Advanced Video Compression Technique of H.264 Codec Using SPIHT Algorithm

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ABSTRACT
The ever increasing bandwidth requirements for transmission of video signals in mobile and internet environment has necessitated video compression and attempts to compare the low bit rate characteristics of the major video compression methods. This paper makes use of H.264 using DCT and wavelet based video compression. Also attempts are made to compare the results of these methods. Initially the compressed signal / data is transmitted and the receiving end the video signals are reconstructed. This paper implements SPIHT(Set Partitioning in Hierarchical Trees) algorithm for video compression. The algorithm codes the most important wavelet transform coefficients first, and transmits the bits so that an increasingly refined copy of the original video can be obtained progressively.

Keywords
H.264, DCT, SPIHT, Video Compression, Wavelet, Low Bit Rate, Matlab, etc.

1. INTRODUCTION
Despite rapid progress in mass-storage density, processor speeds, and digital communication system performance, demand for data storage capacity and data-transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology.

Compression is useful because it helps reduce the consumption of expensive resources, such as hard disk space or transmission bandwidth. On the downside, compressed data must be decompressed to be used, and this extra processing may be detrimental to some applications. Compressed video can effectively reduce the bandwidth required to transmit video via terrestrial broadcast, via cable TV, or via satellite TVservices. Most video compression is lossy it operates on the premise that much of the data present before compression is not necessary for achieving good perceptual quality. Video is basically a three-dimensional array of color pixels. Two dimensions serve as spatial (horizontal and vertical) directions of the moving pictures, and one dimension represents the time domain. A data frame is a set of all pixels that correspond to a single time moment. Basically, a frame is the same as a still picture. The performance of H.264 generally degrades at low bit-rates mainly because of the underlying block-based Discrete Cosine Transform (DCT) scheme. More recently, the wavelet transform has emerged as a cutting edge technology, within the field of image & video compression. Many efforts have been taken in past to discuss image compression techniques [3] [6].

2. PROBLEM STATEMENT
Discrete Cosine Transformation is mainly used for image, video compression but it has several disadvantages such as

- Only spatial correlation of the pixels inside the single 2-D block is considered and the correlation from the pixels of the neighboring blocks is neglected.
- Undesirable blocking artifacts affect the reconstructed images or video frames. (High compression ratios or very low bit rates).
- DCT function is fixed. i.e. it cannot be adapted to source data
- Does not perform efficiently for binary images (fax or pictures of fingerprints) characterized by large periods of constant amplitude, followed by brief periods of sharp transitions.

So, because of all this reasons DCT does not provide efficient image/video compression and we may get noisy image while decompressing data.

3. WAVELET
Wavelet can often compress or de-noise a signal without appreciable degradation. Wavelet transforms are broadly divided into three classes: the continuous wavelet transform, the discredited wavelet transform and multi-resolution based wavelet transform. DWT is good for signal having high frequency components for short durations and low frequency components for long duration e.g. images. When a wavelet transform of the image is performed, a coefficient in a low sub-band can be thought of having four descendants in the next higher sub-band. The four descendants each have four descendants in the next higher sub-band. Discrete wavelet transform (DWT), transforms a discrete time signal to a discrete wavelet representation [1] [4]. A 2D wavelet transforms works as follows [5]:

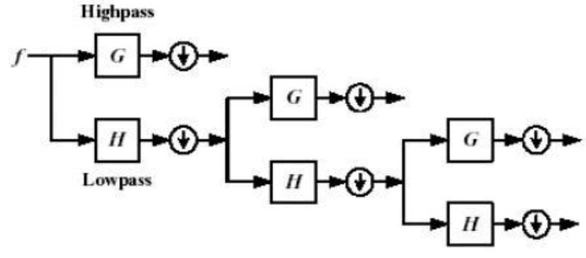

Figure 1: Wavelet Decomposition

Wavelets are functions defined over a finite interval and having an average value of zero. In wavelet decomposition, an image is decomposed into four components namely approximate coefficients, Horizontal coefficients, diagonal coefficients and vertical coefficients. This kind of two-dimensional DWT leads to a decomposition of approximation coefficients at level j in four components: the approximation at level j+1, and the details in three orientations (horizontal, vertical, and diagonal).

