

JPEG 2000 Compression Standard-An Overview

Ambika M¹, Roselin Clara A²

PG Scholar, Department of Computer Science, Stella Maris College, Chennai, India¹

Assistant Professor, Department of Computer Science, Stella Maris College, Chennai, India²

ABSTRACT: An image is a replica of visual information such as drawings, pictures. Lessing the size of a graphics file without lowering the quality of the image is called Image Compression. When the size of the image is leased it allows more images to be stored in memory or disk. In image compression redundancies are removed from the image using a quantizer method. Various types of data redundancies are identified they are Coding Redundancy, Inter- pixel Spatial Redundancy, Inter-pixel Temporal Redundancy, and Psycho visual Redundancy. There are two types of Image compression (i.e.) Lossy Compression and Lossless Compression. Image Files can be compressed using different Standards. The standard that is used here for image compression is JPEG2000. The main feature of JPEG 2000 is it supports both lossless and lossy compression. This paper provides the features of JPEG 2000; a framework for evaluation and the benefits are presented.

KEYWORDS: Image compression, Jpeg2000, Quantization, Discrete Wavelet transform.

I. INTRODUCTION

Image compression is the utilization of data compression on digital images. The objective of image compression is to lessen repetition of the image data in order to store or transmit data in an efficient form [10]. Image compression is used to lessen the quantity of data to illustrate a digital image by eliminating the redundant data. The reduction in file size grants other images to be stored in a stated portion of memory space or the disk [15]. Image compression aims to remove different types of redundancies they are as follows:

- **Coding Redundancy**

Coding redundancy is like representation of information. The information is expressed in the form of codes. If the gray levels of images is organized with further collection of symbols than the appearing image is said to have coding redundancy.

- **Inter-Pixel Spatial Redundancy**

Interpixel redundancy is due to the association between the neighboring pixels in an image. That means neighboring pixels are not statistically separate. The gray levels are not uniformly possible. The value of any given pixel can be signified from the value of its neighbors that is they are greatly associated. The information carried by individual pixel is relatively small. To lessen the interpixel redundancy the difference between adjacent pixels can be used to produce an image.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

- **Inter-pixel Temporal Redundancy**

Interpixel temporal redundancy is the statistical association between pixels from continuous frames in video sequence. Temporal redundancy is also called interframe redundancy. Temporal redundancy can be violated using motion compensated certain coding. Eliminating a large amount of redundancy leads to efficient video compression

- **Psycho visual Redundancy**

The Psycho visual redundancies appear because human approach does not respond all visual information. This will have more loss of information. The information which is mentioned here will be redundant. The redundant information can be removed.

Image compression technique is based on two different categories that is lossy and lossless compression. Both Lossy and Lossless compression are terms that specify whether the original data can be recovered after the file is compressed.

Lossy Compression

In this technique the data is lost. After the data has been compressed the initial data cannot be retrieved or restored. This technique is used for image and sound compression. Telephone and video are examples of lossy compression.

Lossless Compression

This technique involves no loss of data. If data has been compressed, the initial data can be retrieved. Text compression uses lossless compression. Fax Machine, Radiological Imaging are examples of Lossless Compression.

Comparing JPEG 2000 with Other Standards

JPEG 2000 is a new Standard and compared to other previous standards such as JPEG-LS, MPEG-4 VTC, JPEG and PNG it has efficient features. The purpose of the previous standards are, JPEG-LS is a standard that uses Lossless compression to compress images. This standard is based on adaptive prediction, context modeling and golomb coding. It doesn't support any functionality such as scalability and error resilience. MPEG-4 VTC is used to compress images or other visual textures using the MPEG-4 Visual Texture Coding (VTC) algorithm. This algorithm is used in various realistic 3D images or other animated images. This standard is based on the discrete wavelet transform (DWT), scalar quantization, zero-tree coding and arithmetic coding. It supports only of arbitrarily shaped objects, by using the shape adaptive DWT technique. It doesn't not support lossless coding. JPEG is a popular standard. The standard is based on various modes such as baseline, lossless, progressive and hierarchical. The baseline mode supports lossy coding and it is a well-known mode. Whereas lossless mode is based on lossless coding and it is not a well know method. It doesn't not support lossy compression. PNG (Portable Network Graphics) uses W3 recommendation to compress images. This standard is based on predictive scheme and entropy coding. It supports lossless compression, grayscale, palette color and true color etc.

