Region of Interest-based Hybrid Compression Technique for Medical Images

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under the Supervision of

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Certificate

This is to certify that project report entitled "***Region of Interest-based Hybrid Compression Technique for Medical Images*** "submitted by *Ashish Parmar* in partial fulfillment for the award of the degree of Master of Technology in Computer Science & Engineering to the Jaypee University of Information Technology, Waknaghat, Solan has been made under my supervision.

This report has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date:

Supervisor's Signature

Dr. Pardeep Kumar

Associate Professor

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Date:

Signature:

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Abbreviation and Symbols

EHR	Electronic Health Record
MRI	Magnetic Resonance Imaging
CT	Computed Tomography
US	Ultrasound
ECG	Electrocardiogram
EEG	Electroencephalogram
JPEG	Joint Photographic Experts Group
PSNR	Peak Signal-to-Noise Ratio
SVD	Singular Value Decomposition
WBCT	Wavelet-based Contourlet Transform
BAT	Binary Array Technique
CR	Compression Ratio
SPHIT	Set Partitioning in Hierarchical Trees
WDCT	Warped Discrete Cosine Transform
ROI	Region of Interest
NROI	Non-Region of Interest
MIW	Medical Image Watermarking
MRP	Minimum Rate Predictors
TIFF	Tagged Image File Format
SIMM	Structure Similarity Index
HOP	Hierarchical Oriented Prediction
HEVC	High-Efficiency Video Coding
PET	Positron-Emission Tomography
WHT	Walsh Hadamard Transform
HWT	Haar Wavelet Transform
PSO	Particle Swarm Optimization
RLE	Run Length Encoding
VOI	Volume of Interest
CHNN	Competitive Hopfield Neural network
MSE	Mean Square Error
BPP	Bits Per Pixel

SC	Structural Content
PRD	Percent Rate of Distortion
CC	Correlation Coefficient
SNR	Signal to Noise Ratio

Abstract

In this world of evolution, medical technology is evolving day by day and with the more use of medical imaging in clinical practices, digital information is increasing rapidly. So, for the effective storage and transmission of this digital information, there is a need for data compression. In past years, a variety of compression techniques are reported by many researchers for the effective compression of medical images and information. In this work, we presented a review of these compression techniques with the proper classification of these techniques, their performance parameters and their advantages in the field of the medical image compression. After reviewing a variety of papers, selected a mechanism which is the mixture of the region of interest and a combination of transforming techniques for the compression of the medical images. the implementation of the work is simulated in MATLAB environment. It is showed that the presented region of interest-based hybrid technique shows effective and efficient results.

CHAPTER 1

1. Introduction:

In this Modern era, the population is increasing rapidly, due to which the consumption of the resources and the generation of digital data is growing day by day. In earlier days, the most of the medical imaging test is carried out over the radiological films, but now all of the tests are carried out digitally because of the evolution and the improvement in the medical technology which increases the quantity of digital medical data in last few decades. Nowadays, the electronic health record (EHR) systems are adopted by nearly 84 % of the hospitals as per the report of the office of the National Coordinator for Health Information Technology (ONC). EHR systems are able to store every possible digital information such as demographic information, diagnoses, laboratory tests, radiological images, and clinical notes, results and prescriptions of the patient related to its treatment. In medical field, the generation of the digital data in the form of Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Ultrasound (US), Electrocardiography (ECG), Electroencephalograph (EEG), X-rays and Mammograms, etc. are increasing rapidly, so there is a need for the effective storage and the transmission of this digital data. So, most of the researchers are working in the domain of medical healthcare to provide effective and efficient compression techniques so the size of the digital data can be reduced without compromising its quality for the efficient storage and transmission. The compression methods are able to process a large set of images or volumetric data for the fast interactivity, searching context dependent images and for quantitative analysis of the data. The performance of the compression approaches must a good so that, they are able to tackle the limitation of the bandwidth usage and storage. The researchers reported a great number of techniques for the compression of medical images and these techniques are mainly classified into three main categories: lossy, lossless and hybrid compression techniques. The lossy compression is the mechanism which compresses the image with loss of data whereas in lossless there is no loss of the data hence this mechanism used when the information is critical and no loss is acceptable i.e. it is widely used for the medical image compression. Hybrid compression techniques consist of two or more compression techniques to achieve the effective compression of the image. In lossless compression, the image we get after the compression is identical to the original image but in lossy compression, there is degradation of the quality of the image after compression. The major purpose for the designing of these compression techniques is to compress the images with best possible visual quality, reduced size and no or little loss of the information. The compression techniques have a wide range of applications because of the effective and efficient results, the compression techniques can be applied to the areas of the genetics, satellite imaging, medical imaging and many more. Fig 1 represents the various application areas of the compression techniques.

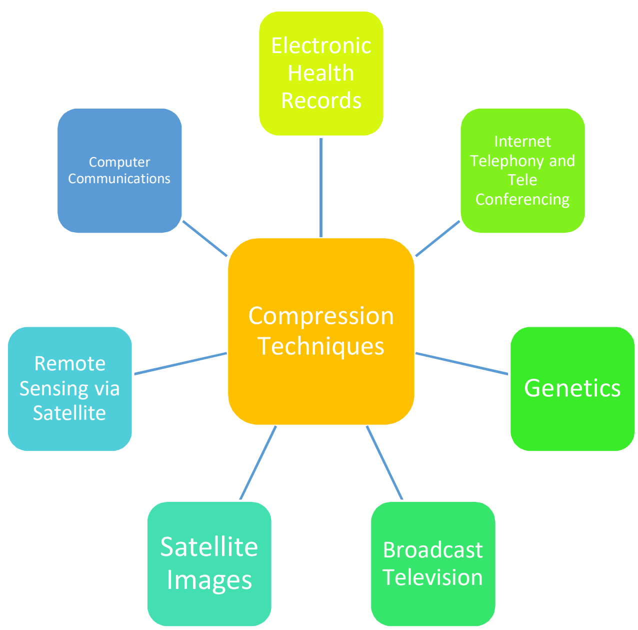

Fig 1: Various application areas of the compression techniques

1.1 Literature Survey:

This section describes the recent literature survey on medical image compression techniques. The whole literature can be categorized into four subsections lossy, lossless and hybrid describing each section in an efficient manner.

