Context-Based Adaptive Variable Length Coding based Compression Scheme for Images

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***Abstract*— In order to achieve a high compression ratio, the Context-Based Adaptive Variable Length Coding (CBAVLC) standard has incorporated a large number of coding modes which must be evaluated during the coding process to determine the optimal rate-distortion trade-off. The coding gains of CBAVLC arise at the expense of significant coder complexity. One coder process that has been identified as having potential for achieving computation savings is the selection between skipping the coding of a macro block and coding of the macro block in one of the remaining coding modes. In low contrast images, a large percentage of macro blocks are "skipped", that is, no coded data are transmitted for these macro blocks. By estimating and identifying macro blocks to be skipped during the coding process, significant savings in computation can be realized, since the coder then does not evaluate the rate-distortion costs of all candidate coding modes. The proposed scheme shows that this approach can result in a time savings of over 80% for low contrast images at a negligible decrease or, in certain cases, a slight increase in quality over a reference codec.**

***Keywords*— Context-Based Adaptive Variable Length Coding (CBAVLC), Macro Blocks (MB), Low-contrast images**

I. Introduction

The CBAVLC Advanced Video Coding standard [1] achieves significantly better compression than earlier standards, enabling high quality video on power-constrained handheld devices. However, compression is achieved at the expense of increased computational complexity [2]. In a coded sequence, each macroblock (MB) can be coded in one of a large number of modes, many of which are typically evaluated before the appropriate coding mode is selected. The modes available for coding an MB using the CBAVLC Baseline Profile which supports Intra (I) and Inter (P) coded slices. These modes include a Skip mode, in which no further data is transmitted after the Skip indication, three classes of Intra coding modes, and four modes that use Inter prediction with up to four macro block partitions. Each partition in a predicted macro block uses motion compensated prediction with a separate motion vector. The 8x8 partition size may be split further into one, two, or four sub-macro block partitions, each with a separate motion vector. Further mode options are available in the Main and High Profiles. The optimum coding mode for given macro block depends on the statistics of the source on the coding parameters, and on previous coding decision.

To achieve good rate-distortion performance, the Rate Distortion Optimized (RDO) mode selection process [3] evaluates the distortion and rate of each candidate mode prior to selecting the mode for the current MB. In the Joint Model (JM) reference encoder, it carried out by coding the macro block in each of the possible modes and choosing the mode that minimizes a rate-distortion cost function [4]. The rate (*R*) and distortion (*D*) corresponding to each candidate mode are calculated using the process. The source MB is encoded using intra or inters prediction, a forward transform, quantization and source coding to produce a sequence of *R* bits, where *R* indicates the rate associated with this particular candidate mode.

A significant amount of research has been carried out to reduce the complexity of the mode selection process. A fast inters mode selection algorithm, in which motion estimation block sizes are predicted using homogeneous region detection [5]. Computation is reduced by carrying out rate distortion optimization for only the predicted block sizes. A similar macroblock partition mode prediction algorithm is [13] utilizes temporal and spatial similarity of blocks for block size prediction. A mode prediction algorithm [14] uses the cost of previously-evaluated modes to determine the most likely modes, whereas [15] presents an algorithm to reduce the number of candidate modes and carry out rate distortion optimization based on rate estimation. A fast inter-mode prediction algorithm [16] in which the original and the reference images are down-sampled and pre-encoded in order to find the best prediction block sizes of the original image. A skip mode detection algorithm based on predicting mean square error (MSE) values [17]. In a combined method which employs an early skip versus code mode prediction with early inter mode selection shows promising results [18] with a time saving of over 40% even for high contrast images. These approaches parameters and thresholds are typically chosen based on heuristics rather than analysis.

A fast mode choice based on estimating and comparing rate-distortion costs of skipping v/s coding a macro-block are presented [19,20]. Early prediction of macro block mode choice is made by estimating a Lagrangian rate-distortion cost function that incorporates an adaptive model for the Lagrange multiplier parameter based on local sequence statistics and utilize the cost in the decision process. In the coder, computations are saved coder which explicitly evaluates the rate and distortion of coding modes, estimates with few computations and thus, low complexity, mode choice of the baseline coder. While successful in reducing coding complexity by up to 67% over a baseline codec, these methods are not enchanted into account macro-block mode statistics thus, further improvement may be realized.

