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Various Compression Algorithms: A Review

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***Abstract* —Compression is presently fundamental for applications, for example, transmission and capacity in information bases. In this paper we audit and examine about the picture compression, need of compression, its standards, and classes of compression and different calculation of picture compression. This paper endeavors to give a formula for choosing one of the prominent picture compression calculations in light of (a) Wavelet, (b) JPEG/DCT, (c) VQ, and (d) Fractal approaches. We survey and talk about the points of interest and hindrances of these calculations for packing grayscale pictures, give an exploratory examination on 256×256 ordinarily utilized picture of Lenna and one 400×400 unique mark picture.**

***Keywords*— Image compression, JPEG, VQ, Wavelet, Fractal.**

I. INTRODUCTION

Picture compression is the utilization of information compression on computerized pictures. In actuality, the goal is to decrease repetition of the picture information keeping in mind the end goal to have the capacity to store or transmit information in an effective shape. Picture compression might be lossy or lossless. Lossless compression is favored for authentic purposes and regularly for restorative imaging, specialized illustrations, cut workmanship, or funnies. This is on account of lossy compression techniques, particularly when utilized at low piece rates, present compression antiques. Lossy techniques are particularly reasonable for normal pictures, for example, photos in applications where minor (some of the time vague) loss of constancy is worthy to accomplish a generous diminishment in bit rate. Uncompressed sight and sound (illustrations, sound and video) information requires impressive capacity limit and transmission transfer speed. Notwithstanding fast advance in mass-stockpiling thickness, processor speeds, and computerized correspondence framework execution, interest for information stockpiling limit and information transmission data transmission keeps on overwhelming the capacities of accessible advances. The ongoing development of information escalated sight and sound based web applications have not just managed the requirement for more proficient approaches to encode flags and pictures yet have made compression of such flags vital to capacity and correspondence innovation.wavelet transform has emerged as a cutting edge technology, within the field of image compression. Wavelet-based coding [13] provides substantial improvements in picture quality at higher compression ratios.

II. PRINCIPLES FOR COMPRESSION?

A typical normal for most pictures is that the neighboring pixels are connected and in this manner contain repetitive data. The premier undertaking at that point is to discover less connected portrayal of the picture. Two central segments of compression are repetition and unimportance lessening. Excess diminishment goes for expelling duplication from the flag source (picture/video). Insignificance lessening precludes parts of the flag that won't be seen by the flag collector, to be specific the Human Visual System (HVS). As a rule, three kinds of repetition can be distinguished:

A. *Coding Redundancy*

A code is an arrangement of images (letters, numbers, bits, and so forth) used to speak to an assortment of data or set of occasions. Each snippet of data or occasions is doled out a succession of code images, called a code word. The quantity of images in each code word is its length. The 8-bit codes that are utilized to speak to the forces in the most 2-D power clusters contain a bigger number of bits than are expected to speak to the powers.

B. *Spatial Redundancy and Temporal Redundancy*

Since the pixels of most 2-D power clusters are corresponded spatially, data is pointlessly repeated in the portrayals of the associated pixels. In video succession, transiently corresponded pixels additionally copy data.

C. *Irrelevant Information*

Most 2-D power exhibits contain data that is overlooked by the human visual framework and unessential to the proposed utilization of the picture. It is excess as in it isn't utilized.

Picture compression inquires about goes for lessening the quantity of bits expected to speak to a picture by expelling the spatial and unearthly redundancies however much as could reasonably be expected.

III. NEED OF COMPRESSION?

The figures in Table 1 show the qualitative transition from simple text to full-motion video data and the disk space transmission bandwidth, and transmission time needed to store and transmit such uncompressed data.

TABLE I
MULTIMEDIA DATA TYPES AND UNCOMPRESSED STORAGE SPACE, TRANSMISSION BANDWIDTH, AND TRANSMISSION TIME

REQUIRED. THE PREFIX KILO- DENOTES A FACTOR OF 1000 RATHER THAN 1024.

