

## Intraframe Compression Using Lifting Scheme Wavelet-Based Transformation (9/7-Tap Filter).



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### Abstract

*Image compression is now essential for applications such as transmission and storage in data bases. This paper proposes a new scheme for image compression; this new method involves two steps. First, we use a lifting scheme wavelet-based transform. Second, we develop a modified entropy coding algorithm. We show how block subband coding leads to increase the compression factor with preserving the quality. The main objective of this work is to encode the intra-frame in a video sequences.*

**Keywords:** Anger Frame Compression Color Transformation Lifting Scheme Adaptive- Quantization Optimized Shift Coding Quality Measurement Compression Factor

### Introduction

Uncompressed multimedia (graphics, audio and video) data requires considerable storage capacity and transmission bandwidth. 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 has not only sustained the need for more efficient ways to encode signals and images but has made the compression of such signals central to the storage and communication technology.

The motion detection algorithms have been used to find the Intra-frame within the video scenes [1].

Current standards for compression of still (e.g., JPEG [2]) and moving images (e.g., MPEG-1 [3], MPEG-2 [4]) use DCT,

which represents an image as a superposition of cosine functions with different discrete frequencies [5].

The block-based segmentation of source image is a fundamental limitation of the DCT-based compression system [6]. The degradation is known as the blocking effect (*artifact*) and depends on block size. A larger block leads to a more efficient coding, but requires more computational power. Image distortion is less annoying for small than for large DCT blocks, but coding efficiency tends to suffer. Therefore, most existing systems use blocks of 8x8 or 16x16 pixels as a compromise between coding efficiency and image quality.

In recent times, much of the research activities in image coding have been focused on the DWT (*discrete wavelet transforms*), which become a standard tool in image compression applications because of data reduction capability [7].

In a wavelet compression system, the entire image is transformed and compressed as a

single data object rather than block by block as in a DCT-based compression system. DWT offers adaptive spatial-frequency resolution (better spatial resolution at high frequencies and better frequency resolution at low frequencies) that is well suited to the properties of an HVS. It can provide better image quality than DCT, especially on a higher compression ratio [6].

In this paper, a new algorithm for Intra-frame compression is developed using 9/7 Tap wavelet filter and optimized entropy coding technique. The diagram of the proposed work is shown in the figure1.

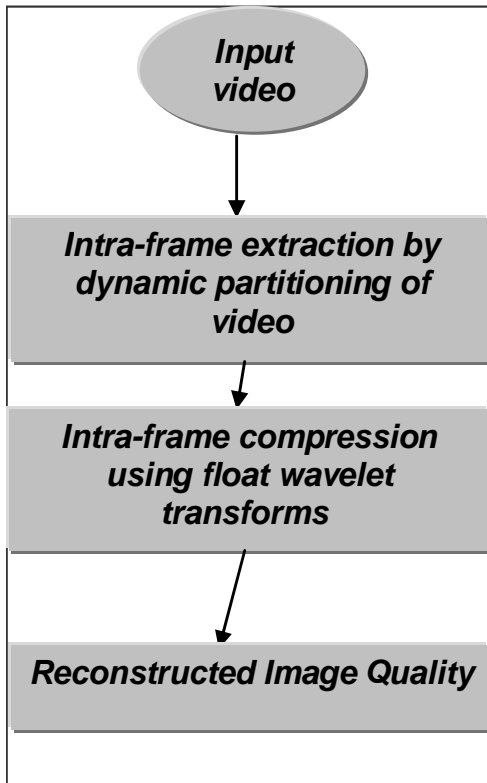


Fig1: the outline of the work

The steps needed to compress an image are as follows:

- 1- Decompose the image into a sequence of wavelet coefficients (w).
- 2- Use threshold to modify the wavelet coefficients from w to another sequence (w').
- 3- Use quantization to convert w' to a sequence (q).
- 4- Apply entropy coding to compress q into a sequence (e).

The images are chosen based on the boundary cut detection in the video. The intra-frames are tested by the coder and decoder scheme that we developed. Figure 2, shows the tested image and its histogram.

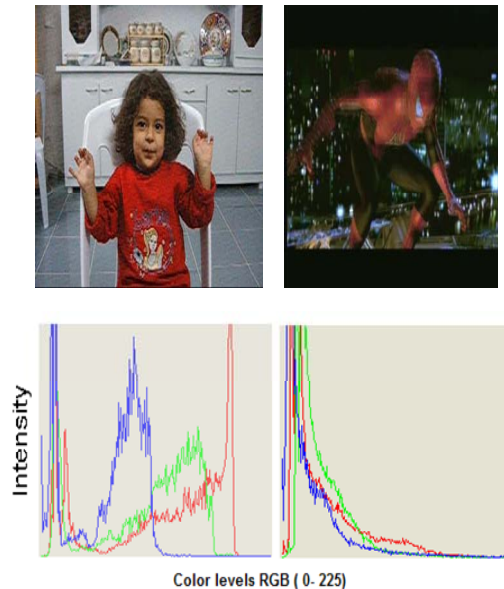


Fig2: image test and its histogram

In section 2, the proposed codec is described in details, while in section 3 the efficiency of lifting scheme is presented. The results and all relevant discussions appear in section 4. Finally, the main conclusions are summarized in section 5.

