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# Impact of Low Intensity Pixels of Gray scale Images in compression

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***Abstract:-*** **Image compression plays a vital role in digital world. Storing and transmitting digital image with high quality is complex task. There are many methods for compressing digital images. In this paper, the digital image is divided into low and high intensity pixels . The low intensity part of image alone is compressed and decompressed using three different methods to know the frequency of low intensity pixels in the image. The impact of low intensity pixels in the compression technique is also studied. DCT based Arithmetic encoding, Haar wavelet and Quad tree decomposition these three compression methods are tested with some images and the best method is compared with JPEG 2000 (Joint Pictures Experts Group 2000) and also analysed.**

**Key Terms- JPEG 2000, Discrete Cosine Transform, Quad-tree Decomposition, Haar Wavelet, Vector Quantization.**

## I. INTRODUCTION

The development of computer technology in various fields has simplified the job of human being but it results in large amount of digital data. The challenge lies in managing this large amount of data, i.e. storing and retrieving it. The storing resources required for it also increases the cost of the overall system. If some technique is used to reduce this digital data without losing the original information, then the cost can be cut down to some extent. One of the techniques to reduce data is compression. Image compression technique is used to reduce the number of bits required to represent an image, which helps to reduce the storage space and transmission cost. Large images can be compressed into smaller size images, so that the memory occupied by the image is considerably reduced. Efficient compression technique should have the property of compressing different types of images giving better Compression Ratio (CR), Low Mean Square Error (MSE), Bits Per Pixel (BPP) and high Peak Signal to Noise Ratio (PSNR).

Image compression algorithms can be divided into two types: lossy and lossless compression [1-3]. The lossy compression results in loss of data during the process of decompression and in lossless the decompressed data is exactly same as the original data. In this paper, both the methods are used. An image consists of low and high intensity pixels. The impact of low intensity pixels in compression is studied in this paper. Hence, some segmentation based image compression algorithms are studied.

A lossless Image Compression Algorithm Using Variable Block Size Segmentation was developed by [4]. It segments the image into variable size blocks and encodes them depending on the characteristics exhibited by the pixels within the block. It outperforms other lossless compression schemes such as the Huffman, the Arithmetic, the Lempel-Ziv and the JPEG. The block-based Maximum a Posteriori (MAP) segmentation for image compression was developed by [5]. Here, the segmentation algorithm using the MAP criterion was used. The conditional probability in the MAP criterion, which is formulated by the Bayesian framework, is in charge of classifying image blocks into edge, monotone, and textured blocks.

Vector quantization [6] is a lossy type image compressing technique because in VQ technique some information may be lost due to quantization. First image is divided into fixed size block called training set and also created a codebook which had indexed image block of the same size of representing types of image block. Then it prepares a string for image by finding corresponding block index and arranging them

The multiscale segmentation for image compression is by [7]. Multiscale segmentation is obtained using a transform [8] which provides a tree-structured segmentation of the image into regions characterized by grayscale homogeneity. An image model is used for comprising separate descriptions of pixels lying near the edges of a region and those lying in the interior. A hybrid coding system that uses a combination of Set Partition In Hierarchical Trees (SPIHT) and Vector Quantization (VQ) for image compression is by [9]. Here, the wavelet coefficients of the input image are rearranged to form the wavelet trees that are composed of the corresponding wavelet coefficients from all the subbands of the same orientation. A simple tree classifier has been used to group wavelet trees into two classes based on the amplitude distribution. Each class of wavelet trees is encoded using an appropriate procedure, specifically either SPIHT or VQ.

Distributed source coding theorem based region of interest image compression method is by[10]. Region-of-interest (ROI) image compression is a new feature in JPEG2000, which allows the ROI to be encoded with better quality than the rest of an image, i.e. background (BG).

JPEG was designed for compressing full-color or grayscale images of natural, real-world scenes [11-12]. It is a lossy compression technique. The useful property of JPEG is that the degree of lossiness can be varied by adjusting compression parameters. Another important aspect of JPEG is that decoders can trade off decoding speed against image quality by using fast but inaccurate approximations to the required calculations.

