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A Novel Approach to Improve Medical Image storage and security by using Wavelet Coding Method

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ABSTRACT
Today's world, an immense number of therapeutic images and clinical information are generated in both 2D and 3D by numerous advanced imaging techniques, in general Magnetic Resonance Imaging (MRI), Ultrasound Imaging (US), Single Photon Emission Computed Tomography (SPECT), Positron Emission Tomography (PET), Nuclear Medicine (Scintigraphy), Computed Tomography (CT), Digital Tomography (CT) images, and more. This paper presents the basis for the development of research problems and data collection for current structures, methods and techniques, and for research scholars to understand the existing contribution of different image compression techniques and the merits and demerits of each type. This article offers an overview of best-in - class image data compression and standards such as JPEG and JPEG-2000 that are generally and widely used in the field of image processing. These standards extend as well to digital data, such as audio, video, natural images and various other forms of data. This article further addresses the important methods and means of compression by using distinctive methodologies and strategies such as variable-length codes, run-length encoding, dictionary-based compression, transformation and quantification.Abstract formulations shall be taken into account, taking into account the final purpose, to allow research scholars to perceive and discern the exploration problem and to discover the probability, viability and practicality of investigating it. This motivates us to explore the dilemma of image compression and to better examine the problems in an attempt to understand whether we have reached any hypothetical points of containment.

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I. INTRODUCTION

It is well established that data compression is one of the effective, prevalent and unavoidable fields in the field of computer vision in general and graphical communication and multimedia computing centred on web technologies in particular [1]. It is a matter of great interest for academic researchers, academia and industry worldwide and has earned many proposals in every field of life [2]. Data compression mechanisms, strategies and procedures have been researched for nearly four decades [3]. Compression algorithms and encoders have been tested in relation to the amount of compression they offer, protocol performance and error susceptibility. While algorithm performance and errors tolerance are relatively independent of the features of the source set, the amount of compression obtained depends to a large degree on the semantics of the source.

Image compression is a major concern in modern and Internet-based communications [4]. As the innovation in computer communications continues to grow, the market for data storage and processing continues to increase and surpass our expectations [5]. Picture compression is the method of reducing the number of bits used to display an image. With data compression, more information can be contained in a given storage area and information can be distributed more easily via communication channels.

Uncompressed text, graphics, audio and video data need a broad and significant storage space considering today's storage technologies. Similarly, data transmission of uncompressed images and video to computerised devices over digital networks requires extremely high data transfer capability and bandwidth for multimedia communications. For e.g., an uncompressed still image of a size of 640x480 pixels with 24-bit colour takes about 7.37 Mbit of storage and an uncompressed full-motion video (30 frames / sec) of a length of 10 seconds needs 2.21 Gbit of storage and a bandwidth of 221 Mbits / sec. Even if we believe that there is an adequate capacity cap available, it is difficult to transfer a large number of images or play video (sequence of images) gradually due to low data transmission speeds and restricted network bandwidths. In the current conditions, the main arrangement is to compress digital data until it is stored and transmitted and to decompress it at the receiver for playback [6].

Data compression is done by eliminating redundancies and non-relevance of the image. In the case of a nut shell, compression is done by eliminating and expelling repetition and unimportant issues of the picture. The purpose of replication and removal is to keep repetition away from the signal source of the image or video material. Irrelevance reduction omits portions of the signal that the signal processor, including the Human Visual System (HVS), would not perceive. Image compression research seeks to reduce the number of bits used to represent the image by minimising spatial and spectral redundancies as much as possible. Image redundancy can be divided into three groups, i.e. inter-pixel duplication or spatial redundancy, psycho-visual excess and coding duplication. The inter-pixel and encoding redundancy of the image can be removed and expelled on the basis of a mathematical approach.

New imaging compression methods and technologies also provide an answer to this question by reducing the storage capacity and the bandwidth of transmission. The most appropriate compression technique for still images, however, is transform coding based on the Discrete Cosine Transform (DCT). This is used in the popular standard of JPEG. In recent years, wavelet transformation has become a state-of-the-art technique for signal processing in general and for compression techniques in particular. In reality, JPEG-2000 norm, the top contenders are Discrete Wavelet Transform (DWT)-based compression algorithms [7].

1.1 DIGITAL IMAGE FILE FORMATS

Image file types are uniform means for arranging and saving digital files. Image files consist of digital information in either of those formats which can be rasterized for use on a screen monitor or printer [8]. An image data type can access the data in uncompressed, compressed, or vector formats. When rasterized, the image becomes a grid of pixels, each of which has a number of bits to show its colour equal to the depth of the system viewing it [9].

