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An Analysis of Compression Methods and Implementation of Medical Images in Wireless Network

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***Abstract*—**The motivation of image compression technique is to reduce the irrelevance and redundancy of the image data in order to store or pass data in an efficient way from one place to another place. There are several types of compression methods available. Without the help of compression technique, the file size is knowingly larger, usually several megabytes, but by doing the compression technique, it is possible to reduce file size up to 10% as of the original without noticeable loss in quality. Image compression can be lossless or lossy. The compression technique can be applied to images, audio, video and text data. This research work mainly concentrates on methods of encoding, DCT, compression methods, security, etc. Different methodologies and network simulations have been analyzed here. Various methods of compression methodologies and its performance metrics has been investigated and presented in a table manner.

***Keywords*—**Image compression techniques, encoding, DCT, lossy compression, lossless compression, JPEG.

I. Introduction

AN image is a picture form that has been generated or copied and stored in an electronic form. An image can be labeled in the form of vector graphics or raster graphics.

There are two kinds of images in common. Two dimensional images can be as a photographic image or a screen display image whereas the three dimensional image can be in the form of a statue or hologram representation. These images may capture by electronic devices like cameras, telescopes, mirrors, etc., and natural objects as the human eye and water.

A digital image is represented as two dimensional images. Its dependencies based on the resolution are fixed or vector/ raster type. The RGB color is normally used in computer screens, but other spaces such as YCbCr, HSV are often used in other contexts. A color image consumes three values for each pixel and they measure the chrominance and intensity of light [33].

A. Image Compression

The image compression mechanism is primarily used to reduce the size of a graphics file without affecting the quality of that image. This process leads to store more number of data in a particular file and it increases the memory space. And also it decreases the time to get an image and to transmit over the internet.

We can observe that there are multiple ways to compress an image file. In the computer world, the most commonly used compression formats are JPEG and GIF formats. In which the JPEG formats are frequently used for photographic images, whereas the GIF method can be used in line arts where the geometric shapes are very simple [17]. The other methods such as fractals and wavelet are used in computer technology. However, in case of signal processing, it dominates other methods. But both methods are able to provide more compression ratios than JPEG and GIF for some kinds of images. One more method that replaces the GIF method is PNG format [3]. Also, we can perform the compression for a file without consideration of errors, but it is restricted in certain extent. These methods are called as lossless compression. While compressing a text or a program file with lossless compression, it may cause some risk because the text or a file may contain any unnecessary data. So, a single error may lead to damaging the entire file or the program file may not able to run [32].

II. Literature Review

The image is one of the biggest multimedia for the people to understand any concept easily. In order to convey this image, there are some possibilities for redundancy occurrences [4]. There are three types of redundancies commonly used:

1) Spatial redundancy
2) Temporal redundancy
3) Spectral redundancy

A. Spatial Redundancy

This method used to remove the repeated data of neighboring pixels.

B. Temporal Redundancy

When we represent the image data, it must be in need of reducing the needed bits in the image.

C. Spectral Redundancy

It represents the different color pixel correlations.

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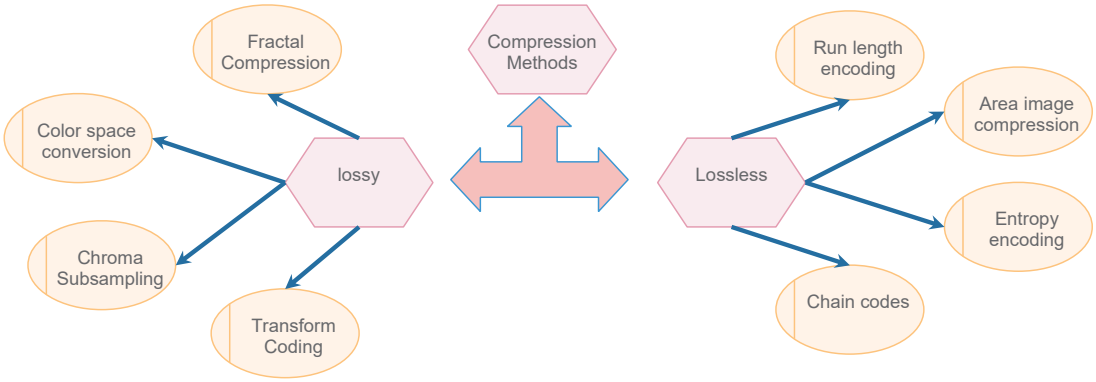