Many research paper on performance analysis has been discussed in past using wavelets transform [2].The following chart describes the basic decomposition step for images

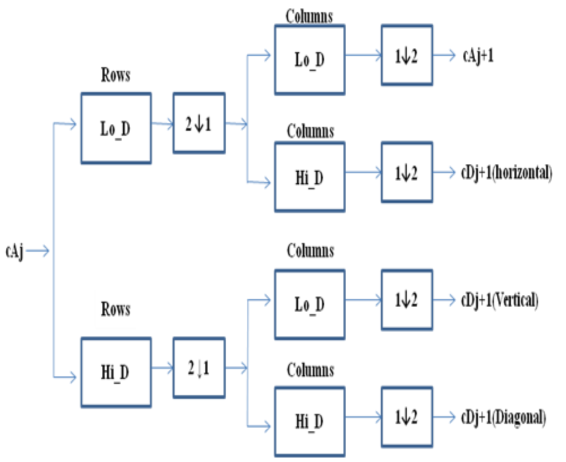

Figure 2: Decomposition Steps

3.1 Algorithm for Image decomposition using DWT

- Apply low pass and high pass on an image.
- Perform column wise down sampling on resultant values of step 1.
- Repeat step 1 on the output of step 2.
- Apply row wise down sampling.(now we get Approximate coefficients, horizontal details, diagonal details and vertical details)
- Stop if the stopping criterion is met or apply step 1 on approximate coefficient.
- For down sampling we can either use averaging method with details or pure interpolation method.
- To reconstruct an image apply the reverse technique of the above algorithm.

Advantages of DWT

- Allows good localization both in time and spatial frequency domain. Transformation of the whole image. Higher compression ratio.
- Higher flexibility.
- Better Performance.

4. THE SPIHT ALGORITHM

One of the most efficient algorithms in the area of image compression is the Set Partitioning in Hierarchical Trees (SPIHT). In essence it uses a sub-band coder, to produce a pyramid structure where an image is decomposed sequentially by applying power complementary low pass and high pass filters and then decimating the resulting images. These are one-dimensional filters that are applied in cascade (row then column) to an image whereby creating four-way decomposition:

- LL (low-pass then another low pass),
- LH (low pass then high pass),
- HL (high and low pass) and
- HH (high pass then another high pass).

The resulting LL version is again four-way decomposed, as shown in Figure 1. This process is repeated until the top of the pyramid is reached.
To take advantage of the spatial relationship among the coefficients at different levels and frequency bands, the SPIHT coder algorithm orders the wavelets coefficient according to the significance test.

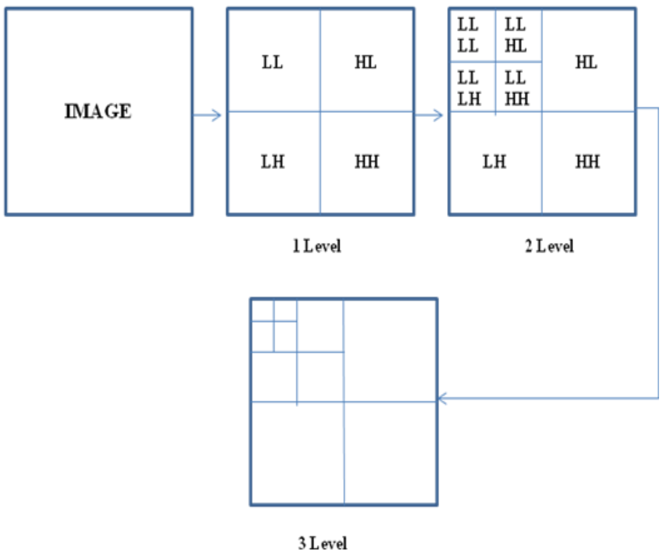

Figure 3: Image decomposition using wavelets

4.1 WORKING OF THE APPLICATION

- Initially Image is transformed into wavelet domain using Wavelet Decomposition.
- Then Wavelet coefficients obtained from Wavelet Decomposition are used as input to the SPIHT compression.
- Finally Compressed Image is obtained.
- Considering that the actual implementation of the SPIHT algorithm is not known, the project is an attempt to make the act clearer.

