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Adaptive JPEG 2000 Standard for Higher Compression with Less Error

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ABSTRACT:-
Image compression techniques generally fall into two categories: lossless and lossy depending on the redundancy type exploited, where lossless also called information preserving or error free techniques, in which the image compressed without losing information that rearrange or reorder the image content, while lossy which remove content from the image, which degrades the compressed image quality, and are based on the utilization of psycho-visual redundancy, either solely or combined with statistical redundancy such as such as vector quantization, fractal, transform coding and JPEG2000. In general, lossy techniques work on segment based that subdivide the image into non-overlapping segments (blocks) of fixed sizes or variable sizes. The variable block partitioning methods utilized by a number of researchers to overcome the fixed partitioning method drawback using partitioning techniques such as quad tree, HV (horizontal-vertical) and triangular method. Lots of techniques are available for the Single channel image compression i.e. for gray images. Since then lots of work had been done on single channel image compression mostly based on JPEG 2000 compression. The available JPEG 2000 standard can able to provide smaller root mean square error but not able to generate higher compression ratio. This arises the need of image compression techniques which can able to keep RMSE within an allowable range and simultaneously able to generate higher compression ratio (CR). This paper brought forward a mathematical modification on available JPEG 2000 image compression algorithm so that it can able to provide higher compression efficiency with allowable error rate.

KEYWORDS: - Single channel image compressions, JPEG 2000 standard, mean square error (MSE), compression ratio (CR).

1. INTRODUCTION

The digital signal processing and multimedia Computing is used to produce and process a large number of images. Storing of raw image takes more space on storage device and more bandwidth over network during transmission. The proposed algorithm does compression of an image by reducing the size of pixel. The size of pixel is reduced by representing pixel using only required number of bits instead of 8 bits per color. The pre-processing step takes care of re-valuing pixel based on occurrence to get better compression ratio. The process of reducing the amount of data needed for storage and transmission of given image on storage place is image compression. The compression helps to reduce transmission bandwidth in case of network or satellite transmission. The proposed Pixel Size Reduction lossy image compression algorithm will retain the originality of an image when it is decompressed. The image is represented as a matrix of pixel value

and each pixel for each color is represented in integer value ranging from 0 to 255 occupying 8bits. The RGB image has 3 planes representing three primary colors namely Red, Green and Blue color as components of an image. The test images used to test the proposed algorithm are 24 bits color.The spatial and spectral redundancies are present because certain spatial and spectral patterns between the pixels and the colour components are common to each other, whereas the psycho-visual redundancy originates from the fact that the human eye is insensitive to certain spatial frequencies. The principle of image compression algorithms are (i) reducing the redundancy in the image data and (or) (ii) producing a reconstructed image from the original image with the introduction of error that is insignificant to the intended applications. The aim here is to obtain an acceptable representation of digital image while preserving the essential information contained in that particular data set.

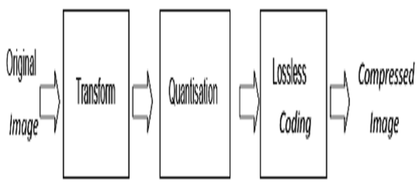


Figure1Image compressions System

The problem faced by image compression is very easy to define, as demonstrated in figure 1. First the original digital image is usually transformed into another domain, where it is highly de-correlated by using some transform. This de-correlation concentrates the important image information into a more compact form. The compressor then removes the redundancy in the transformed image and stores it into a compressed file or data stream. In the second stage, the quantization block reduces the accuracy of the transformed output in accordance with some pre-established fidelity criterion. Also this stage reduces the psycho-visual redundancy of the input image. Quantization operation is a reversible process and thus may be omitted when there is a need of error free or lossless compression. In the final stage of the data compression model the symbol coder creates a fixed or variable-length code to represent the quantizer output and maps the output in accordance with the code. Generally a variable-length code is used to represent the mapped and quantized data set. It assigns the shortest code words to the most frequently occurring output values and thus reduces coding redundancy. The operation in fact is a reversible one. The decompression reverses the compression process to produce the recovered image as shown in figure 2. The recovered image may have lost some information due to the compression, and may have an error or distortion compared to the original image.