Fig. 1 Compression Methods

III. Types of Image Compression

The compression techniques are widely classified into two types;

1. Lossy compression
2. Lossless Compression

Lossless compression is favored for archival purposes and frequently for medical imaging, technical drawings and clip art. Lossy compression process, especially when used at low bit rates, introduces compression artifacts. Lossy methods are especially appropriate for natural images such as snapshots in performances where minor loss of loyalty is acceptable to achieve a significant lessening in bit rate [5].

A. Methods for Lossy Compression

- **Color Space Conversion**: This is the process of reducing the color space to the maximum common colors in the medical image. The selected colors are specified in the color palette in the caption of the compressed medical image. Each pixel is just referencing the index of a color in the color palette. This method can be combined with irresolute to avoid posterization. Converting from RGB to YCbCr gives better performance [20].
- **Chroma Sub Sampling**: This method takes some better advantage of the fact that the human eye perceives spatial changes of brightness more severely than those of color, by averaging or reducing some of the chrominance information in the image.
- **Transform Coding**: This method is the most frequently used method. In particular, a Fourier-related transform such as the Discrete Cosine Transform (DCT) is widely used. The DCT is sometimes referred to as "DCT-2" in the context of a family of discrete cosine transforms. The most recently developed wavelet transform is also used extensively, followed by quantization and entropy coding [5].
- **Fractal Compression**: The main idea of this method is to decompose the image into segments. Each segment looked in a library of fractals. It contains Iterated Function System (IFS) codes which are sets of numbers [5].
- **Block truncation code**: This lossy compression method can reduce the size of digital images along with a better visual quality. It used three bitmaps to compress the color images. This method can also use for data hiding [17].

B. Methods for lossless Compression

- Run-length encoding –this method is used as the default method in PCX, as one of the probable in BMP, TGA, TIFF
- Area image compression
- Predictive Coding and DPCM
- Entropy encoding
- Adaptive dictionary algorithms such as LZW – used in GIF and TIFF
- Deflation – used in MNG, TIFF and PNG
- Chain codes

C. Properties of Compression Method

The best image quality at a given bit-rate is the main goal of image compression; however, there are other important properties of image compression schemes:

- ***Scalability***: It generally refers to a quality fall achieved by handling of the bitstream or file. The other names are suggested for scalability is progressive coding or embedded bitstreams. In-spite of its conflicting environment, scalability also may be found in lossless codes, usually in way of coarse-to-fine pixel scans. Scalability is especially beneficial for screening images while downloading them or for providing flexible quality access e.g., databases.

There are numerous types of scalability:

- **Quality progressive or layer progressive**: Here the bitstream sequentially improves the reconstructed image.
- **Resolution progressive**: In this process initially encodes a lower image resolution; after that, it encodes the variable to higher resolutions.
- **Component progressive**: initially gray pixels are encoded after that color pixel will be encoded.
- **Region of interest coding**: some parts of the image are encoded with higher quality than others. This may be combined with scalability (in need of encode these parts first, others later).
- ***Meta information***: Compressed image may contain some information about that image which may be used to

search, or browse images. Such information like author or copyright etc.

- ***Processing power***: The compression algorithms need various ranges/amounts of processing power to encode and decode processes. Some extraordinary compression algorithms are in need of greater processing power. The world of a compression method is often estimated by the Peak signal-to-noise ratio (PSNR). It measures the amount of noise introduced via a lossy compression of the image; however, the particular judgment of the onlooker also is viewed as an important measure, perhaps, being the most important measure [5].

D. Advantages and Disadvantages of Image Compression

Size Reduction: File size reduction rests the single most significant benefit of image compression. Subject on what file type you are dealing with, you can endure to compress the image until it is in your chosen size. This means the image takes up less space on the hard drive and keeps the same physical size, without you edit the image's physical size in an image editor. The process of file size reduction works perfectly for the Internet, permitting webmasters to generate image-rich sites without using much bandwidth or storing space.

