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Video Coding using Separated Sign Coding and Motion Compensation

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Abstract: Haar wavelet is the most important mathematical tool which has stimulated many developments, particularly in signal and image processing. The main advantage of Haar is the multi-resolution properties. The major challenge in this video coding is motion management using HWT. To reduce the cost of storage and the bandwidth transmission of video file, a new method is proposed in this paper. The new method is the sub-band coding approach that employs Haar Wavelet Transform (HWT) and is based on a separate sign coding (SSC) from wavelet coefficients amplitude. To avoid the problem created by the lack of invariance translation, we use the method motion compensation (MC) technique.Results shows that PSNR become good compared to other techniques.

Keywords: Haar Wavelet transform (HWT), transform, video coding, Motion compensation, SSC.

I. INTRODUCTION

The main objective of video compression is to reduce redundancies in both domains and now we can reduce the size of the data. A video coding is a double-stage process: inter-frame coding techniques are used to remove the temporary redundancies between successive data of a video frames. An intra-frame coding technique is used to remove the spatial domain redundancies obtained by inter-frame coding. An intra-frame coding is mainly generated by orthogonal transforms, which utilize the intra-image correlation. These transforms are used for survey the Discrete Cosine Transform (DCT) [1] used in image coding methods such as JPEG [2], and some video compression standard such as MPEG.1 [3] and MPEG.2 [4]. Much research effort has been spend in the area of wavelet based coding, with the results indicating that wavelet-based approaches to perform better than DCT-based techniques for images. However, the motion management in video sequence is a major difficulty and constitutes a challenge in HWT-based video compression. In result, the management of the video sequence motion is a difficult task. the author has suggest a scheme for image compression establish on Embedded Zerotree Wavelet algorithm (EZW) named separated sign coding (SSC). This scheme provides aggressive results in terms of objective and personal qualities compared to the JPEG.2000 standard and improves it.

The author uses the difference between the image in the coder and the rebuild previous image in the decoder as a technique for separating the temporal redundancies. The results obtained on some standard video frames shows that a high quality decoded video at high bit rates. However, SSC codec is unsuccessful at low bit rates and the representation of the decoded sequence gives a drag movie. To overcome this problem, we have desegregated in SSC codec, that a motion compensation technique is used in MPEG coding.

II. THESEPARATED SIGN CODING (SSC)

The proposed coding scheme uses two types of coding techniques; a spatial coding system called SSC technique and a motion compensation technique for secular redundancy. To understand this we firstly explain our encoding system.

The SSC codec is used to utilize Zero Tree Coding (ZTC) [5] and the principle is same as that of Embedded Zerotree Wavelet codec (EZW) [6]. First we will study EZW algorithm which is made up of three blocks as shown in figure 1.The discrete wavelet transform is applied on the input image in the first block. Here HWT is reversible therefore this block is characterized by lossless data. The second block is disturbed by loss of data because this block is concerned by the quantization of HWT coefficients. The third block is concerned by the entropy coding of the quantized data index and is characterized by lossless of data therefore this block produces the bit stream for transmission or storage.

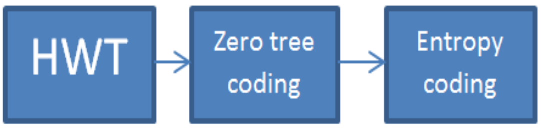

Figure 1: Basic zero tree coding

EZW contains two passes: Dominant Pass that is come behind by Subordinate Pass. For every coefficient an output symbol is produced in every coefficient when the image is scanned in dominant pass. If the complete value of HWT coefficient is higher than the predefined threshold T, a NEG symbol is encoded if the coefficient is negative and a POS symbol is encoded if the coefficient is positive. Here we also used a ZTR symbol to encode an unimportant coefficient in a wavelet tree. If a coefficient is unimportant an isolated zero symbol IZ is encoded, but having at least one nortable child. To inform locations of

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nortable coefficients as efficiently as possible by using IZ and ZTR symbol. The symbol Z is mainly used to encoding the insignificant coef*f*icients possession to the three detail sub-bands of the first decomposition level. To desperate the coding of wavelet coefficients amplitude and their signs we use SSC code. A symbol 'S' is used for coding parameters that must be greater or equal to a predefined threshold value and this symbol replaces NEG or 'POS used by the EZW coding. The absence of symbol S is indicated by the symbol '0' and the presence is by the symbol '0'. A significant map is progressively generated for indicating this.