Multimedia Data	*Size/Duration*	*Bits/Pixel or Bits/Sample*	*Uncompressed Size (B for bytes)*	*Transmission Bandwidth (b for bits)*	*Transmission Time*
A page of text	11"x8.5"	Varying resolution	4-8KB	32-64 Kb/page	1.1 - 2.2 sec
Telephone quality speech	10 sec	8 bps	80 KB	64 Kb/sec	22.2 sec
Grayscale Image	512x512	8 bpp	262KB	2.1 Mb/image	1 min 13 sec
Color Image	512x512	24 bpp	786KB	6.29 Mb/image	3 min 39 sec
Medical Image	2048x 1680	12 bpp	5.16 MB	41.3 Mb/image	23 min 54 sec
SHD Image	2048 x 2048	24 bpp	12.58 MB	100 Mb/image	58 min 15 sec
Full-motion Video	640 x 480, 1min(30 frames/ sec)	24 bpp	1.66 GB	221 Mb/sec	5 days 8 hrs

The examples given in the Table I clearly illustrate the need for sufficient storage space, large transmission bandwidth, and long transmission time for image, audio, and video data.

At the present state of technology, the only solution is to compress multimedia data before its storage and transmission, and decompress it at the receiver for play back. For example, with a compression ratio of 32:1, the space, bandwidth, and transmission time requirements can be reduced by a factor of 32, with acceptable quality.

IV. DIFFERENT CLASSES OF COMPRESSION TECHNIQUES?

Two ways of classifying compression techniques are mentioned here.

A. *Lossless vs. Lossy compression:*

In lossless compression conspires, the remade picture, after compression, is numerically indistinguishable to the first picture. Anyway lossless compression can just accomplish an unassuming measure of compression. A picture reproduced following lossy compression contains corruption in respect to the first. Regularly this is on the grounds that the compression plot totally disposes of excess data. Be that as it may, lossy plans are equipped for accomplishing significantly higher compression. Under ordinary survey conditions, no noticeable misfortune is seen (outwardly lossless).

B. *Predictive vs. Transform coding:*

In prescient coding, data effectively sent or accessible is utilized to anticipate future qualities, and the distinction is coded. Since this is done in the picture or spatial area, it is moderately easy to execute and is promptly adjusted to nearby picture attributes. Differential Pulse Code Modulation (DPCM) is one specific case of prescient coding. Change coding, then again, first changes the picture from its spatial space portrayal to an alternate sort of portrayal utilizing some notable change and afterward codes the changed qualities (coefficients). This strategy gives more noteworthy information compression contrasted with prescient techniques, in spite of the fact that to the detriment of more prominent calculation.

V. A TYPICAL IMAGE CODER?

A typical lossy image compression system which consists of three closely connected components namely (a) Source Encoder (b) Quantizer, and (c) Entropy Encoder. Compression is accomplished by applying a linear transform to decorrelate the image data, quantizing the resulting transform coefficients, and entropy coding the quantized values.

A. *Source Encoder (or Linear Transformer)*

Over the years, a variety of linear transforms have been developed which include Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT) [1], Discrete Wavelet Transform (DWT)[13] and many more, each with its own advantages and disadvantages.

B. *Quantizer*

A quantizer simply reduces the number of bits needed to store the transformed coefficients by reducing the precision of those values. Since this is a many-to-one mapping, it is a lossy process and is the main source of compression in an encoder. Quantization can be performed on each individual coefficient, which is known as Scalar Quantization (SQ). Quantization can also be performed on a group of coefficients together, and this is known as Vector Quantization (VQ). Both uniform and non-uniform quantizers can be used depending on the problem at hand.

C. *Entropy Encoder*

An entropy encoder additionally packs the quantized qualities lossless to give better general compression. It utilizes a model to precisely decide the probabilities for each quantized esteem and delivers a fitting code in light of these probabilities with the goal that the resultant yield code stream will be littler than the information stream. The most regularly utilized entropy encoders are the Huffman encoder and the number-crunching encoder, in spite of the fact that for applications requiring quick execution, basic run-length encoding (RLE) has demonstrated exceptionally successful.

Note that an appropriately outlined quantizer and entropy encoder are completely vital alongside ideal flag change to get the most ideal compression.

VI. VARIOUS COMPRESSION ALGORITHMS

A. JPEG : DCT-Based Image Coding Standard

The JPEG/DCT still picture compression has turned into a standard as of late. JPEG is intended for packing either full-shading or dim scale pictures of regular, genuine scenes. It functions admirably on photos, naturalistic fine art, and comparable material; not all that well on lettering, straightforward toons, or line illustrations. JPEG handles just still pictures, yet there is a related standard called MPEG for movies. JPEG is "lossy," implying that the decompressed picture isn't exactly the same as the one you began with. JPEG is intended to misuse known constraints of the human eye, eminently the way that little shading changes are seen less precisely than little changes in brilliance.

