Hybrid Color Image Compression based DPCM and Slant Transform

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Abstract

Nowadays, still images are used everywhere in the digital world. Images take lot of computer space, in many practical situations, all original images cannot be stored, and a compression must be used. Moreover, in many such situations, compression ratio provided by even the best lossless compression is not sufficient, so lossy compression is used.

In this paper ,Differential pulse code modulation (DPCM) in slantlet transform and Run Length Code for image compression is used.

Apply slantlet transform on each component in the color image(after applying color space conversion from RGB to YCbCr)and encoding Y component by DPCM and encoding Cb and Cr with RLC.The compression ratio and Peak Signal to Noise Ratio (PSNR) are used as measurement tools. When comparing the proposed approach with other compression methods Good result obtained.

Key words: Image Compression, Slantlet Transform , DPCM, RLC

1. Introduction

With the increasing use of multimedia technologies, address needs and requirements of multimedia and Internet applications, many efficient image compression techniques, with considerably different features, have recently been developed. Image compression techniques exploit a common characteristic of most images that the neighboring picture elements [1-3].

The aim of image compression is to reduce the size of an image with or without loss of information (lossy or lossless compression). One of the most commonly used lossy compression methods is that of transform coding using one of the many images transforms available. The idea of any transform is to transform the image into a new domain, where the image is now represented (approximated) by a set of decorrelated coefficients. However, in order to achieve (lossy) compression, the coefficients containing less important information are removed while those with the most important information are kept. At this point, we can inspect qualitatively (visually) and quantitatively (signal to noise ratio) the compressed image by reconstructing it via the inverse transformation.[4]

This paper is organized as follows. Section 2 describes color images, the process of the Slant transform scheme and analysis of all the filters.. The proposed algorithm based on Slant transform and DPCM is given in the section 3. Finally, conclusions are presented in Section 4.

2 Backgrounds

2.1 Color image

In a typical color image, the spatial intercomponent correlation among the red, green, and blue color components is significant. In order to achieve good compression performance, correlation among the color components is first reduced by converting the RGB image into a decorrelated color space [5].The color space conversion modules transforms Red Green Blue (RGB) encoded data into YC_bC_r coding. Y represents luminance (based on inverse gamma-distorted data) and C_bC_r represents chrominance [6].The advantage of converting the image into luminance-chrominance color space is that the luminance and chrominance components are very much decorrelated between each other the transformation from RGB to YCbCr is done based on the following mathematical expression[7].

$$
\left.
\begin{aligned}
Y &= 0.299000*R + 0.587000*G + 0.114000*B + 0 \\
C_b &= -0.168736*R - 0.331264*G + 0.500002*B + 128 \\
C_r &= 0.5*R - 0.418688*G - 0.081312*B + 128
\end{aligned}
\right\} \quad (1)
$$

For values of R,G, and B between 0 and 255.

Accordingly, the inverse transformation from YC_bC_r to RGB is done as [7].

$$
\left.
\begin{aligned}
R &= 1*Y + 0*C_b + 1.40210*C_r + 0 \\
C_b &= 1*Y - 0.34414*C_b - 0.71414*C_r - 128 \\
C_r &= 1*Y + 1.77180*C_b + 0*C_r - 128
\end{aligned}
\right\} \quad (2)
$$

2.2 Slant Transform

2.2.1 Theoretical Background of Slantlet Filterbank

It is useful to consider first the usual iterated DWT filterbank and an equivalent form, which is shown in Figure (1). The "slantlet" filterbank described here is based on the second structure. With the extra degrees of freedom obtained by giving up the product form, it is possible to design filters of shorter length while satisfying orthogonality and zero moment conditions, as it will be shown. For the two-channel case, the shortest filters for which the filterbank is orthogonal and has k zero moments are the well known filters described by Daubechies . For k=2 zero moments, those filters H(z)and F(z) are of length 4. For this system, which is designated D_2 , the iterated filters in Figure(1) are of length 10 and 4[9]

