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# Image compression using Hybrid wavelet Transform and their Performance Comparison

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***Abstract:*** *Image compression is a widely addressed researched area. 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. Wavelet transform is generated from orthogonal transform .Image compression using hybrid wavelet transform is proposed here by using two orthogonal transform. Hybrid wavelet transform are generated using orthogonal transforms alias DCT, DHT, DWT, DKT transform .Different color images of size 256x256 are used for experimentation. Proposed hybrid wavelet transform is applied on red, green and blue planes of image separately. Then in each plane transformed coefficients are sorted in descending order of their energy and lowest energy coefficients are eliminated. Root mean square error between original image and reconstructed image is calculated to check the performance at different compression ratios. Hybrid of DCT and DKT gives the best results among the combination of mentioned image transforms used for generating hybrid wavelet transforms.*
***Keyword:*** *DCT, DHT, DKT, DWT, Hybrid wavelet transform, RMSE, PSNR.*

## I. Introduction

Images may be worth a thousand words, but they generally occupy much more space in hard disk, or bandwidth in a transmission system, than their proverbial counterpart. Compressing an image is significantly different than compressing raw binary data. Of course, general purpose compression programs can be used to compress images, but the result is less than optimal. This is because images have certain statistical properties which can be exploited by encoders specifically designed for them. Also, some of the finer details in the image can be sacrificed for the sake of saving a little more bandwidth or storage space. Compression is the process of representing information in a compact form. Compression is a necessary and essential method for creating image files with manageable and transmittable sizes. The data compression schemes can be divided into lossless and lossy compression. In lossless compression, reconstructed image is exactly same as compressed image. In lossy image compression, high compression ratio is achieved at the cost of some error in reconstructed image. Lossy compression generally provides much higher compression than lossless compression.

Wavelets are used to characterize a complex pattern as a series of simple patterns and coefficients that, when multiplied and summed, reproduce the original pattern. Wavelets transforms are now being adopted for various applications like Industrial supervision of gear-wheel, Speech recognition, Computer graphics and multifractal analysis. Wavelet transform of a function is the improved version of Fourier transform[1]. It is good tool to replace the fourier transform. Fourier transform is a powerful tool for analyzing the components of a stationary signal. But it is failed for analyzing the non-stationary signal. wavelet transform allows the components of a non-stationary signal to be analyzed. Discrete Cosine Transform is widely used[2].It separates an image into different frequency components. Low frequency components are located at top left corner giving high energy compaction. High frequencies are located in bottom right corner. Elimination of these high frequency elements gives transformed image with few low frequency components. If image is reconstructed from such lesser number of transformed, low frequency elements, it gives compressed image without losing much data contents in original image. Hybrid transformation techniques combine properties of two different transforms. It gives compressed image with visually perceptible image quality. Initially focus was on Haar Wavelets. But in recent literature, wavelets of other orthogonal transforms have been introduced and studied. These transform include Walsh, DCT, DKT, Hartley transform.

## II. Related Work

Image compression technique by using wavelet transform by v.v.sunil kumar [3] is concerned with a certain type of compression technique by using wavelet transforms. There are a variety of wavelets for use in compression. Several methods are compared on their ability to compress standard images and the fidelity of the reproduced image to the original image. A lossless image Compression using Approximate Matching and Run Length [4] is proposed by Samir Kumar Bandyopadhyay, Tuhin Utsab Paul, Avishek Raychoudhury.Performance is compared with available jpeg compression technique over a wide number of images. Performance Analysis of Image Compression Using Wavelets [5] by Sonja Grgic, Mislav Grgic, Branka Zovko-Cihlar discusses important features of wavelet transform in compression of still images, including the extent to which the quality of image is degraded by the process of wavelet compression and decompression. In[6]-[7], Dr.H.B.kekre, Sudeep D. Thepade, Adib Parkardisucces the technique to store color information within grayscale image can be used in effective for image compression as the matted grayscale image alone can be used to reconstructed the original color image using haar and kekre wavelet transform. In[8], Prabhakar Telagarapu etl. Proposed Image Compression using DCT and Wavelet Transformations, The JPEG standard makes use of Discrete Cosine Transform (DCT) for compression. The analysis of compression using DCT and Wavelet transform by selecting proper threshold method, better result for PSNR have been obtained. In[9], wavelet transform is generated from orthogonal component transforms of different sizes and it is applied on colour images. DCT, DST, Hartley and Real-DFT are used as component transforms to generate their respective wavelet transforms. Blocking effect is observed in all wavelets except DCT and it depends upon the size of local component transform. Performance Comparison of Image Retrieval Techniques using Wavelet Pyramids of Walsh, Haar and Kekre Transforms is explained in [10], Content Based Image Retrieval (CBIR) is done using the image feature set extracted from Wavelets applied on the image at various levels of decomposition.