It develops an analytical framework with automatic adaptation to changing statistics parameters is studied in this work. The proposed work address the challenge of early estimation of coder mode selection, but, set this decision process in the backdrop of frame-level code versus skip decisions to reduce rate-distortion costs. Similarly, a feature-based intra/inter mode selection algorithm has been proposed. Three features, a spatial feature, a temporal feature and the motion vector magnitude are used to classify each macroblock taken with both parametric and non-parametric models.

II. PROPOSED WORK OF THE RESEARCH

The proposed work is based on Context-Based Adaptive Variable Length Coding (CBAVLC) checks the skip condition and makes the decision between the Class 16 and Class 8 modes based on the factors - homogeneity and temporal movement [8]. It the class is decided with in the class then it uses sub-mode selection algorithm [7] to decide the best mode among the sub-modes.

(i) Compute the MB difference Δ for the current macro block, if Δ is very large then intra mode selection is preferred.
(ii) It assessing the condition for the SKIP mode, if the current 16x16 block has no movement, then SKIP mode is the best mode.
(iii) Once SKIP is ruled out, a decision between Class 16 and Class 8 modes is made the homogeneity of the block is verified. If the macro block is homogeneous then Class 16 is chosen else Class 8 is chosen. The homogeneity of the macro block is determined by the Probability Based Macro block Mode Selection.
(iv) A MB is resolute to be an LMB when the weighted sum is lower than and if the is higher than the minimum of the MB is determined to be a true HMB. Otherwise, motion character has to be classified.

A motion classifier is continually used to determine if the MB contains complex information or simple information. By combining two types of classifiers, each MB can be efficiently categorized to different mode and motion search paths, which significantly reduces encoder complexity for all types of content. The proposed fast mode decision algorithm consists of the following steps:

(i) If the MB is in the first row or column of a frame, test all possible modes, select the best one, then exit.
(ii) Each MB is categorized by a probability classifier. If the predict mode is included in the HMBs, go to Step (iv). Otherwise, go to Step (iii).
(iii) Check the mode of INTER8 × 16 and INTER16 × 8. Go to Step (ix).
(iv) For an image, calculate the RD cost of direct mode. If it is lower than the threshold, which is defined as the minimum of neighboring MBs, skip all other modes. Otherwise, predict mode is included in the TRUE HMBs, go to Step (x), otherwise go to Step (v).
(v) To categorize the MB with a motion classifier, if it has complex motion content, go to step (vi), otherwise, go to Step (viii).
(vi) Check mode INTER8 × 8, INTER8 × 4, INTER4×8, and INTER4×4. If there are more than two sub-macroblock modes are not INTER 8×8, go to step (ix) otherwise, go to Step (vii).
(vii) Check mode INTER 16×16, INTER16×8 and INTER 8×16, if any mode cost is more than INTER 8×8 or the three modes have been tried, go Step (i).
(viii) Check mode INTER 16×16 and INTER 16×8, if cost 16×16 < cost 16×8, go to Step (xi) otherwise, check all the other Inter modes.
(ix) Check INTRA 16×16 and INTRA 4×4.

III. COMPRESSION SCHEME TECHNIQUE

The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components, which is widely used in image compression. The input image is initially segmented into background and foreground. Then the image is divided into 8x8 blocks and DCT values are computed for each block. The quantization is performed according to the predefined quantization table. The quantized values are reordered based on zigzag method. The lower values of coefficient ts are not required from the zigzag ordered list by comparing the threshold value selected by the selector as per the block's presences identified by the classifier. If the block is present in foreground area, then the threshold is set to a higher value by the selector, otherwise, a lower value for threshold is set by the selector. After discarding insignificant coefficients the remaining data are compressed by the standard entropy encoder based on the code table.

(i) Input High Resolution Color image.
(ii) Down sample the input image 2 times.
(iii) Convert the down sampled image to gray scale image (G).
(iv) Find histogram (H) of the gray scale image
(v) Find the lower (L) and upper (U) gray scale value of Background area.
(vi) Find Binary segmented image (B) from the gray scale Image (G)
(vii) Up sample Binary image (B) two times.
(viii) Divide the input image into 8x8 blocks
(ix) Find DCT coefficients for each block
(x) Quantize the DCT coefficients
(xi) Discard lower quantized values based on the threshold value selected by the selector.
(xii) Compress remaining DCT coefficients by Entropy Encoder

Image compression is a method that reduces the amount of memory it takes to store in image. It exploits the fact that the DCT matrix is based on the visual system for the purpose of image compression. The image compression scheme is using computation for each block and produce quantization table from empirical results, which is shown in Figure 1. It creates compressed code using the Quantization table and compress image to accumulate or transmit faster than the existing method.