To abuse this technique, a picture is first parceled into nonoverlapped 8×8 squares. A discrete Cosine change (DCT) [10, 14] is connected to each square to change over the dim levels of pixels in the spatial space into coefficients in the recurrence area. The coefficients are standardized by various scales as per the quantization table gave by the JPEG standard led by some psychovisual confirm. The quantized coefficients are reworked in a crisscross sweep request to be additionally packed by a proficient lossless coding methodology, for example, run length coding, number juggling coding, or Huffman coding. The disentangling is basically the opposite procedure of encoding. Thus, the JPEG compression sets aside about a similar time for both encoding and disentangling. The encoding/disentangling calculations gave by a free JPEG aggregate [14] are accessible for testing true pictures. The data misfortune happens just during the time spent coefficient quantization. The JPEG standard characterizes a standard 8×8 quantization table [14] for all pictures which may not be suitable. To accomplish a superior unraveling nature of different pictures with a similar compression by utilizing the DCT approach, a versatile quantization table might be utilized as opposed to utilizing the standard quantization table.

B. Image Compression by Wavelet Transform

1) *What is a Wavelet Transform?*

Wavelets are capacities characterized over a limited interim and having a normal estimation of zero. The fundamental thought of the wavelet change is to speak to any discretionary capacity (t) as a superposition of an arrangement of such wavelets or premise capacities. These premise capacities or child wavelets are gotten from a solitary model wavelet called the mother wavelet, by enlargements or withdrawals (scaling) and interpretations (shifts). The Discrete Wavelet Transform of a limited length flag x(n) having N parts, for instance, is communicated by a N x N network. For a straightforward and amazing prologue to wavelets, see [3]. For an intensive investigation and uses of wavelets and channel banks [11, 13].

2) *Why Wavelet-based Compression?*

Despite all the advantages of JPEG compression schemes based on DCT namely simplicity, satisfactory performance, and availability of special purpose hardware for implementation; these are not without their shortcomings. Since the input image needs to be ``blocked," correlation across the block boundaries is not eliminated. This results in noticeable and annoying ``blocking artifacts" particularly at low bit rates as shown in Fig. 1. Lapped Orthogonal Transforms (LOT) [6] attempt to solve this problem by using smoothly overlapping blocks. Although blocking effects are reduced in LOT compressed images, increased computational complexity of such algorithms do not justify wide replacement of DCT by LOT.

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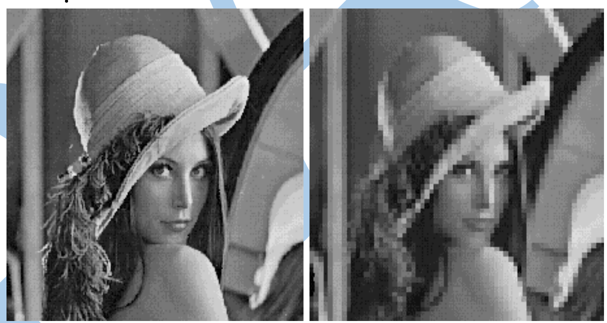


(a) (b)

Fig. 1(a) Original Lena Image, and (b) Reconstructed Lena with DC component only, to show blocking artifacts

Over the past several years, the wavelet transform has gained widespread acceptance in signal processing in general and in image compression research in particular. In many applications wavelet-based schemes (also referred as sub band coding) outperform other coding schemes like the one based on DCT. Since there is no need to block the input image and its basis functions have variable length, wavelet coding schemes at higher compression avoid blocking artifacts. Wavelet-based coding is more robust under transmission and decoding errors, and also facilitates progressive transmission of images. In addition, they are better matched to the HVS characteristics. Because of their inherent multiresolution nature [7], wavelet coding schemes are especially suitable for applications where scalability and tolerable degradation are important.

C. VQ Compression:

A vector quantizer is composed of two operations. The first is the encoder, and the second is the decoder. The encoder takes an input vector and outputs the index of the codeword that offers the lowest distortion. In this case the lowest distortion is found by evaluating the Euclidean distance between the input vector and each codeword in the codebook. Once the closest codeword is found, the index of that codeword is sent through a channel (the channel could be computer storage, communications channel, and so on). When the encoder receives the index of the codeword, it replaces the index with the associated codeword.

