Survey paper on image compression techniques

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Abstract - *This paper attempts to give a best approach for selecting one of the popular image compression algorithms based on (a) Wavelet, (b) JPEG/DCT, (c) VQ, and (d) Fractal approaches. We review and discuss the advantages and disadvantages of these algorithms for compressing grayscale images and colored images. Here we are trying to find the best performance approach amongst the several compression algorithms. This paper shows that all of the four approaches perform satisfactorily when the 0.5 bits per pixel (bpp) is desired. However, for a low bit rate compression like 0.25 bpp or lower, the embedded zerotree wavelet (EZW) approach, SPHIT approach and DCT-based JPEG approach are more practical.*

Key Words: **wavelet compression, JPEG/DCT, vector quantization, fractal, genetic algorithm**

1.INTRODUCTION

As growing of media communication and video on demand is desired, image data compression has received an increasing interest. The main purpose of image compression is to gain a very low bit rate and achieve a high visual quality of decompressed images. Image compression are used all fields of media communication such as multimedia, medical image recognition, digital image processing. The fundamental techniques of video compression are based on the schemes of still gray level image compression and colored image compression.

This paper reviews and lists the characteristics of five popular image compression algorithms based on (a) Wavelet, (b) JPEG/DCT, (c) VQ and (d) Fractal methods (e) genetic algorithm, supports to take decision for selecting a compression technique that gives desired results. The purpose is to give a best decision making for selecting an appropriate image compression algorithm for the problems in hand. The PSNR (peak signal-to-noise ratio) value used to measure the deference between a decoded image F' and its original image F is defined as follows where F'(i , j) is the pixel value of decoded image and F(i, j) is the pixel value of original image . Most image compression systems are designed to minimize the MSE and maximize the PSNR for good quality of decoded images.

$$MSE = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{J=0}^{N-1}[F'(i,j) - F(i,j)]^2$$

$$\text{PSNR}=10\log 10\left[\frac{255\times255}{MSE}\right]dB$$

2. Review of Compression Algorithms

The goal of image compression is to save storage space and to reduce transmission time for image data. Its aims to achieving a high compression ratio (CR) while preserving good fidelity of decoded images. The techniques used to compress and decompress a single gray level image are expected to be easily modified to encode/decode color image sends image sequences. Recent compression methods can be briefly classified into five categories: (a) Wavelet, (b) JPEG/DCT, (c) VQ, (d) Fractal methods and (e) Genetic algorithm, which are briefly describe below.

2.1 Wavelet Compression

Internet teleconferencing, High Definition Television (HDTV), satellite communications and digital storage of images will not be feasible without a high degree of compression. Wavelets compression is very popular compression approach in mathematics and digital image processing area because of their ability to effective represent and analysis of data. Image compression algorithms based on Discrete Wavelet Transform (DWT), such as Embedded Zero Wavelet (EZW) which capable of excellent compression performance, both in terms of statistical peak signal to noise ratio (PSNR) and subjective human perception of the reconstructed image. The current wavelet approach applies a wavelet transform on images in a pyramid fashion up to the desired scale using the theory of multi resolution signal decomposition with the wavelet representation and the concept of embedded zerotree wavelet (EZW) based on the decaying spectrum hypothesis . In a pyramidal structure after a certain scale of wavelet transforms on an image, an algorithm successively determines if a coefficient is significant in the spatial-frequency domain to form a significance map consisting of the sign (+ or−) of a significant coefficient, an insignificant symbol, and a zerotree symbol.It assumes that wavelet coefficients of an image in the finer resolutions corresponding to a zerotree mark have smaller magnitudes than the one marked as zerotree in a coarser resolution for this image according to a practical, but false decaying spectrum hypothesis[2]. An algorithm has been widely tested with desirable results and shown to be very effective. SPIHT is also a wavelet transform method, this is the best algorithms in terms of the peak signal-to-noise ratio (PSNR) and its execution time. Set partitioning in hierarchical trees provide excellent rate distortion performance with low encoding complexity and with higher degree of compression performance.