## III. Basic Theoritical Cosideration

### 3.1 Error Metrics

Two of the error metrics used to compare the various image compression techniques are the Mean Square Error (MSE) and the Peak Signal to Noise Ratio (PSNR) to achieve desirable compression ratios. The MSE is the cumulative squared error between the compressed and the original image, whereas PSNR is a measure of the peak error. The mathematical formulae for the two are :

$$MSE = \frac{1}{MN}\sum_{y=1}^{M}\sum_{x=1}^{N}\left[I(x,y) - I'(x,y)\right]^2 \quad (1)$$

$$PSNR = 20 * \log10\,(255 / \mathrm{sqrt}(MSE)) \quad (2)$$

where I(x,y) is the original image, I'(x,y) is the approximated version (which is actually the decompressed image) and M,N are the dimensions of the images in (1). A lower value for MSE means lesser error, and as seen from the inverse relation between the MSE and PSNR, this translates to a high value of PSNR. Logically, a higher value of PSNR is good because it means that the ratio of Signal to Noise is higher. Here, the 'signal' is the original image, and the 'noise' is the error in reconstruction. So, if we find a compression scheme having a lower MSE (and a high PSNR), we can recognise that it is a better one.

### 3.2 Wavelet Transform

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 coresponding to the detailed parts of an image (wavelet function ) and one for the low frequencies or smooth parts of an image (scaling function ).

### 3.2.1 Discrete Wavelet Transform

One of the big discoveries for wavelet analysis was that perfect reconstruction filter banks could be formed using the coefficient sequences $a_L(k)$and $a_H(k)$ (Fig.4). The input sequence is convolved with high-pass (HPF) and low-pass (LPF) filters and $a_L(k)$ and $a_H(k)$ and each result is downsampled by two, yielding the transform signals $x_H$ and $x_L$. The signal is reconstructed through upsampling and convolution with high and low synthesis filters $s_H(k)$ and $s_L(k)$ . For properly designed filters, the signal is reconstructed exactly (y = x ).

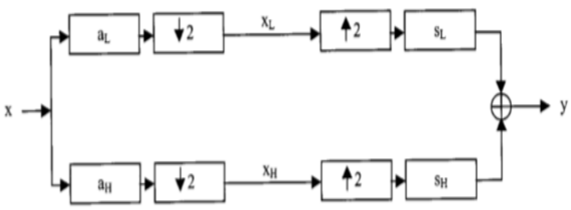


Figure.1 Two-channel filter bank.

The choice of filter not only determines whether perfect re-construction is possible, it also determines the shape of wavelet we use to perform the analysis. By cascading the analysis filter bank with itself a number of times, a digital signal decomposition with dyadic frequency scaling known as DWT can be formed. The mathematical manipulation that effects synthesis is called inverse DWT. The new twist that wavelets bring to filter banks is connection between multiresolution analysis (that, in principle, can be performed on the original, continuous signal) and digital signal processing performed on discrete, sampled signals. Four channel perfect reconstruction filter bank is shown in fig.4

