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Development of Constant Bit Rate JPEG Image Compression Using Fuzzy Logic

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Abstract: ***Due to the increase in need of transmission of images in computer, mobile environments, the research in the field of image compression has increased significantly. Image compression plays a important role in digital image processing. In this paper image compression is done using slant transform exploiting the characteristics of Human Visual System (HVS). Normally JPEG compressors support variable bit error rate.. For few applications like digital camera requires fixed bit rate. In this for different quality values bit rate is achieved by the use of fuzzy logic. Fuzzy logic is conceptually easy to understand. This paper is a survey for lossy image compression using Discrete cosine transform (DCT). The mathematical concepts behind fuzzy reasoning are very simple.***

Keywords: Fuzzy logic, bit rate, DCT (Discrete Cosine Transform), JPEG, HVS.

1. Introduction

Digital images have become popular for transferring, sharing storing and visual information and hence high speed compression techniques are need Among many advantages of image compression, the most important one is to reduce the time for the transmission of images .Basically these compression techniques can be categorized into the Lossy compression techniques and lossless compression techniques. Images exploit three types of redundancies: Inter-pixel redundancy,coding redundancy and psycho visual redundancy. In image, coding redundancy is eliminated by variable length coding by assigning fewer bits to more probable gray values and lengthy codes to less probable gray levels. Based on these redundancies compression is grouped into lossless and lossy compression. In lossless only the first two redundancies are exploited. In lossy all the three types of redundancies are exploited. Joint photographic expert group (JPEG) and JPEG-2000 are used as international standards for compression. Discrete Cosine Transforms (DCT) and Discrete Wavelets (DWT) form base line coding for JPEG and JPEG2000.

1.1 Compression

Compression is a method that reduces the size of files, The aim of compression is to reduce the number of bits that are not required to represent data and to decrease the transmission time, Long P.M. et al, Achieve compression by encoding data and the data is decompressed to its original form by decoding. A common compressed file extensions is .sit, .tar, .zip; which indicates different types of software used to compress.

1.2 Decompression

The compressed file is firstly decompressed and then used. There are many software's used to decompress and it depends upon which type of file is compressed. For example WinZip software is use to decompress .zip file. The basic block diagram of Compression, Decompression And reconstructed data/images is as follows.

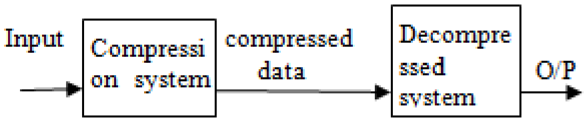

Figure1: Block diagram of compression and decompression.

2. Types of Compression

2.1. Lossless Compression

In lossless image compression, the reconstructed image Z at the output of the decoder is exactly the same as the original image X (Fig. 1) at the input of the encoder,provided the channel is errorless. One form of lossless compression is Huffman coding. In this technique, it is assumed that each pixel intensity is associated with a certain probability of occurrence and this probability is spatially invariant.each intensity value assigns a binary code using Huffman coding , with shorter codes going to intensities with higher probability. If the probabilities can be estimated a priori, then the table of Huffman codes can be fixed at both the encoder and the decoder. Otherwise, the coding table must be sent to the decoder along with the compressed image data. Other lossless compression techniques include run- length coding (RLC) , arithmetic coding, and bit plane coding. Like Huffman coding, they also have limited compression ratios and so are used only in very sensitive applications (such as medical imagery) where knowledge loss is unacceptable, or employed in conjunction with alternative techniques.

