IMPROVED IMAGE COMPRESSION SCHEME USING HYBRID OF DISCRETE FOURIER, WAVELETS AND COSINE TRANSFORMATION

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To my mother, brothers, sisters, beloved wife, children and my friends

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ABSTRACT

The objective of image compression is to reduce the number of bits required to represent an image. The art of developing and designing an image compression scheme is balancing among the compression ratio, distortion and the processing time. Existing compression techniques involve low and high compression ratio of significant loss of image quality. New image compressing technique is required for storage. In this thesis, a new technique is proposed to compress the image and to gain higher compression ratio with smaller distortion. The main features of the proposed hybrid image compression are high compression ratio and high resolution of decompressed images. The new technique is combining three different algorithms: Discrete Fourier Transform (DFT), Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT). The proposed technique uses features of these algorithms and it consists of three steps. In the first step, DFT was applied to compress image, in the second step, DWT was applied and in the third step DCT was applied to compress image. The experimental results show that the proposed hybrid image compression achieved high compression ratio while preserving the quality of the reconstructed image. The experimental results also show that the Peak Signal-to-Noise Ratio (PSNR) value of the proposed technique was 83.6914 and the Mean Square Error (MSE) value was 2.7793 for Lena image. For all standard images, the results show that the proposed hybrid image compression performed better than the existing methods in terms of PSNR and in terms of MSE values. Finally, the proposed hybrid image compression further improves the image transmission and storage capacity of the image.

ABSTRAK

Objektif pemampatan imej adalah untuk mengurangkan bilangan bit yang diperlukan untuk mewakili imej. Seni membangun dan mereka bentuk skim pemampatan imej ialah mengimbangi antara nisbah mampatan, penyelewengan dan masa pemprosesan. Teknik pemampatan sedia ada ini melibatkan nisbah mampatan rendah dan tinggi bagi kehilangan yang signifikan terhadap kualiti imej. Teknik memampatkan imej baru diperlukan untuk penyimpanan. Dalam tesis ini, Teknik baru adalah dicadangkan untuk memampatkan imej dan untuk mendapatkan nisbah mampatan yang lebih tinggi dengan penyelewengan yang lebih rendah. Ciri-ciri utama pemampatan imej hibrid yang dicadangkan adalah nisbah mampatan yang tinggi dan resolusi tinggi imej didekompresi. Teknik baru ini menggabungkan tiga teknik yang berbeza: *Discrete Fourier Transform* (DFT), *Discrete Wavelet Transform* (DWT) dan *Discrete Cosine Transform* (DCT). Teknik yang dicadangkan ini akan menggunakan ciri-ciri algoritma dan terdiri daripada tiga langkah. Dalam langkah pertama, DFT telah digunakan untuk memampatkan imej, dalam langkah kedua, DWT pula telah digunakan dan dalam langkah ketiga, DCT telah digunakan untuk memampatkan imej. Keputusan eksperimen menunjukkan bahawa pemampatan imej hibrid yang dicadangkan mencapai nisbah mampatan yang tinggi sementara mengekalkan kualiti imej yang dibina semula. Keputusan eksperimen juga menunjukkan bahawa nilai PSNR bagi Teknik dicadangkan adalah 83.6914 dan nilai MSE adalah 2.7793 untuk imej Lena. Bagi semua imej piawai, keputusan menunjukkan bahawa pemampatan imej hibrid yang dicadangkan mempunyai prestasi yang lebih baik daripada kaedah sedia ada daripada segi nisbah puncak signal kepada kebisingan dan daripada segi nilai-nilai Ralat Min persegi. Akhir sekali, pemampatan imej hibrid yang dicadangkan selanjutnya meningkatkan keupayaan penghantaran dan penyimpanan imej.

