A NOVEL TECHNIQUE FOR REDUCING TEMPORAL REDUNDANCY IN VIDEO COMPRESSION

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Abstract

Generally, video signal has high temporal redundancies due to the high correlation between successive frames. Actually, this redundancy has not been exploited enough by current video compression techniques. In this paper, we present a new video compression approach which tends to hard exploit the pertinent temporal redundancy in the video frames to improve compression efficiency with minimum processing complexity. It consists on a 3D to 2D transformation of the video frames that allows exploring the temporal redundancy of the video using 2D transforms and avoiding the computationally demanding motion compensation step. This transformation turns the spatial temporal correlation of the video into high spatial correlation. Indeed, this technique transforms each group of pictures to one picture eventually with high spatial correlation. correlation. Thus, the temporal correlation of the video into high spatial correlation. Indeed, this technique transforms each group of transforms each group of pictures to one picture eventually with high spatial correlation. Thus, the decorrelation of the resulting pictures by DCT makes energy compaction, and therefore produces a high video compression ratio. Many experimental tests had been conducted to prove the method efficiency especially in high bit rate and with slow motion video. The proposed method seems to be well suitable for video surveillance applications and for embedded video compression systems

Keywords: Accordion, DCT, temporal redundancy, run length encoding, zigzag scanning

1. INTRODUCTION

The objective of video coding in most video applications is to reduce the amount of video data for storing or transmission purposes without affecting the visual quality. The desired video performances depend on applications requirements, in terms of quality, disks capacity and bandwidth. For portable digital video applications, highly integrated real-time video compression and decompression solutions are more and more required. Actually, motion estimation based encoders are the most widely used in video compression. Such encoder's exploits inter frame correlation to provide more efficient compression. However, Motion estimation process is computationally intensive; its real time implementation is difficult and costly [1][2]. This is why motion-based video coding standard MPEG was primarily developed for stored video applications, where the encoding process is typically carried out off-line on powerful computers. So it is less appropriate to be implemented as a real-time compression process for a portable recording or communication device (video surveillance camera and fully digital video cameras).

To obtain content based representation, the input video sequence must be segmented into objects, termed as video object planes (VOPs) in In theseapplications, efficient low cost/complexity implementation is the most critical issue. Thus, researches turned towards the design of new coders adapted to new video applications requirements Coder based on 3D transform produces video compression ratio which is close to the motion motion estimation based coding one with less complex processing [3][4][5][6]. The 3d transform based video compression methods treat the redundancies in the 3D video signal in the same way, which can reduce the efficiency of these methods as pixel's values variation in spatial or temporal dimensions is not uniform and so, redundancy has notthe same pertinence.

Often the temporal redundancies are more relevant than spatial one [3]. It is possible to achieve more efficient compression by exploiting more and more the redundancies in the temporal domain; this is the basic purpose of the proposed method. The proposed method consists on projecting temporal redundancy of each group of pictures into spatial domain to be combined with spatial redundancy in one representation with high spatial correlation. The obtained representation will be compressed as still image with JPEG coder.

A. DCT BASED CODING METHODS

The transform coding developed more than two decades ago, has proven to be a very effective video coding method, especially in spatial domain. Today, it forms the basis of almost all video coding standards. The most common transform based intraframe video coders use the DCT that is veryclose to JPEG. The video version is called M-JPEG, wherein the M can be thought of as standing for. motion. The input frame is first segmented into N N blocks. A unitary space-frequency transform is applied to each block to produce an N X N block of transform (spectral) coefficients that are then suitablyquantized and coded. The main goal of the transform is to decorrelate the pixels of the input block. This is achieved by redistributing the energy of the

pixels and concentrating most of it in a small set of transform coefficients. This is known as Energy compaction. Compression comes about from two main mechanisms. First, low-energy coefficients can be discarded with minimum impact on thereconstruction quality. Second, the HVS 1 hasdiffering sensitivity to different frequencies. Thus,the retained coefficients can be quantized accordingto their visual importance. Actually, the DCT, will be used in our video compression approach, is widely used in most modern image/videocompression algorithms in the spatial domain (MJPEG, MPEG).