The Paper is classified as follows. Section II describes the JPEG 2000; Section III describes the JPEG 2000 Encoder and the Decoder, Section IV describes the Benefits of JPEG 2000, Section V describes the Literature survey and Section VI Concludes the Paper.

- **Features of JPEG 2000**

- JPEG 2000 is a new compression standard and coding system. It was developed by the Joint Photographic Experts Group with the purpose of appending their original JPEG Standard [6]. JPEG 2000 is a wavelet based image compression method that provides much finer image quality at lesser file sizes than the original JPEG method. JPEG 2000 file format supports both lossless and lossy image compression with the same file. Some features of JPEG 2000 is as follows [1]:

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

- **Lossy and Lossless Compression:** Superior performance at low bit rates is achieved through lossy compression and Progressive decoding is achieved through lossless compression. Applications such as digital libraries/database can use this feature.
- **Protective image security:** The architecture of JPEG 2000 makes the protection technique of digital images such as watermarking, labeling, stamping or encryption accessible.
- **Region –of-interest Coding:** Region of interest (ROI) can be denoted. These ROI's can be encoded and transmitted with finer quality than the rest of the image.
- **Robustness to bit errors:** The standard forms a set of error resilient tools to make the bit-stream more robust to transmission errors.
- **Open architecture:** It is desirable to allow open architecture to improve the system for different image types and applications
- **Random code stream access and processing:** random code stream processing could grant operations such as rotation, translation, filtering, feature extraction and scaling.
- **Content based description:** It is applicable as a part of the image compression system. Operations such as indexing, searching and image archival can be performed.
- **Side channel spatial information (transparency):** Alpha planes and transparency planes are useful for displaying, printing, editing the image. It is also useful for transmitting and storing the data.
- **Progressive transmission by pixel accuracy and resolution:** Progressive transmission grants images to recreate with rising pixel accuracy. This feature allows the recreation of images with various resolutions and pixel accuracy or spatial resolution is needed for many applications. Printer and World Wide Web are examples of application that use this feature.
- **Continuous-tone and bi-level compression:** It has a Coding standard which is capable of compressing both Continuous-tone and bi-level images. This System should compress and decompress images of various ranges within each color component. Images, text, medical images, Computer generated images are examples of applications that use this feature.

• JPEG 2000 ENCODER AND THE DECODER

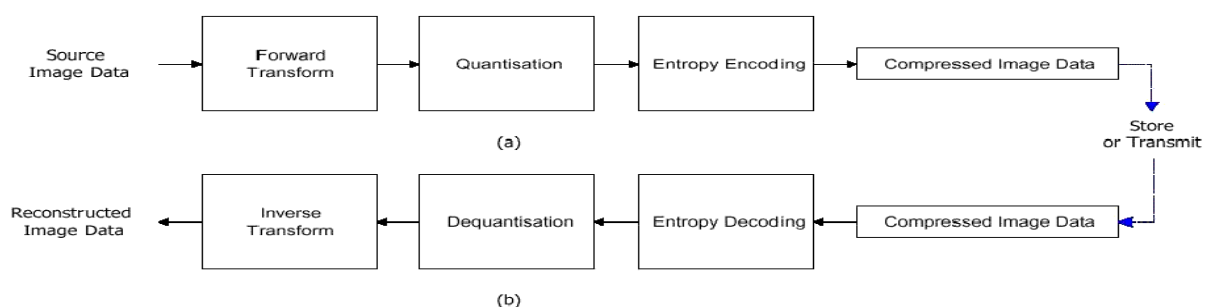


Fig.1 (a) Encoder block diagram (b) Decoder block diagram of JPEG 2000[6].

