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A Novel Side-match Classified Vector Quantization for Image Coding

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ABSTRACT

In this paper, a novel Side Match Classified Vector Quantization with Discrete Cosine Transform is proposed. This proposed method uses side-match where the correlation between adjacent blocks is exploited in order to avoid large transition across block boundaries and classified vector quantization preserves edge integrity in the decompressed image. This scheme transforms the image block from time domain to frequency domain with Discrete Cosine Transform. Due to the Discrete Cosine Transform and side-match classified vector quantization, output block is classified according to the perceptual feature. This classification uses an efficient edge-oriented classifier that employs the proposed transformation coefficients as encoding features. Experimental results show that the proposed image encoding technique gives good PSNR values compared with existing techniques.

Key words: Side Match Vector Quantization, Classified Vector Quantization, DCT.

1. INTRODUCTION

Image Compression is used to store or transmit only a minimal number of samples by reducing the redundancy in image [1]. It can be Lossy or Lossless. Lossy compression system eliminates the finer details in the image so as to save more bandwidth and storage space. Lossless compression system reduces the bit rate of the compressed output without any image distortion. Vector Quantization (VQ) is a technique that effectively compresses the digital images with high compression rate [2-4]. Initially, the input image is separated into non-overlapping blocks [14]. VQ uses K-means algorithm for codebook generation. Quantization is applied to map the input vectors to the nearest code words in the codebook. The indexes of the codeword are used to storing or transmitting the image. Image reconstruction can be achieved by implementing the compression algorithm in the reverse order. The coding bit rate is reduced effectively in vector Quantization than Scalar Quantization [3]. The related problems in VQ are edge degradation and high complexity [5]. The significant portion of the image content constitute edges and the degradation in it causes distortion of image [6]. So Finite State Vector Quantization (FSVQ) is used to reduce the bit-rate by previously encoded blocks correlations [7, 13]. FSVQ maintains the image quality by selecting a smaller state codebook from master codebook. It also achieves the bit rate efficiency. SMVQ scheme incorporates diagonal sampling and rechecking for improving the image quality and encoding time [11]. The SMVQ exploits the correlation of previously encoded blocks to generate the state codebook which increases the compression [12]. Classified Vector Quantization (CVQ) divides the input block into several classes. Each class has its own codebook based on their characteristics [8, 9]. Discrete Cosine Transform (DCT) is a orthogonal transform which maps the image space into frequency domain [1]. DCT has the ability to pack energy in the Lower frequencies for image data. It also reduces the Blocking Artefact effect. The main idea behind the proposed scheme is

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coding images using side match vector quantization [10] with Discrete Cosine Transform coefficients. This scheme reduces the computational time and increases the compression bit rate.

2. DISCRETE COSINE TRANSFORM

A image coding based on DCT with side-match finite-state classified vector quantization in transformation domain, the image is divided into (8x8) blocks. The DCT equation is as follows,

$$D(i,j) = \frac{1}{\sqrt{2N}} C(i)C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} p(x,y) \cos\left[\frac{(2x+1)i\Pi}{2N}\right] \cos\left[\frac{(2y+1)j\Pi}{2N}\right] \quad (1)$$

$$C(U) = \begin{Bmatrix} \frac{1}{\sqrt{2}}, \ U = 0 \\ 1, U > 0 \end{Bmatrix} \quad (2)$$

Where $p(x, y)$ is the x, y^{th} element of the image represented by the matrix p. The size of the block is represented by N. The equation calculates the transformed images entry (i, ^{jth}) from the pixel values of the original matrix. For the standard 8 × 8 block, N equals 8 and x and y range from 0 to 7.

The resulting matrix depends on the horizontal, diagonal, and vertical frequencies because the DCT uses cosine functions. Therefore the image block has change in frequency with a random looking resulting matrix.