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LIST OF ABBREVIATIONS

2DDCT	–	Two Dimension Discrete Cosine Transforms
3D DHT	–	Three Dimension Discrete Hartley Transform
BMP	–	Bitmap
BPP	–	Bits per Pixel
BTC	–	Block truncated Coding
CR	–	Compression Ratio
DCT	–	Discrete Cosine Transform
DFT	–	Discrete Fourier transforms
DPCM	–	Discrete Pulse Code Modulation
DSP	–	Digital Signal Processor
DWT	–	Discrete Wavelet Transform
FDCT	–	Forward Discrete Cosine Transform
FFT	–	Fast Fourier Transform
FRT	–	Finite Ridgelet Transform
GPCA	–	Generalized Principal Component Analysis
HH	–	High High-Band
HL	–	High Low-Band
HPF	–	High Pass Filter
IDCT	–	Inverse Discrete Cosine Transform

IFS	–	Iterated Function System
JPEG	–	Joint Photography Experts Group
JPG	–	Joint Photography Experts Group
LH	–	Low High-Band
LL	–	Low Low-Band
LPF	–	Low Pass Filter
MFHWT	–	Modified Fast Haar Wavelet Transform
MFOCPN	–	Modified Forward Only Counter Propagation Neural Network
MSE	–	Mean Square Error
PNG	–	Portable Network Graphics
PSNR	–	Peak to Signal Noise Ratio
RGB	–	(Red, Green, Blue) Color Model
SDS	–	Spatial Data Structure
SOFM	–	Self-Organizing Feature Maps
SPIHT	–	Set Partitioning in Hierarchical Tree
SVD	–	Singular Value Decomposition
TCVQ	–	Transformed Classified Vector Quantization
VQ	–	Vector Quantization

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CHAPTER 1

INTRODUCTION

1.1 Introduction

At present, millions of images are widely circulated through the internet. The velocity of transmission and storage capacity are the two main factors that arise during the intensive use over the internet. Due to the limited channel band width and the need for faster transmission, image compression is an unescapable resort for this purpose. In addition, color resolution and special resolutions are increasing in accordance with quality requirements. Great amount of data is also naturally used both for pictorial and graphical presentation. Moreover, the needs for storage and communications are high and, in order to solve these problems we need the technique of compressing data which is essential for storage (Veerpal and Gurwinder, 2012).

Image compressionis minimizingthe filesize; the reductionin filesize allows the images to be stored in a given amount of disk or memory space and reduces the time required for imagesto be sentvia the Internet. The bestimage qualityat a givenbit-rate (orcompression rate) is themain goalof image compression (Sunil and Shipra, 2009).

There are two types of image compression. The first one is lossless compression that is specifically used in image archiving, this techniqueallows the

image to be compressed and decompressed without losing any data. The second type is lossy compression which provides higher level of compression but results in a less perfect resolution of the original image (Vijaya and Gurumurthy, 2010).

Lossy compression is used in applications such as video conferencing, television transmission and facsimile, etc. In these kinds of transmission, some amount of error can be tolerated. The main purpose of image compression is to lessen the number of bits required to render an image. The reconstructed image in lossless compression is the same as the original one.Lossy compression compared with lossless ones is capable of attaining high compression ratio. Lossy compression algorithms acquire high compression ratio by taking advantage of human visual characteristics though the reconstructed image in lossy compression is notmatched to the original one and may lose vital information of the image (Sachin, 2011).

Due to the different compression ratio between lossless compression and lossy compression a problem emerges in lossy compression which is the possibility of losing vital information of the image. For this reason, the usage of hybrid image compression efficiently incorporates different compression systems such as DCTVQ and PVQ in a one image compression, the intendedmethod uses lossy compression method with many different quality levels based on the context to compress a single image by avoiding the complexities of using side information for image decompression (Ali and Abir, 2008).

1.2 Background of the Problem

Image compression is one of the important areas in image processing. With fast development of computer and communications and internet technology, information and data are being transmitted via the internet; the data, information and images to be transmitted consume great bandwidth and large storage space.

Many researches interpret various methods of image compression; these methods are rendered in the previous literature including by Veerpal and Gurwinder (2012) who stated that the compression of an image is the process of reducing the magnitude in bytes in the file of graphics deprived of corrupting the value of the image to an insupportable equal. The decrease in size of the file permits extra images to be stuffed in a specified volume of space in the disk or memory. Sunil and Shipra (2009) imparted that image compressionisminimizingthe filesize where the reductionin filesize allows the images to be stored in a given amount of disk or memory space, and reduces the timerequired for images to be sentvia the Internet. Singh and Sharma (2012) reported that video and digital image following each other in arrangement need large amount of storing capability. Compression of an image means dropping the magnitude of graphics file, deprived of bargaining on its quality, contingent on the reassembled image. Therefore, any proposedsolution must consider improvementof image compression.