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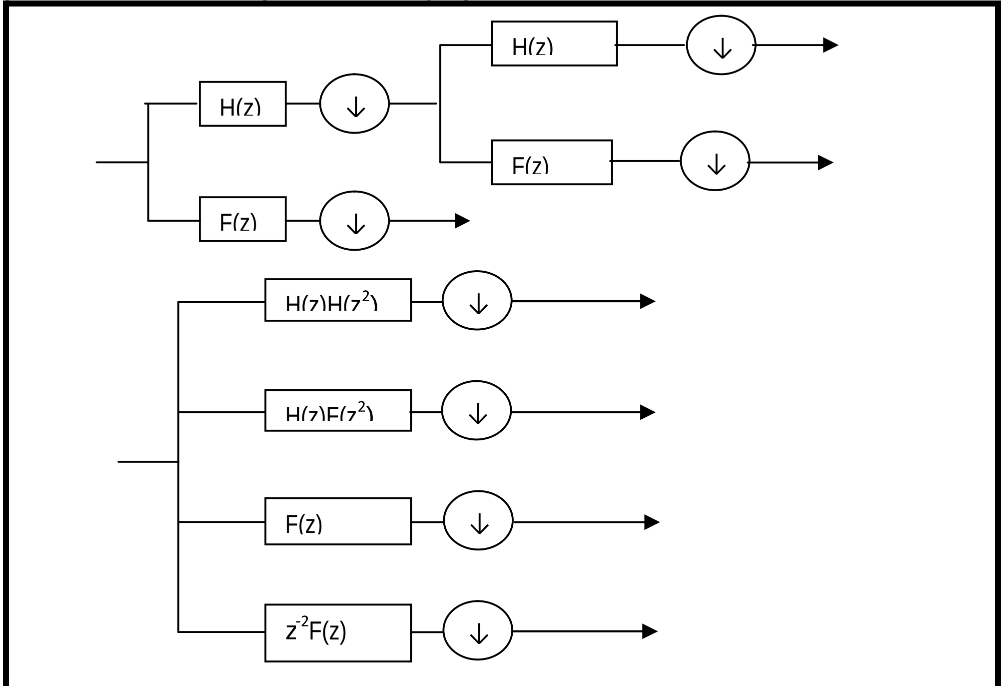
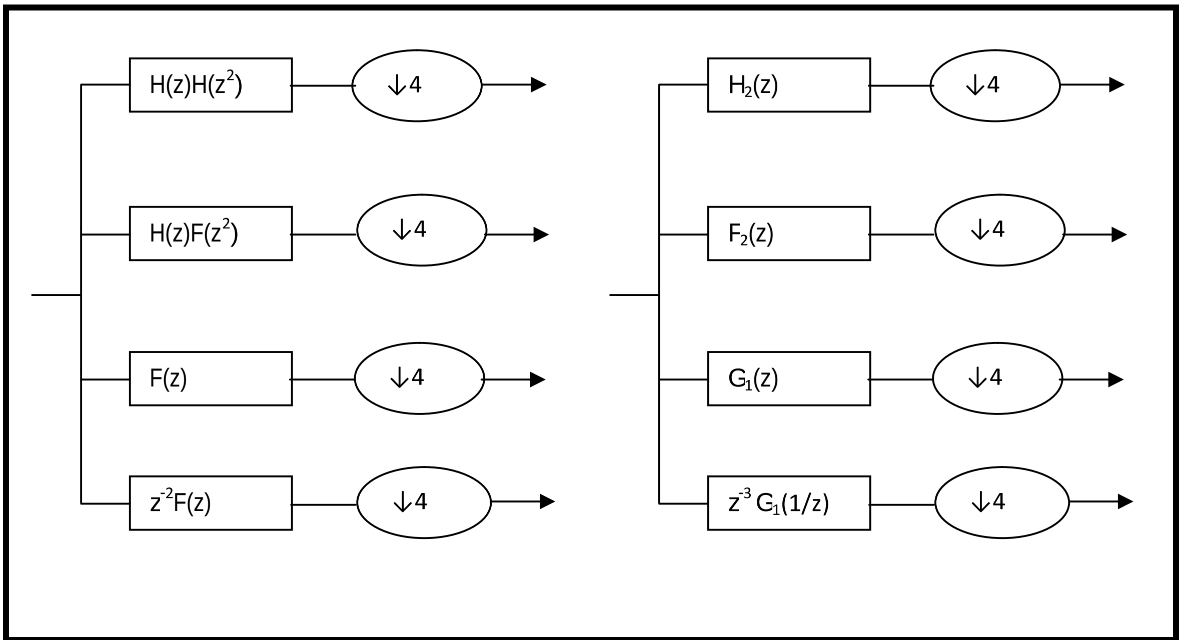


Figure (1) Two-scale Filterbank and an Equivalent Structure.

Without the constraint that the filters are products, an orthogonal filterbank with k=2 zero moments can be obtained where the filter lengths are 8 and 4.

As shown in figure (2), side by side with the iterated D_2 system. That is a reduction by two samples, which is a difference that grows with the number of stages

.