5. H.264/ AVC

H.264 is a next-generation video compression format. H.264 is also known as MPEG-4 AVC. Developed for use in high definition systems such as HDTV, Blu-ray and HD DVD as well as low resolution portable devices such as Sony's PSP and Apple's iPod, H.264 offers better quality at lower file sizes than both MPEG-2 and MPEG-4 ASP. The standardization of the first version of H.264/AVC was completed in May 2003.The H.264 standard can be viewed as a "family of standards", the members of which are the profiles described below. A specific decoder decodes at least one, but not necessarily all profiles. The decoder specification describes which of the profiles can be decoded. It has certain advantages such as an in-loop deblocking filter that helps prevent the blocking artifacts common to other DCT-based image compression techniques, resulting in better visual appearance and compression efficiency. A quantization design including Logarithmic step size control for easier bit rate management by encoders and simplified inverse-quantization scaling Frequency-customized quantization scaling matrices selected by the encoder for perceptual-based quantization optimization.

H.264 / AVC has a variety of new features that improve the picture quality and compression such as:

5.1 In loop deblocking

1. Deblocking is a CPU Intensive technique that attempts to remove blocking artifacts in the decoded picture.
2. H.264 enforces deblocking on every frame during both encoding and decoding.
3. The result is that encoding becomes more efficient because there is less noise present in reference pictures but consequently there is no option to disable deblocking to boost playback performance on slower systems.

5.2 Quarter- pixel motion estimation

H.264 use quarter pixel precision for motion search and this leads to longer search times during encoding as well as more complex texture reconstruction during playback.