- JPEG

The term JPEG stands for "Joint Photographic Experts Group" because that is the name of the Council which created the format for still images [8]. The JPEG format is commonly used for the compression of photographic images due to true colour and high-quality image files. It is a lossy configuration, which means and infers that some quality is lost when the image is compacted. If the image and the image are crammed and compressed heavily, the output images end up becoming distinctly "blocky" and a majority of the nuanced aspect is lost.

- GIF

GIF stands for "Graphics Interchange Format" and is an image file format widely and frequently used for document creation using web images and images [9]. Unlike the JPEG image community, GIFs use a lossless encoding that does not debase and reduce the image and image content. The GIF file format supports a limit of 256 colours. Since GIFs may simply contain 256 colours, they are not suitable for storing advanced images, such as those taken with a computer camera. The JPEG format, which supports millions of colours, is also most widely used for storing digital images.

- PNG

PNG, which can be described as "ping" or "P-N-G," is a packed, realistic raster image format[8]. It is widely and frequently used on the network and is therefore a mainstream application design decision. PNG incorporates the remarkable and notable advantages of both JPEG and GIF roles. This is a vital qualification between GIF and PNG, as GIF images will combine the most impressive of 256 colours.

- BMP

It can be professed and pronounced as "knock," "B-M-P" or "bitmap picture"[10]. BMP is a routinely used raster sensible arrangement for storing image data. It was introduced on the Microsoft Windows level in mid-1990. The BMP architecture stores shading details for every pixel in the image without compression. JPEG and GIF setups are both bitmaps, but they use compression algorithms that can reduce their storage capacity. BMP photos and photos are commonly used for printable images.

- TIF

TIFF stands for "Tagged Image File Format" and is a graphic file format for handling colour depths ranging from 1-bit to 24-bit [8]. Since the key TIFF standard has been shown, people have made a lot of small changes to the programme, but there are actually about 50 TIFF concept numerous sorts. What a great deal for a widespread arrangement. As of late, in spite of its limited record size and Internet resemblance, JPEG has been the most popular all-inclusive configuration.

1.2 TRANSFORM CODING

Transform based image coding is a statistical process that is a technique for separating and overcoming the dependency of image data such that quantization and entropy coding can be implemented quickly and efficiently. Subsequently, image compression can be accomplished by reducing or removing any loss in the input image, which typically contributes to bit savings.

Figure 1.1 displays a transform-based image compression model. It consists of a mapper, a quantifier and an encoder.

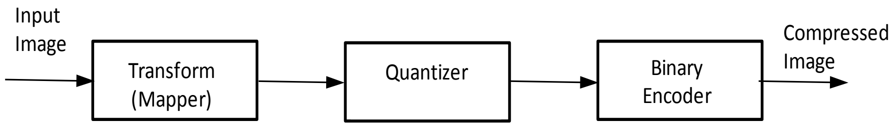

Fig 1.1 Block Diagram of the Image Compression

- Mapper

A mapper translates a two-dimensional (2-D) representation from a spatial domain to a frequency domain. In other terms, it decreases interpixel loss of the input signal. Usually, this process is reversible. Successful transformation can focus valuable knowledge into a few low-frequency transformation coefficients. The HVS is more susceptible to low spatial frequency energy than to high spatial frequency.

- Quantizer

Compression can be accomplished by quantifying the coefficients such that significant coefficients (low-frequency coefficients) are transferred and the excess coefficients are eliminated. The quantifier is used to reduce the psycho-visual loss of the input image. This process is not reversible and it must be excluded if a lossless compression is necessary.

- Entropy encoder

The entropy encoder is used to construct a fixed or variable-length code to represent the output of the quantifier and to map the output according to the code. A variable-length code is used in most situations. This is a reversible operation.

- Transform Techniques

There are several types of transform picture such as the discrete Fourier transform (DFT), the discrete sine transform (DST), the discrete cosine transform (DCT), the Karhunen-Loeve transform (KLT), the Slant transform, the Hadamard transform and the discrete wavelet transform (DWT). For compression purposes, the higher the energy compaction capacity, the easier the transition. Although the transformation of KLT is better in terms of energy compaction (transform coding gain), one downside of the transformation of KLT is that it is data based and the overhead propagation of the transformation will minimise the encoding gain. Another common transformation is the discrete transform cosine (DCT)

Offering turn coding benefits that are similar to KLT and higher than DFT [11]. In addition, the computational complexity of DCT is smaller than that of DFT. Due to these purposes, DCT is now the most commonly used transformation coding technique in JPEG. The DCT-based image coder generates block artefacts at a high compression ratio, which is why DWT is recommended for JPEG-2000.