Due to the need for storage capacity and communications and high speed of transmission of image, technique of compressing data which is necessary for storage is highly needed, and many authors have proposed various methods of image compression. These methods include the method proposed byPrabhakar et al. (2009) named image compression using DCT and wavelet transformations. Chandan and Sukadev (2011) proposed hybrid compression approach using fractal image compression and DCT. Kuo et al. (2006) proposedhybrid gray image representation using spatial and DCT based approach with application to moment computation. Nageswara and Srinivasa (2008) proposed image compression by redundancy reduction. Anurag et al. (2013) proposed image compression using discrete cosine transform and discrete wavelet transform.

The main reason of image compression is to reduce the number of bit required to represent an image.The image compression algorithms are applied to reduce the storage capacity of the image and time of transmission, which have beendiscussed bymany researchers. Among them are Jacob *et al*. (2010) who had presented a hybrid image with diverse level of quality in which the forefront of the appearance of the image is assumed to be more significant than the background. The

segmentation method of an edge based is to segment the image into area of foreground and the area of background. The planned technique extremely conserves superiority of the image of foreground; the compression method of JPEG practices a linear quantization and values of threshold to preserve a definite eminence level in the whole image. Anna and Vidhya (2011) suggested an exclamation method for technique of compression. The technique is by limiting three-dimensional and frequency association from wavelets.Modified Forward Only Counter Propagation Neural Network(MFOCPN) is for organization and practical assignment. The techniques of wavelet crumbles the minor sub band containing inconsequential constants and disregard them. The momentous charming and piercing constants are originated by means of exclamation methods. At this point a fresh technique has been offered named the cosine interpolation that is a substitute towards the adjacent neighboring method of the interpolation. Brendt and Gerhard (1999) mentioned that compression of fractal image is a comparatively new method based on the demonstration of an image through a contractive transform, on the interplanetary of images, aimed at which the secure idea is near to the original image. This comprehensive attitude includes actual wide diversity of coding arrangements. Vijaya and Gurumurthy (2010) have suggested a method to improve the information compression system. A new quantization (DCTQ) and Discrete Cosine Transform structural design have been intended in their effort for accomplishment of image compression. Meng and Zong (2010) have launched the coding of DCT, VQ and a fresh planned technique that syndicates. Wavelet transform and DCT were employed in the carrying out of their anticipated color image compressionalgorithm and their new wished-for algorithm has been demonstrated to accomplish great compression ratio and well-organized by experimentation outcomes.

S. Immanuel and Anitha (2009) have obtained an alter domain based technique for the compression of the color image. The technique of Vector Quantization has been aimed at compression of pictures and Kohonen's Self Organizing Feature Maps which has been used in the project of the VQ codebook. Exceptional structures of SOFM for standard codebook generation allow production of the codebook individual as soon as it has been subjugated through their work. Kuo-Liang et al. (2006) proposed hybrid gray image representation using spatial- and

DCT based approach with application to moment computation which has obtained a spatial along with DCT based hybrid gray image demonstration method.

Few researches have discussed about the hybrid compression issues, which can be summarized as follows:

i. Most existing compression techniques involve low compression, although the need for storage capacity and communication is high.
ii. Some existing compression techniques involve high compression with significantloss of image quality.

1.3 Statement of the Problem

Image compression addresses the problem of reducing the amount of information required to represent a digital image. Every image will have redundant data. Redundancy means the duplication of data in the image. Either it may be repeating pixel across the image or pattern, which is repeated more frequently in the image. The image compression occurs by taking benefit of redundant information of in the image. Reduction of redundancy provides helps to achieve a saving of storage space of an image. At present, millions of images are widely disseminated traveling through the internet. The velocity of transmission and storage capacity are two main factors that arise during the intensive use over the internet. Due to the limited channel band width and the need for faster transmission, image compression is an unescapable resort for this purpose, the chief goal of image compression is torepresent an image in the fewest number of bits without losing the essential information content within an original image. Compression techniques are being rapidly developed for compress large data files such as images. With the increasing growth of technology a huge amount of image data must be handled to be stored in a proper way using efficient techniques usually succeed in compressing images.

There are some algorithms that perform this compression in different ways; some are lossless and lossy. Lossless keep the same information as the original image and in lossy some information loss when compressing the image.

