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Image Compression using DCT and DWT-Technique

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Abstract

This paper provides comparison between two image compression technique such as DCT and DWT. Discrete Cosine Transform (DCT) and Discrete Wavelet Transform (DWT) are the most commonly used transformation. DCT has high energy compaction property and requires less computational resources. On the other hand, DWT is multi-resolution transformation. PSNR and Compression ratio are one of the parameter of image compression. DWT performs much better compression as well as visual perception at higher compression ratio. This scheme reduces “false contouring” and “blocking artifacts” significantly. The simulation results and different PSNR value shows that the DWT algorithm has better quality and efficiency but it takes longer time than DCT.

Keywords: Image Compression, DCT, DWT, PSNR, Coefficient, wavelets, multi-resolution, filter band coefficients, quality, Decompression, Simulink, Color Conversion, pixels, JPEG, JPEG2000, transmission.

Introduction

Image in their original form requires a large amount of storage capacity. Images played a vital role for providing information and it acts as a source of information therefore it become necessary to develop a technique that produces high degree of compression while preserving critical image information. Image is digitally represented in a set of pixel. The neighboring pixels are correlated to each other and are redundant in nature. This redundant nature produces redundancy which occupies non-required storage space. This increases transmission bandwidth as well as cost. Thus it becomes necessary to reduce the irrelevant information which is known as redundancy. It can be achieved by image compression techniques. The basic concept behind the compression technique is to use orthonormal transformation which makes the pixel value smaller than the original. There are various methods of transformations.DCT and DWT are mostly used transformation techniques being used for Image-compression

Image Compression Techniques

DCT and DWT are the image compression techniques which are based on transformation concept. The transformation of the data also makes the coefficients of the transformed matrix uncorrelated to each other.

DCT is generally used for image and video compression. This technique expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies. The JPEG is an image compression process which is based on DCT. Basically DCT separates an original image into parts of differing frequencies. Quantization is to be done after the DCT process in which less important frequencies are discarded. Hence this technique is termed as lossy. As a result, reconstructed images contain some distortion; but these distortions can be adjusted during the compression stage. The complete block diagram of image compression using DCT technique is shown in Fig. 2.1

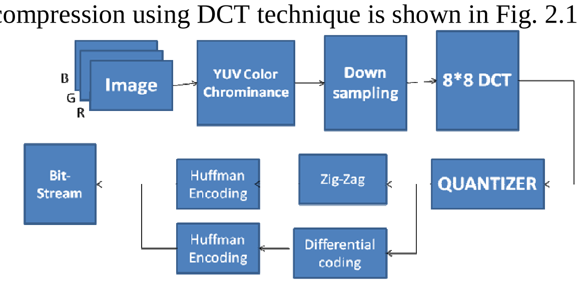

Fig 2.1 Image Compression using DCT

DCT produces better compression at low compression ratio and it takes less time to achieve compression. But it introduces blocking artifacts and the contour effects in reconstructed image. Besides that, it is not the multi-resolution transformation technique. On the other hand, **DWT** is multi-resolution transform technique, generally used for image compression to achieve higher compression ratio. This technique is based on sub-band coding and it provides a time-frequency representation of the signal. The JPEG 2000 is based on the concept of DWT-technique. Wavelet Transform produces wavelet function which is known as wavelets. The Wavelet Transform uses wavelets of finite energy and multi-resolution technique by which different frequencies are analyzed with different resolutions. The DWT represents an image as a sum of wavelets with different location and scale. The DWT is computed by successive low pass and high pass filtering of the discrete time-domain signal. It is easy to implement and reduces the computation time and resources required. In the given figure,"f" is represented as an input image. This input image is compressed using DWT technique. The block diagram of image compression using DWT technique is shown as in Fig. 2.2