Although its efficiency, it produces some undesirable effects; in fact, when compression factorsare pushed to the limit, three types of artifacts start to occur:. graininess. due to coarse quantization of somecoefficients, blurring. due to the truncation of high frequency Coefficients, and blocking artifacts, which refer to artificial discontinuities appearing at the borders of neighboring blocks due to independentprocessing of each block.[7]] Moreover, the DCTcan be also used in the temporal domain: In fact, the simplest way to extend intra frame image coding methods to inter frame video coding is to consider 3- D waveform coding. The 2D-DCT has the potential of easy extension into the third dimension, i.e. 3D- DCT. It includes the time as third dimension into the transformation and energy compaction process [3][4][5][6]. In 3-D transform coding based on the DCT, the video is first divided into blocks of M N K pixels (M; N; K denote the horizontal, vertical, and temporal dimensions, respectively). A 3-D DCT is then applied to each block, followed by quantization and symbol encoding, as illustrated in Figure1.

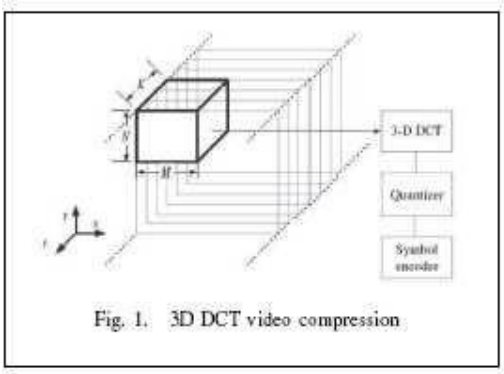

Fig. 1. 3D DCT video compression

A 3-D coding method has the advantage that it does not require the computationally intensive process of motion estimation. However, it presents some disadvantages; it requires K frame memories both at the encoder and decoder to buffer the frames. In addition to this storage requirement, the buffering process limits the use of this method in real-timeapplications because encoding=decoding cannot begin until all of the next K frames are available. Moreover, the 3D DCT based video compression method produce some side effects in low bit rates, forexample the effect of transparency produced by the DCT 3D [8].The techniques of transformed 3Ds were revealed since the 90s,but the research in video compression was oriented towards the coding based on motion estimation. The design tendency of new coding diagrams led some researchers restarting the exploitation of transformed 3Ds in video compression. The coders based on this type of transformation produce high compression ratio with lower complexity compared to motion

compensated coding. 3D DCT based video compression methods treat video as a succession of 3D blocks or video cubes, in order to exploit the DCT properties in both spatial and temporal dimensions. The proposedcoding method will be based on the same vision. The main difference is how to exploit temporal and spatial redundancies. Indeed, the proposed method puts in priority the exploitation of temporal redundancy, which is more important than the spatial one. The latter assumption will be exploited to make a new representation of original video samples with very high correlation. The new representation should be more appropriate for compression.

2. PROPOSED APPROACH

The basic idea is to represent video data with high correlated form. Thus, we have to exploit both temporal and spatial redundancies in video signal. The input of our encoder is so-called video cube, which is made up of a number of frames. This cube will be decomposed into temporal frames, which will be gathered into one frame (2 dimensions). The final step consists of coding the obtained frame. In the following, we detail the method design steps. Many experiences had proved that the variation of the 3D video signal is much less in the temporal dimension than the spatial one.