Some important features of lossy image compression are high compression ratio and high resolution reconstructed images. lossy compression reduces a file by permanently eliminating certain information, especially redundant information. When the file is uncompressed, only a part of the original information is still there (although the user may not notice it). Lossy compression is generally used for video and sound, where a certain amount of information loss will not be detected by most users. Lossy compression provides higher level of compression but results in a less perfect resolution and may lose some information of the original image.

The summary for the problem statement of this research is as detailed below:

i. The problem:
    a. Storage capacity
    b. Speed of transmission

ii. The solution is image compression.

iii. The required solution should:
    a. Minimize the file size.
    b. Reduce the storage capacity.
    c. Increase the speed of transmission of the image.
    d. Preserve the quality of retrieved image as much as possible.

Many researchers interpret different problems of image compression; these problems are presented in the literature review including the research by Chandan and Sukadev (2011) which found that severaldomains usuallyuse digital image. Great quantityof information is essential to denote the images consequentlythe broadcast andstoring of such digital imagesare time wasting and infeasible. The facts in the

images are beaten through individual pull out of the noticeable fundamentals. Habitually the technique of image compression can decrease the storing and broadcast costs. El-Sharkawy et al. (1997) said that a great amount of internet data is used either pictorial or graphical in nature. The need for communication and storage is high. Image compressing is one of the ways to solve this problem. Jundi et al. (2008) suggested that image compressioncan improvethe performance ofthe system wheretime can be reduced inthe transfer andstorage of images withouta large reduction in image quality.

1.4 Questions of Research

To prove the research hypothesis, the following questions are addressed:

i. How to limit the repetition of theimage data for it to be capable of storing and transferring data in an effective form?

ii. How to further improve the effectiveness and efficiency of image compression technique to achieve greater compression of the image without significant loss of image quality?

iii. How to save the most space while preserving mostof thecontent of the image?

iv. How dowe select the better image compression techniqueor parameters?

1.5 Aim of the Research

The main aim of this research is to increase the amount of PSN and decrease the MSE value of image compression and to preserve the quality of retrieved image as much as possible.

1.6 Objectives of Research

The main objectives of this research are:

i. To develop and design a new hybrid (DFT-DWT-DCT) image compression technique capable of achieving high compression of the image.

ii. To develop and design a new image compression technique to reduce the cost of images storage and the time of image transmission without significant loss of image quality.

1.7 Research Scope

This research has the following limitation and scopes:

i. The database used in this research are as follows:
   a. USC-SIPI imagesdatabase, as widely used to support research in image processing.
   b. CCITT Fax standard images, CMU CIL's, CMU PIE database, CMU VASC Image Database, Caltech Image Database, used bymany researchersin the fieldof image compression.

ii. The types of images used in this research are as follows:

a. Joint Photographic Expert Group (JPEG): JPEG uses lossy JPG compression,JPEG file format, developed for storing photographic images. It has become the standard format for storing images on internet web pages and JPEG files provide a smaller file size by compressing the image.

b. Portable Network Graphics(PNG): PNG is lossless compression and larger files than JPG.PNG was designed to replace the older and simpler GIF format, also compresses better than Gif in almost every case.

c. Bitmap Image File (BMP): designed to store bitmap digital images independently of a display devise. This file type is lossless compression and larger file than JPG.

d. Tagged Image File Format (TIFF) file format isa standard in the printing and publishing industry, TIFF files are significantly larger than their JPEG

iii. The image size used in this research are as follows:

Big images need large space in thememory and will make the computersstruggle. Memory cost foran image was calculated from theimage size, images have various sizes such as 1024x1024 pixels, 512x512 pixels, 256x256 pixels,. All imagesare 24 bitsfor color images, 8 bits for grayscale image (RGB).

iv. Performance of the system was evaluated by PSNR and MSE values, the PSNR and MSE was calculatedto evaluate theperformance of the proposed system, a higher valueof PSNR isbetter because it means thatthe ratio ofSignal toNoise ishigher. And a lowervalue for MSEmeans lessererror.