The probability is to find a negative coefficient that is equal to zero in the approximation sub-band, then a sign map is also progressively generated only for the details sub-bands. The positive important coefficient is denoted by the symbol '0' and the negative important coefficient is denoted by the symbol '1'. The concept of Zero Tree coding, representing the relationship between the roots and descendants of different wavelet coefficients trees (see figure 2a & b) and scanning order is in the coding procedure (see figure 2c). In the subordinate pass, '1' defines the quantization of the significant coefficients. The location information of all the coefficients that have been encrypted in the previous passes is in the subordinate list. The coefficients corresponding to the values of subordinate list is in the interval (T, 2T) and the subordinate passes then it gives an output '1'. If it is in the upper limit is within (3T/2,2T) and output '0' then it is in the lower limit of the interval within (T, 3T/2)".

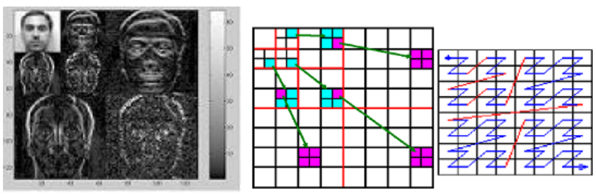

Figure 2 :(a) Wavelet decomposition, (b) Trees of coefficients, (c) the scanning procedure of coefficients coding.

III.THE SEPARATED SIGN CODING WITH MOTION COMPENSATION ENCODER (SSC-MCE)

Here we use SSC for video coding system. The difference between frames in the coder and the reconstructed past frame in the decoder is used for recovering the temporal redundancies. For video coding, a group of pictures (GOP) structures specifies about the arrangements of intra- and inter-frames. The GOP is a group of successive pictures included in an encoded video stream and first frame of every GOP is encoded in intra frame by using SSC algorithm . Then the subsequent frames are encoded by using the difference between the reconstructed previous frame in the decoder and current frame in the coder. Then this difference is encoded by using SSC technique. The output shows that the system can provides better reconstruction quality. But in the visual effect of the video sequences reconstructed by this method, a jerky video is obtained. This jerkiness is the resultant of applying the non-redundant HWT on the residual frames. Since the translation invariance is not guaranteed in the non-redundant HWT, this exhibits itself in the reconstructed video sequence that is not same as that of original video sequence. In this work the objective is to overcome this drawback, the jerkness become removed and we get high quality video sequence.

Our idea is based on SSC codec and motion compensation called SSCMC or SSCMCE that is to use the motion estimation and compensation technique (ME&MC). The motion compensation (MC) technique is used in video coding such as H.264 and MPEG (7). The motion compensation algorithms works under the process of each video frame through a set of Macro blocks (MBs).

A compressed file by using MC contains, in one hand the motion vector (MV) between the candidate MB (actual MB) and the reference MB. But in the other hand the error representing the difference between the reference MB and the actual MB. Then three types of frame are considered: I frame (or intra-coded frame) which are the key frame; I frame is encoded without any reference to another frame. P frame (or mono-directional predictive frame) which contains only the displaced MBs; P frame is encoded with reference to a previous P or I frames. Finally B frame (or bi-directional predictive frame) which is predicted by two motion compensations: the one from the past I or P frames and the other from the future I or P frames. We recall that B frame must not be encoded with reference to another B frame because the decoder would be unable to decode a B frame without having received the reference frames. In consequence, I frame of the next GOP is sent before the B frames in the current GOP.