1.3 IMAGE COMPRESSION AND CODING MODELS

Objectively speaking, pictures and images are two-dimensional information obtained from the human visual system (HVS). At the moment where the film is digitised, this becomes a visual image. The most fundamental prerequisite for digital image compression is the digitization of an image object (or merely an image) such as a physical image, a text page, and so on. The digitization of the image requires two methods, sampling and quantification. The sampling method maps the physical image to the pixel array by spatially sampling points of the physical image. On the other hand, the quantization method requires a finite number of bits to represent each pixel.

Quantization is the method of transforming a constant set of values to a finite range of discreet values. In other words, quantization is the method of mapping a large number of input values to a smaller (countable) number.Digital image quantization is the method of deciding which portions of the image coefficients can be eliminated or discarded of in order to strengthen with minimum qualitative losses. Image quantization is inherently lost, though, i.e. the image quality is decreased due to the lack of certain data. This is normally achieved through a method of rounding, truncation, or some other permanent, nonlinear method of degradation of information. Quantization is a critical prerequisite to digital processing, since the image strength must be interpreted with a finite precision (limited by word length) in every digital processor. Quantization can usually be categorised as Scalar Quantization (SQ) and Vector Quantization (VQ). In SQ, input is processed separately to produce output, while in V Q, inputs are clustered together into vectors and processed for output.

- Scalar Quantization

Scalar quantization is the method of transforming the constant value of observations to one of several distinct values by means of a non-invertible function. It is a single-symbol approach for the loss coding of an information source with real-value outputs [9]. A scalar quantifier followed by variable-length lossless coding (entropy coding) will work amazingly well, making this approach common in applications where implementation complexity is a key factor.

Vector quantization (VQ) is built on the idea of the block of meant to represent the code. It's a fixed-to-fixed length algorithm. A VQ was nothing but an estimate. The principle is close to that of "rounding-off" (say, the nearest integer) [9]. The vector quantization output is also lost. The output of the VQ is usually specified in terms of the signal-to-distortion ratio (SDR):

$$\mathrm{SDR} = 10\log_{10}\left(\frac{\sigma^2}{\mathrm{D_{ave}}}\right) \text{ in dB} \qquad (1.1)$$

Where $\sigma^2$is the root variance, and D_{ave} is the average squared-error distortion. The higher value of the SDR means that the output of the compressed image is greater.

- Quantization for DCT

Quantization is accomplished by dividing each element in the transformed image matrix D by the corresponding element in the quantification matrix, and then scaling to the closest integer value. Quantization is carried out according to the given formulas:

$$C_{i,j} = round\left(\frac{D_{i,j}}{Q_{i,j}}\right) (1.2)$$

Where $C_{(i, j)}$ is the quantized variable, $D_{(i, j)}$ is the DCT coefficient, and $Q_{(i, j)}$ is the value of the quantization table. The quantified values are rounding off and then standardised by the phase scale of the quantizer. The higher the quantization coefficient, the more data is lost. Due to the scaling, a number of 0's can be obtained and the resulting coefficients contain a large amount of duplicate information. Figure 1.2 displays the DCT-based transform with a quantifier at the middle of the coding method.

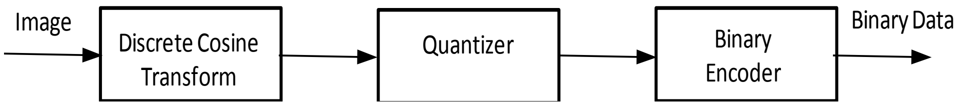

Figure 1.2 DCT based transform coder

The Huffman binary coder or variable entropy coder will remove the redundancies*, resulting in smaller JPEG data.

- Quantization for DWT

After introducing the Discrete Wavelet Transform (DWT) forward to the 2-D graphic, the wavelet coefficients are quantified by either a scalar or vector-based methodology which is shown in the following block diagram of the DWT-based transform coder (Fig 1.3).