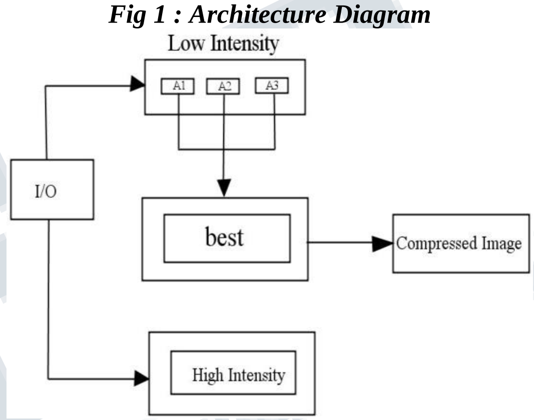
Quadtree algorithms are the simple compression techniques. Qualitative Image Compression Algorithm Relying on Quadtree was introduced by [13]. The quadtree algorithms are based on simple averages and comparisons. A quadtree is a tree-like data structure where each node either terminates on a leaf containing useful information, or branches into four sub-level quadtrees [14]. Here, a qualitative algorithm is designed based on the quadtree to divide the image. This algorithm divides the image into blocks and save them in a way that can restore the blocks again easily. Two stacks are used during the process of dividing the original image into blocks depending on a threshold value. These stacks are used as an alternative of tree, and the divided blocks are numbered effectively to determine these blocks correctly. This is designed to restore compressed images again in easy way quickly. The compression ratios are dependent on the threshold values, which can be affected the quality of compression [15].
The proposed method uses the benefits of various methods to reduce redundancy present in low intensity pixels. The results of the proposed method are compared with JPEG and some of recent methods.

## II. SYSTEM ARCHITECTURE

Initially the image is divided into high and low intensity pixels. The low intensity pixels are encoded using three different methods and the high intensity pixels are left as such. After decoding the low intensity pixels, the high intensity pixels are synthesized to get the output image. The methods discussed in Section I are used for compressing low intensity pixels. Here, the image is not segmented, only the pixel values are sent for compression.

The overall system architecture is shown in Fig.1. Initially, the input image is divided into low and high intensity components. The low intensity components are compressed while the high intensity components are left as such. The decompressed low intensity components are combined with high intensity components to get the reconstructed output image. The proposed method uses three different methods to compress low intensity components. They are: Arithmetic encoding, vector quantization and Quad tree decomposition.

***Fig 1 : Architecture Diagram***




A1-Arithmetic Encoding
A2-Quadd Tree Decomposition
A3-Vector Quantization

***Efficiency measures:***
Compression ratio is used to quantify the reduction in data-representation size produced by a data compression algorithm and is defined as the ratio between the uncompressed size and the compressed size:

Compression Ratio = Uncompressed Size/Compressed Size (1)

The term peak signal-to-noise ratio (PSNR) is an engineering term for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. The PSNR is most commonly used as a measure of quality of reconstruction in image compression etc. It is most easily defined via the Mean Squared Error (MSE) which for two m×n monochrome images I and K where one of the images is considered a noisy approximation of the other is defined as:

$$MSE = \frac{1}{MN}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}\|I(i,j) - K(i,j)\| \quad (2)$$

The PSNR is defined as

$$PSNR = 20log_{10}\left(\frac{MAX_I}{\sqrt{MSE}}\right) \quad (3)$$

Here, $MAX_I$ is the maximum possible pixel value of the image. When the pixels are represented using 8 bits per sample, this is 255.

Signal –to-noise is defined as the ratio of a signal power to the noise power corrupting the signal. Signal-to-noise ratio is the ratio between a signal and the background noise:

$$SNR = \frac{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} K(i,j)^2}{\sum_{i=0}^{m-1}\sum_{j=0}^{n-1} I(i,j)-K(i,j)^2} \quad (4)$$

### III. EXPERIMENTAL RESULTS

The proposed method is tested with 7 images. The list of images and its sizes are listed in Table 1. The proposed method is compared with JPEG and recent methods in terms of PSNR, SNR, Compression ratio and bits per pixel.