6. RESULTS

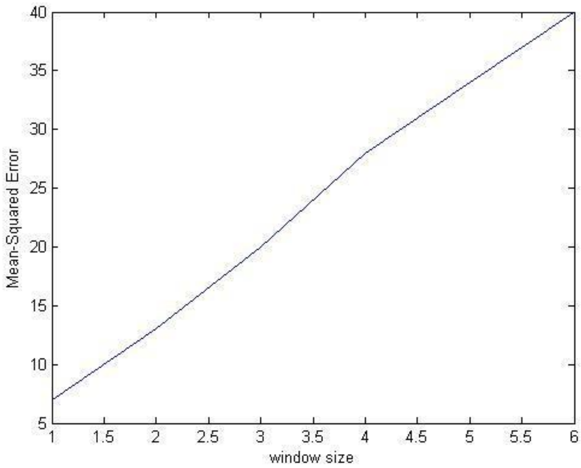

Figure 4(a) Mean Squared Error vs. window size for DCT

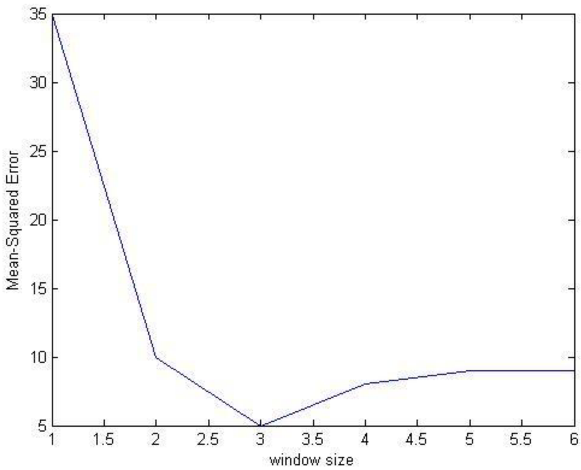

Figure 4(b) Mean Squared Error vs. window size for DWT

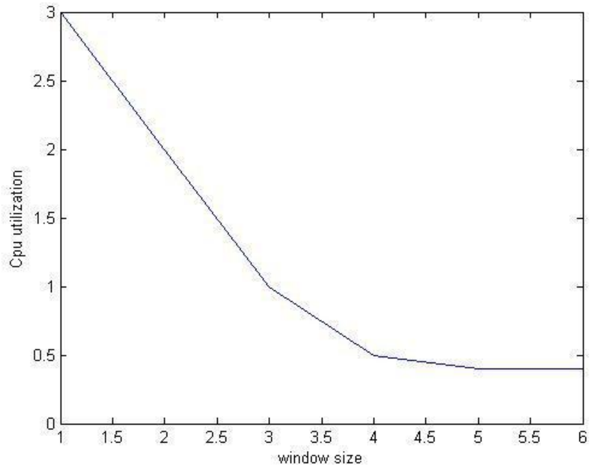

Figure 4(c) CPU Utilization vs. window size for DCT

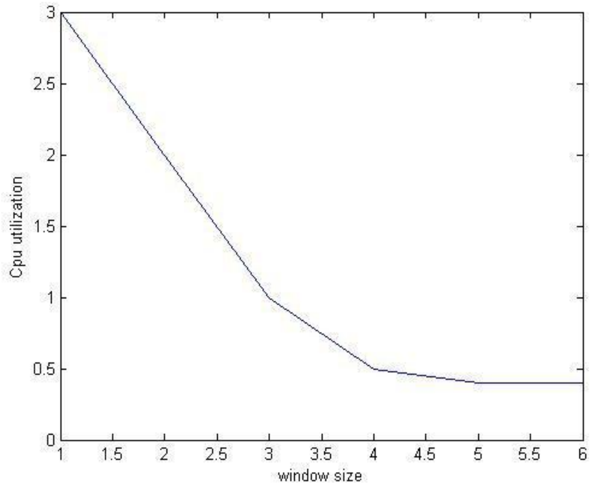

Figure 4(d) CPU Utilization vs window size for DWT

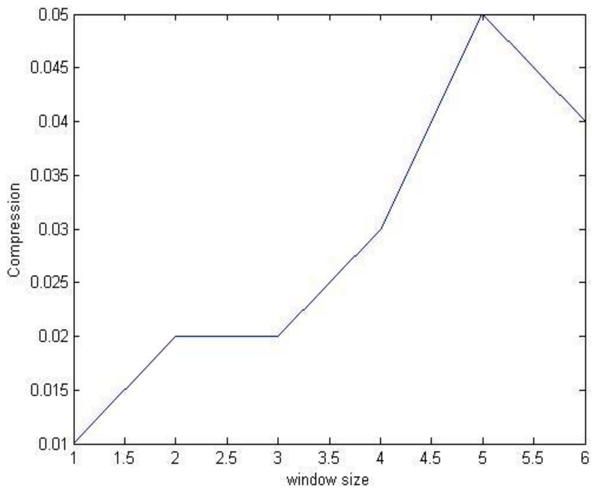

Figure 4 (e) Compression vs. window size for DCT

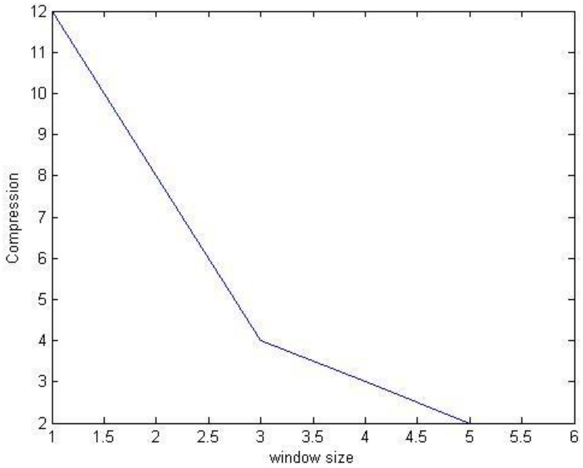

Figure 4(g) Compression vs. window size for DWT

Figure 5: INPUT 1

Figure 7: INPUT 2

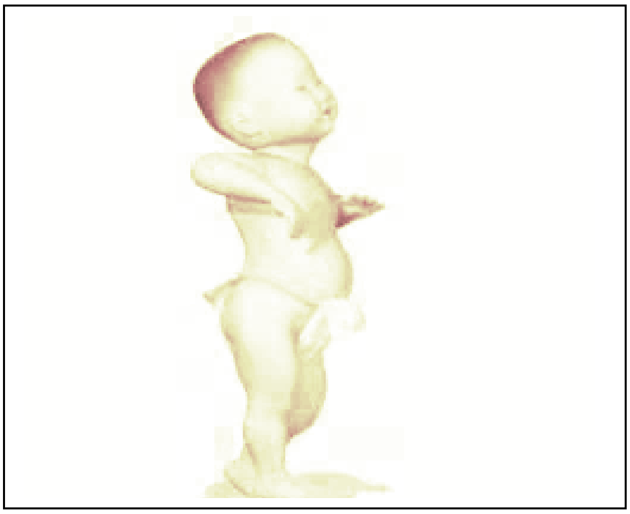

Figure 6 output1 psnr value = 43.91

Figure 8:Output2 psnr value = 43.91

7. CONCLUSION

One of the unexpected results of the latest research effort has been the realization that SPIHT provides better video compression without effecting image quality. The current simulation serves its users with H.264 video Compression using SPIHT and it provides better quality of service. It provides a base for further research and development in the area of wavelets and general objective of achieving high degree of quality of service can be met.

7. ACKNOWLEDGEMENTS
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8. REFERENCES
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