2.2. Lossy Compression

Lossy compression is used to compress multimedia data (audio, video and still images). JPEG [6] "Joint Photographic Experts Group" was developed still image compression standards. JPEG was formally accepted as an international standard in 1992. JPEG is a lossy image compression method. It employs a transform coding method using the

DCT (Discrete Cosine Transform) .The effectiveness of the DCT transform coding method in JPEG relies on the major observation that the useful image contents change relatively slowly across the image, i.e. it is unusual for intensity values to vary widely several times in a small area, for example, within an 8×8 image block. Much of the information in an image is repeated, hence "spatial redundancy". Psychophysical experiments suggest that humans are much less likely to notice the loss of very high spatial frequency components than the loss of lower frequency components. The spatial redundancy can be reduced by largely reducing the high spatial frequency contents.

3. Literature Review

3.1 JPEG compression using Slant Transform

The first step in slant based JPEG compression is to partition the input into non-overlapping pixel blocks of size 8×8 and forward slant transform is applied to each block as shown in equation Equ. 1

$$Y = S8\ Z\ S8 \tag{1}$$

Where Z is 8 × 8 block of original image. The Kernel *S*8 is computed recursively from the kernel *S*2 and *S*4. *S*2 is computed from equation given in Equ.

$$S2 = \frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ -1 & 1 \end{pmatrix} \tag{2}$$

The slant coefficients are given below

$$a_N = \frac{3N^2}{4(N^2-1)} \tag{3}$$

$$b_N = \frac{N^2-1}{4(N^2-1)} \tag{4}$$

Using Equ. 1,2,3 compute slant kernel *S*4

$$S_4 = \frac{1}{2}\begin{bmatrix} 1 & 0 & 1 & 0 \\ a_4 & b_4 & a_4 & b_4 \\ 0 & 1 & 0 & -1 \\ -b_4 & a_4 & b_4 & a_4 \end{bmatrix}$$

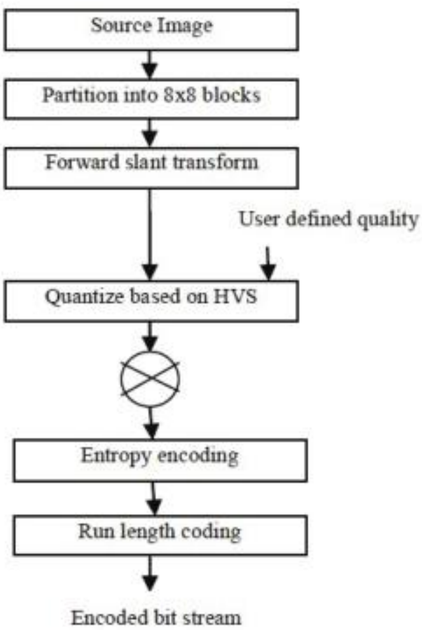

Figure 2: Block diagram of compressor with out Fuzzy Logic

$$Q(U,V) = \frac{q}{H(U,V)} \tag{6}$$

Where Q is the quality factor ranges from 0 to 100. The quantization matrix is multiplied by an adaptive gain α given in Equ. 6

$$Qnew(U,V) = \alpha Q(U,V) \tag{7}$$

As shown in figure. 2 coding redundancy is reduced by entropy coder. In this paper entropy coding is used based on default AC and DC Huffman coding tables provided by the JPEG standard, but the user has full freedom to construct custom tables that may be based on the characteristics of the image being compressed. Similarly interpixel redundancy is reduced by using mapper. In this paper mapper is based on run length coding. In [2] run length coding images with repeating intensities along the rows (or columns) can often be compressed by representing runs of identical intensities as run length pairs, where each run length pair specifies the start of a new intensity and the number of consecutive pixels that have that intensity. Psychovisual redundancy is eliminated by quantizer. The quantizer used is the one developed in [4]. In decoding stage, the inverse mapper, decoder and inverse slant trans-form is applied to all 8 × 8 blocks and later inverse slant transform in equation 10 applied and merged to obtain the reconstructed image. The inverse slant transform is given by