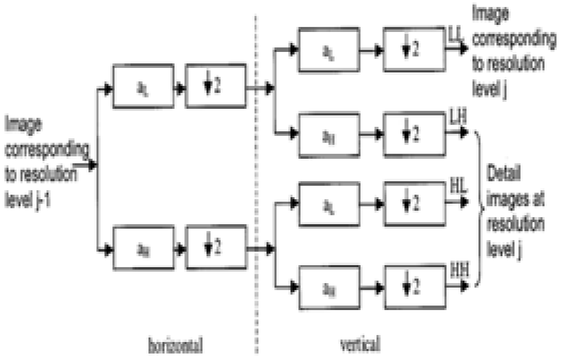


Figure.2 (a) one filter stage in2-D DWT

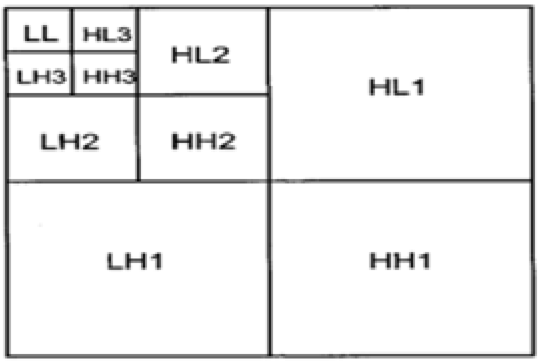


Figure.2 (b) Pyramidal structure of a wavelet decompression.

Each filter is 2-D with the subscript indicating the type of filter (HPF or LPF) for separable horizontal and vertical components. The resulting four transform components consist of all possible combinations of high- and low-pass filtering in the two directions. By using these filters in one stage, an image can be decomposed into four bands. There are three types of detail images for each resolution: horizontal (HL), vertical (LH), and diagonal (HH). The operations can be repeated on the low–low band using the second stage of identical filter bank. Thus, a typical 2-D DWT, used in image compression, will generate the hierarchical pyramidal structure shown in Fig.2(b).

**3.2.2. Discrete Cosine Transform(DCT)**

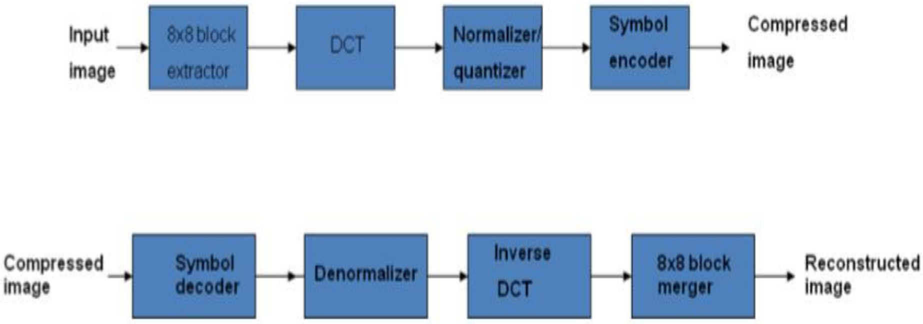


Figure.3 Image compression and decompression using DCT

The discrete cosine transform (DCT) is a technique for converting a signal into elementary frequency components. Like other transforms, the Discrete Cosine Transform (DCT) attempts to de correlate the image data. After de correlation each transform coefficient can be encoded independently without losing compression efficiency.

Proposed DCT Algorithm

1. The image is broken into 8x8 blocks of pixels.
2. Working from left to right, top to bottom, the DCT is applied to each block.
3. Each block is compressed through quantization.
4. The array of compressed blocks that constitute the image is stored in a drastically reduced amount of space.
5. When desired, the image is reconstructed through decompression, a process that uses the inverse Discrete Cosine Transform (IDCT).

## IV. Proposed Algorithm

Proposed technique uses the concept of generating hybrid wavelet transform from two orthogonal transforms and extends it with different orthogonal transforms like DCT, Walsh, DKT, DHT wavelet. Here Discrete Cosine Transform (DCT) is used to represent the global properties of an image. Walsh, DHT, DKT transforms are used one by one to represent local properties of an image. Pairing these transforms with DCT transform gives following hybrid transforms: DCT-DWT, DCT-DHT, DCT-DKT, DCT-Walsh.

1. Consider color image of size 256x256.
2. Separate R, G, B components of an image
3. Base transform 'DCT' of size 16x16 and second component transform of size 16x16 is selected to obtain hybrid transform of 256x256 sizes. Base transform is varied as DKT, Walsh, Hartley transform to compare their performances.
4. Full Hybrid Wavelet Transform of image 'f' is obtained as 'F'= [T]*[f]*[T]T. where T is transform matrix.
5. Elements in transformed plane are sorted in descending order of their energy and in each step (8x256) lowest energy elements are eliminated.
6. Reconstruct the image by applying inverse transform.
7. Calculate RMSE and PSNR between original image and reconstructed image at different compression ratios.

