ARCHITECTURAL IMPLEMENTATION OF VIDEO COMPRESSION THROUGH WAVELET TRANSFORM CODING AND EZW CODING

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ABSTRACT

With the increasing growth of technology and the entrance into the digital age, we have to handle a vast amount of information every time which often presents difficulties. Wavelets provide a mathematical way of encoding information in such a way that it is layered according to level of detail. These layers can be stored using a lot less space than the original data. The basic video compression is based on the block discrete cosine transform (DCT). By using this, blocking artifacts are more in the frames. This paper presents a video compression by using Haar wavelet transform, down sampling and embedded zero tree wavelet. The video is represented as a group of images. These frames are given to the haar wavelet transform and then down sampling of the frames are done. The output of the down sampling is given to the EZW encoder and the output of the EZW encoder is given to the channel encoder. The reverse phenomenon was observed at the receiver. So the blocking effect is removed and the video quality was improved. For video quality Assessment the peak signal to noise ratio between the frames is calculated. This video compression is implemented in matlab and vhdl code.

Key words—DCT, Haar wavelet transform, EZW

I. INTRODUCTION

Video compression is the process of encoding information using fewer bits. Compression is useful because it helps to reduce the consumption of expensive resources such as hard disk space or transmission bandwidth. The video is actually a kind of redundant data i.e. it contains the same information from certain perspective of view. By using data compression techniques, it is possible to remove some of the redundant information contained in images. Image
compression minimizes the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The reduction in file size allows more images to be stored in a certain amount of disk or memory.

Wavelets are a mathematical tool for hierarchically decomposing functions. Though rooted in approximation theory, signal processing, and physics, wavelets have also recently been applied to many problems in Computer Graphics including image editing and compression, automatic level-of detail control for editing and rendering curves and surfaces, surface reconstruction from contours and fast methods for solving simulation problems in 3D modeling, global illumination, and animation. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios is shown in fig 1. The Haar wavelet is the simplest possible wavelet. The technical disadvantage of the Haar wavelet is that it is not continuous, and therefore not differentiable. Discrete Wavelet Transform is carried out by decomposing the image into four sub bands (LL, LH, HL and HH) use separable wavelet filters and critically subs sampling the output. The next coarser level of coefficients are obtained by decomposing the low frequency Sub band LL. Downsampling and Upsampling are widely used in image display, compression, and progressive transmission. Downsampling is the reduction in spatial resolution while keeping the same two-dimensional (2D) representation. It is typically used to reduce the storage and/or transmission requirements of images. Upsampling is the increasing of the spatial resolution while keeping the 2D representation of an image. It is typically used for zooming in on a small region of an image, and for eliminating the pixelation exact that arises when a low-resolution image is displayed on a relatively large frame. Bit-Plane Slicing is a technique in which the image is sliced at different planes. It ranges from Bit level 0 which is the least significant bit (LSB) to Bit level 7 which is the most significant bit (MSB). The input to this method is an 8-bit per pixel image. This is a very important method in Image Processing. EZW coding is a proven technique for coding wavelet transform coefficients. Besides superior compression performance, the advantages of EZW coding include simplicity, an embedded bit stream, scalability, and precise bit-rate control. EZW introduced a data structure called a zero tree, built on the parent-child relationship. The embedded code represents a sequence of binary decisions that distinguish an image from the “null” image. The EZW algorithm was able to exploit the multi-resolution properties of the wavelet transform to give computationally less complex algorithm with very good performance. Improvement and enhancement to EZW have resulted in similar algorithms such as set partitioning in hierarchical trees (SPIHT) and zero-tree entropy (ZTE) coding.

II. WAVELET TRANSFORM

A Haar wavelet is the simplest type of wavelet. In discrete form, Haar wavelets are related to a mathematical operation called the Haar transform. The Haar transform serves as a prototype for all other wavelet transforms. Like all wavelet transforms, the Haar transform decomposes a discrete signal into two sub signals of half its length. One sub signal is a running average or trend; the other sub signal is a running difference or fluctuation. The Haar wavelet transform has a number of advantages:

- It is conceptually simple.
- It is fast.
- It is memory efficient, since it can be
calculated in place without a temporary Array.

- It is exactly reversible without the edge effects that are a problem with other Wavelet transforms.