The Block diagram of JPEG 2000 Encoder is illustrated as follows: The JPEG 2000 compression contains the working of both the encoder and the decoder. The process of encoder follows these steps in the First step the image is divided into tiles or blocks in the second step Discrete wavelet transform is applied on each tile .In the third step Quantization is performed. The quantized Coefficients are further divided in the fourth step. In the final step the source image is retrieved. The working of the encoder is briefly explained below:

Tiling

The Source image is divided into rectangular non overlapping blocks called tiles and these tiles are compressed individually as specific image. All activities such as component mixing, wavelet transform and entropy coding are

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

executed individually on each tile. The tiles that are represented have the same width apart from the tiles which are at the right and lower boundary of the image. As the tiles are recreated individually they reduce memory requirements. Tiling is used for decoding specific sections of the image. After Tiling each tile is shifted in the component using the DC left Shifting by subtracting the quantity. DC level shifting is applied on the unsigned tiles that are in the components.

Discrete Wavelet Transform

A Discrete Wavelet Transform (DWT) is applied on each image tile. The DWT produce an image as a sum of wavelet functions, known as wavelets, with various location and scale. To execute a forward DWT the standards represents the image into low pass (approximate) and high pass (detail) coefficients. [15] Then the image is divided into $n \times n$ blocks. The blocks are passed through two filters. To dissolve the image data into approximation and detail coefficients, the first level decomposition is performed. Then the detail and approximate coefficients are separated as LL, HL, LH, and HH coefficients when the transformed matrix is obtained. LL coefficients are transferred to the second level and all other coefficients are rejected.

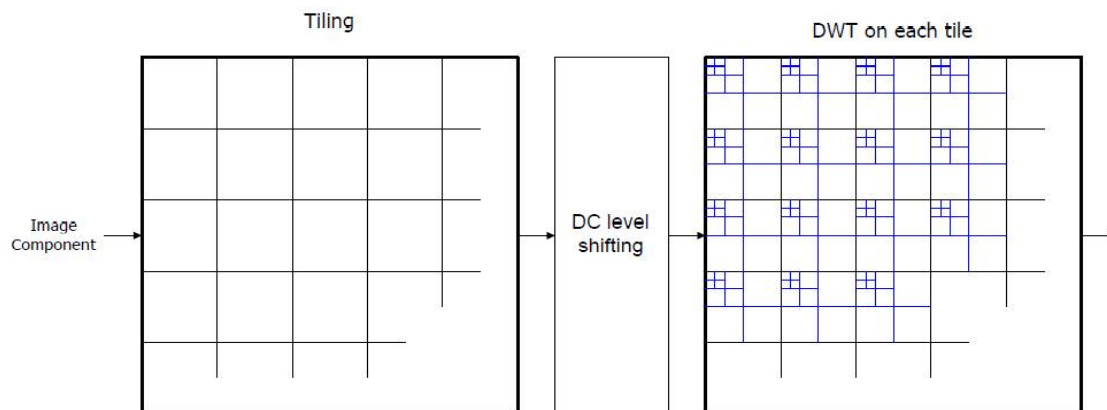


Fig.2 Tiling, DC level shifting and DWT on each image tile component [6].

Quantization

Quantization is a mechanism by which the coefficients are decreased in precision. It is a method where the data is greatly compressed. It is one of the modes of lossy compression. After applying the wavelet transformation, the coefficients are quantized and this is done to reduce the number of bits to make the image more compressible. The simplest method of quantization in JPEG 2000 is the scalar quantization. Scalar quantizer is applied to the coefficients of images which are produced by the wavelet transform. This makes the image to be in good quality. The parameter that can be changed to set the final quality is the quantization step: the greater the step, the greater is the compression and the loss of quality. With a quantization step that equals 1, no quantization is performed [13].