1.8 Research Significance

This research is significant for the following motivations:

i. Dimensionality the proposed hybrid approach is to reduce the image size to allow the imageto be stored in a givenamount of memoryspace and reducethe time requiredfor imagesto be sentoverthe Internet.

ii. The proposedalgorithm can beused foractualtime applicationsforexample videoconferencing, telemedicine, where fast transmission is required.

iii. The proposedtechnique may present a good option of imageprocessor for wirelesscapsuleendoscopicsystem.

1.9 Organization of the Thesis

This thesis encompasses five chapters. Chapter 1 presents current challengesand historical background of image compression. In addition the objectives and scopes of thesis are in this chapter. Chapter 2 presents the methods of image compression. In this chapter the basic algorithm and mathematical background of image compression is introduced. Additionally, the related works about image compression are reviewed. Chapter 3 presents the methodology of the current study. Framework and overview of the research methodology, instrumentation and data set, and evaluation metrics of the research are introduced in this chapter. Chapter 4 presents the new approaches of image compression based on hybrid (DFT-DWT-DCT) algorithm that led to improve performance of image compression. Finally, chapter 5 concludes the achievements in this study and future works are recommended.

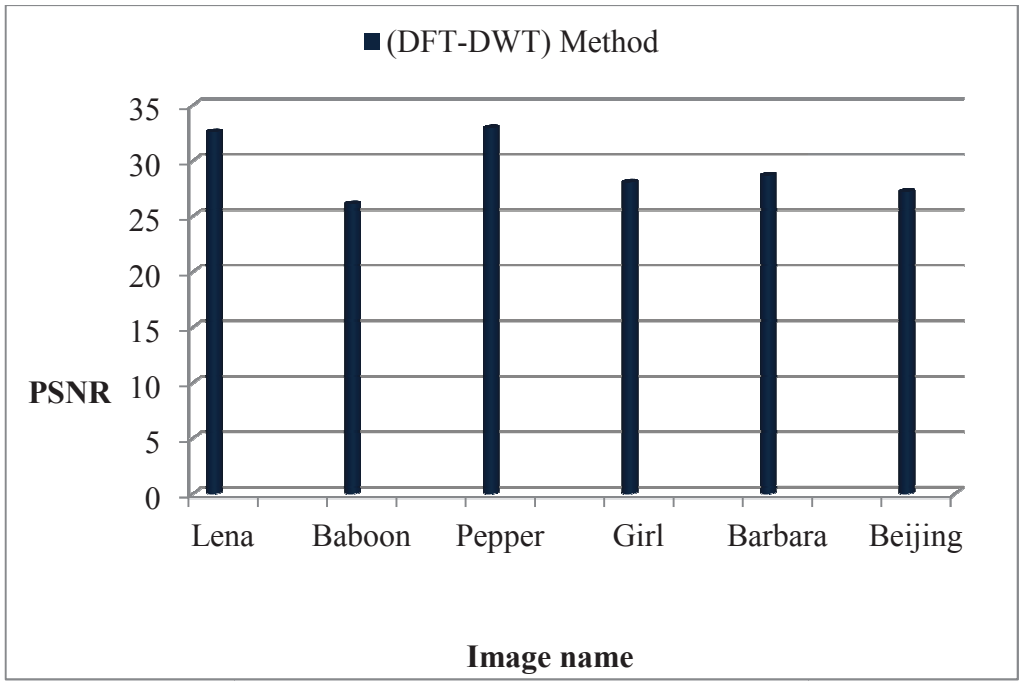

Figure 4.25 PSNR value for Lena, Baboon, Pepper, Girl, Barbara and Beijing images using (DFT-DWT) method.