### CODER / DECODER Steps

Figure (3) shows the coder steps. The decoder scheme is shown in the diagram below (see figure (4)): The coder and decoder can be explained in the following steps [2]:

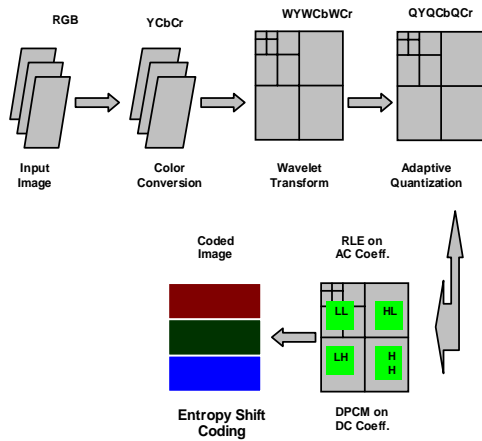


Fig3: Coder

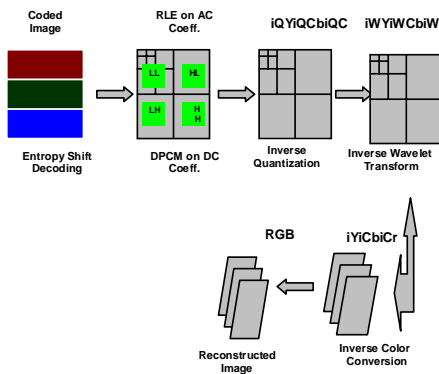


Fig4: Decoder

### Color Conversion (RGB2YCbCr)

YCbCr refers to the color resolution of digital component video signals, which is based on sampling rates. In order to compress bandwidth, Cb and Cr are sampled at a lower rate than Y, which is technically known as "chroma subsampling." This means that some color information in the video signal is being discarded, but not brightness (luma) information [7]. Figure 5 shows the RGB to YCbCr conversion.

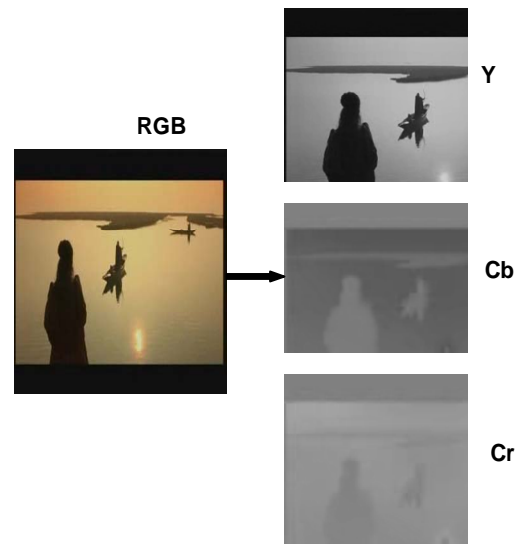


Fig5: RGB2YCbCr

### Wavelet Transformation

Wavelet transform (WT) represents an image as a sum of wavelet functions (wavelets) with different locations and scales. Any decomposition of an image into wavelets involves a pair of waveforms: one to represent the high frequencies corresponding to the detailed parts of an image (wavelet function) and one for the low frequencies or smooth parts of an image (scaling function) [3].

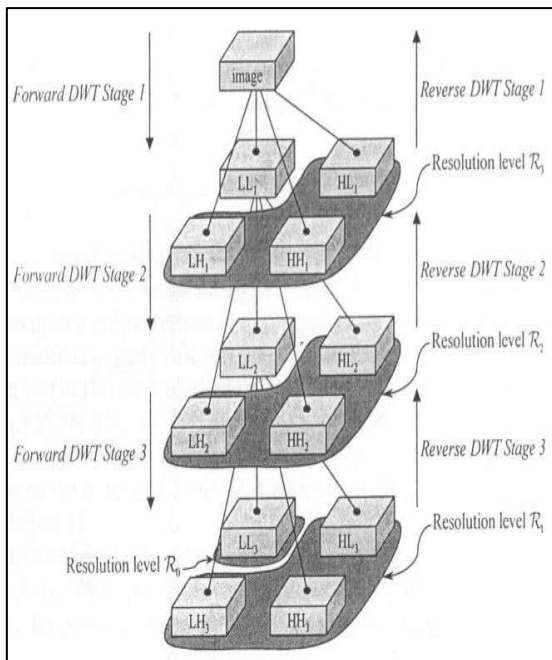
The filter which is used for this transformation is a non reversible filter and can only be used for lossy coding.