Figure(2) Comparison of two-scale iterated D2 filterbank (left-hand side) and two-scale slantlet filterbank (right-hand side).

2.2.2 Derivations of Filters

That the filters $g_i(n)$, $f_i(n)$, and $h_i(n)$ are linear which they are central to the following derivation. When coupled with the zero moments, it simplifies orthogonality conditions. First, suppose that $g_i(n)$, $f_i(n)$, and $h_i(n)$ are each linear over the interval $n \in \{0,\ldots\ldots,2^i-1\}$ and over the interval

$n \in \{2^i,\ldots\ldots,2^{i+1}-1\}$, as in Figure. (2).

Because the sought-after filter $g_i(n)$ is to be linear over the two above-mentioned intervals, it is described by four parameters and can be written as

$$g_i(n) = \begin{cases} a_{0,0} + a_{0,1}n, \quad for \quad n = 0,\ldots 2^i - 1 \\ a_{1,0} + a_{1,1}(n-2^i), \quad for \quad n = 2^i,\ldots,2^{i+1}-1 \end{cases} \qquad 3$$

Therefore, to obtain such that the sought-after –scale filterbank is orthogonal with two zero moments requires obtaining parameters and so that we have the following.

1)$g_i(n)$ is of unit norm.

$$\sum_{n=0}^{2^{i+1}-1} g_i^2(n) = 1 \qquad 4$$

2) $g_i(n)$ is orthogonal to its shifted time reverse.

$$\sum_{n=0}^{2^{i+1}-1} g_i(n) g_i(2^{i+1}-1-n) = 0 \qquad (5)$$

3) $g_i(n)$ annihilates linear discrete time polynomials.

$$\sum_{n=0}^{2^{i+1}-1} g_i(n) = 0 \qquad (6)$$

$$\sum_{n=0}^{2^{i+1}-1} n g_i(n) = 0 \qquad (7)$$

where

$$m = 2^i ,$$

$$s_1 = 6\sqrt{m/((m^2-1)(4m^2-1))} \qquad (8)$$

$$t_1 = 2\sqrt{3/(m.(m^2-1))} \qquad (9)$$

$$s_0 = -s_1.(m-1)/2 \qquad (10)$$

$$t_0 = ((m+1)s_1/3 - mt_1)(m-1)/2m \qquad (11)$$

$$a_{0,0} = (s_0 + t_0)/2 \qquad (12)$$

$$a_{1,0} = (s_0 - t_0)/2 \qquad (13)$$

$$a_{0,1} = (s_1 + t_1)/2 \qquad (14)$$

$$a_{1,1} = (s_1 - t_1)/2 \qquad (15)$$

$$h_i(n) = \begin{cases} b_{0,0} + b_{0,1} n, & for\, n = 0,..2^i - 1 \\ b_{1,0} + b_{1,1}(n - 2^i), & for\, n = 2^i,..2^{i+1} - 1 \end{cases} \qquad (16)$$

$$f_i(n) = \begin{cases} c_{0,0} + c_{0,1} n, & for\, n = 0,..2^i - 1 \\ c_{1,0} + c_{1,1}(n - 2^i), & for\, n = 2^i,..2^{i+1} - 1 \end{cases} \qquad (17)$$

The orthogonality and moment conditions require the following.

1) $f_i(n)$ and $h_i(n)$ are of unit norm.

$$\sum_{n=0}^{2^{i+1}-1} h_i^2(n) = 1 \qquad (18)$$

$$\sum_{n=0}^{2^{i+1}-1} f_i^2(n) = 1 \qquad (19)$$

2) $f_i(n)$ and $h_i(n)$ are orthogonal to their shifted versions.

$$\sum_{n=0}^{2^{i}-1} h_i(n) h_i(n+2^i) = 0 \qquad (20)$$

$$\sum_{n=0}^{2^{i}-1} f_i(n) f_i(n+2^i) = 0 \qquad (21)$$

$$\sum_{n=0}^{2^{i+1}-1} h_i(n) f_i(n) = 0 , \qquad (22)$$

$$\sum_{n=0}^{2^{i}-1} h_i(n) f_i(n+2^i) = 0 \qquad (23)$$

3) $f_i(n)$ annihilates linear discrete time polynomials.

$$\sum_{n=0}^{2^{i+1}-1} f_i(n) = 0 \qquad (24)$$

$$\sum_{n=0}^{2^{i+1}-1} n f_i(n) = 0 \qquad (25)$$

By expressing the orthogonality and moment conditions as a multivariate polynomial system, we obtain the following solution for $f_i(n)$ and $h_i(n)$:

$m = 2^i$,	26
$u = 1/\sqrt{m}$	27
$v = \sqrt{(2m^2+1)/3}$	28
$b_{0,0} = u.(v+1)/(2m)$	29
$b_{1,0} = u - b_{0,0}$	30
$b_{0,1} = u/m$	31
$b_{1,1} = -b_{0,1}$	32
$q = \sqrt{3/(m.(m^2-1))/m}$	33
$c_{0,1} = q.(v-m)$	34
$c_{1,1} = -q.(v+m)$	35
$c_{1,0} = c_{1,1}.(v+1-2m)/2$	36
, $c_{0,0} = c_{0,1}.(v+1)/2$	37

In these expressions for $h_i(n)$,$f_i(n)$, and $g_i(n)$, the signs of any of the square roots can be negated. Doing so merely negates or time reverses the sequences. We note that $h_i(n)$ and $f_i(n)$ specialize to the Daubechies length-4 filters for i=1 , as expected[8].

2.2.3 Inverse Transform

The reconstruction (inverse transform)is very easy since half band filters form orthonormal bases[9]. The above procedure is followed in reveres order and the signals at every level passed through the synthesis filters . The interesting point that the analysis and synthesis are identical to each other ,except for a time reversal[9].

2.3 Run Length Coding (RLC)

The idea behind this approach to data compression is this: If a data item *d* occurs *n* consecutive times in the input stream, replace the *n* occurrences with the single pair *nd*. The *n* consecutive occurrences of a data item are called a *run length* of *n,* and this approach to data compression is called *run length coding* or RLC[10].

2.4 DPCM

Data compression can be further achieved using differential pulse code modulation (DPCM). The general idea is to use past recovered values as the basis to predict the current input data and to then encode the difference between the current input and the predicted input. Since the difference has a significantly reduced signal dynamic range, it can be encoded with fewer bits per sample [11].Therefore, we obtain data compression.

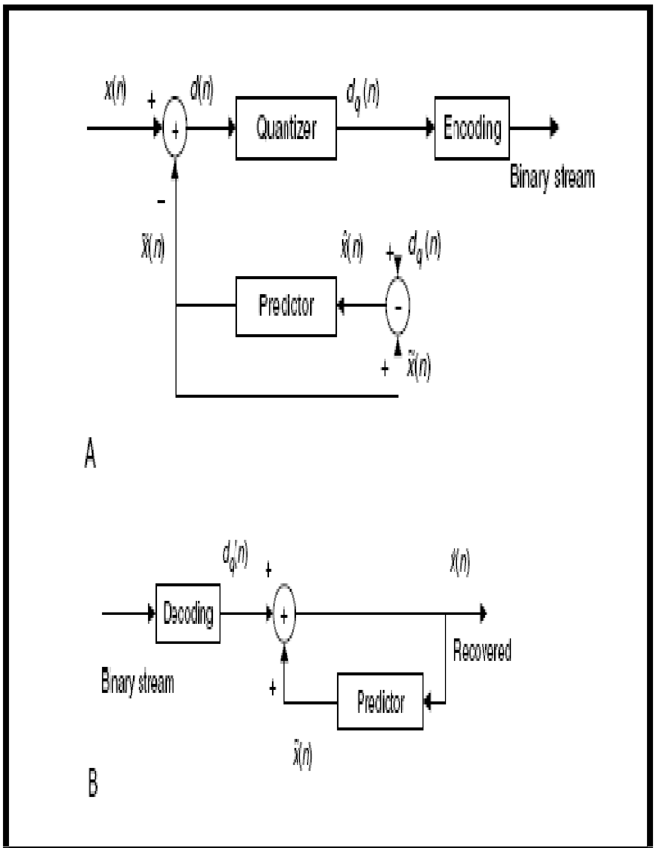


Figure 3 DPCM block diagram: (A) encoder; (B) decoder

Fig. 3 shows a schematic diagram for the DPCM encoder and decoder. We denote the original signal x(n); the predicted signal x(n); the quantized, or recovered signal ^x(n); the difference signal to be quantized d(n); and the quantized difference signal dq(n). The predictor uses the past predicted signal and quantized difference signal to predict the current input value x(n) as close as possible. On the other hand, the decoder recovers the quantized difference signal, which can be added to the predictor output signal to produce the quantized and recovered signal, as shown in Fig. 3(b)[11].