The Haar transform also has limitations which can be a problem with for some applications. In generating each of averages for the next level and each set of coefficients, the Haar transform performs an average and difference on a pair of values. Then the algorithm shifts over by two values and calculates another average and difference on the next pair. The high frequency coefficient spectrum should reflect all high frequency changes. The Haar window is only two elements wide. If a big change takes place from an even value to an odd value, the change will not be reflected in the high frequency coefficients.

Discrete Wavelet Transform is carried out by decomposing the image into four sub bands (LL, LH, HL and HH) use separable wavelet filters and critically subs sampling the output. The next coarser level of coefficients are obtained by decomposing the low frequency Sub band LL.

The Haar wavelet’s mother wavelet function $\psi(t)$ can be described as:

$$\Psi(t) = \begin{cases} 1 & 0 \leq t < 1/2 \\ -1 & 1/2 \leq t < 1 \\ 0 & otherwise \end{cases} \quad \ldots \ldots (1)$$

Fig 1: Block diagram of video compression

Fig 2: A two-level subband decomposition.
And its scaling function $\varphi(t)$ can be described as:

$$\varphi(t) = \begin{cases} 1 & 0 \leq t < 1 \\ 0 & \text{otherwise} \end{cases} \quad \ldots \ldots (2)$$

The Haar wavelet has several notable properties, the most useful property that can be extended to modify types, is the wavelet/scaling functions with different scale have a functional relationship:

$$\varphi(t) = \varphi(2t) + \varphi(2t-1) \quad \ldots \ldots (3)$$

$$\psi(t) = \varphi(2t) - \varphi(2t-1) \quad \ldots \ldots (4)$$

The Haar wavelet transformation is composed of a sequence of low-pass and high-pass filters, known as a filter bank. The low pass filter performs averaging/blurring operations, which is expressed as:

$$L = \frac{1}{\sqrt{2}} (1 + 1) \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (5)$$

The high-pass filter performs a differencing operation and can be expressed as:

$$H = \frac{1}{2} (1 - 1) \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (6)$$

The low and high filter’s equations above, can be formulated simultaneously through four filters i.e., (LL, HL, LH, and HH) each of (2x2) adjacent pixels which are picked as group and assed.

In this transform, the bases of these 4-filters could be derived as follows:

The horizontal low pass followed by the vertical low pass filter is equivalent to:

$$LL = \frac{1}{2} \begin{pmatrix} 1 \\ 1 \end{pmatrix} \begin{pmatrix} 1 & 1 \end{pmatrix} = \frac{1}{2} \begin{pmatrix} 1 \\ 1 \end{pmatrix} \quad \ldots \ldots (7)$$

The horizontal high pass filter followed by vertical low pass filter is:

$$LL = \frac{1}{2} \begin{pmatrix} 1 \\ -1 \end{pmatrix} \begin{pmatrix} 1 & 1 \end{pmatrix} = \frac{1}{2} \begin{pmatrix} 1 + 1 + 1 \\ -1 - 1 \end{pmatrix} \quad \ldots \ldots (8)$$

While the horizontal low pass filter followed by vertical high pass filter is equivalent:
Finally, the horizontal high pass filter followed by vertical high pass filter is:

\[
LH = \frac{1}{2} \begin{pmatrix} 1 \\ -1 \end{pmatrix} \left( \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix} \right) \ldots \ldots (9)
\]

\[
HH = \frac{1}{2} \begin{pmatrix} -1 \\ 1 \end{pmatrix} \left( \begin{pmatrix} -1 & 1 \\ 1 & -1 \end{pmatrix} \right) \ldots \ldots (10)
\]

The Haar transform is simple, efficient in memory usage due to high zero value spread (it can use sparse principle), and exactly reversible without the edge effects as compared to DCT (Discrete Cosine Transform).

III. SAMPLING

Wavelet representation can also be used as a tool for subsampling and interpolation. Video applications often involve some form of format conversion through subsampling and interpolation. For example, in the CCITT H.261 standard, all incoming video signals are converted to a common intermediate format (CIF) or a quarter of CIF (QCIF) format depending on the available channel rate. In certain MPEG specification, the CCIR 601 resolution has to be subsampled to meet the target rate of 1.5 Mb/s. There are many subsampling and interpolation schemes.