The recent method of quantization is vector quantization. Vector Quantization (VQ) is a technique that quantizes blocks of code called vectors rather than single individual samples and it is based on block coding. Each vector is called code word and set of all code words is called code book. VQ has an encoder as well as a Decoder. VQ encoder takes input as a vector and returns the outputs as index of the code word that offers smallest closest code word. The VQ decoder changes the gathered index with related code word and outputs a different code word.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

Precincts - Layers – Packets- Code blocks

After applying Quantization the image is divided into tiles or blocks. These individual tiles or blocks is called as precincts. Precincts are factors of low memory operations. They are used to access specific areas in an image. After the compression, the precincts are arranged together and this forms a Packet. The packet contains the information of each tile. A layer is a collection of packets. The packets is divided into rectangular non overlapping blocks to form a code blocks. The size of the code blocks will be ranging from $64*64$ and it will not be less than $32*32$. The code blocks creates the input for the Entropy Coder.

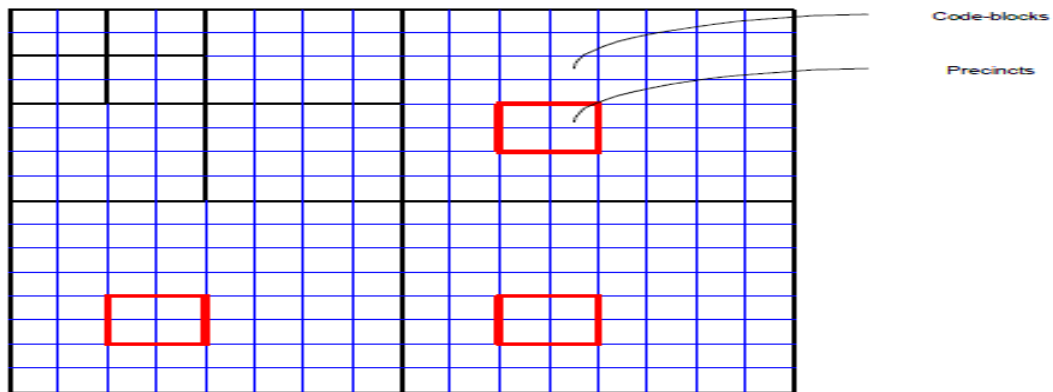


Fig 3.Tile is divided into sub bands, code-blocks and precincts [6].

Entropy Coding

After Quantization the data is represented in finite set of values which allow the entropy coder to further compress the data. Arithmetic coding is used to do Entropy Coding. The Arithmetic coding system is used to compress binary symbols which are similar to the adaptive probability model with various coding context. Arithmetic coding encodes the entire message into a single number. MQ algorithm is used to maintain the probability model. The recursive probability interval subdivision of Elias coding is the basis for the binary arithmetic coding process [7]. The context model will be reloaded at as soon as the code blocks is created. The arithmetic coder will always expire at the end of each code block.

The recent techniques of entropy coding are Shannon fanon coding, Elias gamma coding, Tunstall coding, Golomb coding and range coding. Shannon fanon coding is one form technique for compressing data. It creates a prefix code based on the symbols and the probabilities that is measured. Elias gamma coding is universal encoding technique which is used for coding integers. The gamma coding is used to compress data which occurs frequently. Tunstall coding is a form of lossless compression technique which maps source symbols to fixed number of bits. Golomb coding is a lossless compression technique that uses compressed codes. The optimal prefix code that is generated as a golomb code occurs due to the geometrical distribution by the alphabets. Range coding is similar to Arithmetic coding but it discovers a FIFO arithmetic code. It is used to encode digits rather than bits and this helps in efficient compression. Thus the source image is compressed and stored.