3. Proposed method

The following steps are followed in the encoder phase:

1: Color space conversion:-in this step the color components RGB are transformed to YCbCr according to eq (1).

2- Slant transform:-in this step 2D Slant transform is applied on the each component which result from step 1 , according to equations 3,16 and 17 after resizing it to power of two [256 x 256]pixels.

3- Thresholding:- the Slant coefficients whose magnitude values are less than a prespecified value called (Threshold value) are set zero (discarding). So that the transformed image after thresholding will contains long strings of zeros

4-Applying the DPCM for the low frequencies (Approximate coefficients) in the Y component.

5-Because the importance of high frequencies in the Y component is less than importance of the low frequency in this component, therefore it will be encoding with RLC.

6-The chrominance channels contain much redundant information and can easily be compressed without sacrificing any visual quality for the reconstructed image, therefore most coefficients of slant transform in the Cb and Cr components are zero and will contains long strings of zeros ,therefore RLC will be very useful to encoding it.

3.1 Decompression

Decompression Steps

The steps of decompression process are:

Step 1: Decoding the apprioxmat coffiecnets in the Y component with DPCM decode while the other coffiencts are decoding by RLC.

Step 2: Applying inverse slant transformation (discussed in section 2.2.3).

Step 3: Inverse transformation from YCbCr to RGB is applied on the image using eq.(2).

Figure 8 shows the flowchart of compressed procedure while figure 9 shows the decompressed procedure.

4. Simulation Results

In this section, the implementation results and the performance of the proposed algorithm when compared to other available approaches are presented. The proposed algorithm is implemented using Matlab package with test images with size 256*256 pixels. After applying the proposed method on the image and thresholding the images with different value for thresholds we get different compression ratios. The comparison is measured by the compression ratio (CR) and Peak to Signal Ratio (PSNR), i.e. the ability of reconstructing the original image (measured in term of PSNR)[8].Several quantities are commonly used to express the performance of a compression method [8].

Compression Ratio

CR) = (1 - (Compressed Image Size/Original Image Size)) x 100. …	**38**

Compression Factor

(CF) = (Original Image Size/ Compressed Image Size)	39

Where Original Image Size =256*256 pixels, pixel=8 bit for gray image and 24 for color image. fig.4 show the flowchart of image compression procedure wile fig. 5 show flowchart of image decompression procedure. Table No.2 shows different compression ratio (80%,85%,90%,95%) and the PSNR in dB obtained using the proposed method and wavelet based compression for different color images

$$SNR_{PEAK}=10\log\left(\frac{(255)^2}{\frac{1}{N}\sum_{r=0}^{N-1}\sum_{c=0}^{N-1}\left[\hat{I}(r,c)-I(r,c)\right]^2}\right) \quad \textbf{40}$$