The easiest method is the uniform subsampling in which every other samples (say for 2:1 sampling) are discarded. Some nonuniform subsampling techniques were also developed to discard samples in terms of its local activity. In the receiver, different linear or nonlinear interpolation schemes are engaged to retrieve the video signals. The drawback of this type of sample discarding is the "aliasing effect," caused by the inadequacy of the sampling rate. Some filtering techniques developed in image coding and enhancement can also be used as generalized subsampling and interpolation.

III.1. Down Sampling

Down sampling is widely used in image display, compression, and progressive transmission. Down sampling is the reduction in spatial resolution while keeping the same two dimensional (2D) representations. It is typically used to reduce the storage and/or transmission requirements of images.

Down sampling an image reduces the number of samples that can represent the signal. In terms of frequency domain, when a signal is downsampling, the high frequency portion of the signal will be aliased with the low frequency portion. When applied to image processing, the desired outcomes to preserve only the low frequency portion. In order to do this, the original image needs to be preprocessed (alias-filtered) to remove the high frequency portion so that aliasing will not occur.
III.2. Up Sampling

Upsampling is the increasing of the spatial resolution while keeping the 2D representation of an image. It is typically used for zooming in on a small region of an image, and for eliminating the pixilation exact that arises when a low resolution image is displayed on a relatively large frame.

The minimum requirement in the coordinates correspondence is that upsampling an image containing arbitrary random values by an integer factor. Upsampling an image consisting of just on uniform value, followed by opposite operation, should result in an image consisting of the same value uniformly, with minimal numerical deviations. Repeatedly applying pair of up-sampling/down-sampling should minimize the shift in image content as much as possible. Repeatedly applying pairs of upsampling/downsampling should minimize the shift in image content as much as possible.

IV. EZW TRANSFORM

This algorithm laid the foundation of modern wavelet coders and provides excellent performance for the compression of still images as compared to block based DCT algorithm. Introduced by Shapiro in 1993, this algorithm uses the multi-resolution properties of wavelet transform.

As the name implies, embedded means the encoder can stop encoding of image data at any desired target rate. Similarly, the decoder can stop decoding at any point resulting in image quality produced at the truncated bit stream of the image data. While the zero-tree structure is analogous to the zigzag scanning of the transform coefficients and end of block (EOB) symbol used in DCT based algorithms.

The EZW algorithm first uses DWT for the decomposition of an image where at each level \( i \), the lowest spatial frequency subband is split into 4 more subbands for next higher level \( i+1 \), i.e., \( LL_{i+1}, LH_{i+1}, HL_{i+1} \) and \( HH_{i+1} \) and then decimated. The algorithm uses the idea of significance map as an indication of whether a particular coefficient is zero or nonzero (i.e., significant) relative to a given quantization level. This means that if a wavelet coefficient at a coarse scale or highest level is insignificant (quantized to zero) with respect to a given threshold \( T \), then all wavelet coefficients of the same orientation at the same spatial location at next finer scales (i.e., lower level) are likely to be zero with respect to \( T \). The coefficient at coarse scale is called parent while the coefficients at the next fine scales in the same spatial orientation are called children.
This ezw transform counts the number of zeros and returns the value of the number of zeros in the receiver.

V. Results

The matlab result of the proposed method for which the PSNR values for every frame is calculated and the average is obtained.

![PSNR vs No of Frames](image)

Fig 5 plot for PSNR vs no of frames

This matlab code is also implemented in vhdl code. The synthesis report of the wavelet transform and the inverse wavelet transform.
VI. CONCLUSION

In this paper, we have presented a new video compression technique that uses the embedded zero tree wavelet, down sampling, up sampling in order to remove the redundancies between the frames. The ezw code is used to remove the number of zeros in the video. Here the difference of the frames is obtained by using the down sampling. Hence by using the haar wavelet the blocking effect occurred while using the DCT is removed.
REFERENCES


BIOGRAPHIES


B.K.N.Srinivasa Rao received M.Tech degree in Visual Information and Embedded Systems Engg from IIT, Kharagpur. B.Tech degree in Electronics and communication Engineering. He is working as Associate Professor, Department of Electronics and Communication Engineering at Gudlavalleru Engineering College, Gudlavalleru. He has a total teaching experience (UG and PG) of 10 years. he has guided and co-guided 6 P.G students. His research areas include VLSI Design, Embedded Systems and Digital Signal Processing.