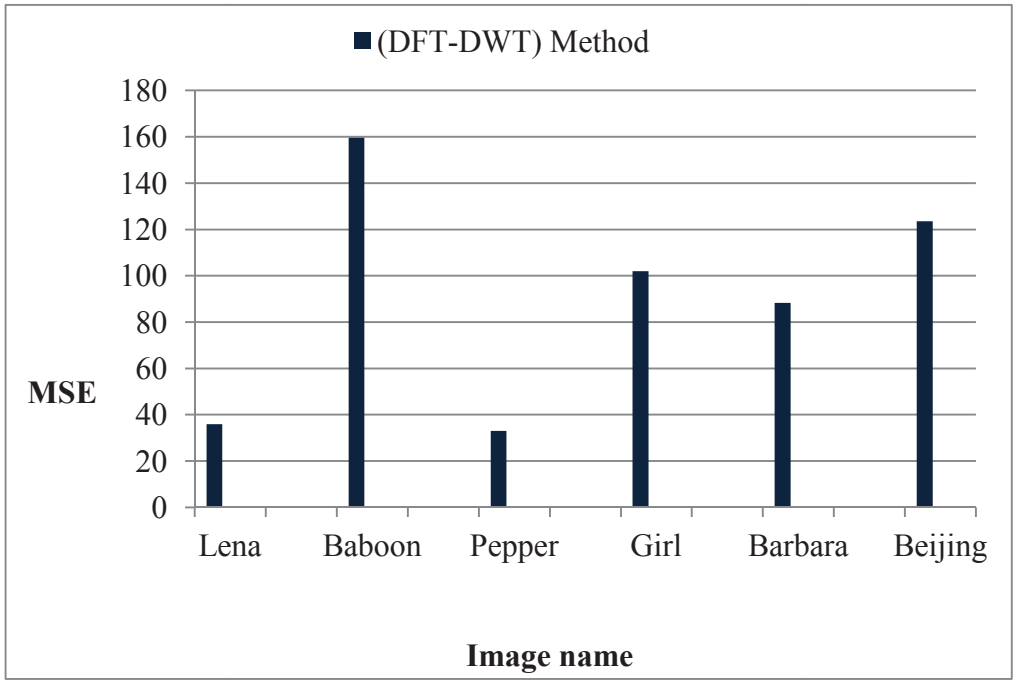

Figure 4.26 MSE value for Lena, Baboon, Pepper, Girl, Barbara and Beijing images using (DFT-DWT) method.

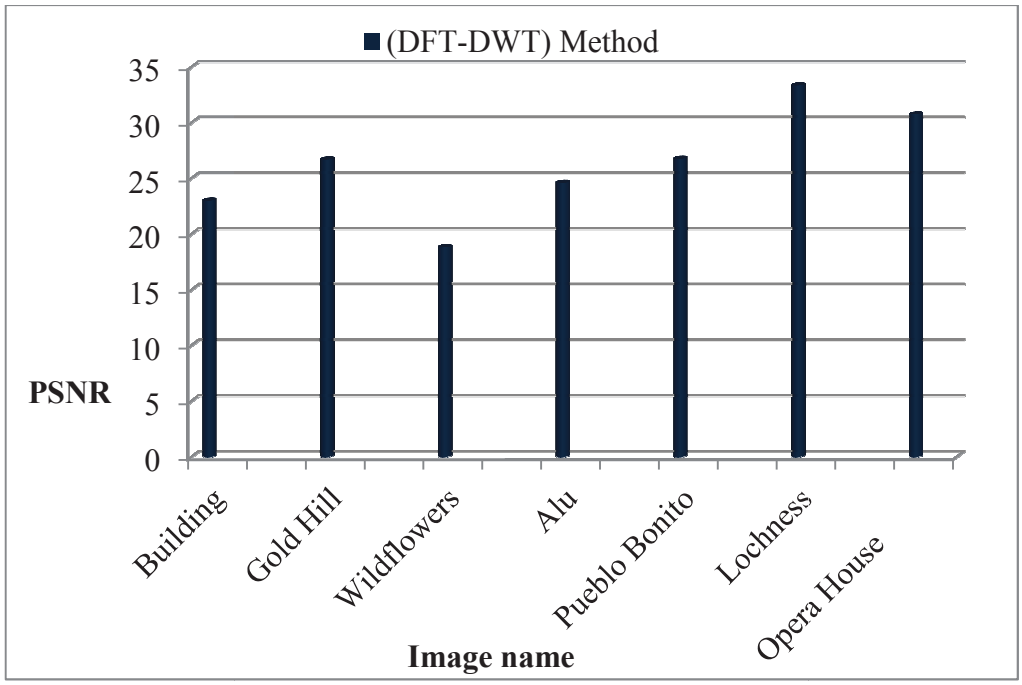

Figure 4.27 PSNR value for Building, Gold Hill, Wildflowers, Alu, Pueblo Bonito, Lochness and Opera House images using (DFT-DWT) method.