## V. Experiments And Results

Proposed technique is applied on a set of three color images of size 256x256. Experiments are performed Using Matlab 13b on intel core i3 processor with 4 GB RAM. Images chosen for experimental work are shown in Fig.6

Figure 4. The test bed of three color images belonging to different categories and namely Aishwarya,strawberry,Doll.

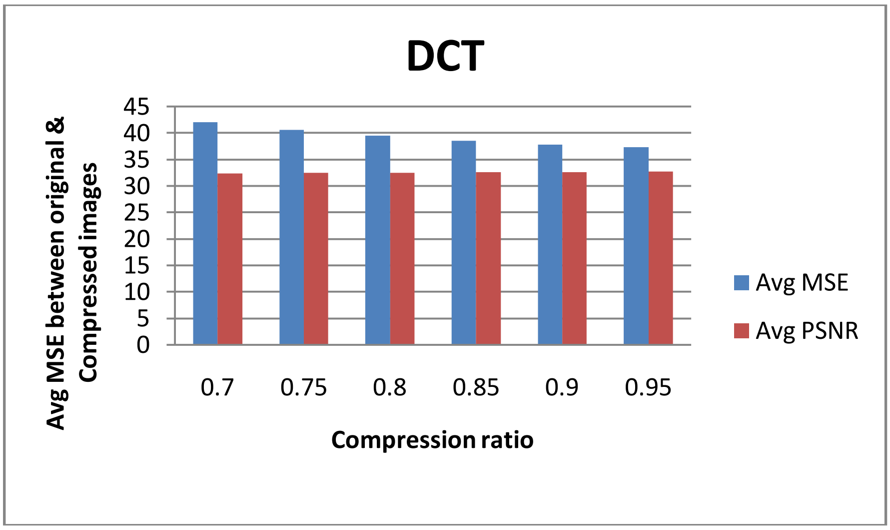


Figure 5: Performance comparsion of image compression using Discrete Cosine Transform(DCT) at different Compression ratios

Fig 5 shows the average of mean squared error(MSE) differences of the original and respective compressed image pairs plotted against data compression from 0.7 to 0.95 for image compression done using

Discrete Cosine Transform(DCT).Here the performance of DCT at compression ratio 0.95 is the best as indicated by minimum MSE values over the other compression ratios.

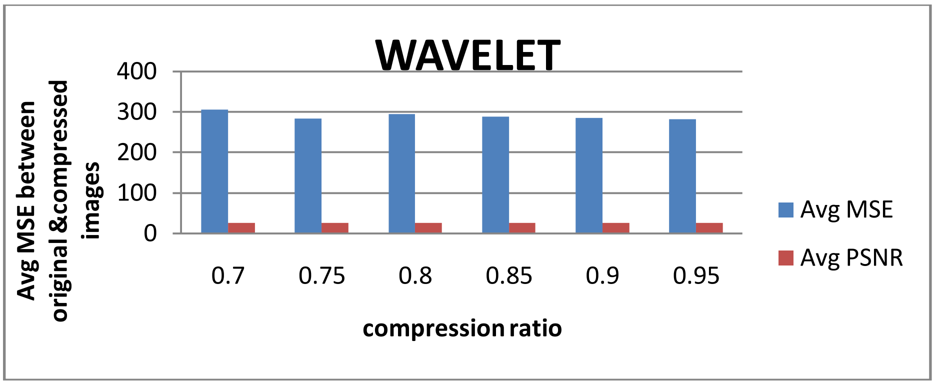


Figure 6: Performance comparsion of image compression using Wavelet at different compression ratios

Fig 6 shows the average of mean squared error(MSE) differences of the original and respective compressed image pairs plotted against data compression from 0.7 to 0.95 for image compression done using Walete trasform.Here the performance of wavelet at compression ratio 0.95 is the best as indicated by minimum MSE values over the other compression ratios.