The Decoder process is the reverse of the Encoder (Fig 1b). The compressed image is decoded. Then in the decoded image de-quantization is applied. After inverse discrete wavelet transform is performed, the original image is retrieved.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

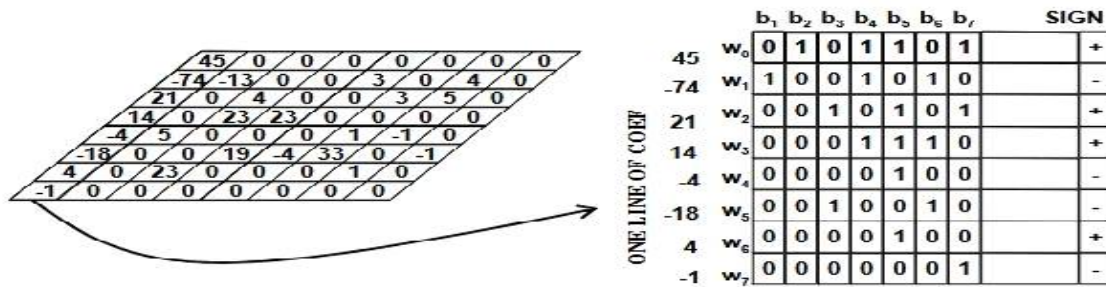


Fig 4.Coefficients and binary representation [9].

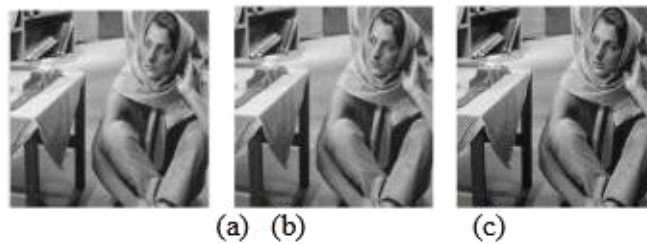


Fig 5.Barbara image (a) JPEG (b) JPEG 2000 (c) L-JPEG [13]



Fig 6.Lena Image (a) JPEG (b) JPEG 2000 (c) L-JPEG [13]

Image	JPEG 2000 compression	JPEG	L-JPEG
Lena	101.90	60.23	69.81
Barbara	76.09	61.87	66.24

TABLE-1. Values of different compression Standards [13]

Gray scale images (Lena and Barbara) of different standards were tested and the compression ratio for the above JPEG 2000 images were high and they provide greater quality.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

• BENEFITS OF JPEG 2000

- JPEG 2000 encodes each frame independently. This is a great advantage for content editing applications, as the video signal can be cut at any place without effect.
- It is especially well-suited for high-quality video.
- As there is no dependency between the signaled frames, JPEG 2000 technology will provide the required ultra-low latency.
- It offers easy editing for both resolutions and finer quality.
- JPEG 2000 is a particularly good choice for contribution of video over IP as it is exceptionally robust to transmission errors.
- This standard uses both the lossless and lossy compression in the same filestream.
- A higher compression ratio is offered by JPEG 2000 for lossy compression.
- It display images in different resolution and sizes from the same image filestream.
- The standard is robust to bit errors introduced by noisy communication channels, due to the coding of data in relatively small independent blocks.

II. LITERATURE SURVEY

N. R. Thota & S. K. Devireddy [10] states that JPEG compression standard which is based on Discrete Cosine Transform (DCT). DCT is a function that converts digital image from the spatial domain to frequency

domain. The major Steps in JPEG coding involve: DCT, Quantization, Zigzag Scan, and DPCM on DC Component, RLE on AC Components, Entropy Coding. Quantization is the process of reducing the number of possible values of a quantity, thereby reducing the number of bits needed to represent it. Entropy coding is a technique for representing the quantized data as compactly as possible. The purpose of the Zigzag Scan is to group low frequency coefficients in top of vector. Another encoding method used is Differential Pulse Code Modulation (DPCM) on DC component: It is large but closes to Previous values Run Length Encode (RLE) on AC components- it is a simple technique here encodes is done in pairs and skips zeroes.