The fundamental idea of VQ for image compression is to establish a codebook consisting of code vectors such that each code vector can represent a group of image blocks of size $m \times m$, (m=4 is always used). An image or a set of images is first partitioned into $m \times m$ nonoverlapping blocks which are represented as m2-tuple vectors, called training vectors. The size of training vectors can be very large. For example, a 512 × 512 image contributes 16,384 training vectors.

The goal of codebook design is to establish a few representative vectors, called code vectors of size 256 or 512, from a set of training vectors. The encoding procedure is to look for a closest code vector in the codebook for each nonoverlapped 4 × 4 block of an image to be encoded. The most important work is to design a versatile codebook. Nasrabadi and King [22] give a good review of VQ. Chen's comparison [16] indicates that a codebook developed based on LBG [21] algorithm generally has higher PSNR values over some other schemes despite its slow off-line training. In this paper, we adopt LBG algorithm for training a codebook of size 256×256 to meet a desired 0.5 bpp compression ratio.

D. Fractal Compression:

Fractal image coding was introduced in the late 1980s and early 1990s [20, 26]. It is used for encoding/ decoding images in Encarta/Encyclopedia [15]. Fractal coding is based on the Collage theorem and the fixed point theorem [15, 19] for a local iterated function system consisting of a set of contraction affine transformations [15]. A fractal compression algorithm first partitions an image into nonoverlapping 8×8 blocks, called range blocks and forms a domain pool containing all of possibly overlapped 16×16 blocks, associated with 8 isometries from reflections and rotations, called domain blocks. For each range block, it exhaustively searches, in a domain pool, for a best matched domain block with the minimum square error after a contractive affine transform is applied to the domain=block.

A fractal compressed code for a range block consists of quantized contractively coefficients in the affine transform, an offset which is the mean of pixel gray levels in the range block, the position of the best matched domain block and its type of isometry. The decoding is to find the fixed point, the decoded image, by starting with any initial image. The procedure applies a compressed local affine transform on the domain block corresponding to the position of a range block until all of the decoded range blocks are obtained. The procedure is repeated iteratively until it converges (usually in no more than 8 iterations).

Two serious problems that occur in fractal encoding are the computational demands and the existence problem of best range-domain matches [19]. The most attractive property is the resolution-independent decoding property. One can enlarge an image by decoding an encoded image of smaller size so that the compression ratio may increase exponentially [15, 18]. An algorithm based on [20] using range and domain block matches of fixed sizes is written and is used for a comparison in this paper [17]. Other algorithms using various block sizes of domain and range blocks associated with a quad tree structure can be found in [19].

VII. ADVANTAGES AND DISADVANTAGES OF VARIOUS COMPRESSION ALGORITHM

There are some advantages and disadvantages of various algorithms which are shown in table II.

TABLE II

Method	Advantages	Disadvantages
Wavelet	• High Compression Ratio • State-Of-The-Art	• Coefficient quantization • Bit allocation
JPEG	• Current Standard	• Coefficient(dct) quantization • Bit allocation
VQ	• Simple decoder • No-coefficient quantization	• Slow codebook generation • Small bpp
Fractal	• Good mathematical Encoding-frame	• Slow Encoding

VIII. EXPERIMENTAL COMPARISON

Image compression algorithms based on Wavelet Transform [23], JPEG/DCT [25], Vector Quantization [16], and Fractal [15] methods were tested for 256×256 real image of Lenna and 400×400 fingerprint image. The results of performance are shown in Table III, IV and V.

In Table III, IV and V the performance of different algorithms is shown in which there is PSNR value and CPU Time (Encoding and Decoding) is shown. And we summarize the comparison of Compression ratio of different algorithm in Table VI given below.

TABLE III
PERFORMANCE OF CODING ALGORITHMS ON 256×256 IMAGES

Algorithm	PSNR values OF Leena's image (in dB)	CPU time	
		Encoding	Decoding
Wavelet	34.66	0.35 sec	0.27 sec
JPEG	31.73	0.12 sec	0.12 sec
VQ	29.28	2.45 sec	0.18 sec
Fractal	29.04	5.65 hrs	1.35 sec

TABLE IV
PERFORMANCE OF CODING ALGORITHMS ON A 400×400 FINGERPRINT IMAGE OF 0.5BPP

Algorithm	0.5bpp		
	PSNR values	Encoding Time	Decoding Time
Wavelet	36.71	0.8 sec	0.7 sec
JPEG	34.27	0.2 sec	0.2 sec
VQ	28.26	6.0 sec	0.7 sec
Fractal	27.21	6.3 hrs	3.5 sec