We provide a sample figure3 that shows the relationship between the various types of frames included in a GOP. As shown, I-frames are independent and provide input to support the other frames; this means that an error in the I-frames will have more distortions in the video sequence. The most common method of the motion estimation is MB and is adopted by most part of video compression standards such as H.261, H.262, H.263, H.264, H.26L, MPEG.1, MPEG.2, MPEG.4

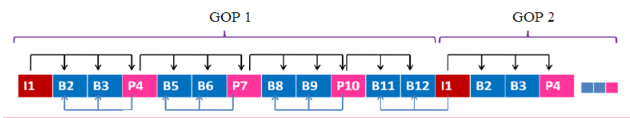

Figure 3: GOP relationship

The figure 4 shows architecture of the proposed video compression standard where figure 4a represents the encoder and figure 4b represent the decoder. The video sequence is decomposed into GOP (generally a GOP contains 12 frames) and each GOP is passed by a two stages video compression process.

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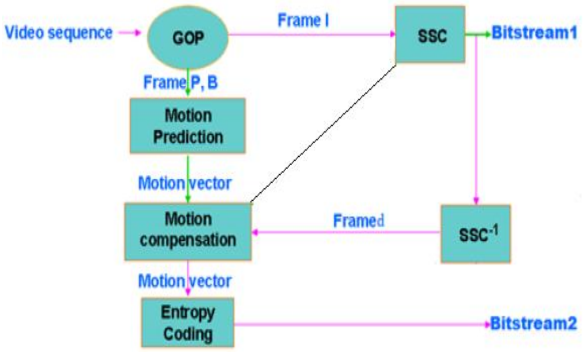


Figure 4(a): Encoder architecture

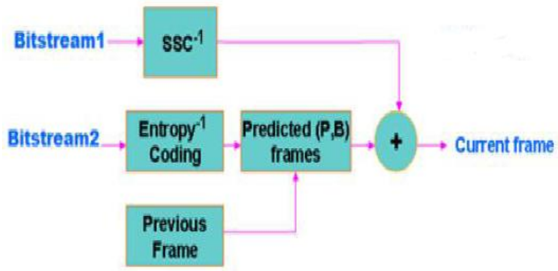


Figure 4(b): Decoder architecture

IV. ARITHMETIC MOTION VECTOR CODING

The motion vectors play an important role in the error propagation process between inter-frames. The slightest error in transmission or detection of these vectors affects the encoded video quality. Thus, for a video color, these vectors are encoded by an entropic coding. The cost of motion vectors depends on various parameters such as image resolution, motion vectors precision (pixel, half pixel, quarter-pixel), the used MB size (which can vary from 4x4 to 16x16) etc. This cost can be very important, which is not a problem at high speed, but can cause problems at low speed. In this part of work we propose an approach for encoding motion vectors. During the motion estimation and compensation, the SSCMC codec decay P and B frames into MBs and finds a MV pointing to the best prediction MB in a reference frame or field. The morality of MB prediction is in general evaluated by minimizing a cost function that may be the absolute error or the mean squared error. The cost function is applied to the MB is called block matching algorithm (BMA).

In fact, a color frame which has a resolution M x N, divided into MBs (the size of a MB is B x B) formed by the three color components to match the color space chosen. In particular, for the YCbCr space [8], each color component of motion vector has two coordinates x and y as indicated in equation 1 where YMV, CbMV and CrMV are respectively the MV of luminance (Y), the MV of blue chrominance (Cb) and the MV of red chrominance (Cr):

$$YMV\ frame = (M \times N) / B2 \times (\Delta Xy \Delta Yy)$$
$$CbMVframe = (M \times N) / B2 \times (\Delta XCb \Delta YCb)$$
$$CrMVframe = (M \times N) / B2 \times (\Delta XCr\ \Delta YCr)$$

where M and N are respectively the horizontal displacement and the vertical displacement of the current MB. The size of global motion vector (GMV) for a sequence of length L which contains V motion is given by equations delta x and y.

$$Size\ (GMV) = 2*3*(M*N)/B2\ *V*8$$
$$V = L - (L/GOP).$$

Each vector value is encoded using 8 bits (1 byte).