A. Hypothesis

Many experiences had proved that the variation of the 3D video signal is much less in the temporal dimension than the spatial one. Thus, pixels, in 3D video signal, are more correlated in temporal domain than in spatial one [3]; this could be traduced by the following expression: for one reference pixel I (x,y,t) where: _ I: pixel intensity value _ x; y: space coordinate of the pixel _ t:time(video instance) we could have generally:

$$I(x; y; t) - I(x; y; t + 1) < I(x; y; t) - I(x + 1; y; t) \rightarrow (1)$$

This assumption will be the basis of the proposed method where we will try to put pixels - which have avery high temporal correlation - in spatial adjacency

B. Accordion. based representation

To exploit this succeeding assumption, we start by carrying out a temporal decomposition of the 3D video signal, the figure 3 shows temporal and spatial decomposition of one 8X8X8 video cube:

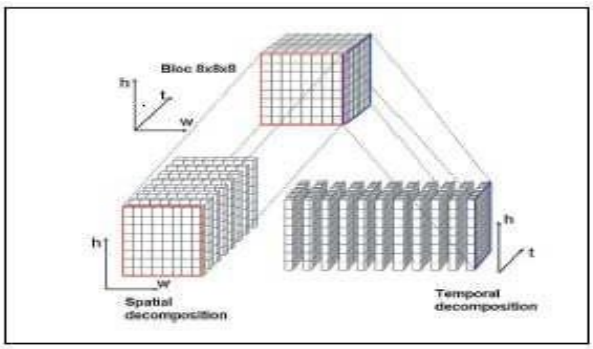

Fig. 2. Spatial and temporal decomposition principle

Frames obtained following the temporal decomposition will be called temporal frames. These latter are formed by gathering the video cube pixels, which have the same column rank. According to the mentioned assumption, these frames have a stronger correlation compared to spatial frames to increasecorrelation in Accordion Representation we reverse the direction of event frames. Figure 3 illustrates the principle of this representation.

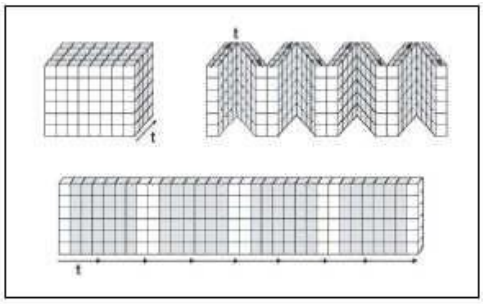

Fig. 3. ACCORDION Representation

Thus, the Accordion representation is obtained as following: first, we start by carrying out atemporal decomposition of the video 3D. Then, the event temporal frames will be turned over horizontally (Mirror effect). The last step consists of frames successive projecting on a 2D plan further called"IACC" frame. The Accordion representation. tends to put in spatial adjacency the pixels having the same coordinates in the different frames of the video cube. This representation transforms temporalcorrelation in the 3D original video source into a high spatial correlation in the 2D representation ("IACC").

The goal of turning over horizontallythe event temporal frames is to more exploits thespacial correlation of the video cube frames extremities. In this way,Accordion representation also minimizes the distances between the pixels correlated in the source. That's could be clearer in figure 4:

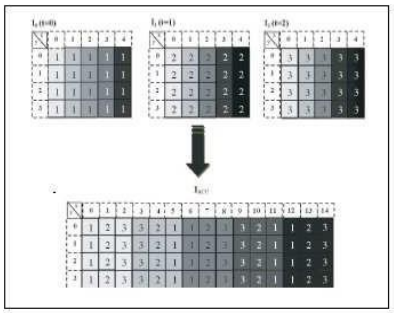

Fig.4.ACCORDION representation example

Figure 5 shows the strong correlation obtained in the Accordion representation made of 4 frames, which are extracted, from Miss America. Sequence.



Fig. 5. Accordion representation example (Miss America)

C. .Accordion. Analytic representation

The Accordion representation is obtained following a process having as input the GOP frames(I1..N) and has as output the resulting frame IACC. The inverse process has as input the IACC frame and as output the coded frames (I 1.N). The analysis of these two processes leads to the following algorithms The algorithm 1 describes how to make Accordion representation (labeled ACC); The algorithm 2 represents the process inverse (labeled ACC $^{-1}$).

Let us note that:

1) L and H are respectively the length and the height of the video source frames.
2) NR is the number of frames of a GOP.
3) IACC(x, y) is the intensity of the pixel which is situated in "IACC" frame with the co-ordinates x,y according to .Accordion representation" repair.
4) In(x, y) is the intensity of pixel situated in the Nth frame in original video source.