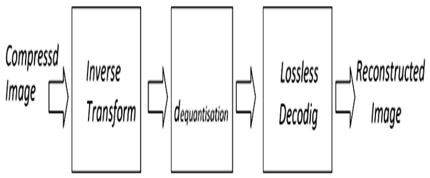


Figure2 Image decompression System

2. BASIC ARCHITECTURE OF THE JPEG 2000 STANDARD

The block diagram of the JPEG2000 encoder is illustrated in Fig. 3(a). The discrete transform is first applied on the source image data. The transform coefficients are then quantized and entropy coded, before forming the output code stream (bit stream). The decoder is the reverse of the encoder (Fig.4.1b). The code stream is first entropy decoded, de-quantized and inverse discrete transformed, thus resulting in the reconstructed image data. Before proceeding with the details of each block of encoder in Fig. 1, it should be mentioned that the standard works on image tiles. The term 'tiling' refers to the partition of the original (source) image into rectangular non-overlapping blocks (tiles), which are compressed independently, as though they were entirely distinct images. Prior to computation of the forward discrete wavelet transform (DWT) on each image tile, all samples of the image tile component are DC level shifted by subtracting the same quantity (i.e. the component depth). DC level shifting is performed on samples of components that are unsigned only. If colour transformation is used, it is performed prior to computation of the forward component transform. Otherwise it is performed prior to the wavelet transform.

At the decoder side, inverse DC level shifting is performed on reconstructed samples of components that are unsigned only. If used, it is performed after the computation of the inverse component transform. Arithmetic coding is used in the last part of the encoding process. The MQ coder is adopted in JPEG2000. This coder is basically similar to the QM-coder adopted in the original JPEG standard [1]. The MQ-coder is also used in the JBIG-2 standard [7]. To recapitulate, the encoding procedure is as follows [8, 9]:

- The source image is decomposed into components.
- The image and its components are decomposed into rectangular tiles. The tile-component is the basic unit of the original or reconstructed image.
- The wavelet transform is applied on each tile. The tile is decomposed in different resolution levels.
- These decomposition levels are made up of sub bands of coefficients that describe the frequency characteristics of local areas (rather than across the entire tile-component) of the tile component.
- The sub bands of coefficients are quantized and collected into rectangular arrays of "code-blocks".
- The bit-planes of the coefficients in a "code-block" are entropy coded.
- The encoding can be done in such a way, so that certain ROI's can be coded in a higher quality than the background.
- Markers are added in the bit stream to allow error resilience.
- The code stream has a main header at the beginning that describes the original image and the various decomposition and coding styles that are used to locate, extract, decode and reconstruct the image with the desired resolution, fidelity, region of interest and other characteristics.
- The optional file format describes the meaning of the image and its components in the context of the application. It should be noted here that the basic encoding engine of JPEG2000 is based on EBCOT (Embedded Block Coding with Optimized Truncation of the embedded bit streams) algorithm, which is described in details in [20, 21].

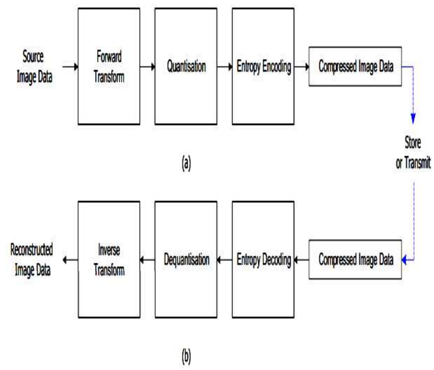


Fig.3 Block diagram of the JPEG 2000

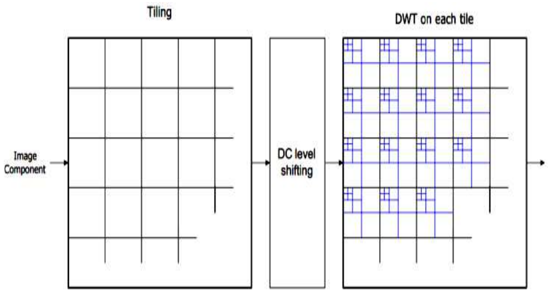


Fig.4.Tiling DC level shifting and DWT of image each tile

3. PROPOSED METHODOLOGY

The methodology of this paper proposes a serious modification of the available JPEG 2000 for achieving higher compression as compared to the available JPEG 2000 standard. Hence first part of this paper is to modify JPEG 2000 termed as modified JPEG 2000. The basic idea of JPEG 2000 is discussed in figure (3), the main modification is the preprocess the image with a transfer function given by equation (1), which makes the image more suitable for JPEG 2000 technique and hence able to provide higher compression with less error. The modified JPEG 2000 proposed is shown in figure (5).