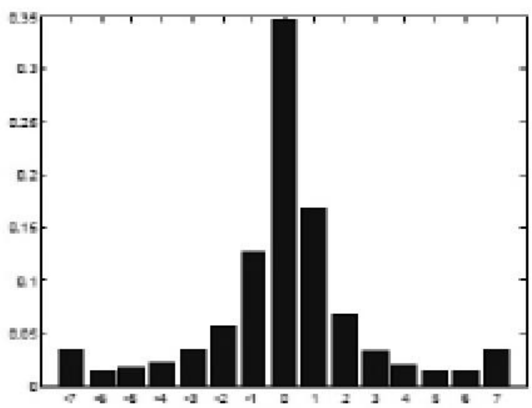
A. STUDY OF SYMBOLS

We have study the frequency distributions of each value in the MV for the video test sequences. We have calculated the occurrence of each value in the MV; the ratio of the occurrence of each value by the sum of all occurrences give the frequency distribution (or histogram) of each value. Histograms of dispensation of all sequence are concentrated around the value "0"; this may be explained by the fact that in general there is a little changing between two successive frames. The consequence is that "0" is the dominant symbol in the motion vectors. We can also find that the motion vectors are formed by positive and negative values belong to the interval [-7; 7] and we can observe the symmetry of the histograms. Some differences may be observed between luminance (Y) histogram and chrominance histograms (Cr and Cb); these differences may be explained by equation 3 which transforms the RGB space YCbCr space where all coefficients are positive in the calculation of luminance pixels. Figure 5 and figure 5 present the histograms for foreman.

$$Y = 0.299R + 0.587G + 0.114B$$
$$Cb = -0.14713R - 0.28886G + 0.436B$$
$$Cr = 0.615R - 0.51498G - 0.10001B$$

Based on the independence of color component histogram, here we propose a method to encode the global motion vector instead of encoding individual motion vector. In our approach, the luminance motion vector YMV, the blue chrominance motion vector CbMV and the red chrominance motion vector CrMV form a single global motion vector known as GMV by using a single arithmetic code.

$$GMV = YMV.\ CbMV.\ CrMV$$



(a)

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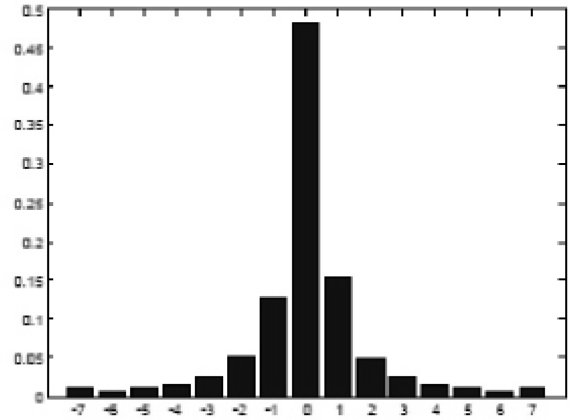
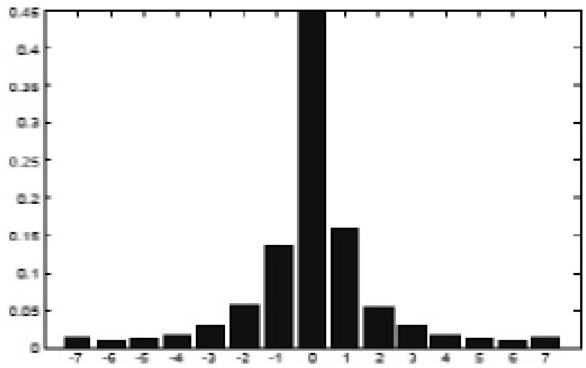
B.ARITHMETIC CODING