M.W. Marcellin, M. Gormish, A. Bilgin, and M. Boliek [1] states that JPEG 2000 is described from the point of view of encoding. This is how the coding engine works: First the image is divided into tiles and transform is applied after this transform all components are treated independently. After transformation, all wavelet coefficients are subjected to uniform scalar Quantization employing a fixed dead-zone about the origin. This is accomplished by dividing the magnitude of each coefficient by a quantization step size and rounding down. After quantization, each sub band is subjected to a packet partition. This packet Partition divides each sub band into regular non-overlapping rectangles. Entropy coding is performed independently on each code-block. This coding is carried out as context- dependent, binary, arithmetic coding of biplanes. The compressed bit streams associated with some number of sub- biplanes from each code-block in a packet partition location are collected together to form the body of a packet. A layer is a collection of Packets.

M.D. Adams and F. Kossentini [4] states that The JPEG-2000 codec handles both lossy and lossless compression using the same transform-based framework. The encoding process proceeds as follows Forward multicomponent transform is applied to the image data. A wavelet transform is optional. After wavelet Transform quantization is applied. The decoding Process is first de-quantization is applied after de-quantization Inverse wavelet transform is applied after that Inverse multicomponent is applied to the image data.

Pallavi B, Sunil M P , C.A. Christopoulos, A.N. Skodras, and T. Ebrahimi , Diego Santa-Cruz and TouradjEbrahimi[13, 6, and 5] states that Jpeg 2000 involves both encoder and decoder.jpeg 2000 is divided into five different stages in the first stage the image is divided into non overlapping tiles. In the second stage DWT is applied .The purpose of DWT is to produce a large number of values having zeroes or near zero magnitude. In the third stage

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

quantization is performed. Multiple levels of DWT give a multi-resolution image. The lowest resolution contains the low-pass image while the higher resolutions contain the high-pass image.

Anithas [11] states that DCT and quantization method for reducing the blocking artifacts in reconstruction. The performance is further analyzed for the reduction in image size. The DCT is applied separately to blocks of the images. The DCT coefficients for each block are quantized separately by discarding the redundant and information high-coefficients. De-quantized and compressed image is reconstructed by using Inverse discrete cosine transformation although there is some loss of quality in the reconstructed image. The PSNR is a metric used to compare two pictures is also used to get a better quality of the picture.

AthanassiosSkodras, CharilaosChristopoulos, and TouradjEbrahimi [7] states that the encoder, the discrete transform is first applied on the source image data. The transform coefficients are then quantized and entropy coded before forming the output code stream (bit stream). The decoder is the reverse of the encoder. The code stream is first entropy decoded, De-quantized and inverse discrete transformed, thus resulting in the reconstructed image data. After transformation, all coefficients are quantized. Entropy coding is achieved by means of an arithmetic coding system that compresses binary symbols relative to an adaptive probability model associated with each of 18 different coding contexts. Features of the standard such as ROI (Region of Interest) .The MAXSHIFT method is an extension of the general ROI scaling-based coding method

Kavinder, VinayChopra, HarsimranjeetKaur [12]states that vector quantization is applied for improvement that is its finds the average gray scale values that is used to represent nearing pixel values for the transformed image SandeepKaur, Sukhjeet Singh [16] states the different types of recent encoding techniques will is helpful in Entropy coding .

III. CONCLUSION

In this paper the basic concepts of image compression are introduced. We propose the JPEG 2000 compression standard which is based on discrete wavelet transform and it provides a wide range features of which are applicable in certain areas. JPEG 2000 is a new form of image compression .It offers higher compression ratios and display images in finer quality. The DWT and quantization, entropy coding techniques has applied to compress the images. The original image is retrieved by applying the de-quantization and IDWT techniques. The advantages of JPEG 2000 are also discussed. The JPEG 2000 is also compared with other recent Standards. It offers many efficient features by providing lossy and lossless compression, progressive and parse able bit-streams, error resilience, region of interest, random access that are absent in other standards. By providing higher compression ratios that is used to display images in a finer quality and by using these efficient features JPEG 2000 is expressed to be more flexible. Thus, JPEG 2000 is considered to become as an International standard.