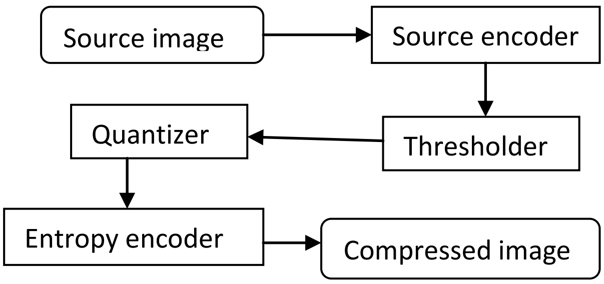

Fig1.wavelet compression

2.2 JPEG Compression

The JPEG/DCT image compression has become a standard and very popular compression scheme. To take advantage of this method, firstly, an image is partitioned into non overlapped 8×8 blocks. A discrete Cosine transform(DCT) is applied to each block to convert the gray levels of pixels in the spatial domain into coefficients in the frequency domain. The coefficients are normalized by different scales according to the quantization table provided by the JPEG standard conducted by some psychovisual evidence. The quantized coeffcients are rearranged in a zigzag scan order to be further compressed by an efficient lossless coding strategy such as run length coding, arithmetic coding, or Huffman coding . The decoding is simply the inverse process of encoding. So, the JPEG compression takes equal time for both encoding and decoding. The encoding and decoding algorithms provided by an independent JPEG group are available for testing of real-world images.

The information can be loss that occurs only in the process of coefficient quantization. The JPEG standard describe the standard 8×8 quantization table for all images which may not be appropriate or efficient. To achieve a better decoding quality of various images with the same compression by using the DCT approach, an adaptive quantization table may be more efficient approach instead of using the standard quantization table.

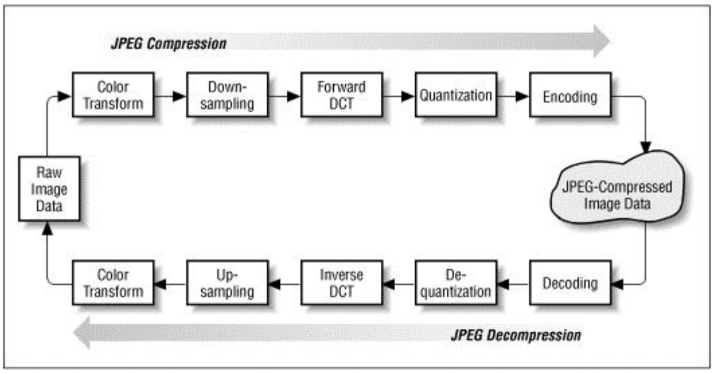

Fig2. JPEG/DCT compression

2.2.1 Requirements

The goal of JPEG compression has been to develop a method for Continuous tone image compression which meets the following requirements:

a) Be at or near the state of the art with regard to Compression rate and accompanying image Fidelity, over a wide range of image quality ratings, and especially in the range where visual fidelity to the original is characterized as “very good” to “Excellent”;

also, the encoder should be parameterizable, so that the application (or user) can set the desired compression/quality tradeoff[8];

b) Be applicable to practically any kind of continuous tone digital source image (i.e. for most practical purposes not be restricted to images of certain dimensions, color spaces, pixel aspect ratios,resolution, etc.) and not be limited to class of imagery with restrictions on the scene contents, such as complexity, range of colors, or statistical properties.

c) Have tractable computational complexity, to make a feasible software implementations with available performance on a range of CPU's, as well as hardware implementations with viable cost for applications require high performance.

2.3 VQ Compression

Vector quantization is a very powerful technique for digital image compression. A vector quantization(VQ) is defined as a mapping Q of K dimensional Euclidean space P^K in to a finite subset Y of P^K. Shown in the following equation: Q: $P^K \rightarrow Y$ where Y={x_i; $i = 1,2,3 \ldots N$}, is the set of reproduction vectors and also called a vector quantization codebook, and N is the number of vectors in Y. For generating codebook there exists different algorithms, like a Linde, Buzo and Gray (LBG) algorithm explain in [3] and Self Organizing Feature Map (SOFM) explain in [4] etc. Firstly, An image or a set of images is first partitioned into m × m non overlapping 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 non overlapped 4×4 block of an image to be encoded. The most important work is to design a versatile codebook. Chen's comparison [5] indicates that a codebook developed based on LBG algorithm generally has higher PSNR values over some other schemes despite its slow off-line training.