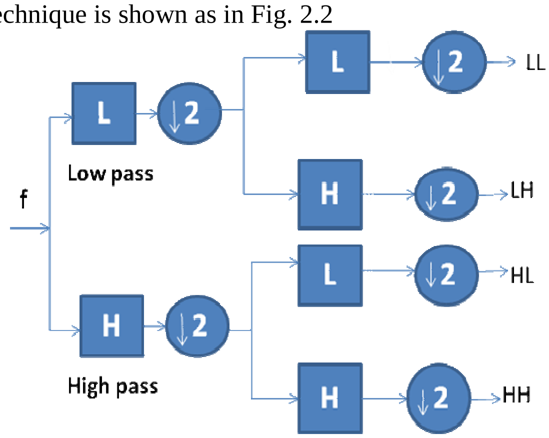

Fig.2.2 Image compression using DWT-technique

Image is 2-dimensional signal. So, it is compressed from row-wise as well as column-wise separately.. Therefore, the input image "f" is passed to the filter bands which get decomposed into an approximation and the detail coefficients. The down sampling by 2 is to be done to reduce sampling rate in an individual channel. After getting the transformed matrix, the detail and approximate coefficients are separated as LL, HL, LH, and HH coefficients. There is a lot of amount of information in the low frequency band-coefficients. So, all the coefficients are discarded, except the LL coefficients. The LL coefficients are again transformed into its second level decomposition. The process continues for one more level. This shows the multi-resolution transformation done by DWT – technique. The decomposition levels is shown as in Fig.2.3

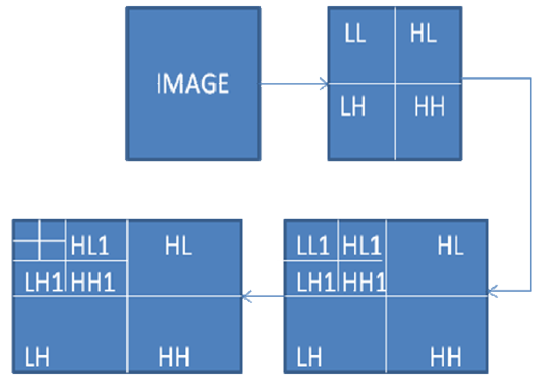

Fig.2.3 Image decomposition levels of DWT

It is proved from the above figure that DWT is better for image compression at high compression ratio. There are a number of basic functions that can be used as the mother wavelet for Wavelet Transformation. Mother wavelet produces all wavelet functions which are used in the transformation through translation and scaling. Some of the commonly used wavelets are Haar, Daubechies, symlets, etc. Haar wavelet is one of the oldest and simplest wavelet.

Image Compression in Simulink

Simulink is an environment in which complete model can be drawn using various blocks. Blocks can be placed using Drag & Drop facility and a model can be drawn .With the help of Simulink,we can draw the block diagram of Image Compression using DCT as well as DWT.The given flowchart shows the basic idea of the project. The step by step description of image compression and decompression is given below:

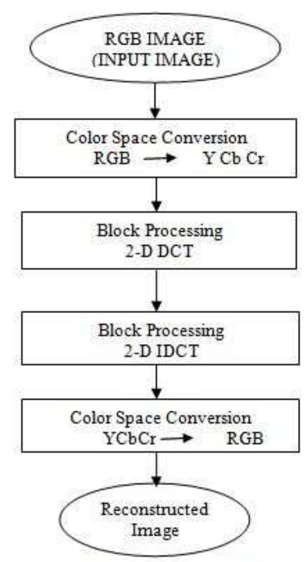

Fig.3.1 Flowchart for DCT-technique

Using different blocks from the simulink environment, Image compression using DWT can be drawn easily. The DWT acts as filter band which produces filter band coefficients. Then the image is compressed row wise as well as column wise separately through matrix-transpose. The decimation by 2 is to be done in order to take alternate samples and drop alternate samples. It becomes necessary as the number of samples is increasing through the filter band coefficients. The step by step description of the image compression using DWT is given by the flowchart. The flowchart is shown as in Fig.3.2