Slow Devices: Some of the electronic devices, such as computers or cameras may load growth, uncompressed images very slowly. CD drives, for example, it can just read only the data at a specific rate and cannot show large images in real time. Also, for some web hosts that handover data slowly, compressed images remain necessary for a fully functional website. Other systems of storage mediums, such as hard drives, will also have struggled to loading the uncompressed files quickly. Image compression allows for the quicker filling of data on slower devices.

Degradation: While you compress a medical image, at times you will get image degradation, since the quality of the image has failed. If saving a GIF or PNG file, the data remain even though the quality of the image has been declined. If you need to demonstrate a high-resolution image to somebody, large or small, you will find images compression as a disadvantage.

Data Loss: With some common file types like JPEG, while an image shrinks in size the compression will remove some of the photo's figures permanently. To compress these kinds of images, we want to ensure that, we had an uncompressed backup before starting. Or else, we will miss the high quality of the original uncompressed image permanently.

IV. Image Compression Algorithms

Some of the image compression algorithms are:

- Flat/deflate
- JPEG
- JPEG2000
- Huffman
- LZW
- RLE

A. JPEG

JPEG image is one of the popular techniques in image compression. Now JPEG is applied most commonly in digital image compression field. The input image is divided into small blocks and each block consists of 8×8 pixels. Each block is converted by the two dimensional discrete cosine transformation (DCT) to the incidence domain. The transformed coefficients are quantized to reduce the redundant data. The selection of DCT coefficients is performed in order to their rearrange the zigzagged way from low to high frequencies, and only middle and low frequencies are nominated without much loss of information. [1].

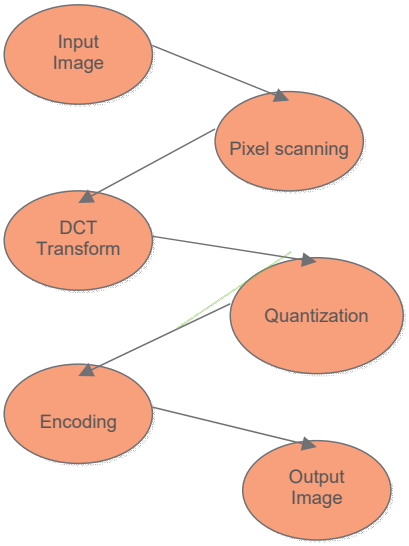

Fig. 2 JPEG Compression

In order to improve the performance of Bayer CFA images, a new method introduced is near-lossless compression method. It is based on the channel separated filtering mechanism [2].

For the fractal image compression, the compression technique takes much time to encode it. The fundamental idea of FIC is an Iteration Function system. To overcome this problem, we can use the PSO algorithm to reduce the encoding time. By using this algorithm, we can gain better quality in medical images [3].

B.JPEG 2000

JPEG 2000 image compression is most commonly used for still images. JPEG 2000 uses wavelet transform compression, so initially the image must be transformed from spatial domain representation to wavelet transform. It majorly depends on three closely components, they are Reverse transformer, quantizer and Entropy encoder/decoder. In distributed JPEG 2000 compression the two basic approaches are 1) Divide by rows/columns 2) Tiling [6].

Some of the metrics are need to be concentrating on lossless compression methods like PSNR, MSE and MAE:

- **PSNR**: Peak Signal Noise Ratio; it used to eliminate the noise in the images.

- **MSE**: Mean Square Estimation; it is a sequential collection of errors between the neighboring pixels of original and compressed images.
- **RMSE**: Root Mean Square Estimation; it is the root value of MSE.
- **Pixel level interleaving:** After CDT transformation and Quantization the block of image pixels divided into two parts to gain upper and lower areas. Then the lower and upper areas are merged separately in order to do a scan. After interleaving Huffman code is applied [7].