Arithmetic coding creates one word-code to be associated with each GMV sequence, contrarily to Huffman coding which assigns variable lengths word-codes for each symbol of the GMV. This code is associated with a source that is a real number in the interval [0, 1].
Let us consider a source {S1… SN} containing N symbols with probabilities {P1… PN}; for any integer K in [1, N], $P\ \{SK\} =$. To encode a sequence $SM = S\alpha1, S\alpha2\ldots$ □αM of M symbols, we use the following algorithm:



(b)



(c)

Figure 5: Normalized histograms of motion vectors for Foreman sequence: a) Luminance, b) Blue chrominance, c) Red chrominance

1) The first interval is initialized with two bounds: the lower bound $LC = 0$ and the upper bound $HC = 1$. The size of this interval is thus defined by: $size = HC - LC$

2) This interval is partitioned into N sub-intervals L, according to the probabilities of each symbol Sk of the source; the N sub-intervals are the initial partitions. By considering the Length $HSk - LSk$ of these sub-intervals which is given by $LSk - HSk =$,

$$L_{s_k} = L_c + size \times \sum_{i=1}^{k-1} p_i \text{ and } H_{s_k} = L_c + size \times \sum_{i=1}^{k} p_i .$$

3) The sub-interval corresponding to the next symbol Sαk in the sequence is defined in. Then the initial interval [LC,HC] is

LC = LC + size * LSK
HC = LC + size * HSK

4) This interval is divided again by the same method used in step 2

5) The Steps 2, 3 and 4 are repeated till the word-code representing the complete sequence of symbols sources obtained. This algorithm is applied on all the video test sequences.

V. RESULTS

The SSCMC developed is applied on the video test sequences. All the frames in each video test sequences are transformed from the RGB space (Red Green and Blue) to the YCbCr space and also gray scale. Then the motion compensation is operated with the BMA, the size of MB is 4x4 and the method of block matching is Full search. Therefore the decoded frames are compared with H.264/AVC coding. The peak signal to noise ratio or PSNR given by equation

PSNR = 10LOG10 (2552/MSE)

where MSE is the mean square error calculated by

$$MSE = \frac{1}{HL} \sum_{i=1}^{H} \sum_{j=1}^{L} \left(X(i,j) - \hat{X}(i,j)\right)^2$$

Where H and L are respectively the height and width of each frame of the video sequence, X and Y respectively the original frame and the reconstructed frame.
The global PSNR of the components R, G and B is the average of PSNR of the 3 components, given by the equation

Global PSNR = (PSNRR + PSNRG + PSNRB)/3.

VI. CONCLUSION AND FUTURE WORK

In this paper, we present a new color video compression scheme based on separate sign coding of wavelet coefficients and motion compensation technology. The coding performance of the proposed method is compared to H.264-AVC standard in terms of PSNR. It is shown that significant PSNR gains can be achieved. The value of PSNR is higher than AVC and it is shown that the proposed scheme gives a high visual quality competitive with H.264-AVC standard. We are planning to extend this work in future for better results.

Figure6: Original image foreman

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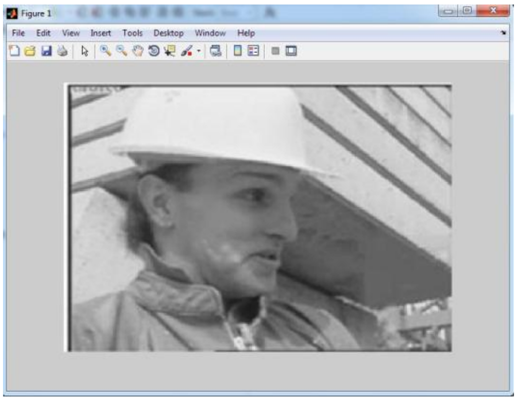

Figure 7: Decoded quality of foreman using SSC-MCE (MC)

Figure 8: Decoded quality of foreman using H.264 (from net)

Figure 9 : Decoded quality of flowers using SSC-MCE

Figure 10: Decoded quality of a moving car video

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