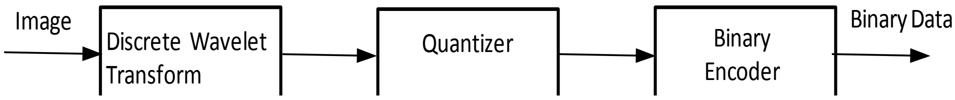

Figure 1.3 DWT based transform coder

The quantization process reduces the precision of the coefficients. In JPEG2000 standard, a scalar quantizer is used and it is defined as:

$$q_b[n] = sign(y_b[n])\left\lfloor\frac{|y_b[n]|}{\Delta_b}\right\rfloor \quad (1.3)$$

Where Δ_b is the quantization phase number, and $y_b[n]$is the transformation coefficient for subband b. The quantization phase is lost unless the coefficients are integers as generated by the LeGall 5/3 tap philtre. In the event that the coefficients are integers, the quantization step size is set to 1, which ensures that no quantization is carried out and the coefficients remain constant.

II. LITERATURE REVIEW

This chapter introduces the state-of-the-art literature survey on the design and creation of lossless and lossless compression techniques for biomedical images in general and performance analysis in particular. Image compression is one of the most effective, prevalent and unavoidable fields of research in the field of image processing and wavelet is a cutting-edge technology. A wide range of image coders have been introduced by scholars, educators and scientists worldwide over the last three decades. This literature survey is divided into nine subcategories, such as transform-based compression and wavelet coding for biomedical applications and performance analysis of the new coders, etc. This in-depth literature study and review would be valuable and helpful not just for applications for image processing, but also for research scholars interested in knowledge of the performance analysis of medical image compression using wavelet technologies and methodologies.

Poon et al.(2015) observes that there has been a rising appetite for radiological services over the last few years and a rising movement for the adoption of medical imaging through hospitals worldwide. Medical imaging technology consist of a variety of modules, including PACS (Picture Archiving Communication Systems), RIS (Radiology Information Systems) and HIS (Hospital Information Systems), which are usually connected and interfaced by a computer network. He concluded that the application of the technical components of medical imaging, in particular digital imaging, and PACS / RIS was very costly [12].

Effective compression algorithms have been proposed and used for the past two decades to reduce transmission time and storage costs. Quality assessment of medical image compression is a crucial process for delivering cost-effective services to common men in the healthcare industry.Motivation for the investigation of the proposed thesis is that image quality assessment is still an unresolved issue today[13].New experiments using certain elements of the HVS report have been relatively effective in quantifying certain forms of distortion based on subjective ranking. This topic continues to grow and has attained a certain degree of sophistication within the multimedia networking and multimedia computing community[14].

IT is well accepted that cloud storage is available on demand and offers versatile and scalable computing services from remote locations to store, process and exchange data without significant capital expenditures [15]. Due to the intrinsic properties of cloud computing, such as increased scalability, easier rollout and more stability, companies in a variety of sectors have chosen to pursue their market adventures on a cloud network in a cost-effective manner [16]. Since teleradiology companies operate with a large number of images across different advanced modes, it is important for them to store, exchange and migrate images on a cloud-based infrastructure to optimise their benefits. Nowadays, the majority of hospitals are going towards filmless imaging and are entirely automated, allowing the Image Archiving and Communication System (PACS) to minimise file sizes on their storage requirements while retaining the necessary diagnostic information [17].

As a matter of fact, digital images typically involve large quantities of spatial and spectral redundancy. Spatial redundancy is due to the similarity of neighbouring pixel values, and spectral redundancy is due to the similarity of various colour planes. Image compression (coding) techniques minimise the number of bits needed to represent the image by taking full advantage of these redundancies [18]. The inverse process called decompression (decoding) is applied to the compressed data to obtain a reconstructed image. The aim of image compression is not only to preserve the storage area, but also to keep the resolution and visual consistency of the restored image as similar as possible to the original image [19].

Many image coders have been designed, developed, built and used over the past two decades, and each method has its own merits and demerits[20].Shapiro suggests an EZW (Embedded Zero-tree Wavelet) algorithm in 1993 and the complexity of the proposed is not high and the streaming is embedded. It is easy to monitor the compression ratio and to achieve scalable coding [21]. Said and Pearlman introduced a new method of efficient improvement in 1996, namely SPIHT (Set Partitioning In Hierarchical Tree) using a spatial path tree [22]. This approach reveals an effective and reliable wavelet coefficient of zero tree structure, which improved compression performance and decreased coding complexity [20]. It's James Walker et. Al (2002) implements the Wavelet Difference Reduction (WDR) encoder in 2000 and the improved version of WDR is renamed the Adaptively Scanned Wavelet Difference Reduction (ASWDR) encoder in 2001 for an image compression system that is very powerful and fast as of the date [23].