3. PROPOSED SIDE MATCH CLASSIFIED VECTOR QUANTIZATION (SMVQ)

Initially in an image, a high statistical correlation exists in the adjacent blocks. In SMVQ (side match vector quantization) the intensity transitions present in the borders of adjacent blocks is smoothen by exploiting this correlation. Thus the Upper left blocks of the input current block is used in generating the state codebook *SC*. The state codebook SC consists of the codewords that match the upper (u) and adjacent left (l) blocks described in figure1.

$$\text{Dis}(x)=\text{Dis}_h(x)+\text{Dis}_v(x) \text{ where } \text{Dis}_h(x) = \sum_{i=0}^{w-1} \left[x(0,i) \ + \ c_y(0,i) \right]^2 \quad (3)$$

$$\text{Dis}_v(\text{x}) = \sum_{i=0}^{h-1} \left[x(0,i) + c_y(0,i) \right]^2 , \ c_y \in MC \text{ for } y = 1, 2, \ldots, n. \quad (4)$$

Thus by using the calculated distortion, the SMVQ, chooses the code words from the master codebook which is nearest to the smaller distortion to build the state codebook *SC* and used in encoding input blocks.

3.1. Classified Vector Quantization (CVQ)

In CVQ, image is classified into several blocks, Based on the perceptual features these blocks are further classified into various classes. Every single block is considered as a code vector and for constructing the code book, the code vector that belong to the same class is used. For each class a separate code book is designed. In CVQ the input vector is mapped to the appropriate class and the table look up process is performed on the code book and results the index value. The figure 2 is about the general CVQ scheme. The input image is partitioned into several blocks such as (C0, C1, C2, C3,…., Cm) which is further mapped to the corresponding code book (0,1,2….., m) results the index value as output.