$$Z = S_8^T Y S_8 \tag{8}$$

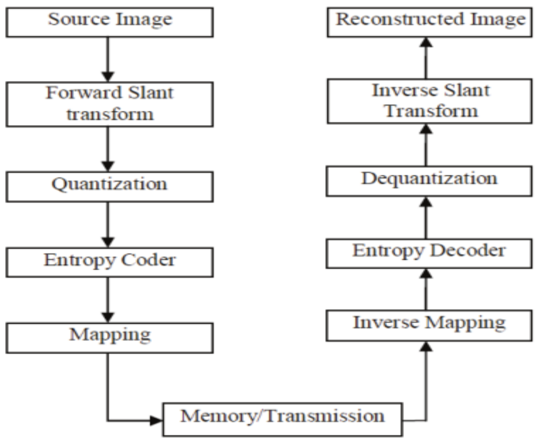

Figure 3: Encoder and decoder blocks of proposed algorithm

where Y is the 8 × 8 segment of transformed image. The quality of compressed image is judged by a metric called peak signal to noise ratio. The peak signal to noise ratio is computed from original and reconstructed image using the equation given in Equ(9)

$$PSNR = 10\log10\left(\frac{I_{max}^2}{MSE}\right) \tag{9}$$

where MSE is the mean square between the original and reconstructed image given in Equ.(10)

$$MSE = \frac{\sum_1^N \sum_1^M (X_{i,j} - Y_{i,j})^2}{MN} \tag{10}$$

The compression ratio of the compressor is defined in Equ(11)

$$CR = \frac{Bytesaftercompression}{Bytesbeforecompression} \tag{11}$$

The peak signal to noise ratio and the compression ratio of proposed compressor and decompressor shown in Fig.1 is tabulated in Table .I The encoded bit stream from compressor as shown in Fig.2 is tabulated in Table.II As shown in Table .II variable encoding stream obtained at different quality factors. So the parameters error and error rate are computed for the compressor which in later stage applied as inputs to fuzzy logic.For obtaining this the quality factor 35 is assumed as a reference point for zero error. For remaining quality factors the error is computed as the difference between encoded bits at quality factor 35 and the encoded bits for the given quality factor. The error rate is computed as the error bits at a given quality factor divided by the encoded bits obtained at quality factor 35 as shown in Table II

Table 1: Compression ratio and peak signal to noise ratio of image of reconstructed image and original image

Quality	Compression ratio	PSNR
20	10.65	36.60
25	11.13	35.67
30	12.09	34.88
35	12.42	34.22
40	12.69	33.66
45	12.77	32.69
50	13.20	36.60
60	14.75	31.92
70	16.21	30.98
80	18.00	30.61
90	19.30	30.07
100	20.1	29.61

Table 2: Quality used in quantizer and corresponding encoded bit stream

Quality	Encoded bit stream
20	76000
25	64300
30	56780
35	50000
40	45600
45	41200
50	37600
60	34000
65	32800
70	30000
75	27000
80	24300

4. Fuzzy Logic

Fuzzy Inference Systems (FIS): fuzzy set theory, which have been applied with success in many fields including compression. Their success is mainly due to their closeness to human reasoning, as well as their simplicity, which are important factors for acceptance and usability of the systems . The main modules of FIS are of particularinterest: a fuzzifier, a rule base and a defuzzifier. The fuzzifier and defuzzifier have the role of trans- forming external information in fuzzy quantities and vice versa, the core of a FIS is its knowledge base, which is ex-pressed in terms of fuzzy rules and allows for approximate reasoning . The main feature of FIS is that both the antecedents and the consequents of the rules are expressed as linguistic constraints. As a consequence, a Mam-dani FIS can provide a highly intuitive knowledge base that is easy to understand and maintain, though its rule formalization requires a time consuming defuzzification procedure.

5. Conclusion

In this paper, it has been surveyed about the existing works on the jpeg image compression techniques by the use of fuzzy logic. In this bit rate is variable for different Q values. For different Q values also the value of PSNR , MSE and CR are changed. So if we want to compress an image on particular bit rate is difficult to get.

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