Any of these methods are transform coding, vector quantization, fractals, or sub band / wavelet coding for the elimination of psycho-visual and predictive image loss [16]. It is well known that image quality measurement plays a key role in many multimedia computing and connectivity applications in general and biomedical applications, in particular that each compression technique creates artefacts, producing blocky, distorted, patchy or muddy images. Automated quantitative measurements are also often proposed for the research and measurement of different imaging compression methods or equipment. However, the aim and intent of the quality metric is simple to measure and able to quantify all forms of image artefacts.

Several approaches have been proposed in the literature to attempt to address the limitations of quantitative interventions. The well-known and classic quality management work for image systems is outlined here. Wang et al.(2004) propose how Image quality measurement can be calculated from error visibility to structural similarity [24]. Oh, Wang and A. In their research paper, C. Bovik (2004) explains why image quality evaluation is so difficult, particularly in the multimedia domain. These metrics produce consistency outcomes in compliance with human judgement, and include the incorporation of the key features of the Human Visual System (HVS).

An objective measurement of the image or video content is based on different parameters for the determination of an objective quality score. Eskicioglu et al. (1995) suggest a systematic guide to image quality measurements and their output based on a quantitatively based approach. Rehman et al. (2011) propose how the reduced reference image consistency measurement by the Structural Similarity Estimate (SSIM) can be used for still images and video applications. Seshadrinathan et al. (2010) performed a review on the subjective and objective content evaluation of video based on the structural resemblance index and found that SSIM yields better results than the PSNR or MSE index [25]. Grgic et al. (2001) experimentally illustrate the consistency measurement of image compression efficiency using wavelet techniques.

Several versions of the original model can be found in the literature with regard to data fidelity and compressed image. Many of the suggested quality management techniques in the literature are error-based methods. There are a number of prominent reviews of the quality metrics of the picture. In specific, Kim et al. (2010) present an in-depth survey of a variety of consistency metrics specifically related to mathematically based metrics [26]. Eckert et al. (1998) elucidate a valuable discussion of a variety of visual variables that could be integrated into a perceptual metric evaluation to forecast picture quality.

Sakrison (1977) suggested an image quality scale and offered an interactive vision for image coding applications. Tulu et al. (2008) intimate how to perform an observational analysis of quantitative and subjective video quality for internet-based telemedicine [27]. Oh, Lukas and a. (1982) propose a picture quality forecast based on a visual paradigm for still photographs and video coding applications.Kunt et al.(1979) recognise the strategies of second-generation image-coding and point out an emperor formula for the consistency measurement of video-coding. Miyahara (1988) provides consistency evaluations for visual support, covering only the fundamentals of the image evaluation. Value calculations are typically rendered using the digitised image pixel components. A continuous field of image can be created by two-dimensional interpolation of the pixel matrix for a more accurate assessment. Image quality metrics have been described in either the spatial or the frequency domain. Two-dimensional discrete wavelet transformation is a standard method for frequency domain analysis.

It is obvious from the literature survey that lossless image compression, encoding time and algorithm complexity are too high. A powerful hybrid algorithmic approach to medical image compression based on the Discrete Wavelet Transform (DWT) and an effective variable entropy encoding is proposed to address these difficulties. Second, the characteristics of current algorithms are closely researched and find that the trade between the compression ratio and the image quality is either examined or evaluated on the basis of various wavelet philtres, the number of decompositions, the image value and the statistical analysis of medical pictures. Third, the study work further explores, discusses and describes the numerous state-of-the-art Gray Image Consistency Measurements and their application to the Medical Image Compression System[28].

Effective compression algorithms have been proposed and used for the past two decades to reduce transmission time and storage costs. Quality assessment of medical image compression is a crucial process for delivering cost-effective services to ordinary men in the health care industry. In the above-mentioned literature review, we have found that image quality estimation is still an unresolved problem today. New experiments using certain elements of the HVS report have been relatively effective in quantifying certain forms of distortion based on subjective ranking. This topic continues to grow and has attained a certain degree of sophistication within the multimedia networking and multimedia computing [29].

