessing to the storage can improve the throughput; this has been implemented and tested in MATLAB.

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