1.1.1 Lossy Compression Techniques:

Bruylants et al., [5] presented a novel Wavelet-based mechanism that affirms JPEG 2000 with its volumetrically extension. The presented approach enhances the performance of the JPEG2000 for volumetric medical image compression. In this work, generic codec mechanism, directional wavelet transforms and generic intraband prediction mode tested for the wide range of compression settings for the volumetric compression. In this paper, three medical modalities (CT, MRI, and US) are considered to compute the efficiency of the presented approach. In this comparison of the proposed approach is made with the latest video codec and it is concluded that the use of directional wavelet transform is effortless and generic intraband slightly enhance the compression performance for some specific images. Ayoobkhan et al., [6] presented a new compression mechanism PE-VQ for the lossy compression of medical images. In this approach, artificial bee colony and genetic algorithms are used to compute the optimal results and prediction error and vector quantization concepts are involved in this approach for the effective compression of the images. Here, X-ray images are considered to analyze the experiment and conclude the results. In this paper, the evaluation measures which are used to compare the results are compression ratio and PSNR. It is observed that the proposed technique is able to achieve better PSNR for a given compression ratio in comparison to the other algorithms. Rufai et al., [7] described a novel lossy compression technique for the medical image compression. The reported approach comprises of singular value decomposition (SVD) and Huffman coding. So, firstly SVD is applied over the image to decompose it and reduce the rank after the decomposition, at last, the Huffman coding is applied over the reconstructed image to compression it. In this paper, MRI modality is referred to compute the experimental results. It is showed that the reported approach is able to provide improved quantitative and Visual results in comparison to the other conventional techniques like Huffman coding and JPEG2000. Selvi and Nadarajan., [8] proposed a 2-D lossy compression technique for the compression of the MRI and CT images. The aimed approach relies on WBCT and BAT. Here, the high-frequency sub-band is decomposed into several directional subbands with the use of WBCT whereas BAT is used to compress the quantized coefficients. Here, the medical modalities (MRI and CT) are used to simulate the experiment and conclude the results. It is concluded that the proposed approach requires less processing time and generate precise output results in comparison to the current wavelet-based set partitioning in hierarchical and embedded block coders. Sriraam and Shyamsunder., [9] introduced a 3D wavelet encoder approach to compress the 3D medical images. Here, the reported approach work is two stages, firstly the encoding can be done with quadruplet wavelet transforms. In this paper, MRI and X-ray modalities are considered to perform the experiment and evaluation of results. It is showed that the 3D Cohen-Daubechies-Feauveau 9/7 and 3-D SPHIT able to provide more adequate and efficient results for the compression of the medical images. Hosseini and Naghsh-Nilchi., [10] described contextual vector quantization for the medical image compression. In this work, the contextual region is encoded with minimal loss of the data and high resolution with the help of the proposed approach (low compression ratio and higher bit rate) and the region other than the contextual can be encoded with minimal resolution using different aspect of proposed approach (High CR and low bit rate), after that both encoded regions can be combined to generate the reconstructed image. Here, the medical modality ultrasound is used to simulate the experiment and conclude the results. It is showed that the reported approach is capable to achieve a higher compression ratio and PSNR in comparison to the other conventional algorithms (JPEG, JPEG2K, and SPHIT). Bairagi et al., [11] reported a text-based approach to compress the medical images effectively. The reported mechanism deals with visual quality rather than the pixel-wise fidelity. Here, the proposed approach utilizes the inpainting and the textual parameters concepts well to provide a better quality of images. In this paper medical images of the brain are used to compute the potency of the projected algorithm. It is concluded that good restoration techniques should be included since medical images should always to be of better visual quality. Prabhu et al., [12] presented 3-D WDCT for the compaction of the MRI images effectively. The presented approach relies on the concept of 2-D WDCT and in this paper, an image coding scheme is used for the large datasets which rely on the concept of 3-D WDCT approach. Here, the efficiency of the proposed approach is compared from the simulation results and it is concluded that the proposed 3-D WDCT is capable to achieve higher PSNR in comparison to 3-D DCT for the higher bitrate operations.

1.1.2 Lossless Compression Techniques

Juliet et al., [13] discussed a novel methodology, which includes Ripplet transform to provide a good quality of the images and achieves high compression rate. In this work, to attain the higher compression rate the images are represented at different scales and directions. In this methodology, MRI images are used to compute the results and compared them with the other state of art technologies. It is demonstrated that the nominated methodology allows for an ampler compression ratio as compared to the other previous techniques and also achieves high PSNR.