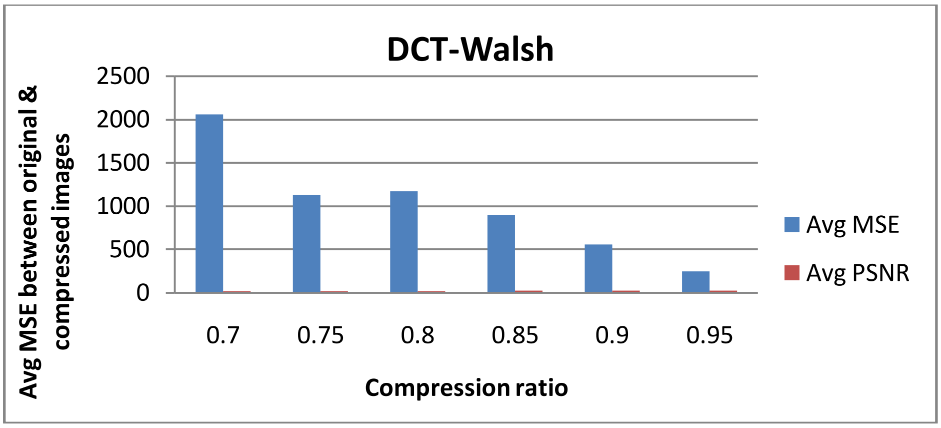


Figure 7: Performance comparsion of image compression using Discrete Cosine Transform(DCT)- Discrete Walsh transform at different compression ratios

Fig 7 shows the average of mean squared error(MSE) differences of the original and respective compressed image pairs plotted against data compression from 0.7 to 0.95 for image compression done using hybrid Discrete Cosine Transform(DCT)- Discrete Walsh transform.Here the performance of wavelet at compression ratio 0.95 is the best as indicated by minimum MSE values over the other compression ratios.

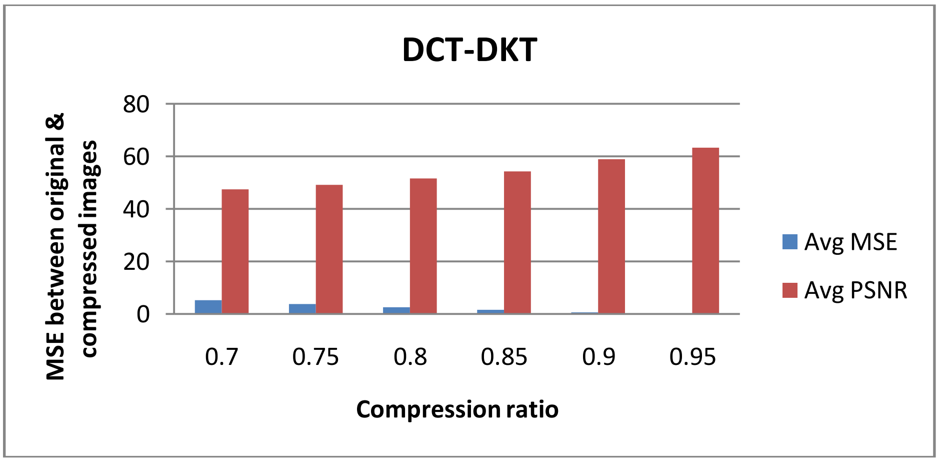

Figure 8: Performance comparsion of image compression using Discrete Cosine Transform(DCT)-Discrete Kekre transform at different compression ratios

Fig 8 shows the average of mean squared error(MSE) differences of the original and respective compressed image pairs plotted against data compression from 0.7 to 0.95 for image compression done using Discrete Cosine Transform(DCT)- Discrete kekre transform.Here the performance of wavelet at compression ratio 0.95 is the best as indicated by minimum MSE values over the other compression ratios.