| Image | size |
|---|---|
| Cman.tif | 256x256 |
| Baboon.tif | 256x256 |
| Barbara.png | 512x512 |
| Boat.gif | 512x512 |
| Lena.png | 512x512 |
| Peppers.png | 512x512 |
| Lifting.png | 256x256 |
| GoldHill.bmp | 256 x 256 |

***Table 1 Test Image and its size***

Figure 2 shows the input and the final reconstructed output of Barbara image for the three methods. Table 2 compares Compression ratio, PSNR and bits per pixel achieved by the proposed method

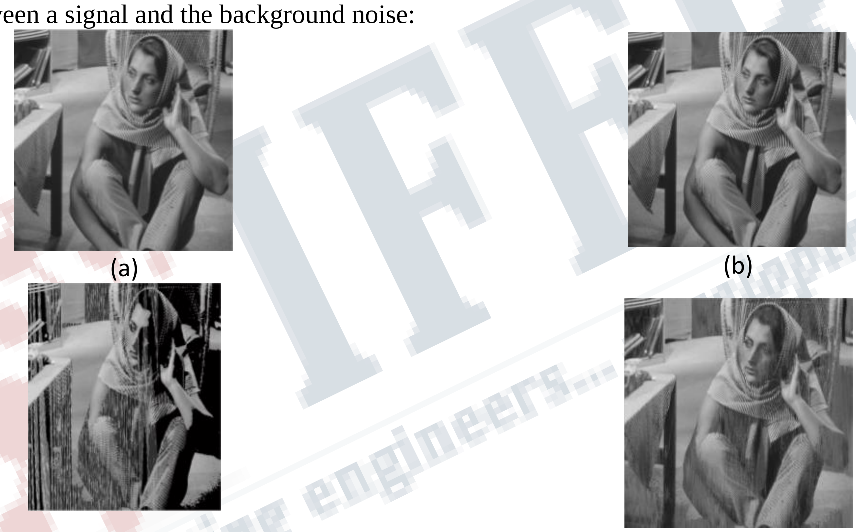



***Fig 2. (a) Input Image (b) Arithmetic coding (c) Quad-tree Decomposition (d) Vector Quantization***

***Table 2 Comparison of three different methods***

| Method/ Image | Compression Ratio | | | PSNR (dB) | | | Bits per Pixel | | |
|---|---|---|---|---|---|---|---|---|---|
| | M1 | M2 | M3 | M1 | M2 | M3 | M1 | M2 | M3 |
| Cman | 1.3376 | 1.3713 | 1.3712 | 64.4631 | 29.5617 | 16.5553 | 5.9810 | 5.8338 | 5.8345 |
| Baboon | 1.7016 | 1.8061 | 1.8158 | 62.3231 | 25.8523 | 17.1116 | 4.7014 | 4.4293 | 4.4059 |
| Barbara | 2.1694 | 2.3666 | 2.4448 | 61.1853 | 24.7652 | 12.9916 | 3.6876 | 3.3804 | 3.2722 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Boat | 1.3699 | 1.3979 | 1.4200 | 64.1750 | 25.1497 | 16.7412 | 5.8398 | 5.7229 | 5.6338 |
| Lena | 1.7360 | 1.8191 | 2.9661 | 62.2715 | 26.0758 | 13.0168 | 4.6082 | 4.3978 | 2.6911 |
| Peppers | 1.8838 | 1.9922 | 2.0512 | 61.8109 | 25.1516 | 13.7079 | 4.2468 | 4.0157 | 3.9002 |
| Lifting | 1.2059 | 1.2243 | 1.2323 | 66.2318 | 29.8082 | 20.8019 | 6.6343 | 6.5345 | 6.4918 |
| Average | **1.6292** | 1.7110 | 1.9002 | **63.2087** | 26.6235 | 15.8466 | 5.0998 | 4.9021 | **4.6042** |

M1 – Arithmetic Encoding
M2 - Quad-tree Decomposition
M3 - Vector Quantization

From Table 2, it is observed that DCT based Arithmetic encoding achieves a very tremendous PSNR when compared with Quad-tree decomposition and Vector quantization with little increase in Bits per pixel. The DCT based Arithmetic encoding also achieves better PSNR when compared to other methods. Hence this method alone is compared with JPEG 2000, Variable Block Size coding (VBS) [16], Adaptive Predictive Combination (APC) [17] and Encryption Then Compression (ETC) [18].