III. RESEARCH MOTIVATION AND DISCUSSION

Despite rapid progress in mass storage density, processing speed and digital communication system efficiency, the demand for data storage and data transmission bandwidth continues to exceed the capacities of available technologies. Extensive efforts have therefore been made to establish accurate compression techniques that offer cost-effective solutions for the storing and delivery of visual knowledge for therapeutic and medical applications.

One of the problems and actual concerns for health care organisations and hospitals is the collection and transmission of vast amounts of medical images across small bandwidth network configurations for utility computing. Image compression strategies have improved feasibility not only by reducing the need for bandwidth, but also by supplying cost-effective imaging images for primary diagnosis.Image compression thus plays a crucial role both in saving memory space and in transferring such a vast amount of data across the globe via compressed format. As a matter of fact, medical image compression is one of the most successful research areas in the world, not just for computer science and medical practitioners, but also for ordinary men, for the cost-effective delivery of patient care.

There are different procedures and techniques used for image compression in both loss and lossless situations. Despite the fact that lack of compression gives a high compression ratio, the accuracy of the restored image is low and cannot be used for medical purposes due to the adverse effects of diagnosis and legal proceedings. Researchers around the world are now trying to reach a high compression ratio and improved picture quality for telemedicine.The purpose and objective of the compression algorithm is to optimise the compression ratio and decrease the average square error of the image.

In the light of these and other considerations, the data compression and resources needed in this area are the backbone of these applications. Be it as it might, image compression is not an easy task, as it has its own hardness and limitations. Computational sophistication, computing time, resource usage and storage area are among these problems and difficulties. This proposal follows on from past issues in order to provide an effective hybrid algorithmic approach to data transformations used in image and video compression systems, especially as these issues become critical for multidimensional signals, such as medical images and video streams for the cloud platform.

IV. PROPOSED METHOD

The Spatial-Orientation Tree Wavelet (STW) algorithm is a updated version of SPIHT image coder proposed by Said et al. [21] in 1993. The decomposition of the wavelet image provides a hierarchical data structure for the representation of images with each coefficient corresponding to the spatial area in the image. A spatial orientation tree is characterised as a tree with a structured set of coefficients beginning at one of the directional bands (i.e. LH, HL, and HH) at any level. The three immediate descendants of each LL band coefficient are tree roots of three full-profile spatial orientation trees These three trees bear high-frequency information in three distinct longitudinal, vertical and diagonal directions of the corresponding spatial area. We call it a full depth spatial orientation tree when the tree root starts at the highest level of the directional bands.The STW coder performance is based on three concepts: partial ordering of the transformed image by magnitude, transmission of coordinates via a subset partitioning algorithm, and exploitation of the hierarchical structure in the subband transformation.

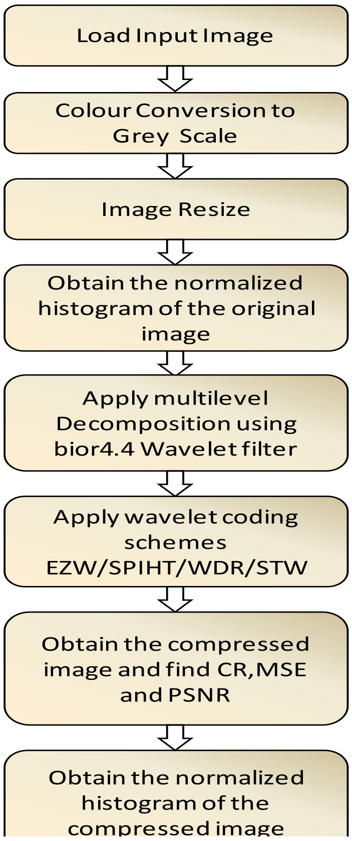

Fig 4.1 Flow Diagram of the proposed method for evaluation of state of the art coder

V. CONCLUSION

In the literature survey, it has been stated that the majority of hospitals and health care organisations are moving towards filmless imaging and digital photography, allowing the Picture Archiving and Communication System (PACS) to minimise file sizes on their storage requirements while retaining appropriate diagnostic information. In this study, we have shown, modified a cross-breeding method to deal with the use of the wavelet transformation in the field of the medical image compression method. Owing to the introduction of the JPEG-2000 standard for still images, the transformation of wavelets has become a critical and inevitable technique for image compression. Wavelet-based coding technology offers considerable improvement and dramatic change in image quality at high compression ratios, primarily due to enhanced energy compaction properties of wavelet transformations. The wavelet transformation is also a de facto statistical technique used primarily for the study of signals in both the time and frequency domain.

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