Cyriac and Chellamuthu., [14] proposed a Visually Lossless Run Length Encoder/Decoder to solve the expansion problem of the traditional Run Length Encoder/Decoder. In the technique, the run length is collected in the pixel value itself rather than stored separately. Here, medical modalities like CT and MRI are used to compute the results. In this paper, the proposed technique is able to adequately compress the image and also helps in the faster hardware implementation of real-time applications. Brahimi et al., [15] describe a novel compression technique in which the signal and the image both get jointly compressed with single codec. The main focus of this technique is to embed the wavelet-decomposed signal into the decomposed image and the resultant image is used for the compression. In this work, spiral insertion function is used at the insertion stage. In this paper, the natural and medical both images are considered to compute the results. It is evaluated form the observational results that the novel multimodal compression scheme is much effective and superior to the other compared multimodal schemes. Arif et al., [16] proposed an efficient method for the compression of the fluoroscopic images without any loss. The main focus of this work is to enhance the outline of ROI so, there is ease to identify the area and to extract the region of interests form the fluoroscopic images. In this work, the extracted ROI is compressed with a compounding of Run Length and Huffman coding. In this manuscript, concluded results states that the advised methodology provides a compression ratio of 400% in comparison to other conventional techniques. Das and Kundu et al., [17] reported the MIW approach which relies on the concept of ROI. The main direct of this work is to allow for solutions to the multiple problems regarding the medical data distribution like protection, content certification, safe archiving and safe retrieval and transfer of data. The presented technique comprises of the encryption technique and the lossless data compression to insert the image into the metadata. In this paper, seven different modalities are used to depict and compared the results to show that the proposed technique is simple and evident in providing security to the medical database. Lucas et al., [18] presented a novel lossless compression technique 3-D MRP for volumetric sets of medical images. The presented technique relies on the mechanism of MRPs. In this paper, the presented technique uses the concept of a volume base optimization mechanism to process a group of 32 frames. In this work, two medical modalities are referred to conclude the results and these are CT and MRI. In this paper, it is concluded that the presented technique is able to improve the error probability of the MRP algorithm and it attains high compression efficiency over the HEVC and another standard for depth medical signals. Špelič and Žalik., [19] proposed a novel an algorithm coined as segmented voxel compression algorithm to compress 3D CT images and for effective transmission of graphical data obtained from CT scanner. This paper describes that firstly Hounsfield scale is used to segment the medical data and then compression is applied. In this work, a prototype machine is used to compute the efficiency of the aimed algorithm. This work illustrates that the purported approach is competitive to other methods and acts as a good option to store 2D and 3D medical images. Anusuya et al., [20] introduced a novel lossless codec using entropy coder to compress the 3D brain images. In this work, firstly the 3D images are converted into 2D slices and 2D stationary wavelet transform applied on it. After that, embedded block coding is used to compress the decimated coefficient parallelly. The bit streams generated after the embedded block coding were decoded and reconstructed with the help of inverse SWT. In this work, MRI modality was used to analyze the efficacy of the aimed algorithm and this work focus on cutting down the computation time with the use of parallel computing. Xio et al., [21] introduced Integer Discrete Tchebichef Transform to compress a variety of images without any loss of data. In this work, the proposed technique is presented on the basis of factorization of $N \times N$ Discrete Tchebichef Transform into N+1 single row simple reversible matrices with minimal rounding errors. The proposed technique achieved integer to integer mapping for effective lossless compression. In this paper, the medical modalities referred are CT and MRI to evaluate the results and it is concluded that the reported technique is able to accomplish a higher compression ratio than iDCT. Amri et al., [22] presented two lossless compression methods coined as "wREPro.TIFF (watermarked Reduction/Expansion Protocol coupled with TIFF format) and wREPro.JLS (wREPro coupled with JPEG-LS format)". In this work, the presented techniques are used to decrease the image size and encoding algorithms for lossless compression. In this paper, square-square decimation step is used with four expansion algorithms and these algorithms are "Zero-padding", "nearest neighbor interpolation", "cubic interpolation" and "transformed B-Spline". In this paper, two medical modalities (MRI and CR) are referred to compute the observational results of the proposed algorithm. Here, the aimed technique able to preserve the image quality for high compression rates and it also provides various enhancement over conventional JPEG image compression standard. Ramesh and Shanmugam., [23] described the Wavelet Decomposition Prediction Solution for lossless contraction of medical modalities. In this manuscript, the forecasting equation of each subband relies on the correlation analysis. In this paper, the coefficient graphic method is used to compute the predictor variable and to avoid multicollinearity problem. In this work, MRI and CT images are used as modalities to evaluate the experimental results. It is detected from the data-based results that the proposed approach provides higher compression rate as compared to SPHIT and JPEG2000 standard. Ibraheem et al., [24] presented two new lossless compression techniques which rely over the logarithmic computation. The proposed approaches are able to provide enhanced image quality in comparison to conventional DWT. In this paper, the first approach relies on logarithmic number system and the second is the combination of LNS and Linear Arithmetic. In this work, SSIM was used to evaluate the character of the image. In these two medical modalities (MRI and X-Ray) are considered to compute the experiment. It is seen that the computed PSNR and SIMM are quite more upper than the standard DWT and both the approaches attain compression ratio like to WAAVES coder which relies upon classical DWT. Avramovic and Banjac., [25] introduced a novel lossless compression technique in which simple context-based entropy coder is used. The proposed approach relies on the concept of prediction to remove the spatial redundancy in images and effectively compress the images without any loss of data. In this work, two medical modalities (CT and MRI) and two natural modalities are conceived to compute the potency of the aimed approach and the proposed approach is compared with the compression techniques like JPEG2000 and JPEG-LS. It is concluded that the suggested mechanism is able to achieve similar performance for high-quality images as the other standardized algorithms. Bairagi., [26] reported the concept of symmetry for the compression of the medical images. Here, the presented approach is lossless and able to remove the redundant data from the image effectively and efficiently. In this work, the reported concept is collaborated with the existing techniques to conclude the results. Here, medical modalities (CT and MRI) are considered to simulate the experiment and conclude the results. It is showed that the reported approachable to provide lossless compression with no redundant data and better quality of the compressed image. Zuo et al., [27] presented an improved medical image compression approach IMIC-ROI to effectively and efficiently compress the medical images. The proposed technique relies upon the concept of Region of Interest (ROI) and non-ROI regions. Here, the given image is being partitioned into cardinal regions, ROI and non-ROI regions and the lossless compression technique is employed over the ROI region, and wavelet-based lossy compression and image restoration techniques are used over the non-ROI region. Here, brain images (MRI) are used to simulate the experimentation and to conclude the efficiency of the aimed algorithm. It is seen that the presented approachable to achieve higher compression ratio and good values of GSM and SSIM in comparison to other conventional techniques. Srinivasan et al., [28] described a coder for the effective compression of the electroencephalograph (EEG) signal matrix. The mechanism described consists of two stages, firstly lossy coding layer (SPHIT) and residual coding layer (arithmetic coding). Therein work, the EEG signal is converted to 2-d Matrix for the effective compression. Here, the database used to simulate and compare the performance of this mechanism is the University of Bonn database and Mental Imagery database. It is concluded that the 2-stage compression scheme is effective and the concept of pre-processing able to provide 6% improvement and 2 stage yields 3% further improvement in the compression. Taquet and Labit., [29] reported a Hierarchical Oriented Prediction (HOP) approach for the resolution of the scalable lossless and near-lossless compression of the medical images. The reported approach is the combination of DPCM schemes and novel HOP and it is showed that the proposed approach is not usable for the smooth images. Here, medical modalities (MRI and CT) are considered to simulate the experiment and conclude the results. It is seen that the offered mechanism is best used for the near lossless compression since it is able to provide slightly better or equal PSNR for a high bit rate in comparison to the JPEG 2000 standard.