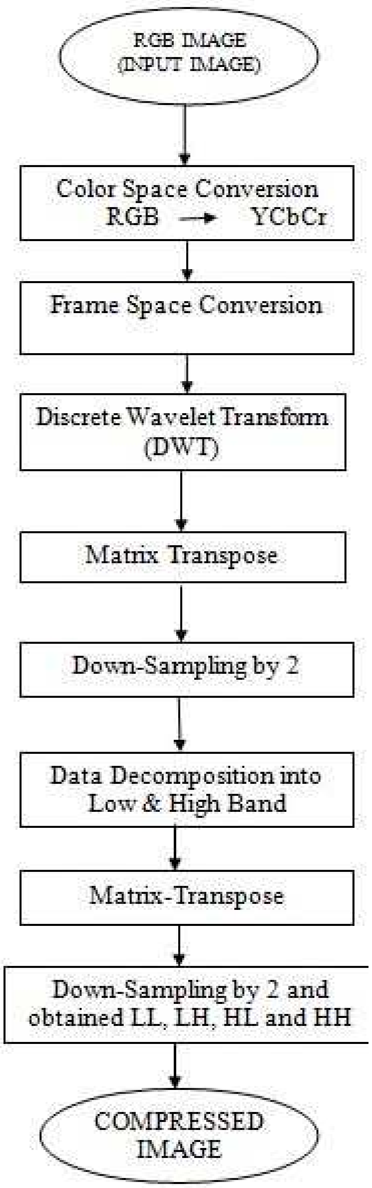

Fig.3.2 Flowchart for an Image Compression using DWT – technique

Image can be compressed by DWT – technique and it can be decompressed by using IDWT-technique. The original image can be reconstructed at the receiver side by using the reverse process such as IDWT-technique, Up-sampling by 2, and Color space conversion from YCbCr to RGB. Thus, an image is obtained at the receiver side same as at sender-side.

Results

Compression of colored image can be done by DWT-technique. The colored image is called in the SIMULINK environment through the block named as “Image from file”. Here the original colored image is shown as in Fig 4.1

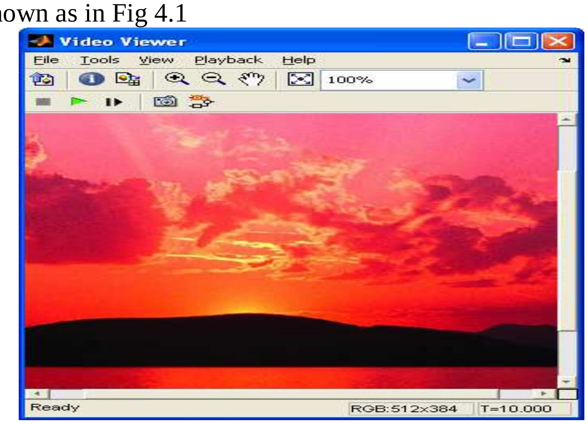

Fig.4.1 Original Image

DWT-technique and DCT technique works on 2-D signal and color image is 3-D signal. So, it becomes necessary to convert 3-dimensional signal into 2-dimensional signal. The 2-D image signal can be obtained through the “Color Space Conversion” block. The color space converted image is shown in Fig4.2

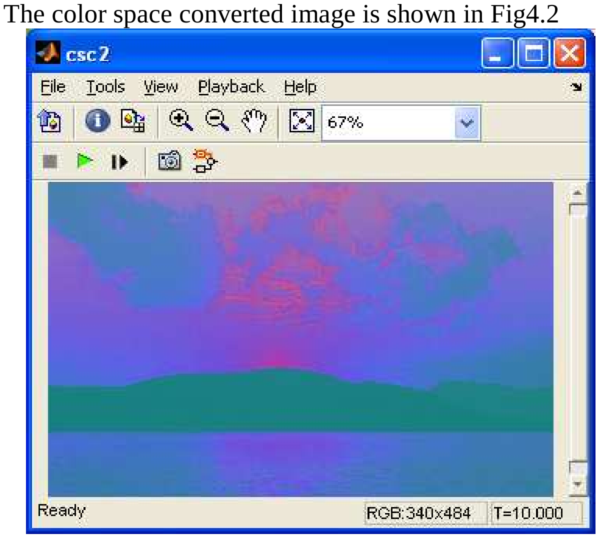

Fig.4.2 Color Space Converted Image

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DCT decomposes an input image into blocks.Thus,it introduces blocking artifacts.It is an image compression technique which is used for compressing an image at low compression ratio.The DCT compressed –image is shown in Fig.4.3.