TABLE I
COMPARISON TABLE

S. No	Reference	Methodology	Performance Metrics	Parametric Analysis	Conclusion
1.	[1]	The proposed novel Low Energy Image Compression Algorithm (LEICA) that is based on an interest area in WMSNs. LEICA can keep an image quality of an interest area and increase the compression ratio of the whole image.	Lifetime	LEICA divides the whole image into Regions of Interest (ROI) and tiles. ROI which monitored objects appear on are compressed at a low compression ratio.	LEICA can increase the compression ratio of the whole image while meeting an image quality of ROI. LEICA can decrease the energy consumption on the computation and transmission.
2.	[2]	Based on channel-separated-filtering, several typical Bayer CFA image compression methods are compared with the proposed remainder set algorithm.	Compression performance	To get high compression performance, filtering is very important in one channel. Because of natural pixels' random city, equiprobable filtering is reasonable.	Based on channel-separated-filtering, several other typical CFA image compression methods are compared with our remainder set method. Obviously, the results show that our method has better compression performance and better PSNR.
3.	[3]	A fast fractal encoding system is proposed using particle swarm optimization (PSO) to reduce the encoding time. Here, an optimization technique is used for the MSE based on the stopping criterion between range block and domain block.	Image Quality	The fundamental idea of fractal image compression is based on an Iteration Function System (IFS) in which the governing theorems are the Collage Theorem and the Contractive Mapping Fixed-Point Theorem	Fractal image compression can produce better compression ratio at acceptable quality. By using PSO for fractal coding can reduce the encoding time with 1.2dB loss in image quality.
4.	[9]	In this paper, a novel medical data compression algorithm, termed layered set partitioning in hierarchical trees (LSPIHT) algorithm, is presented for telemedicine applications.	Rate-distortion Performance	The LSPIHT algorithm can be viewed as a sequence of operations using the SPIHT algorithm with one operation for each layer. Starting from the base layer, the LSPIHT constructs one layer at a time until the design of the final layer is completed.	Based on the same resolution and CR at each layer, the algorithm outperforms other methods for the compression of MRI and ECG data.
5.	[10]	The approach is based on the embedded zerotree wavelet (EZW) algorithm. This algorithm offers a tremendous amount of flexibility in meeting the bandwidth and image quality constraints in a radiological imaging environment.	Image transmission	This method in producing the low to fine-resolution images was limited to the total number of scales in the wavelet transform space, and so the size of the original image.	The EZW-based PIT system can effectively use and control the resources at all stages of the transmission. This framework can be applied to RIS environments, where network bandwidth is at a premium and image quality requirements are high
6.	[11]	Aiming to improve the productivity of radiologists and the cost-effectiveness of the system, we strive to achieve high decoder throughput, random access to coded data volume, progressive transmission, and high compression ratio in a balanced design approach.	High decoding throughput, and progressive transmission capability,	To maximize compression gains it is tempting to use adaptive arithmetic coding driven by a high-order 3-D context in entropy coding of M3DW coefficients. But this has some operational drawbacks.	A measured success in obtaining this goal has been achieved by using a modified 3-D dyadic wavelet transform scheme and optimized Rice code.
7.	[12]	In the approach, an image is first compressed at a high compression ratio but with loss, and the error image is then compressed losslessly. The resulting compression is not only strictly lossless, but also expected to yield a high compression ratio, especially if the lossy compression technique is good.	Image quality	The original images are gray scale images with 8 bits per pixel. A VQ block size of 4x4 was used. This size is chosen for minimum perceptual ambiguity. As the block size is increased to 8x8, check boards and loss of perceptual quality is observed and with smaller block sizes of 2x2, the compression ratio achieved is not valuable.	The results can be improved if number of test vector presented to NNVQ and number of epochs to train NNVQ are increased. Lempel Ziv coding may be another choice for lossless compression.
8.	[13]	This paper discusses a Picture Archiving and Communication Systems (PACS) application designed for viewing DICOM compliant medical images using Wavelet compression to ROI coding, support, on mobile devices.	Accuracy of compressed image	This technique is designed to be as simple as possible and to use less amount of memory during the compression, decompression process; therefore, it is suitable for usage on mobile devices. In the DLWIC, the image to be compressed is first converted to the wavelet domain with the orthonormal Daubechies wavelet transform	The test results indicate the benefits of lossless and lossy wavelet compression optimizing the network performance of the application especially in the case of the GPRS network, and also present the effects of symmetric data encryption Additionally, the provided ROI coding enables additionally compression with varying image quality.
9.	[18]	The approach is motivated by the fact that, often in medical applications, massive amount of correlated images from the same family are available as training data for	Image compression	In the proposed method, the outcome of the learning phase, called M, of memory-assisted compression is available on both S and D. Then, using M, just the residuals of	Our experimental results using the JRST database showed that the performance of traditional lossless algorithms can be improved by an