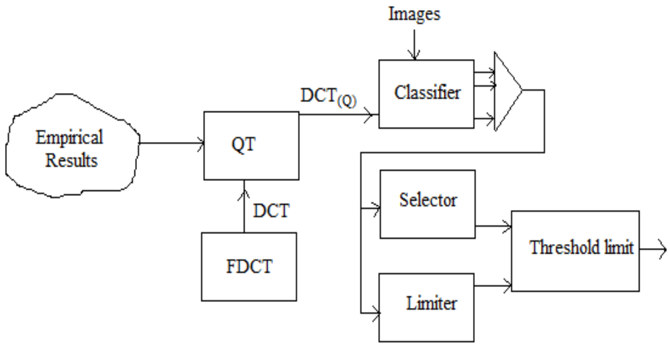

Fig. 1 Compression classifier scheme

A. *Upsampler and Downsampler*

Upsampler and Downsampler are two basic and widely used image operations with applications in image display, compression and progressive transmission. Upsampler increases the spatial resolution, while retaining the 2D image representation. It is used for zooming in on a small region of an image and for eliminating the pixelation effect that arises when a low-resolution image is displayed on a relatively large frame.

Downsampler does the reduction in spatial resolution, while keeping the same two-dimensional (2D) representation. It is typically used to reduce the storage or transmission requirements of images. In terms of frequency domain, when a signal is downsampled, the high-frequency portion of the signal will be aliased with the low-frequency portion. When applied to image processing, the desired outcome is to preserve only the low-frequency portion. In order to do this, the original image is preprocessed (alias-filtered) to remove the high-frequency portion so that aliasing will not occur.

IV. RESULTS AND DISCUSSION

The CBAVLC method is implemented according to the description in section III and tested with a set of test images shown in Figure 2 and Figure 3. Figure 2(a) shows the original input image and Figure 2(b) shows the segmented object and background area is discriminated by black and white.

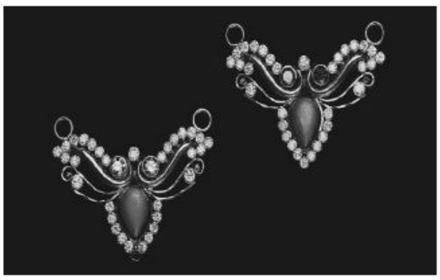

Fig. 2 (a) Input Image

Fig. 2 (b) Output Image

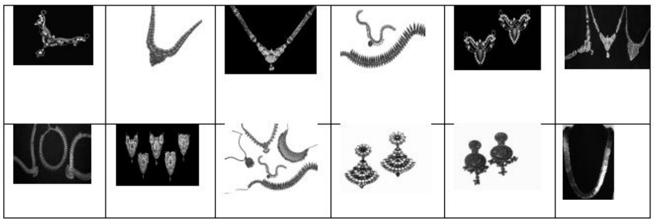

Fig. 3 Test Images (1 to 12 from Left to Right)

The compressed bit rates of the twelve test images are computed and tabulated in Table 1.

TABLE I (a) COMPRESSION RATIO AND PSNR VALUES OBTAINED BY PROPOSED ALGORITHM

	LQ		Hybrid	
Image	**CR1**	**PSNR1**	**CR2**	**PSNR2**
3	26.00	21.52	7.46	27.82
5	25.29	22.09	6.80	28.87
10	23.83	20.78	5.41	28.09
4	24.33	22.08	6.61	31.13
11	27.75	25.33	8.62	35.67
9	24.92	21.62	6.58	30.45
1	27.54	23.03	8.40	29.37
7	24.85	17.71	4.01	23.38
8	24.63	21.97	6.73	31.05
12	29.18	22.73	5.92	28.70
6	26.47	20.12	5.54	25.31
2	22.84	20.40	7.91	27.93