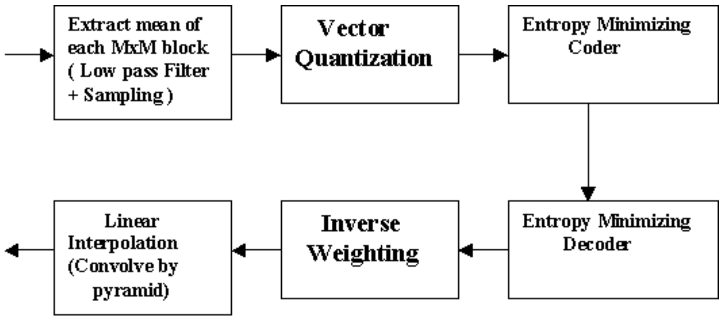

Fig3.vector quantization compression

2.4 Fractal Compression

Fractal coding is based on the Collage theorem and the fixed point theorem [4] for a local iterated function system (IFS) that consist of a set of contraction affine transformations. The amazing property of IFS is that when the set is evaluated by iteration, a unique image emerges. This latent image is called the fixed point or attractor of the IFS. As guaranteed by a result known as the contraction theorem that completely independent of the initial image. This compression algorithm first partitions an image into nonoverlapping 8×8 blocks, called range blocks and forms a domain pool containing all of possible 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 achieving 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 contractivity coefficients in the affine transform, an offset which means of pixel gray levels in the range block, the position of the best matched domain block and its type of isometry. The decoding is used 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 the position of a range block until all of the decoded range blocks are obtained as desired result. The procedure is repeated iteratively until it converges. Two major problems that occur in fractal encoding are the computational demands and the existence problem of best range-domain matches. The most important and 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 increased exponentially. An algorithm based on [5] using range block and domain block matches of fixed sizes is written and is used for a comparison in this paper [6]. Other algorithms using various block sizes of domain and range blocks are associated with a quadtree structure can be found in [7].

2.5 Genetic algorithm

Genetic Algorithms (GAs) are procedures that follow the principles of natural selection and natural genetics code, that have proved to be very efficient searching for approximations to global optima in large and complex spaces in relatively short time.

The basic components of GAs are:

- genetic operators (mating and mutation)
- an appropriate representation of the problem that is to be solved
- a fitness function
- an initialization procedure

With these basic components of GA, the procedure as follows. It starts with the initialization procedure to generate the first population. The members of the population are basically the strings of symbols (chromosomes) that represent possible solutions to the problem to be solved. Each members of the population for the given generation is evaluated, and, according to its fitness, it is assigned a probability to be selected for reproduction. By using this probability distribution, the genetic operators select some of the individuals. New individuals are obtained, by applying these operators. The mating operator selects two population members and combines their respective chromosomes to create offspring. The mutation operator selects a member of the population and changes some part of its chromosomes. The elements of the populations with the worst fitness measure are replaced by the new individuals.

3.Comparesion between compression techniques

There are given a comparesion between image compression techniques. These techniques have some advantages and disadvantages which consider in table.

Method	Advantages	Disadvantages
Wavelet	a)High compression ratio b)state-of-the art c)low encoding complexity d)it produces no blocking artifacts	a)Coefficient quantization b)bit allocation c)less efficient
JPEG/DCT	a)current standard b) high quality and small degree of compression c)comparatively fast with others methods	a)Coefficient quantization b)bit allocation
VQ	a)Simple decoder b)no coefficient quantization	a)slow codebook generation b)small bpp
Fractal	a)good mathematical encoding frame b)resolution free decoding	a)slow encoding
Genetic algorithm	a)capable of handling complexity and irregular solution spaces b)robust technique	a)repeated fitness function evaluation for complex problem b)not more efficient

4. CONCLUSIONS

We have summarized the characteristics of four up-to-date image coding algorithms based on Wavelet, JPEG/DCT, VQ, Fractal, Genetics approaches. Any of the five approaches is satisfactory when the 0.5 bits per pixel is requested. However, for a very low bit rate, for example 0.25 bpp or lower, the embedded zerotree wavelet (EZW) approach is more applicable and superior to other approaches. For practical applications, we conclude that (1) Wavelet transform based compression algorithms[9,10] are strongly recommended, (2) JPEG/ 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 and slow processed, (4) Fractal approach should utilize its resolution-free decoding property for a low bit rate compression but it is also slow encoding approach, (5) Hybrid compression algorithms based on some of these four approaches may be pursued to achieve a higher compression ratio while preserving a better quality of up-to-date decoded images.

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