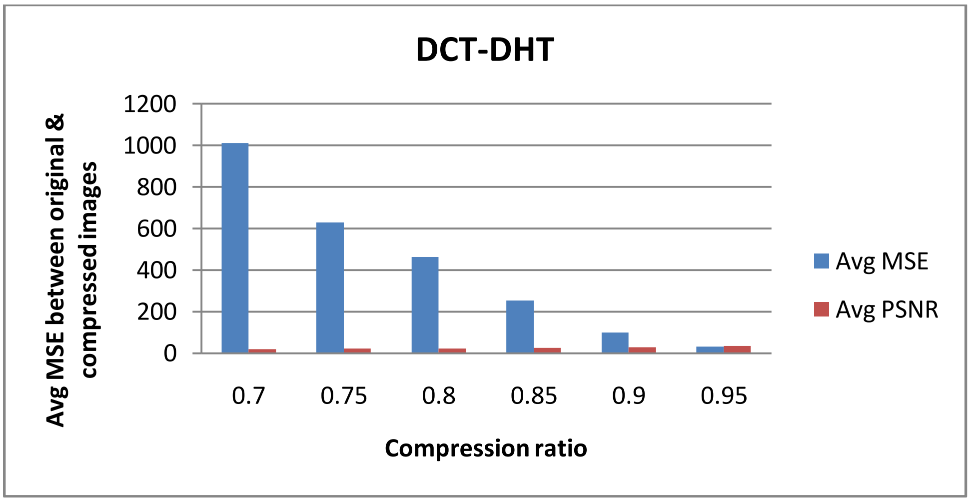


Figure 9: Performance comparsion of image compression using Discrete Cosine Transform(DCT)-Discrete Hartley transform at different compression ratios

Fig 9 shows the average of mean squared error(MSE) differences of the original and respective compressed image pairs plotted against data compression from 0.7 to 0.95 for image compression done using hybrid DCT-DHT trasform.Here the performance of Discrete Cosine Transform(DCT)- Discrete Hartley transform(DHT) at compression ratio 0.95 is the best as indicated by minimum MSE values over the other compression ratios.

TABLE I: Performmanse comparsion of hybrid wavelet transform of DCT-DKT

| DCT-DKT | Image1 | Image2 | Image3 | | Image1 | Image2 | Image3 | |
|---|---|---|---|---|---|---|---|---|
| Ratio | MSE1 | MSE2 | MSE3 | **Avg MSE** | PSNR1 | PSNR2 | PSNR3 | **Avg PSNR** |
| 0.7 | 0.15409 | 0.61909 | 15.5167 | 5.42996 | 56.2564 | 50.2162 | 36.2342 | 47.56893 |
| 0.75 | 0.1017 | 0.41037 | 10.9582 | 3.823423 | 58.059 | 52.0018 | 37.743 | 49.26793 |
| 0.8 | 0.051406 | 0.21509 | 7.6985 | 2.654999 | 61.0213 | 54.8077 | 39.2697 | 51.69957 |
| 0.85 | 0.027704 | 0.096907 | 4.7953 | 1.63997 | 63.7059 | 58.2719 | 41.3258 | 54.43453 |
| 0.9 | 0.009 | 0.025401 | 2.3136 | 0.782667 | 68.2316 | 64.0872 | 44.4903 | 58.93637 |
| 0.95 | 0.003871 | 0.007889 | 0.86247 | 0.29141 | 72.2528 | 69.1623 | 48.7755 | 63.39687 |

Original | 0.85 compression | 0. 90 compression | 0.95 compression

MSE:887.68 PSNR:18.69 | MSE:581.63 PSNR:20.59 | MSE:227.47 PSNR:24.62

Figure 10.The compression of strawberry image using Hybrid wavelet transform(DCT-Walsh) genetrated using discrete cosine transform and discrete Walsh transform with respect to 0.85 to 0.95 of data compression

| Original | 0. 85compression | 0. 90 compression | 0.95 compression |
|---|---|---|---|
| | MSE: 0.097 | MSE: 0.025 | MSE: 007 |
| | PSNR: 25.58 | PSNR: 64.09 | PSNR: 69.2 |

Figure 11. The compression of strawberry image using Hybrid wavelet transform(DCT-DKT) genetrated using discrete cosine transform and discrete Kekre transform with respect to 0.85 to 0.95 of data compression.

## VI. Conclusion

In this paper, experimental work is done to generate hybrid wavelet transform using two orthogonal component transforms. Discrete Cosine Transform (DCT) is used as one component transforms which contributes to global properties of an image. Second component transform that contributes to local properties of image is varied. For 256x256 size image, hybrid wavelet transform of size 256x256 is generated. Here the hybrid wavelet transforms are generated using Discrete Walsh Transform (DWT), Discrete Kekre Transform (DKT), Discrete Hartley Transform (DHT) and Discrete Cosine Transform (DCT) for image compression. The various orthogonal transforms can be considered for crossbreeding to generate the hybrid wavelet transform based on the expected behavior of the hybrid wavelet transform for particular application. The experimental results have shown that hybrid of DCT with DKT gives best results of image quality among other hybrid wavelet transform. DCT-DKT gives a minimum error of 0.2(MSE) and image quality upto 63.4(PSNR).


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