S. No	Reference	Methodology	Performance Metrics	Parametric Analysis	Conclusion
		learning the dependencies and deriving appropriate reference models.		other test images are encoded at node S a decoded at node D. The proposed memory-assisted lossless compression method consists of two main phases: 1) Learning 2) Memory-assisted Compression	average of 20% using the proposed algorithm.
10.	[19]	In this study a novel active contour method is proposed which is adaptive and marks the outer region of interest without edges. Based on the ROI, the active area of interest is compressed using lossless compression and the other areas compressed with lossy wavelet compression techniques.	Lossless image compression	The biorthogonal wavelets introduced by Cohen, Daubechies and Feauveau contain in particular compactly supported biorthogonal spline wavelets compactly supported duals.	An improved active contour technique to find the region of interest based on fuzzy logic was proposed. The proposed method provided a better compression method compared to lossless compression of the whole image

V. Medical Image Compression

In the field of medical science, various types of images can be observed such as endoscopic images, electrocardiography images, resonance imaging, computed tomography and magnetic resonance, etc. In nature, the processes of compressing a medical image needs two types of methods called DCT and Colomb-Rice code [20] [11].

The fundamental approach to apply in three dimensional images (3D) is wavelets. By using wavelet coding we can increase the throughput and operability of an image [11].

Region of interest (ROI) estimation is necessary to estimate. The disease estimation in a particular part is very important. To estimate this value, we must calculate PSNR, MSE values. A good MSE value will decide the compression ratio of that image [19]. In telemedicine application, medical video transmission is a key to successful deployment. Normally, the patient states are two types defined as Normal and urgent. The patient situations are monitored by using sensors like ECG, HR, BP and PR [15].

The web based telemedicine applications are used to analyze and display the medical images of patients. It enables a connection between PC through internet. DICOM is a standard medical image format. It describes the format and exchange of actual medical image [8].

The telemedicine applications have used some of the algorithms to compress the medical images like LSPIHT (Layered set Partitioning in Hierarchical Trees), in which the encoded bits are initially divided into several layers in order of transmission and reconstruction. And it attains better distortion performance than other algorithms [9].

By using the lossless compression, the original state of an image can be extracted from the compressed image. Most of the compression methods used is lossless rather than the lossy compression method. After applying compression technique, Huffman coding is used to get the exact compressed image. In Huffman coding short characters are assigned as the input [12].

TABLE II
Compression Techniques

Type of data to be compressed	Formats	Compression Software
Video	MJPEG, Motion JPEG 2000, MPEG1, MPEG2, MPEG4, MPEG H.	Lossy: 3ivx, DivX, Nero Digital, FFmpeg, CoreAVC, Blu-code, QuickTime x264 Lossness: FFV1, Huffyuv, Lagarith, MSU Lossless, YULS
Audio	MP3, MPEG Layer-II, MPEG-Layer I. AAC, MPEG-4 ALS, MPEG-4 SLS, MPEG-4 DST etc.	Lossy: LAME, TooLAME, libavcodec, libcelt, libopus, libspeex, Musepack, libvorbis, Windows Media Encoder Lossless: ALAC, FLAC, libavcodec, Monkey's, Audio, mp4als, OptimFROG, Shorten, TTA (True Audio), WavPack
Image	CCITT Group 4, JPEG, JPEG 2000, JPEG XR, Lossless JPEG, JBIG, PNG, TIFF/EP, TIFF/IT, HEVC.	7-Zip, Ark, Expander, File Roller, PAQ, ZPAQ.

The Genetic Algorithm protocol has been tested for transferring the data in wireless network environment [30]. Some of the swarm intelligence algorithms were discussed in presence of Mobile Adhoc Network [31].

The fundamental of Scalable Wavelet Difference Reduction (SWDR) is a Wavelet Difference Reduction method, in which the Signal Noise Ratio (SNR) has been estimated. In the process of compression and transmission of a medical image needs high utility and small region must be affected. By using the zero-tree concept, it rearranges the images of patients in order to compress efficiently [14].