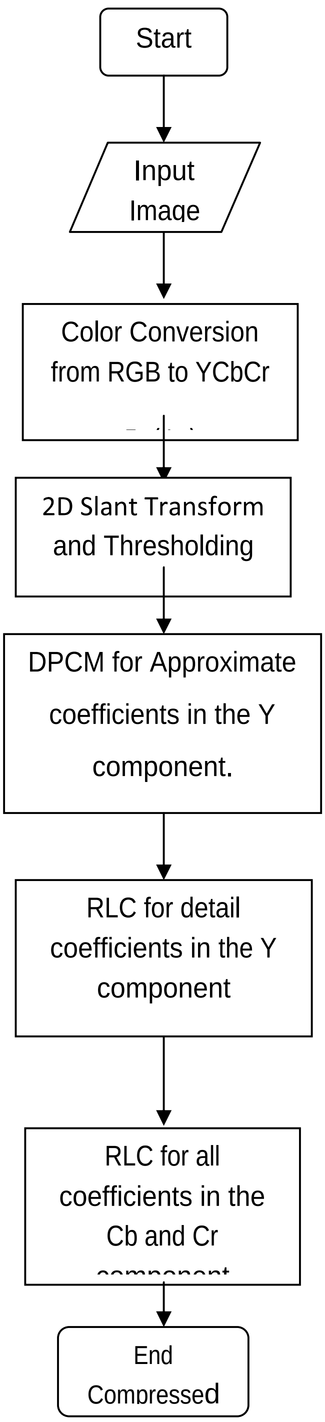


Fig. 7 Compression Procedure

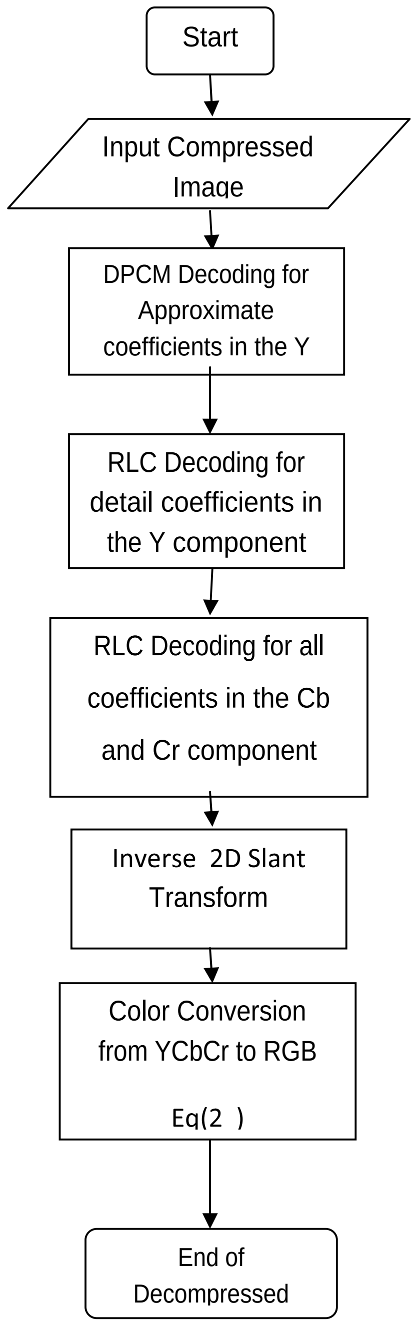
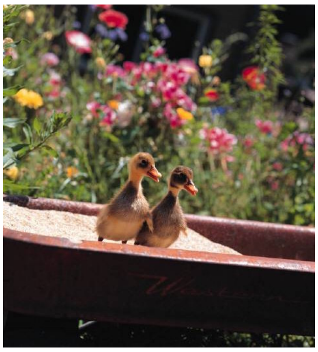


Fig. 8 Decompression Procedure

Table 1
Compression ratio and the PSNR in dB obtained using the slantlet and wavelet based compression for different image .

Image	Transform	CR=80% CF=5	CR=85% CF=6.7	CR=90% CF=10	CR=95% CF=20
1	wavelet	30. dB	29.33 dB	29. dB	25 dB
	Proposed	34.25 dB	33 dB	31dB	28.36 dB
2	wavelet	32 dB	30. dB	27. dB	22.6 dB
	Proposed	36 dB	33 dB	29 dB	24.97 dB
3	wavelet	38 dB	36.95 dB	34.40 dB	29 dB
	Proposed	43.14 dB	38.59 dB	37.96 dB	32.25 dB



a) Image 1

b) Image 2

c) Image 3

Fig 9. Test Images

5.Conclusions

In this paper, the proposed model has been applied for compression of image. The compression performance of the new approach is assessed through computer simulation and the results are compared with the DWT approaches Since the digital filter is achieved by shifting and delay operations and the slantlet transform has short filters with length approach to (1/3) length of iterated wavelet filter bank, the slantlet transform is faster than wavelet transform. The slantlet transform gives good result in the image which contains large smooth region because it has linear filters which work well in linear data and the data in the smooth region is linear. Results obtained show high compression ratio , because the color image has C_b and C_r components which have large redundant information and more smoothness.

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ضغط الصورة الملونة اعتمادا علي تضمين الفرو قات وتحويل الانحدار المائل

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الخلاصة

في عصرنا الحاضر أصبحت الصور تلعب دورا كبيرا في العالم الرقمي. ولكنها تأخذ حيزا كبيرا وفي معظم التطبيقات لا يمكن خزن الصورة بل يتم ضغطها.وان نسب الضغط بواسطة طرق الضغط التي لاتوجد فيها خسائر أصبحت غير كافية.في هذا البحث استخدمت طريقة تضمين الفرو قات (DPCM) و وتحويل الانحدار المائل(slantlet transform) و Run Length Code.

طبق تحويل الانحدار المائل على كل مركبة من مركبات الصور الملونة(بعد تحويلها من نظام RGB إلى نظام to YCbCr وترميز مركبة ال Y بطريقة DPCM ومركبات ال Cb و Cr بطريقة ال RLC. نسب الضغط ونسبة الإشارة إلى الضوضاء استخدمت كأدوات قياس. وتم الحصول على نتائج جيدة بالمقارنة مع طرق الضغط الأخرى