1.1.3 Hybrid Compression Techniques

Mofreh et al., [30] reported LPC-DWT-Huffman, a novel image compression technique to enhance the compression rate. This reported technique is the mixture of the LPC-Huffman and the DWT- Huffman. In this, firstly the LPC transformation is applied to the image and then DWT is applied over the output of the LPC transformation and at last, Huffman is applied to convert the wavelet coefficients. It is seen that the reported technique is able to provide higher compression rate as compared to the Huffman and

DWT- Huffman. Raza et al., [31] presented a hybrid lossless compression technique for medical image sequences. The presented technique uses spatial structure prediction with interframe encrypting to acquire better compression ratio. In this work, firstly spatial structure forecasting technique is used for fast block matching and later the number of bits required for carrying can be reduced and stored in single pixel value with Huffman coding. In this paper, two medical modalities are referred to compute the experimental results. It is observed that the reported technique is able to achieve enhanced compression rate as compared to other existing techniques. Eben Sopphia and Anitha., [32] proposes an improved context-based compression technique for the medical images. The proposed approach relies upon the concepts of wavelet transformation, standardization, and prognostication. In this paper, the proposed approachable to achieve a beneficial quality image in comparison to the master image for the chose context area. In this work, initially 2D wavelet transform is applied on the image to generate the approximate coefficients after that, for the prediction normalization of each subband is be done separately and finally, arithmetic coding is used to entropy-encode the prediction coefficients. Here, medical modalities (MRI, US, and MRE) are used to analyze the proposed technique and compute and compare the results with the other conventional algorithms. Here, observed that the projected technique competent to achieve better functioning quantitively and qualitatively. Parikh et al., [33] described the use of HEVC for medical image compression. In this report, the complexity of high bit-depth and acceptable range of lossy contraction for medical image compression are studied, a novel approach to handle complexities is proposed. In this work, three medical modalities (MRI, CT, and CR) are used to compute the experimental ensues and compared these results with JPEG2000, it is observed that the presented method shows an increase in compression performance by 54% in comparison to the JPEG2000. In this, the author described that HEVC intra encoding complexity can be condensed 55% with a slight increase in file size. Somassoundaram and Subramaniam., [34] reported a hybrid approach in which 2D Bi-orthogonal multiwavelet transform and SPECK- Deflate encoder is used. The main purpose of this approach is to diminish the transmitting bandwidth by compressing the medical data. In this work, 2D Bi-orthogonal multi wavelet approach can be applied over the DIACOM file and the encoding of the coefficients can be done with the help of SPECK encoder. In this paper, GRUSELAMBIX is the dataset considered to compute the experiment and conclude the results of the proposed approach. Here, seen that the projected mechanism is capable to achieve higher compression ratio than other conventional algorithms. Haddad et al., [35] proposed a novel joint watermarking scheme for the medical images. The proposed technique is the combination of JPEG-LS and bit substitution watermarking modulation. In this work, the proposed approach is able to trace the authenticity of the images from the compressed bitstream. In this work medical modality (US) is used to compute the experiment and the efficiency of the proposed algorithm. Here, showed that the intended technique able to provide the same watermarked images with high-security services in comparison to the other techniques. Perumal and Rajasekaran., [36] presented a Hybrid algorithm DWT-BP for medical image compression. In this paper, the author compare the DWT coding, Back Propagation Neural Network, and hybrid DWT-BP to analyze the performance of the presented approach. In this work, some measures like CR, PSNR, BPP, and MSE are used to make a comparison in the performance of the various and proposed algorithm. In this paper, medical modalities (CT, MRI, and PET) are considered to compute the experiments and analyze the results. It is concluded that the purported hybrid technique is capable to provide better CR and achieves better PSNR. Karthikeyan and Thirumoorthi., [37] describe Sparse Fast Fourier Transform, a hybrid technique for the medical image compression. In this work, the author also compares the proposed technique with the other three compression methods like Karhunen-Loeve Transforms, Walsh- Hadamard Transform (WHT) and Fast Fourier Transform. In this paper, the medical modality (CT) is used to simulate the experiments and conclude the results. In this, the evaluation of the results relies upon the CR, PSNR, Structural Content, and MSE. It is observed that the proposed technique able to provide enhanced and efficient results in all of the evaluation measures in comparison to the author described methods. Thomas et al., [38] reported a hybrid image compression approach for the medical images using lossy and lossless mechanism for the telemedicine application. The reported approach is the combination of Fast-discrete curvelet transform and adaptive arithmetic coding. The primary aim of the purported hybrid approach is to achieve higher CR and less error rate. In this paper, medical modality MRI and ROI technique is used to compute the simulation and conclude the results. Here, seen that the projected hybrid mechanism able to achieve higher CR and having a minus loss of information with the effective use of arithmetic entropy coding. Vaishnav et al., [39] aimed a novel crossbred technique for the lossy and lossless compression of the medical images. The proposed approach is the combination of the dual-tree wavelet transform and arithmetic coding approach. In this work, the dual-tree wavelet is the enhanced version of the discrete wavelet transform and this proposed technique ensures the protection of all image information required for storage and transmission. In this paper, medical modality (MRI) is referred to compute the experiments and the evaluation measures used to compare the results are PSNR, Compression Ratio, and MSE. It is seen that the proposed approach is much effective and efficient than the other conventional algorithms like DWT and SPHIT and able to achieve higher PSNR and compression ratio. Rani and Chitra., [40] reported a novel hybrid technique for medical image compression. The reported approach relies on Haar Wavelet Transform (HWT) and Particle Swarm Optimization (PSO). The principal focus of this work is to compact the images efficiently and transmit data efficiently. In this work, the proposed approach uses the advantages of the Haar, PSO, RLE and Vector Quantization to achieve better compression ratio without reducing the image quality. In this paper, medical modalities (MRI, Mammogram and X-ray) are considered to simulate the experiment and conclude the results. Here, observed that the purported technique is capable to achieve higher compression ratio and PSNR. Abo-Zahhad et al., [4] nominated a new compression technique DPCM-DWT Huffman for the Compression . In this work, firstly the image is pre-used by Differential Pulse Code Modulator and wavelet transform is applied to its output and at last resulting coefficients are encoded with the help of the Huffman coding. In this work medical modality (CT) is referred to simulate the experiment and compare the proposed approach with DPCM- Huffman and DWT- Huffman. It is evaluated from the model results that aimed approach is efficient and achieve a higher compression rate than other techniques. Jiang et al., [41] presented a hybrid algorithm for medical image compression. The presented algorithm relies upon the vector quantization and the