We can also present the Accordion Representation"with the following formulas: ACC formulas:
IACC = In(xdivN, y) (2) with n=((x div N) mod2)(N-1) + 1-2((x div N) mod 2)(x mod N)
ACC inverse formulas:
In(x, y)= IACC(XACC, y) (3) with XACC = ((x
div N) mod 2)(N-1) + n(1-2('x div N) mod 2))+x

D.Diagram of coding ACC - JPEG

ACC - JPEG Coding is preceded as follows:
1) Decomposition of the video in groups of frames (GOP).
2) Accordion Representation" of the GOP.
3) Decomposition of the resulting "IACC" frame into8x8 blocks.
4) For each 8x8 block:

- discrete cosine Transformation (DCT).
- Quantisation of the obtained coefficients.
- Course in Zigzag of the quantizedcoefficients.
- Entropic Coding of the coefficients (RLE,Huffman)

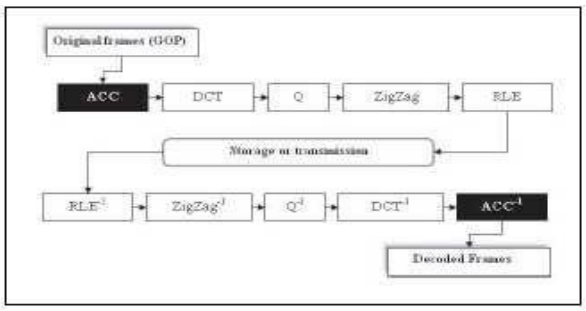

Fig.6.ACC-JPEG diagram coding

3. EXPERIMENTAL RESULTS

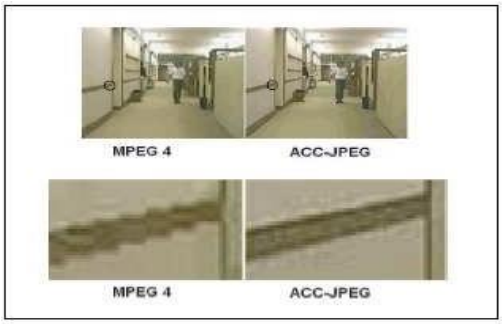

Fig 7 MPEG-4 Vs ACC-JPEG

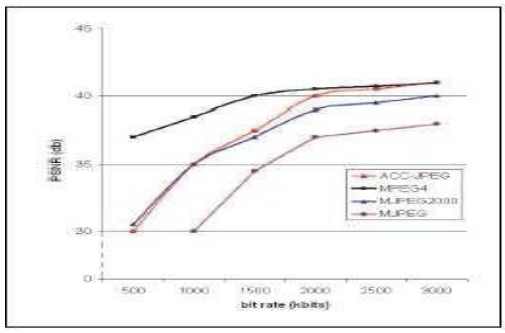

Fig 8 PSNR evaluation (Hall monitor)

4. CONCLUSION

The video signal has high temporal redundancies between a number of frames and this redundancy has not been exploited enough by current video compression techniques. In this research, we suggest a new video compression method, which exploits objectively the temporal redundancy. With the apparent gains in compression efficiency we foresee that the proposed method could open new horizons in video compression domain; it strongly exploits temporal redundancy with the minimum of processing complexity, which facilitates its implementation in video embedded systems. It presents some useful functions and features which can be exploited in some domains as video surveillance. In high bit rate, it gives the best compromise between quality and complexity. It provides better performance than MJPEG and MJPEG2000 almost in different bit rate values. Over 2000kb/s" bit rate values our compression method performance becomes comparable to the MPEG 4 especially for low motion sequences. There are various directions for future investigations. First of all, we would like to explore others possibilities of video representation. Another direction could be to combine Accordion representation" with other transformations such as wavelet transformation. The latter allows a global processing on the whole of the Accordion representation. On the contrary of the DCT which generally acts on blocks.

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