$$Nmn = T(X_{mn}) = \left[1 + \frac{X_{max} - X_{mn}}{F_d}\right]^{-F_e}$$

Where F_e, F_d are constants, and

X_{max} = Maximum gray value of input image.

X_{mid} = Mid gray value of input image.

$$F_d = \frac{X_{max} - X_{mid}}{0.5^{\frac{-1}{F_e}} - 1}$$

And N is the new transformed image, which is suitable for JPEG compression.

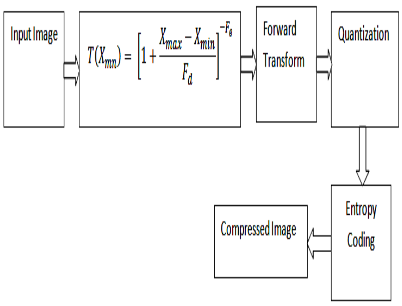


Figure (5) Modified JPEG2000-DWT

Effect of Proposed modification

It is commonly found that most of the image compression techniques based on lossy image compression provides good compression ratio. Most of the times the input image is a raw image. This project work deals with the development of transfer function that can make input image more suitable so that the same algorithm will provide higher compression ratio as compare to previous case when the image is in raw form. There are two important reasons, why algorithms provide less compression ratio when input image is in raw form.

1) In Most of the cases input image has high contrast, in that case compression technique has to keep large no. of pixels to track contrast changes and hence compression ratio is decreased.

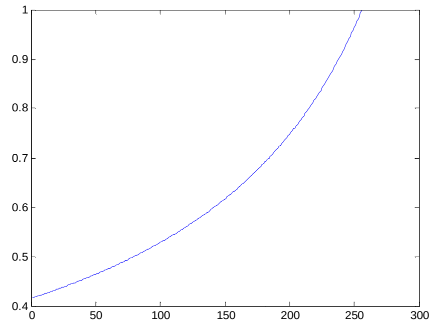
2) In some cases input image has good brightness, in that case compression technique has to keep again large no. of pixels to track Brightness changes and hence compression ratio is again decreased.

To increase the compression ratio, possible solution is

1) Decrease the Contrast of input image while keeping contrast information of original image.

2) Decrease the Brightness of input image while keeping brightness information of original image.

During implementation of this concept one possible problem is the retaining of contrast and brightness information during proposed transformation, for the solution of this problem lot of algorithms are already available to stretch the contrast and brightness level of images after reconstruction. Below table shows the effect of proposed transfer function on raw input image, and it is observable that proposed transfer function effectively reduces the contrast and brightness level of input image so that higher compression can be achieve during compression. The proposed modification function is plotted in following figure.



For example let's consider the input matrix is

11	16	78
22	14	36

The output matrix after using the proposed function is given as

0.4259	0.4306	0.4993
0.4363	0.4287	0.4503

The values obtained in the output matrix clearly indicated that all the pixel values are transferred in approximately same values and values reduced leads to reduction in brightness and values lies in same values indicates the reduction in contrast of the image.

4. RESULTS AND DISCUSSIONS

The algorithm has been successfully developed and implemented in MATLB 7.10 to develop an efficient gray image compression. The following section deals with the description and discussion about various results obtained from the developed algorithm and normal JPEG 2000. Since it is not possible to estimate the performance of any algorithm on the basis of single image, hence for the performance evaluation of the developed algorithm three different gray images has been used. These images are shown in figure (6), figure (7) and figure (8). To compare the results obtained from the developed algorithm and normal JPEG 2000 two most important image compression parameters are used.

1) ***Compression Ratio (CR).***
2) ***Root Mean Square Error (RMSE).***

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 (6). For the performance assessment 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 JPEG 2000 (NJPEG2000) and Modified JPEG 2000 (MJPEG2000) are shown from figure (6.1), figure (6.2) and figure (6.3).