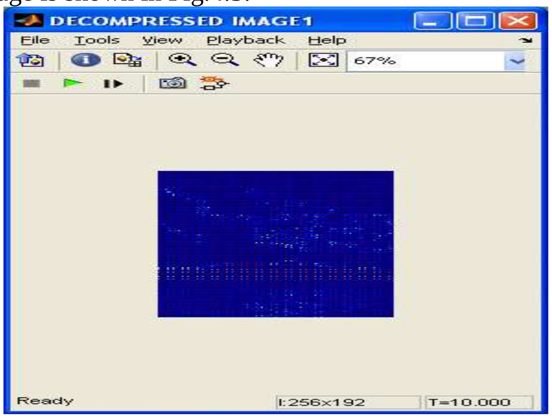

Fig.4.3 DCT compressed Image

In case of the DWT image compression technique,image does not decomposed into blocks.So, it does not produces any blocking artifacts and false contouring effects.After the color space conversion process,the sampling mode of the image-signal is decided through the "frame space conversion" block. Then, the DWT technique is applied which produces filter band coefficients. DWT is based on multi-resolution transformation.The first level of decomposition produces four filter-band coefficients such as LL,LH,HLand HH.These four coefficients splits image into four parts.Filter band-cofficient images are shown below. The HH coefficient image is shown in Fig.4.4

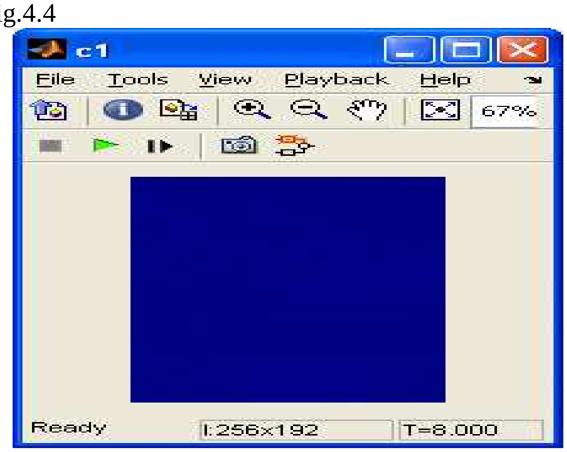

Fig.4.4 DWT-HH compressed Image

The HH-band coefficient contains very less amount of information.Hence, it is discarded.The next-coefficient is known as LH-coefficient.It is the combination of column-wise transformation coefficient and row- wise coefficient.The LH coefficient image is shown as in Fig.4.5

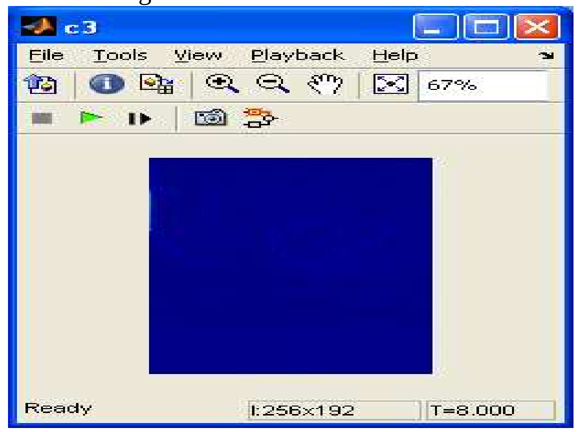

Fig.4.5 DWT-LH compressed Image

The another coefficient is known as HL-coefficient.It is the combination of row-wise transformation coefficient and column- wise coefficient.The HL coefficient image is shown as in Fig.4.6