At each level the area is divided into 4 sub-bands:

- **LL<sub>i</sub>**: down-sampled, low-resolution version of the original block.
- **HL<sub>i</sub>, LH<sub>i</sub>, HH<sub>i</sub>**: down-sampled residual version of the original block.

The forward and inverse 2D-DWT for three levels is shown in the figure 6.

This step compacts the more energy of the image into the LL level with a few coefficients. An illustrative example determined for three levels are shown in figure 7.



**Fig6: Three level image decomposition**



**Fig7: Image decomposition L=3**

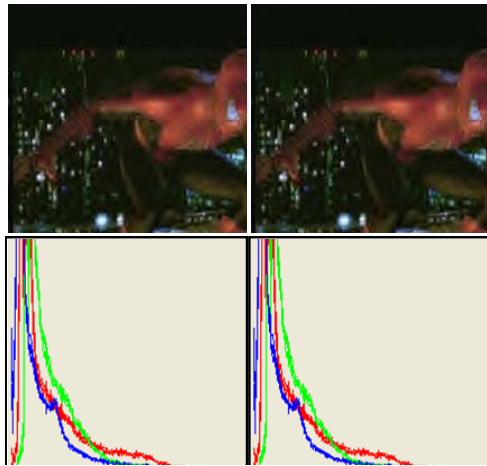
### Adaptive Quantization

The retained coefficients must be quantized for the compression purpose. The luminance component Y requires the small step of quantization while Cb and Cr need a large step. After this step, we obtain a large sequence of zeros especially in (HL,LH,HH) part of the image. Adaptive algorithm for forward and inverse quantization is as follow:

$$Q_I = \text{round}\left(\frac{YCbCr(x, y)}{Q_L}\right) \rightarrow \text{For.}$$

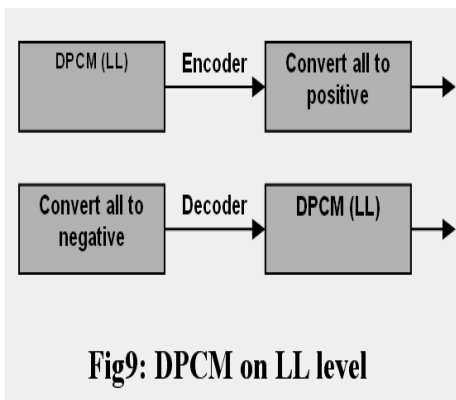
$$YCbCr(x, y) = Q_I * Q_L \rightarrow \text{Inv.}$$

Figure 8 presents the reconstructed image for different values of quantization step for Y and Cb,Cr components. It also shows its histogram.



**Fig(8): Reconstructed Image**  
**Left: Y=5, CbCr=30**  
**Right: Y=15, CbCr=30**

The forward and inverse differential pulse code modulation is applied on the LL coefficients. And then all coefficients must be converted into positive values by mapping to positive technique. The block diagram of this step is as follow (see figure(9)):



**Fig9: DPCM on LL level**

### Optimized Shift Coding

Different techniques can be used to encode wavelet coefficients. The entropy-based coding is more popular for color image coding like (Huffman, Arithmetic and etc.). The proposed codec scheme is a variable length coding which gives a few numbers of bits to the short codeword and many numbers of bits to the long codeword. The main idea behind the shift coding algorithm is to find the max wavelet coefficient in the data set and optimize this coefficient to take a small numbers of bits. The other coefficient within the set is coded with the same number of bits.

The pseudo code for encoding and decoding scheme is as follow:

- Find the max no. in the set (positive wavelet coefficient).
- Compute the number of bits of the max called (n).
- Compute the histogram of the set coefficient.
- Optimize the total size of (short and long codeword).

#### Encoder:

```
P = 2optimal codeword - 1
FOR I = 0 to NoCoef DO
  IF Coef(I) < P THEN
    Output Coef(I), optimal codeword
  ELSE
    Output P, optimal codeword
    Output Coef(I) - P, n
  ENDF
ENDFOR
```

#### Decoder:

```
P = 2optimal codeword - 1
FOR I = 0 to NoCoef DO
  Coef(I) = Get(optimal codeword)
```

```

IF Coef(I) = P THEN
  Coef(I)=Coef(I) + Get(n)
ENDIF
ENDFOR

```

Where  $j$  is the index levels and  $k$  is an integer number for even and odd samples. The performance of the designed codec will be presented in the next section.