Figure (6.1) input image.

Figure (6.2) Output image using (NJPEG2000)

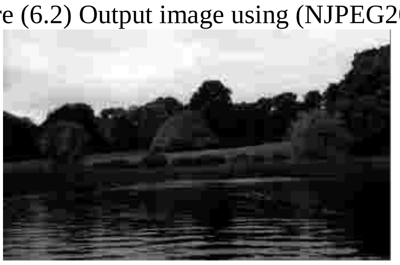


Figure (6.3) Output image using (MJPEG2000)

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

Parameters	Results for NJPEG2K	Result MJPEG2
Bi (size of first input image in bytes)	71070 bytes.	71070 bytes.
Bc (size of first compressed image in bytes)	66256 bytes.	2884 bytes.
Bo (size of first decompressed image in bytes)	71070 bytes.	71070 bytes.
Cr1	22.9703	197.1429
R.M.S.E1	10.9844	35.1643

Similarly the results obtained for second input image i.e. (lena.jpeg), who's Size, is 415X445 and memory requirement to store is 180525 bytes are shown from figure (7.1) to figure (7.3). The compression parameters obtained after Second input image compression and decompression process using normal JPEG 2000 (NJPEG2000) and Modified JPEG 200 (MJPEG2000) are as follows.

Figure (7.1) input image.

Figure (7.2) Output image using (NJPEG2000)

Figure (7.3) Output image using (MJPEG2000)

S. No.	Parameters	Results for NJPEG2000	Results for MJPEG2000
1	Bi (size of first input image in bytes)	180525 bytes.	180525 bytes.

2	Bc (size of first compressed image in bytes)	121096 bytes.	7334 bytes.
3	Bo (size of first decompressed image in bytes)	180525 bytes.	180525 bytes.
4	Cr2	30.6807	196.9185
5	R.M.S.E2	8.1344	34.2543

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 (8.1) to figure (8.3). The compression parameters obtained after third input image compression and decompression process using normal JPEG 2000 (NJPEG2000) and Modified JPEG 2000 (MJPEG2000) are as follows.

S. No.	Parameters	Results for NJPEG2000	Results for MJPEG2000
1	Bi (size of first input image in bytes)	81920 bytes.	81920 bytes.
2	Bc (size of first compressed image in bytes)	42336 bytes.	1878 bytes.
3	Bo (size of first decompressed image in bytes)	81920 bytes.	81920 bytes.
4	Cr3	39.1587	348.9670
5	R.M.S.E3	9.5739	44.9676

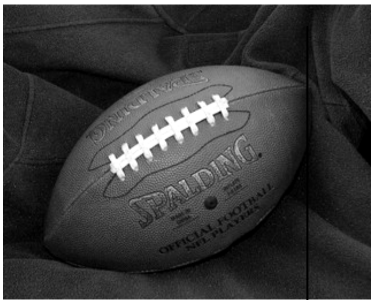


Figure (8.1) input image.

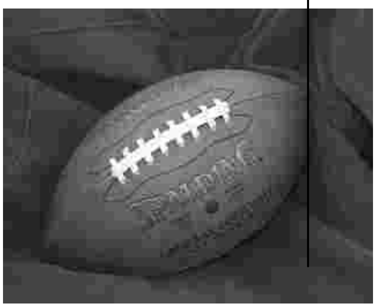


Figure (8.2) Output image using (NJPEG2000)


Figure (8.3) Output image using (MJPEG2000)

V. CONCLUSIONS

In this Modern area image Transmission and processing plays a major role, and during the 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 has brought forward some serious modifications on available JPEG 2000 image compression method. After the successful implementation of the proposed modification it has been found the modification proposed in conventional JPEG 2000 leads to the efficient solution to provide higher compression as compare to available JPEG 2000.

In addition to this in the result section it is found that though the proposed modification generates very high compression ratio but simultaneously increases the compression error. The key concept behind the acceptance of this increment in the compression error is that the change in error percentage is very small as compare to change in compression ratio. Hence the proposed modified JPEG 2000 provides efficient compression for gray scale images.

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