wavelet transforms. The major aim of the projected approach is to compress the symptomatic related information with a high compression ratio. In this work, Huffman coding and vector quantization are used to manipulate the high and low-frequency components. In this paper for the experimental simulation MRI image of the brain is used and the ensues are equated with the different well-known algorithms like JPEG, JPEG2000 and Fractal coding. Here, observed that the intended technique is capable to achieve good PSNR and effective running time in comparison to the other described

Ref.	Technique Used	Compression Type	Method Used	Medical Modality Used	Merits
Ref [30]	Hybrid	Lossless	LPC-DWT-Huffman	Not Mention	Provides Higher Compression Rate
Ref [13]	Lossless	Lossless	Ripplet Transform	MRI and CT	Attains High PSNR and Compression Rate
Ref [14]	Lossless	Lossless	Visually Lossless Run Length Encoder/Decoder	CT and MRI	Provides faster hardware implementation for real-time applications.
Ref [15]	Lossless	Lossless	Wavelet-based multimodal compression	X-ray and MRI	Attains High PSNR and Low Computational Complexity
Ref [16]	Lossless	Lossless	AutoShaped Lossless Compression	Fluoroscopic Images	Provides Higher Compression Rate
Ref [17]	Lossless	Lossless	Fragile Image Watermarking technique	CT, MRI, USG, X-Ray, Barium study and Mammogram	Secure the Medical metadata and archives Lossless compression
Ref [18]	Lossless	Lossless	3D -Minimum Rate Predictor	CT and MRI	Attains High compression efficiency and improves error probability
Ref [19]	Lossless	Lossless	Segmented Voxel Compression Algorithm	CT	Ease of transfer data and Ease of decompress desired data
Ref [20]	Lossless	Lossless	Lossless codec with an Entropy coder	MRI	Reduces the computation time and attains high compression ratio
Ref [21]	Lossless	Lossless	Integer Discrete Tchebichef Transform	CT, MRI and Anatomic Images	Attains High Compression ratio
Ref [31]	Hybrid	Lossless	Super Spatial structure prediction	CT and MRI	Attains High Compression Ratio

			with Inter-Frame coding		
Ref [22]	Lossless	Lossless	wREPro.TIFF and wREPro.JLS	MRI and Computed Radiography	Preserve image quality for high compression rates
Ref [23]	Lossless	Lossless	Wavelet Decomposition Prediction Method	CT and MRI	Avoids Multicollinearity problem and Provides higher compression rate
Ref [24]	Lossless	Lossless	LNS-DWT and Logarithmic DWT	MRI and X-Ray	Provides High PSNR and SIMM
Ref [25]	Lossless	Lossless	Predictive Lossless compression	MRI and CT	Simple approach and able to achieve the same performance as other standardized algorithms
Ref [5]	lossy	lossy	Generic codec Framework (JP3D)	CT, MRI, and US	JP3D Does not suffer from ambiguity problems
Ref [32]	Lossy and lossless	Lossy and lossless	Normalized wavelet transformation	MRI, US, and MRE	Attains Good PSNR in low bits and high Bits
Ref [33]	Lossy and lossless	Lossy and lossless	High-efficiency Video Coding	MRI, CT, and CR	Increase compression performance, reduced cost, and reduction in complexity
Ref [34]	Hybrid	Lossless	2D Bi-orthogonal multiwavelet transform and Hybrid speck-deflate algorithm	Angiogram sequence	Achieves higher compression ratio
Ref [35]	Hybrid	Lossless	JPEG-Ls and Bit substitution watermarking modulation	US	Provides better security services