TABLE V
PERFORMANCE OF CODING ALGORITHMS ON A 400×400 FINGERPRINT IMAGE OF 0.25BPP

Algorithm	0.25bpp		
	PSNR values	Encoding Time	Decoding Time
Wavelet	32.47	0.7 sec	0.5 sec
JPEG	29.64	0.2 sec	0.2 sec
VQ	N/A	N/A	N/A
Fractal	N/A	N/A	N/A

TABLE VI
PERFORMANCE ON THE BASIS OF COMPRESSION RATIO OF DIFFERENT CODING ALGORITHMS

Method	Compression ratio
Wavelet	>>32
JPEG	<=50
VQ	<32
Fractal	>=16

The associated PSNR values and encoding/decoding times shown in Table III ,IV and V for the images shown in Figure 2 indicate that all the four approaches are satisfactory at 0.5 bpp request (CR=16). However, the EZW [23, 24] has significantly larger PSNR values and a better visual quality of decoded images compared with the other approaches.

At a desired compression of 0.25 bpp (CR=32) for the fingerprint image, the commonly used VQ cannot be tested, and the fractal coding cannot be achieved unless resolution-free decoding property is utilized which is not useful for the current purpose; both EZW [23] and JPEG [25] approaches perform well, and the results of EZW have significant larger PSNR values than that of JPEG.

The original images of Lenna and fingerprint are shown in Figure 2.

(a) (b)

Fig. 2 Original images of (a) Lenna and (b) fingerprint

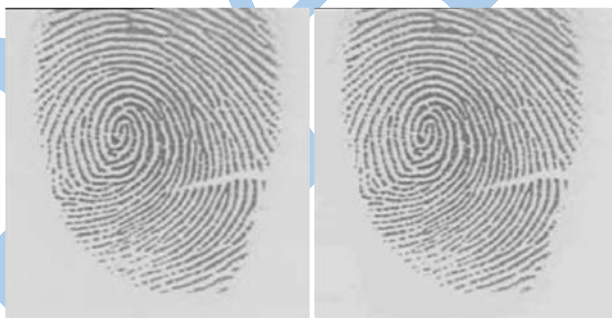
The decoded images of Leena based on the four approaches (a) Wavelet Transform, (b) JPEG, (c) Vector Quantization, (d) Fractal are shown in Figures 3.

(a) (b)

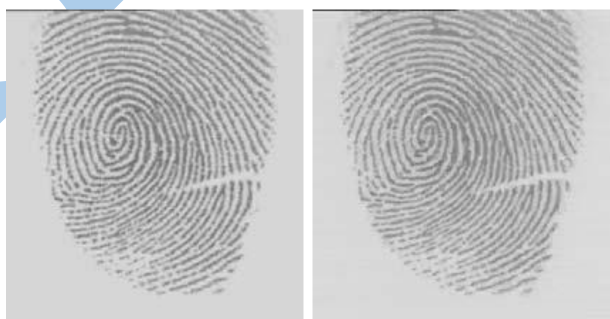
(c) (d)

Fig. 3: Decoded image of Lena by (a) Wavelet, (b) JPEG, (c) VQ, and (d) Fractal algorithms

The decoded images of fingerprints based on the four approaches (a) Wavelet Transform, (b) JPEG, (c) Vector Quantizations, (d) Fractal are shown in Figures 4.



(a) (b)



(c) (d)

Fig. 4 Decoded fingerprints by (a) Wavelet, (b) JPEG, (c) VQ, (d) Fractal algorithms.

IX. CONCLUSION

We have reviewed and summarized the characteristics of image compression, need of compression, principles behind compression, different classes of compression techniques and various image compression algorithms based on Wavelet, JPEG/DCT, VQ, and Fractal approaches. Experimental comparisons on 256×256 commonly used image of Lenna and one 400×400 fingerprint image suggest a recipe described as follows. Any of the four approaches is satisfactory when the 0.5 bits per pixel (bpp) is requested. However, for a very low bit rate, for example 0.25 bpp or lower, the embedded zero tree wavelet (EZW) approach is superior to other approaches. For practical applications, we conclude that (1) Wavelet based compression algorithms are strongly recommended, (2) DCT based approach might use an adaptive quantization table, (3) VQ approach is not appropriate for a low bit rate compression although it is simple, (4) Fractal approach should utilize its resolution-free decoding property for a low bit rate compression.

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