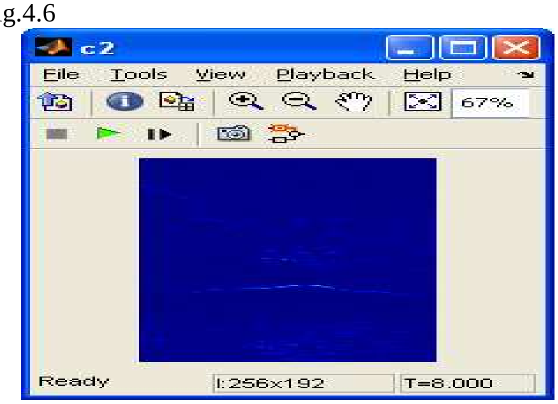

Fig.4.6 DWT-HL compressed Image

The last coefficient is known as LL-coefficient which contains a large amount of information or content of the signal. Hence, it produces high degree of compression while maintaining the content of the image. It is the combination of column-wise transformation coefficient and column- wise transformation coefficient.The LL coefficient image is shown as in Fig.4.7

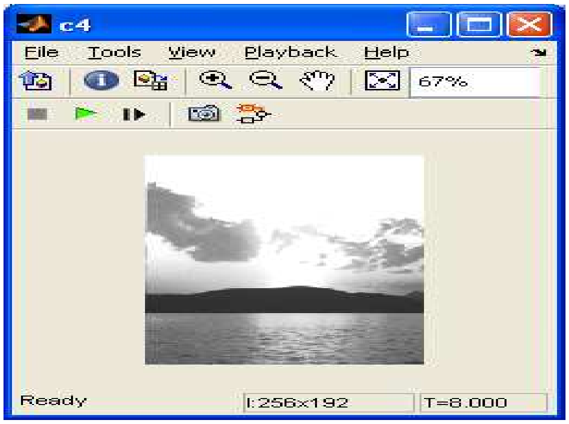

Fig.4.7 DWT-LL compressed Image

From the visual content, it is observed that DWT technique provides better compression than the DCT-technique. DWT-LL compressed image does not shows any blocking artifacts. DWT maintains the content of the image. In order to obtain an original image at the receiver, decompression technique is needed. Here, IDCT is a corresponding decompression technique for the DCT and IDWT is a corresponding decompression technique for the DWT. Reconstructed DCT-image is shown in Fig.4.8

Fig 4.8 Decompressed DCT image

Reconstruction of an image helps in computing PSNR. It is one of the parameter of the image which defines the quality of the image. Here, the reconstructed DWT-image is shown as in Fig. 4.9

Fig 4.9 Decompressed DWT image

Performance Analysis

Performance of an image can be measured with the help of PSNR. It refers to the peak signal to noise ratio .It defines the quality of the reconstructed image. PSNR is one of the parameter of Image Compression. PSNR can be measured after the reconstruction of an input image. It measures the value in decibels .The high PSNR value shows that better quality of the reconstructed image. The flowchart is shown as in Fig 5.1

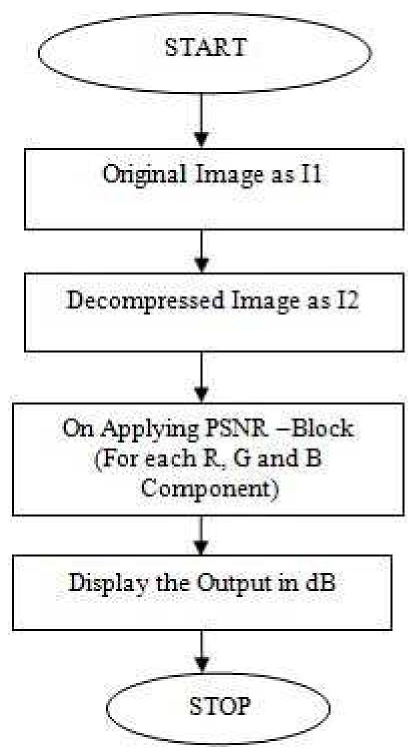

Fig 5.1 Flowchart of PSNR - measurement

Original image can be reconstructed with the help of corresponding decompression technique such as IDCT and IDWT. The PSNR value of the DCT and DWT technique is shown through the table 5.1.