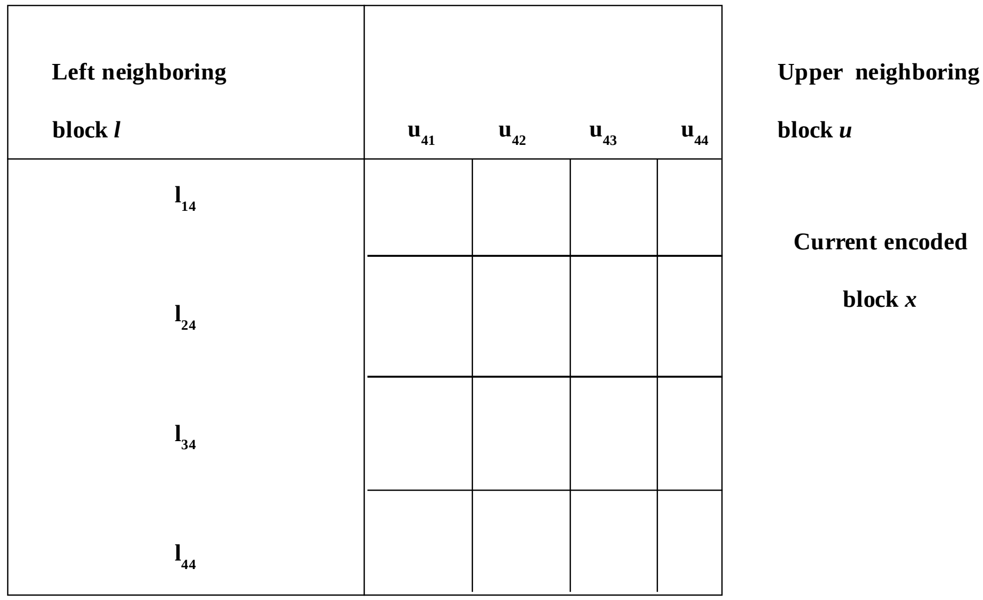

Figure 1: Encoding-SMVQ

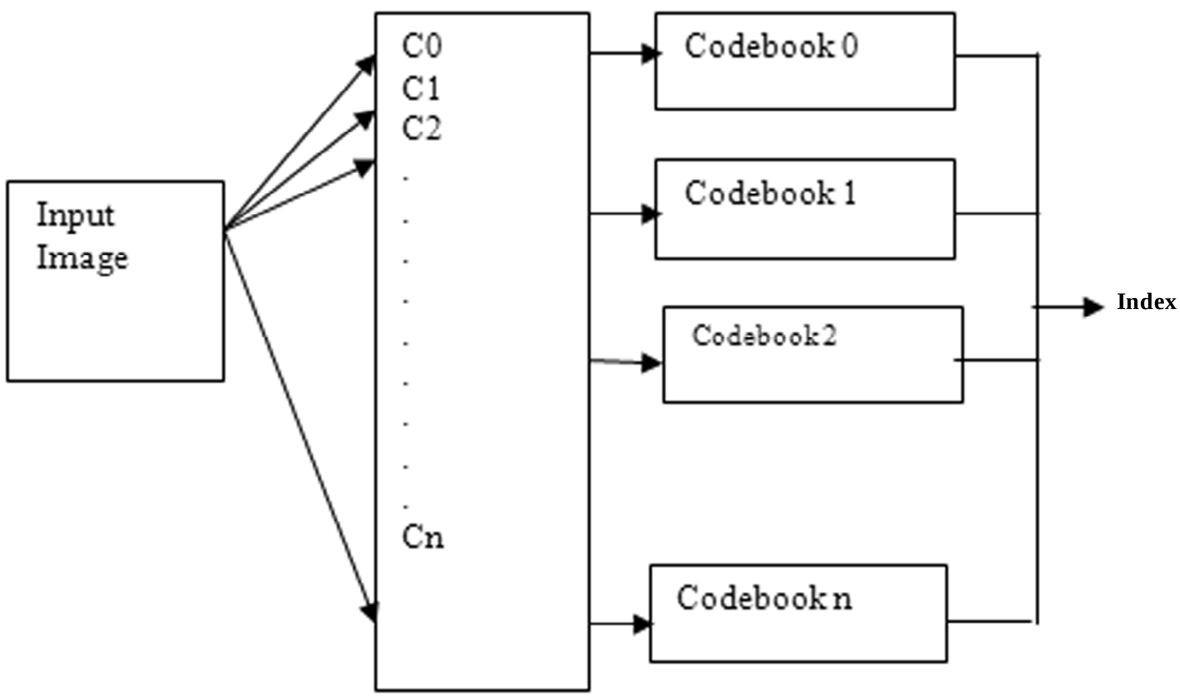

Figure 2: CVQ-Block Diagram

A new image coding scheme using side-match(SM)-finite-state(FS) classified vector quantization(CVQ) in discrete cosine polynomial based transform is proposed. The idea behind this scheme is to combine the SMVQ and CVQ in the discrete cosine transform domain mainly to increase the compression rate and to decrease the computational time. This approach maps the original image blocks from the spatial domain into frequency domain by the proposed discrete cosine based transformation. While encoding, input image [I] is partitioned into non-overlapping image regions of size (*nxn*). Discrete Cosine Transform is applied for each sub image of 8x8 block of pixels. Each pixel value ranges from 0 to 255, where o indicates black and 255 indicates white. The DCT matrix is obtained from the DCT equation. In order to apply DCT the pixel value must range from -128 to + 127. So, the values are levelled-off by subtracting 128 from it. The resultant matrix is multiplied with the DCT matrix and its transformed matrix. The final matrix for performing quantization is obtained. The code book is generated using Side Match Vector Quantization (SMVQ) which is the class of Finite State VQ (FSVQ). The distortion between the compared codeword in the master codebook and the input block is calculated. Using the distortion, the SMVQ picks up the nearest N_f code words with smaller distortion, from the master code book and builds the state codebook SC_x. This is subjected to entropy coding and the coded value is transmitted to the receiver through channel. While decoding, the image is subjected to de-quantization and the resultant blocks of de-quantization are subjected to inverse DCT and the image is reconstructed.

3.2. Proposed algorithm

Input: color image (*ROWXCOL*) size.

1. Partition the input image [I] into non overlapping image regions of size ($n \times n$).
2. Repeat the steps 3 to 4 for all the image regions.
3. Compute the Discrete Cosine Transform coefficients [β'].
4. Form a training vectors T_i using the high energy transformed coefficients.
5. The codebook is generated from the matrix using side match vector quantization (SMVQ), where the state code book is constructed from the master code book using the correlation of previously encoded blocks.
6. In SMVQ, the correlation is exploited to smoothen the intensity transition along the borders of adjacent blocks using the left and upper blocks of the current input block to generate the state code book (SC).
7. In the state codebook SC, the input block x consists of the code words that match the Adjacent left(l) and the upper(u) blocks. The distortion between the input block x and the compared codeword in the master codebook is calculated. Using this Distortion, the SMVQ picks up the nearest codeword with smaller distortion, from the master codebook and built the state codebook SC.
8. This is subjected to entropy coding and the coded value is transmitted to the receiver end through the channel.
9. End.