***Table 3 Bits per pixel Comparison of the proposed method with JPEG and recent method***

| Method / Image | JPEG 2000 | VBS (2010) | APC (2013) | ETC (2014) | Proposed |
|---|---|---|---|---|---|
| Barbara | 4.600 | 3.1815 | 3.75 | 1.223 | 3.6876 |
| Lena | 4.684 | 4.280 | 3.45 | 0.766 | 4.6082 |
| GoldHill | 4.603 | 4.207 | 4.20 | 1.137 | 3.1134 |

Table 3 shows that the proposed method achieves better bits per pixel than JPEG 2000 whereas higher bits per pixel than the recent methods. Compression ratio and PSNR values of the proposed method are compared with 2D ALP (2014) [19] method. It is shown in Table 5.

***Table 4 PSNR and Compression Ratio comparison of the proposed method with recent method***

| Method/ Image | PSNR (dB) | | Compression Ratio | |
|---|---|---|---|---|
| | 2D ALP | Proposed | 2D ALP | Proposed |
| Barbara | 27.840 | 61.1853 | 10.479 | 2.1694 |
| Boat | 28.003 | 64.1750 | 8.795 | 1.3699 |
| Cman | 29.616 | 64.4631 | 9.661 | 1.3376 |

The proposed method achieves double the PSNR value when compared to 2D ALP method. Also, the proposed method achieves better compression ratio than 2D ALP method. Both the comparisons are shown in Fig. 3 and 4.

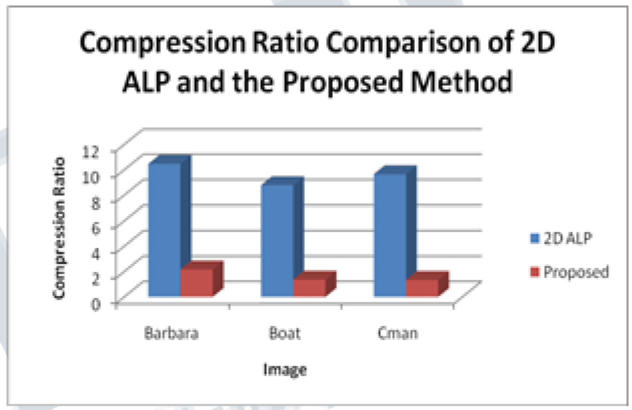



***Fig. 3 Comparison of compression ratio of the proposed method with 2D ALP method***

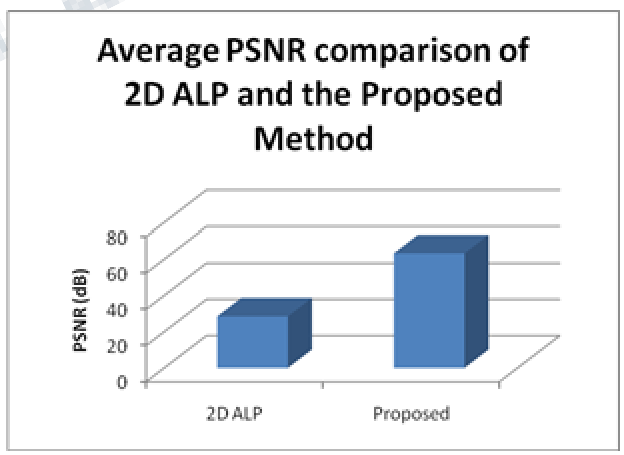



***Fig. 4 Average PSNR comparison of the Proposed Method and 2D ALP method***

## CONCLUSION

Image compression is used in storage and transmission. Many methods were to improve the compression efficiency. This paper studies the impact of low intensity pixels in compression. The image is divided into low and high intensity pixels. Among which only low intensity pixels are encoded and the high intensity pixels are not coded. The low intensity pixels are encoded using three different methods and tested with various types of images. JPEG 2000 is the most popular standard used in many devices. The best method is chosen and compared with JPEG 2000 and the obtained results are tabulated. It indicates that low intensity pixels plays a significant role in image compression.

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