Table 5.1 PSNR value of DCT and DWT – technique

Image Compression Technique	PSNR (R)	PSNR (G)	PSNR (B)
DCT Technique	37.89	37.76	37.75
DWT Technique	28.99	28.95	28.75

From the above observation, it shows that PSNR value of DCT –technique for each R, G and B component is greater than PSNR value of DWT-technique. The bar graph represents the comparison of PSNR value with true color of an image such as R, G and B. The bar graph representation of the above table is shown in Fig. 5.2

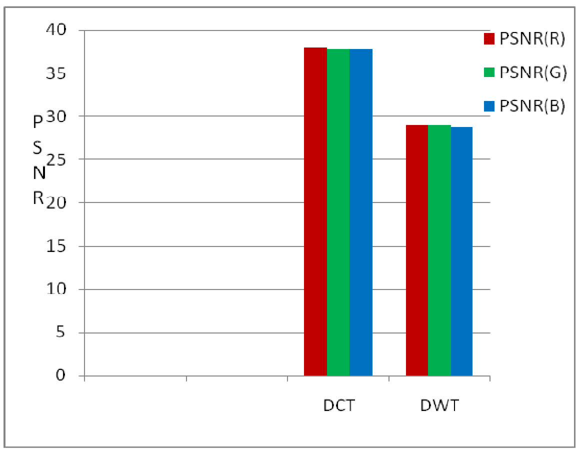

Fig. 5.2 PSNR (in dB) versus Image compression techniques (DCT and DWT)

PSNR value is not only the parameter to judge the performance of the applied process. The compressed-output of the given image shows that DWT does not produce any blocking artifacts and false contouring effects as DCT produces.DWT performs better compression and visual quality at high compression level and high compression degrades the quality of the reconstructed image Here, PSNR value is measured of the given image by considering the different type of DWT. The table is shown as in table 5.2

Table 5.2 PSNR value of different type of DWT

Wavelet	Image Dimensions	PSNR (R)	PSNR (G)	PSNR (B)
Haar	512*384	28.99	28.95	28.75
Daubechis -1	512*384	28.99	28.95	28.75
Daubechis -2	512*384	24.20	24.29	23.99
Symlet-2	512*384	24.20	24.29	23.99
Coiflet-1	512*384	21.52	22.45	21.73
Biorthogonal 1/3	512*384	21.24	22.44	21.51
Biorthogonal 2/2	512*384	21.62	22.46	21.73

The Haar, Daubechies, Symlets and Coiflets are compactly supported orthogonal wavelets. Haar wavelet is most popular used and simplest wavelet. The wavelets are selected based on their shape and their ability to analyze the signal in a particular application.

Conclusion

DWT is an image compression technique. It uses multi-resolution analysis through which we get compression at higher levels without any false contouring and blocking artifacts.An image having larger dimension can be easily compressed with DWT-Algorithm.But as the image compresses at higher levels,it is not easy to obtain the high quality of the reconstructed image.On the other hand,DCT is an efficient technique at low compression ratio.DCT shows better PSNR-value than the DWT-technique.So, it is concluded that DWT provides better compression-quality and efficiency to the image and DCT-technique provides better performance and it is time saving process.With the combination of both DCT-DWT techniques,an image having larger dimension can be compressed by DWT using multi-resolution analysis and once the image gets small dimension,it is compressed easily by DCT-technique.Thus,we can obtain better PSNR-value than individuals.

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