PACS (Picture Archiving and Communication System) are used to view the DICOM compliant patient medical images. This technique uses DWT and ROI methods for mobile devices. In this paper both lossy and lossless compression methods have optimized the network performances [13].

A hybrid lossless compression technique was developed to concentrate on both compression and decompression methods. This hybrid technology consists of Prediction by Partial Matching (PPM) and 3D JPEG 4 compression methods. The main objective of this method is to identify the 3D image and high rate of compression fast with decompression ratio. It is designed for without loss in the images. So that it used Huffman encoding technique [16].

Embedded Zerotree Wavelet (EZW) algorithm was introduced to control the resources at all the times so that the

wavelet transform space gets decreased in order to get the original size of image [10].

FMMIS - Fuzzy Min-Max neural network for image segmentation method increases the boxes from a particular set of pixels which helps to find the minimum bounded rectangle in every object which presents in images. This algorithm performed on the wooden images, and it performed alternative by way of detection rate of the object, the detection rate of false positive and average execution time [21].

The color segmentation algorithms are classified as; [22]

1) Histogram thresholding.
2) Feature space clustering.
3) Region based approaches.
4) Edge detection.
5) Fuzzy approaches.
6) Neural network.
7) Physics-based approaches.
8) Hybrid techniques.

The authors in [24] presented a framework for simulation testbed to implement the jointly exploit multiple image compression techniques. For that they have used OMNeT++ simulator. Collection Tree Protocol (CTP) is a protocol for wireless sensor networks as it provides "best effort anycast datagram communication to one of the collection routes in a network". The two types of messages used in CTP are; routing messages and data messages. DSC – Distributed Source Coding method is an efficient compression technique. It also can transfer, computational complexity from encoder to decode. It this work image sensor network was considered to DSC. In this method the coding is related to compression of data which is from several correlated sources which cannot communicate with each other. During the video coding DSC algorithm showed an efficient result. For an image coding it gave a better compression result than contemporary single source image coding [23].

In [27], the authors provide a framework for medical image archiving, processing, analysis and communication system for Teleradiology. This work consists of two works; 1. Capturing analog imaging data 2. Bringing digital imaging data. One of the major criteria while compressing an image is energy. In order to make the energy efficient compression and image quality, a distributed image compression method has been used. It also intersects with the Discrete Wavelet method. The performance shows that it can provide longer lifetime. The major concentrations of this method are Background on image compression, Distributed wavelet transform and Quantization & coding [25].

The authors in [26] proposed a parameter free image classification method which is based on the data compression method. Here two kinds of compressors were used for efficient compression method. They are 1) ZIP the general purpose compressor 2) JPEG compressor. This work is apply to the Shannon information theory and Kolmogorov complexity. Compression method also used in telemedicine applications. Layered Set Partitioning in hierarchical Trees (LSPIHT) algorithm, it divides the encoded bits into a number of layers for transmission. It requires more resources and it leads to overhead in managing. At the receiving end also different resolution and SNR are required [9].

Power consumption is one of the difficult processes in MANET. In order to reduce the power consumption a new method has been introduced. It explains how we can implement the compression method in MANET. So it uses a protocol called Lemple – Ziv – Welch (ZLW) compression algorithm was implemented. It is a very effective method for the files which containing repetitive data. This algorithm builds a string translation table which maps fixed length coding by using 12 bits. This method used GloMoSim as a simulator [28].

In [29], the combined algorithms were used. This method is a combination of Lempel – Ziv – Welch (LZW) and Bose, Chaudhuri and Hoc-Quenghem (BCH) error correction and detection algorithms. The basic idea of this method is to reduce the redundancy of data which is present in the image; thereby we can reduce the time in storage or transmission of image data.

VI. Conclusion

There are several methods are available in image compression processes. In this survey paper some of the methods and its process have been analyzed. The algorithms used for compression techniques also descriptively. By analyzing these methods combining two techniques or hybrid methodology has given some greater performance than other algorithms. Since the medical image needs to compress and decompress, so both lossy and lossless techniques were analyzed.

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