Ref [36]	Hybrid	Lossy and lossless	Hybrid DWT-BP	MRI, CT, and PET	Provides better compression ratio and archives higher PSNR
Ref [37]	Hybrid	Lossy and lossless	Sparse Fast Fourier Transform	CT	Achieves higher compression ratio, Structural content, and PSNR
Ref [38]	Hybrid	Lossy and lossless	Fast-Discrete Curvelet with adaptive arithmetic coding	MRI	Achieves higher compression ratio and less loss of information
Ref [39]	Hybrid	Lossy and lossless	Dual-tree Wavelet transform and arithmetic coding	MRI	Achieves better PSNR and compression rate
Ref [40]	Hybrid	Lossy and lossless	Haar Wavelet Transform and Particle Swarm Optimization	MRI, Mammogram, and X-ray	Attains higher PSNR and Better compression rate
Ref [4]	Hybrid	Lossless	DPCM-DWT-Huffman	CT	Achieves Higher compression rate
Ref [6]	Lossy	Lossy	PE-VQ compression method	X-ray	Achieves higher PSNR for a given CR
Ref [7]	Lossy	Lossy	Singular Value Decomposition and Huffman Coding	MRI	Achieves Better Visual and quantitative results
Ref [8]	Lossy	Lossy	WBCT and BAT compression method	MRI and CT	Less processing time and precise results
Ref [26]	lossless	Lossless	Symmetry-based compression	CT and MRI	No -redundant data and better quality of the image
Ref [9]	Lossy	Lossy	3D wavelet encoder	MRI and X-Ray	Provide Higher PSNR

Ref [32[	Hybrid	Lossy and lossless	Vector Quantization and wavelet transform	MRI	Achieves Higher PSNR and effective Running time
Ref [10]	Lossy	lossy	Contextual Vector Quantization	US	improved visual quality and ease for transfer of data
Ref [11]	Lossy	Lossy	Text-based mechanism	Brain images	Enhanced visual quality
Ref [42]	Hybrid	Lossy and lossless	Optimized Volume of Interest (3-D Integer Wavelet transform and EBCOT)	MRI and CT	Effective reconstruction quality
Ref [27]	Lossless	Lossless	Improved Medical Image Compression (IMIC-ROI)	Brain images	Achieves Better compression ratio
Ref [28]	Lossless	Lossless	2 stage Coder Mechanism	EEG	Improves compression performance
Ref [29]	Lossless	Lossless	Hierarchical oriented Prediction	CT and MRI	Better PSNR on Noisy images
Ref [43]	Hybrid	Lossy and lossless	Improved watershed transforms and vector quantization with competitive Hopfield neural network	Mammogram	better reconstruction and quality of the mammogram
Ref [12]	Lossy	Lossy	3-D Warped Discrete Cosine Transform (WDCT)	MRI	Attains High PSNR for higher bit rate

Table1: List of paper reviewed in this survey with proper specification and description.

algorithms. Sanchez et al., [42] described a new mechanism for the compression of the 3-D medical images with the Volume of Interest (VOI) coding. The proposed mechanism relies upon the concepts of modified EBCOT and 3-D integer wavelet transform to create a single bit stream. In this work, the proposed mechanism uses the optimal technique since due to which output bit-stream after encoding reorders and the bits which belong to the VOI are decoded with the best possible quality and any possible bit rate, the other left bits are decoded with increasing quality nearer to the VOI area. Here, the medical modalities (MRI and CT) are included to simulate the experiments and get the results of the proposed mechanism. It is observed that the proposed approachable to achieve better reconstruction quality in comparison to the 3-D-JPEG2000 and MAXSHIFT with VOI coding. Hsu., [43] proposed a mechanism to separate the tumor from the mammogram with the help of improved watershed transform with prior information. The goal of the proposed mechanism to efficiently compress the mammogram without compromising the quality of the required region. Here, the work is to be done in two stages, firstly segmentation is to be done with canny edge detector and improved watershed transform to generate segments as tumor, breast without tumor and back off and later in second stage vector quantization with CHNN is employed over the three segments with varying compression rates so that important regions get compressed effectively. It is showed from the experimental results that the proposed mechanism reconstructs effectively and efficiently in the application of mammogram compression.

CHAPTER 2

2. Problem Description:

In this manuscript, a large and great variety of contraction techniques are explored for medical image compression. These proficiencies are able to provide significant results but some of the open issues in the area of medical image processing are:

1. In this work, some of the compaction techniques are able to achieve a higher compression rate but much complex in nature and have efficiency and optimization issues.
2. Here, some of the techniques are much efficient and effective but consumes a large amount of time which is a matter of concern.
3. In Medical compression, watermarking techniques are able to compress the images but not able to preserve the quality of it.
4. This work depicts that most compression techniques use MRI and CT as their modalities but some of these techniques are only able to work on CT and MRI, not on other medical modalities.
5. In lossy compression, the background noise removal techniques should be improved for the effective and efficient compression.
6. In Region of Interest compression, the AutoShaping is done manually by the physician i.e. chances of error should be there.
7. Minimal the loss of the critical data
8. Enhance the data transmission speed and efficient storage of electronic health records.
9. High compression rate of the compression technique during compression.