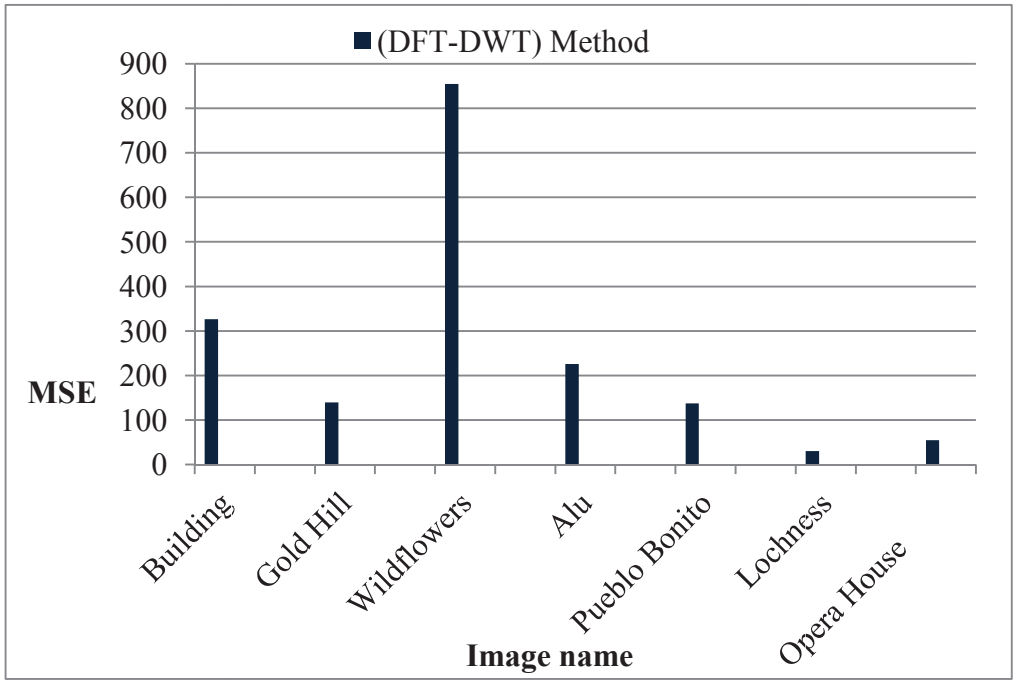

Figure 4.28 MSE value for Building, Gold Hill, Wildflowers, Alu, Pueblo Bonito, Lochness and Opera House images using (DFT-DWT) method.