4. PERFORMANCE ANALYSIS

The performance of the proposed side match vector quantization technique is reported by calculating the value of peak signal-to-noise ratio (*PSNR*) as follows

$$PSNR = 10\log_{10}\left[\frac{255}{e_{ms}{}^{2}}\right]^{2} \tag{5}$$

where e_{ms} is the average mean-square error

$$e_{rms}^{2} = \frac{1}{NM}\sum_{i=1}^{N}\sum_{i=1}^{M} E\left(u_{i,j} - u'_{i,j}\right)^{2} \tag{6}$$

where $\{u_{i,j}\}$ and $\{u'_{i,}j\}$ represent the ($N \times M$) input and reconstructed images respectively.

5. EXPERIMENTS & RESULTS

The proposed Discrete Cosine Transform based image coding with Side-Match Classified Vector Quantization has been experimented with 2000 test images, having different low level primitives. For illustration two test images viz, Lena and baboon, both of size (128 × 128) with gray scale values in the range (0–255) is shown in figure 3(a) and 3(b) respectively. The input images are partitioned into various non-overlapping sub-images of size (8 × 8). We then apply the proposed DCT as described in section 2 and obtain the transformed block [β′] for each block. The high energy vectors and the codebook thus generated are subjected to SMVQ to obtain the index value for each vector corresponding to the sub-blocks under analysis. These index values are transmitted to the receiver side. In the decompression process, these index values are used to generate the approximated transform coefficients, by performing SMVQ with the help of the corresponding codebook that are generated in the earlier stage Classified Vector Quantization. We then reconstruct the original image with the inverse Discrete Cosine Transform functions. The bit per pixel (bpp) scheme is used to estimate the transmission bit rate. The performance of the proposed scheme is measured with (PSNR) Peak-Signal-to-Noise-Ratio. We could achieve PSNR values of 33.25dB and 33.11dB for the bit rates of 0.25 for the input images 3(a) and 3(b) respectively and the corresponding resulting images are shown in figure 4(a) and Figure 4(b) respectively. The experiment is repeated by varying the bpp for all the 2000 images and the results for the Lena and Pepper images are presented in table 1 in terms of PSNR measure.

In order to measure the efficiency of the proposed Discrete Cosine Transformation based scheme, we conduct experiments based on Transformed Vector Quantization. In our proposed system Discrete Cosine

(a) lena

(b) baboon

Figure 3: Sample original test images

(a) lena

(b) baboon

Figure 4: Reconstructed images

Table 1
PSNR values obtained by (i) Proposed SMCVQ Scheme,
(ii) DWT based SMFSCVQ Scheme and (iii) SMVQ for different bpps

Bit rate (bpp)	*Proposed Scheme*		*DWT based Scheme*		*SMVQ*	
	Lena	*Baboon*	*Lena*	*Baboon*	*Lena*	*Baboon*
0.25	33.25	33.11	33.44	33.12	32.11	32.11
0.20	30.37	31.85	30.12	30.44	30.19	30.90
0.18	29.03	30.45	29.01	29.21	29.86	29.30
0.16	29.11	29.66	29.21	29.16	28.66	29.46
0.14	28.05	29.45	28.51	28.35	28.49	28.20

Transform is applied followed by SMVQ. The experiments are conducted for different bpp and the corresponding PSNR values are obtained and are presented in the same table 1, for both the input images. The proposed scheme is also compared with side match vector quantization (SMVQ) in spatial domain. The experiments are carried out for varying bit rates for different images and the corresponding results are incorporated in the same table 1. From table 1 and figure 4, it is evident that our proposed scheme proves to increases the compression rate and decrease the computation time.

6. CONCLUSION

In this paper a new color image coding scheme with Side-Match Classified Vector Quantization has been proposed for 2-D images. This scheme starts by first transforming the image data to the frequency domain using a class of Discrete Cosine Transform. Then the transformed sub-image is classified into one of the four different classes. The code book is constructed for each class. As a result, the sub-image is side-match finite-state classified vector quantized. The performance of the proposed encoding technique is measured with PSNR values and is compared with DCT based scheme and SMVQ type algorithms and hence proves to decrease the computation time and increases the compression rate.

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