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2.2 Proposed Solution:

In order to solve some of these troubles, we planned to propose a novel crossbreed technique which is the compounding of the region of interest and Two transforming techniques and a lossy compression technique. The proposed model will be able to achieve a higher compression ratio, better visual quality and reduced size for effective transmission.

CHAPTER 3

3. Methodology:

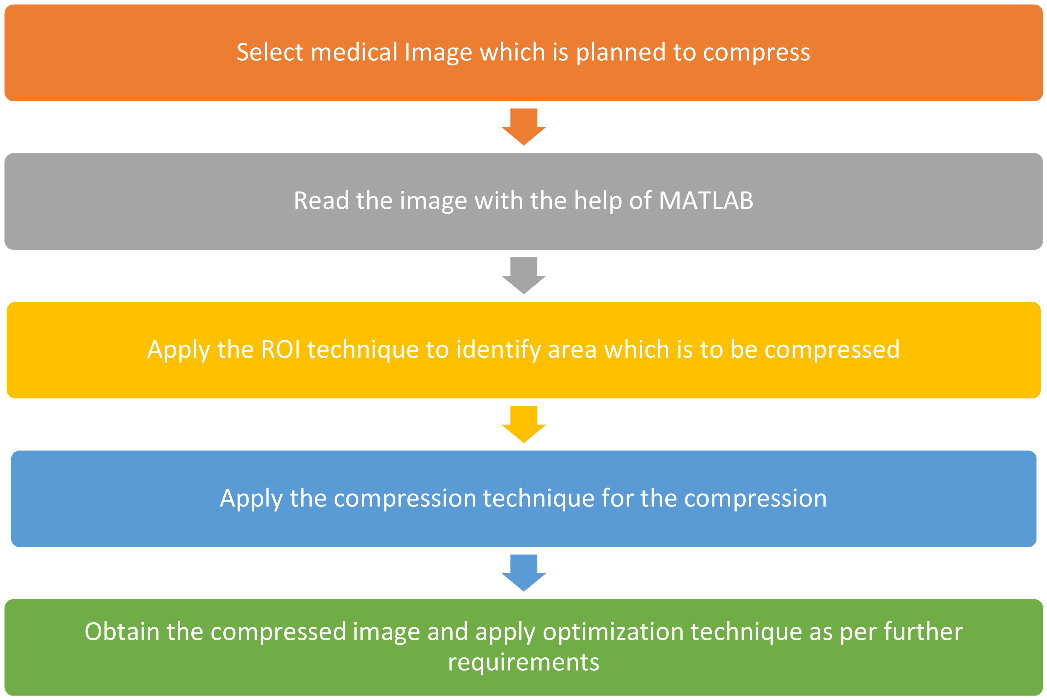


Fig 2: Methodology of the Project

3.1 Performance Parameters:

In this work, the compression techniques use a wide number of performance measures to compute their efficiency and performance. The metrics used to compute the performance are:

1. **Peak Signal to Noise Ratio (PSNR):** PSNR is determined as the ratio of the maximum pixel intensity to the mean square error [4]. The formula used to compute the PSNR is represented as Follows

$$\text{PSNR}= 20log(\frac{2^B-1}{MSE})dB$$

…... (1)

Here, B is the number of bits and MSE is the mean square error

2. **Compression Ratio (CR):** Compression ratio (CR) is the proportion of the size of the master image to the size of the compressed image. It can be computed as

$$CR= \frac{Size\ of\ the\ original\ image}{Size\ of\ the\ compressed\ image}$$ …… (2)

3. **Mean Square Error (MSE):** MSE is the description of the accumulative squared error between the compressed image and the archetype image [37]. It can be computed with the use of the following formula

$$MSE=\frac{1}{MN}\sum_{j=1}^{M}\sum_{K=1}^{N}\left(X_{j,k}-X'_{j,k}\right)^2$$

……. (3)

Here, M and N are digital image dimensions.

4. **Structure Similarity Index (SSIM):** SSIM is used to mount the tendency of resemblance between the original image and the compressed image [32]. The formula used to find SSIM is:

$$SSIM=\frac{(2\mu_f\mu_{-f}+C_1)(2\delta_{f-f}+C_2)}{\left(\mu_f^2+\mu_{-f}^2+C_1\right)\left(\delta_f^2+\delta_{-f}^2+C_2\right)}$$

…….(4)

Here, f is the original image, -f is the reconstructed image C_1 and C_2 are the constants, μ is the average gray value and δ is the variance.

5. **Bits Per Pixel (BPP):** BPP is defined as the proportion of the total size of the compressed image to the full number of the pixel in the image [36].

$$BPP=\frac{Size\ of\ the\ compressed\ image}{Total\ no.\ of\ Pixel\ in\ the\ image}$$

……(5)

6. **Signal to Noise Ratio (SNR):** SNR can be defined as the ratio of the signal power to the noise power. It is measured in dB and can be computed as

$$SNR= 10log\left\{\frac{\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}[f(i,j)^2]}{\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}[|f(i,j)-f^*(i,j)|^2]}\right\}$$

…….(6)

7. **Percent rate of distortion (PRD):** it is the measure of the distortion in the reconstructed image. Lesser the value of the PRD the reconstructed image is less distorted [8]. It can be computed with the use of the following formula

$$PRD= \sqrt{\frac{\sum_{x=1}^{M}\sum_{y=1}^{N}[f(x,y)-f'(x,y)]^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}[f(x,y)]^2}}\times 100$$

…… (7)

Here, $M \times N$ represents the size of the image, $f(x, y)$ is the original image and $f'(x, y)$ is the reconstructed image.