REFERENCES

- [1] M.W. Marcellin, M. Gormish, A. Bilgin, and M. Boliek, "An overview of JPEG 2000," in Proc. IEEE Data Compression Conf., Snowbird, UT, Mar.2000, pp. 523-541
- [2] N. Skodras, C. Christopoulos and T. Ebrahimi, "JPEG2000: The Upcoming Still Image Compression Standard", (Invited paper) Proc. 11th Portuguese Conf. Pattern Recognition (RECPAD 2000), pp. 359-366, Porto, Portugal, May 2000.
- [3] D.SantaCruza,T.Ebrahimia,J.Askelöfb,M. Larsson and C. A. Christopoulos,"JPEG 2000 still image coding versus other standards", In Proc. of the SPIE's 45th annual meeting, Applications of Digital Image Processing XXIII, volume 4115, pages 446-454,San Diego, California, Jul.30 Aug. 4, 2000.
- [4] M.D. Adams and F. Kossentini, "Jasper: A software-based JPEG-2000 Codec implementation," in Proc. IEEE Int. Conf. Image Processing, Vancouver, Canada, Sept. 2000, vol. II, pp.53-56
- [5] Diego Santa-Cruz and TouradjEbrahimi,"A study of JPEG 2000 still image coding versus other standards," in Proc.of the X European Signal Processing Conference,Tampere,Finland, Sept. 2000, vol. 2, pp. 673-676.
- [6] C.A. Christopoulos, A.N. Skodras, and T. Ebrahimi, "The JPEG 2000 still image coding system: An overview," IEEE Trans. Consumer Electron., vol. 46, pp. 1103-1127, Nov. 2000.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 6, Special Issue 11, September 2017

- [7] AthanassiosSkodras, CharilaosChristopoulos, and TouradjEbrahimi,"The JPEG 2000 Still Image Compression Standard, "in Proc.IEEE signal processing magazine, Volume: 18, Sep 2001
- [8] Diego Santa-Cruz, Raphael Grosbois, TouradjEbrahimi,"JPEG 2000 performance evaluation and assessment", Signal Processing: Image communication 17 (2002) 113–130.
- [9] Jin Li"Image Compression: The Mathematics of JPEG 2000 "Modern Signal Processing MSRI Publications Volume 46, 2003.
- [10] N. R. Thota& S. K. Devireddy, "Image compression & DCT", Georgian electronic Scientific Journal of Computers science & Telecommunication, 3 (17) 2008, 35-43
- [11] Anithas, "image compression DCT and DWT", international journal of scientific and engineering research, 2 (8) 2011, 17-24
- [12] Kavinder,VinayChopra,HarsimranjeetKaur,"DICOM image compression using Huffman coding technique with vector quantization", International Journal of Advanced Research in Computer Science, Volume 4, No.3, March 2013
- [13] Pallavi B, Sunil M P,"Comparative Analysis of JPEG2000 Image Compression with Other Image Compression Standards using Discrete Wavelet Transforms Technique", IJETT, Volume 13, July 2014.
- [14] MalwinderKaur, NavdeepKaur,"A literature survey on lossless image compression ", International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, March 2015.
- [15] D.Meenakshi&V.Karthika Devi, "Literature review of image compression technique ", International Journal of Computer Science & Engineering Technology, Vol 6, 05 May 2015
- [16] SandeepKaur, Sukhjeet Singh, "Entropy Coding and Different Coding Techniques", Journal of Network Communications and Emerging Technologies (JNCET),Volume 6,May 2016.