The efficiency and the results of this algorithm is presented in the section 4.

### Results and Performance Evaluation

#### Wavelet Transform by Lifting Scheme

The codec algorithm is tested on girl image (three level decompositions) for different cases:

Lifting scheme is a rather new method for constructing wavelets. The main difference with the classical constructions is that it does not rely on the Fourier transform. In this way, lifting can be used to construct second-generation wavelets. The basic idea behind the lifting scheme is very simple; one tries to use the correlation in the data to remove redundancy.

case1 - perform the shift coding on each level and find the optimal codeword for each level.

case2 - perform the shift coding on each sublevel and find the optimal codeword for each sublevel.

case3 - perform the shift coding on each block sublevel and find the optimal codeword for each block sublevel.

At first the data is split into two sets (*Split phase*): the odd samples and the even samples.  $N$  even samples are used to predict the value of a neighboring odd value (*Predict phase*). The third step (*Update phase*) updates the even samples using the newly calculated odd samples such that the desired property is preserved [4]. The forward and inverse transform based-lifting scheme is depicted in the following block diagram (figure 10).

Table1 contains the experimental results for the above cases. The quantization step for luminance (Y) and chrominance (Ycb,Ycr) components is varying from (10 to 55, 15 to 60) respectively.

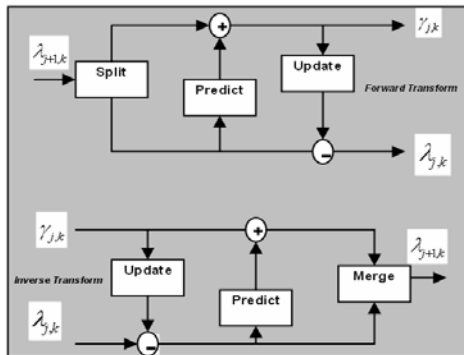


Fig10: Lifting scheme based DWT

Table1: C.F for three case studies versus PSNR

C.F (Levels)	C.F (SubLevels)	C.F (BlockSubLevels)	PSNR
3.9056	4.2584	7.973996	38.8165
4.2967	4.8872	10.05643	36.7028
4.4102	4.9804	11.46299	35.2311
4.5725	5.588	13.14962	34.0781
4.7299	5.662	14.69061	33.191
4.7985	5.7761	16.39738	32.3725
4.8334	6.3995	18.08227	31.6984
4.8849	6.8307	19.44769	31.1542
4.9591	6.8867	20.61969	30.6962
4.9793	6.9134	21.56623	30.2656

The quality of the reconstructed image is measured by the *PSNR* (*peak signal to noise ratio*). The lifting scheme based wavelet transformation reduces coding time in comparison with the traditional one. The performance of the proposed codec is based on *PSNR*, compression factors and coding time. The test results are shown in the figure 11. The block sublevel coding needs more time for coding than sublevel and level coding for the same reconstruct image quality as depicted in figure 11. Finally, figure 12 presents the original and reconstructed image using block sublevel coding with their histogram.

## Conclusions

The performance of the algorithm is based on the quality of the reconstructed image, compression factor and coding time. The tested result shows that the quality maintains the same value for different coding techniques.

The compression factor reaches a good ratio with block sublevel coding algorithm but the computational time is costly.

The compression factor reaches a poor ratio with level coding algorithm but the computational time see a considerable reduction.

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## كەمكردنەوهی قەبارەى وینەى وەستاو بە بەكارهینانی رینگەى گۆرانى شە پۆلى بچووك

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لەم تۆیژینەوهییدا رینگەیهکی نۆی پەرهی پین درا بۆ كەمكردنەوهی قەبارەى وینەى وەستاو لە قیدیۆدا كە پێك هاتوووە لە :  
1- بەكارهینانی رینگەیهکی كورت بۆ گۆرانى شە پۆله بچووكە كان 2- پەره پیندانی ئە لگۆریسی كۆد كردنى زانیاری. وو نمان كردهوه كە ئەم ئە لگۆریسمە ریزەى پەستان بۆ كەمكردنەوهی قەبارەى وینەیهك بە شیبوهیهکی بەرچاوی زیاد دەكات.

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یتناول البحت اسلوب جدید لضغط البینات ویتكون من مرحل :  
1- استخدام اسلوب مختصر لتحويلات موجة المصفرة 2- تطوير خوارزمية ترميز كمية المعلومات. سنوضح كيفية ترميز الحزم الجزئية للكتل من اجل زيادة نسبة الضغط مع الحفاظ على نوعية الصور. ان الهدف الرئيسى لهذا البحت هو ترميز الصور الثابتة فى افلام