TABLE 1(b) HYBRID PROPOSED SCHEME

Hybrid/HQ	**HQ**	
PSNR@ MainSubject	CR3	PSNR3
27.84	7.46	27.82
28.93	6.80	28.87
28.13	5.41	28.09
31.20	6.60	31.13
36.25	8.61	36.01
30.56	6.56	30.51
29.40	8.37	29.37
23.43	3.92	23.38
31.13	6.64	31.10
29.07	5.61	28.93
25.33	5.19	25.30
28.21	7.25	28.06

The results obtained from the implementation of the proposed are shown in Figure 4, Figure 5. The low quality (LQ) and high quality (HQ) JPEG compression is performed and the corresponding compression ratios (CR) and PSNR values are tabulated. The Peak Signal-to-noise Ratio (PSNR) is higher for HQ and CR is higher for LQ. The Hybrid JPEG compression performs HQ compression on main subject area and LQ compression on background area thus the PSNR value at main subject area is the same for Hybrid JPEG and HQ JPEG. Figure 4 shows the comparison of normalized CRs of Hybrid JPEG and HQ JPEG, it is observed that all of the images are compressed better than classical JPEG compression. Figure 5 shows how well the compression ratio is increased compared to the classical JPEG compression method. The compression images ratio is presented in Figure 6.

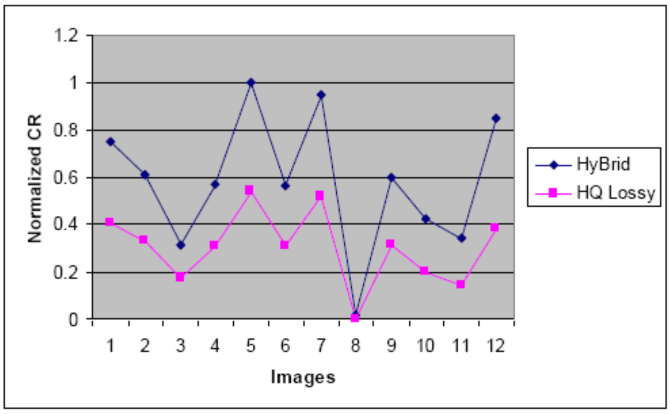

Fig. 4 Normalized Compression Ratio Obtained for Test Images

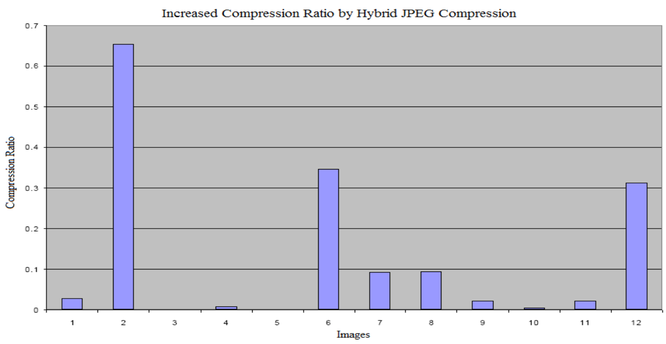

Fig. 5 Increased Compression Ratios by Hybrid Compression

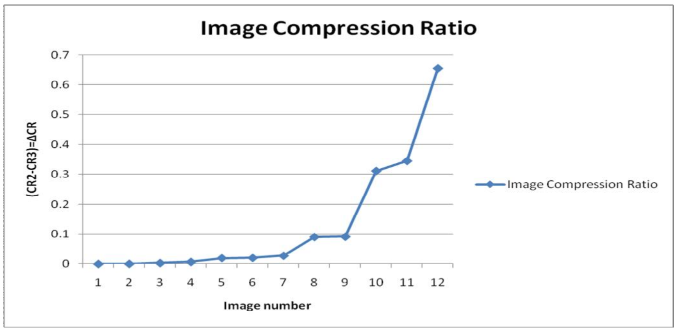

Fig. 6 Compression Ratio

V. CONCLUSION

The compression ratio of Hybrid JPEG method is higher than JPEG method in more than 90% of test cases. In the worst case both Hybrid JPEG and JPEG method gives the same compression ratio. The PSNR value at the main subject area is same for both methods. The PSNR value at the background area is lower in Hybrid JPEG method which is acceptable since, the background area is not vital. The Hybrid JPEG method is suitable for imagery with larger trivial background and certain level of loss is permissible.

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