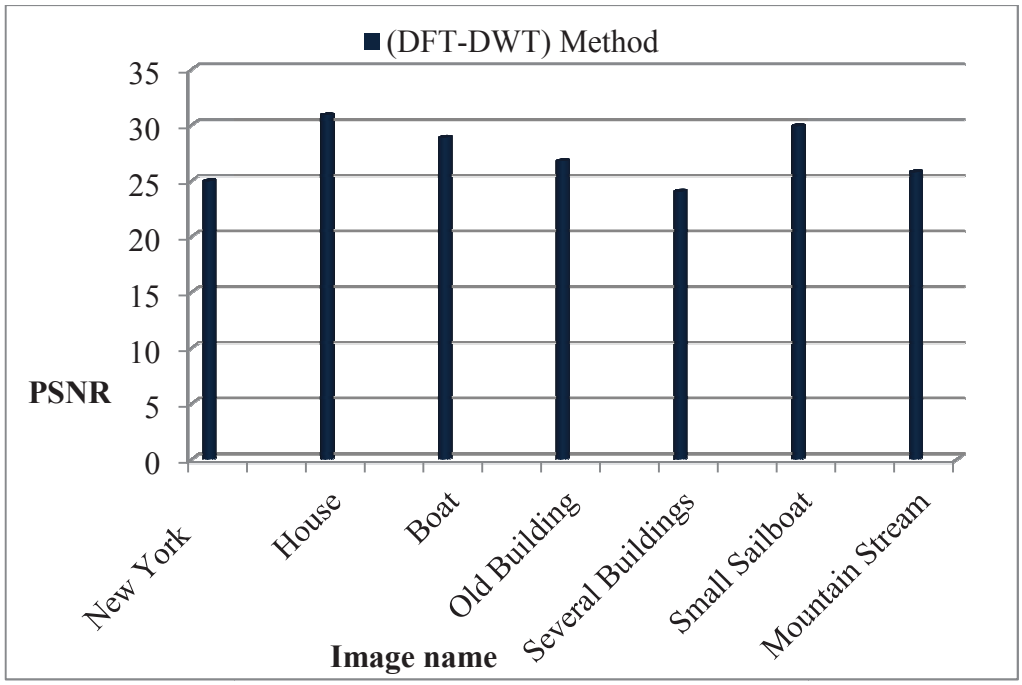

Figure 4.29 PSNR value for New York, House, Boat, Old Building, Several Building, Small Sailboat and Mountain Stream images using (DFT-DWT) method.

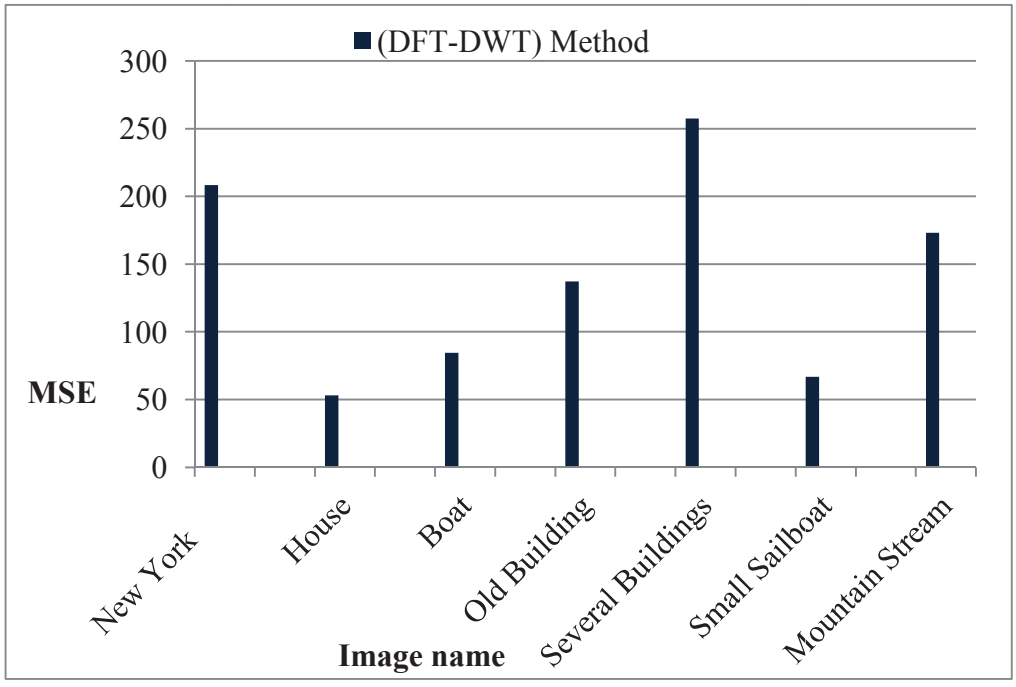

Figure 4.30 MSE value for New York, House, Boat, Old Building, Several Building, Small Sailboat and Mountain Streamimages using (DFT-DWT) method.

Table 4.8: Compression ratio of (DFT-DWT) algorithm.

Image Name	Original Image Size (kb)	Compressed Image Size (kb)	Compressed Ratio
Lena	462	15.2	30.39
Baboon	611	19.3	31.65
Pepper	768	16.4	46.82
Girl	446	12.4	35.96
Barbara	1180	24.9	47.38
Beijing	114	20.9	5.45
Building	128	22	5.81
Gold Hill	132	25.4	5.19
Wildflowers	613	28.6	21.43
Alu	853	22.7	37.57
Pueblo Bonito	707	17.6	40.17
Lochness	1300	19.7	65.98
Opera House	1050	20	52.5
New York	1310	26.4	49.62
House	685	21.1	32.46
Boat	604	19.6	30.81
Old Building	719	25	28.76
Several Buildings	769	27.2	28.27
Small Sailboat	606	20.8	29.13
Mountain Stream	803	27.4	29.30

Table 4.8 show the compression ratio of the (DFT-DWT) method. Theexperimental results show that the (DFT-DWT) algorithm achieved low compression ratio and lost the quality of the reconstructed image.