8. **Correlation Coefficient (CC):** It is used to describe the existing correlation between the archetype image and the reconstructed image [8]. It can be calculated by,

$$CC=\frac{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)\times f'(x,y)}{\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(f(x,y)\right)^2}\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(f'(x,y)\right)^2}} \quad ......(8)$$

Here, $M \times N$ represents the size of the image, $f(x, y)$ is the original image and $f'(x, y)$ is the reconstructed image

9. **Structural Content (SC):** it is used to depict the comparison between two images inherited in small patches and to determine the images of the common things have [37]. Higher the value of SC poorer the quality of the image.

$$SC=\frac{\sum_{j=1}^{M}\sum_{k=1}^{N} X_{j,k}^2}{\sum_{j=1}^{M}\sum_{k=1}^{N} {X'}_{j,k}^2} \quad .... (9)$$

Here, M and N are the dimensions of the image.

References	Performance Metrices	Formula Representation
Ref [30], Ref [13], Ref [14], Ref [15], Ref [20], Ref [32], Ref [34], Ref [35], Ref [36], Ref [37], Ref [39], Ref [4], Ref [9], Ref [41], Ref [10], Ref [42]	Mean Square Error	$MSE=\frac{1}{MN}\sum_{j=1}^{M}\sum_{K=1}^{N}\left(X_{j,k}-X'_{j,k}\right)^2$
Ref [37],	Structural Content	$SC=\frac{\sum_{j=1}^{M}\sum_{k=1}^{N} X_{j,k}^2}{\sum_{j=1}^{M}\sum_{k=1}^{N} {X'}_{j,k}^2}$
Ref [8], Ref [41], Ref [10]	Correlation coefficient	$CC=\frac{\sum_{x=1}^{M}\sum_{y=1}^{N} f(x,y)\times f'(x,y)}{\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(f(x,y)\right)^2}\sqrt{\sum_{x=1}^{M}\sum_{y=1}^{N}\left(f'(x,y)\right)^2}}$

Ref [30], Ref [4]	Signal to Noise Ratio	SNR= $10log\left\{\frac{\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}[f(i,j)^2]}{\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}[\lvert f(i,j)-f^*(i,j)\rvert^2]}\right\}$
Ref [30], Ref [16], Ref [18], Ref [20], Ref [31], Ref [32], Ref [36], Ref [37], Ref [38], Ref [39], Ref [40], Ref [4], Ref [26], Ref [10], Ref [27], Ref [28]	Compression Ratio	CR= $\frac{Size\ of\ the\ original\ image}{Size\ of\ the\ compressed\ image}$
Ref [13], Ref [17], Ref [22], Ref [24], Ref [32], Ref [33], Ref [34], Ref [39], Ref [40], Ref [27]	Structure Similarity Index	SSIM= $\frac{(2\mu_f\mu_{-f}+C_1)(2\delta_{f-f}+C_2)}{(\mu_f^2+\mu_{-f}^2+C_1)(\delta_f^2+\delta_{-f}^2+C_2)}$
Ref [35], Ref [36], Ref [29]	Bits Per Pixel	BPP= $\frac{Size\ of\ the\ compressed\ image}{Total\ no.\ of\ Pixel\ in\ the\ image}$
Ref [30], Ref [13], Ref [14], Ref [15], Ref [17], Ref [20], Ref [22], Ref [24], Ref [5], Ref [32], Ref [33], Ref [35], Ref [36], Ref [37], Ref [38], Ref [39], Ref [40], Ref [4], Ref [6], Ref [7], Ref [8], Ref [9], Ref [41], Ref [10], Ref [42], Ref [29], Ref [43], Ref [12]	Peak Signal to Noise Ratio	PSNR= $20log(\frac{2^B-1}{MSE})dB$
Ref [15], Ref [8],	Percent rate of distortion	PRD= $\sqrt{\frac{\sum_{x=1}^{M}\sum_{y=1}^{N}[f(x,y)-f'(x,y)]^2}{\sum_{x=1}^{M}\sum_{y=1}^{N}[f(x,y)]^2}}\times 100$

Table 2: Table representing various performance metrics used to compute the performance of the compression techniques

CHAPTER 4

4. Implementation and Experimental Results:

The Implementation Plan of the project can be described best with the following diagram:

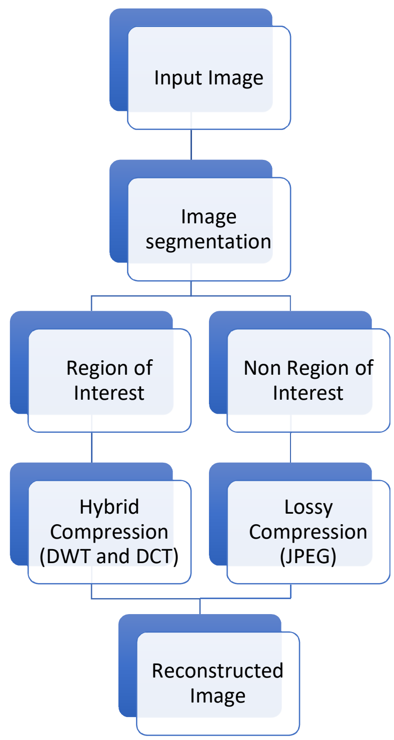


Fig 3: Implementation Plan of the Project

4.1 Proposed Framework:

In this work, we proposed an algorithm which is the combination of ROI and compression techniques. Here the medical modalities such as CT, MRI, etc. can be divided into two categories according to the importance of the region by a classified physician. The region of medical modality used to investigate the case is concerned to as the ROI and the remaining another part of the medical modality is referred to as the NROI.

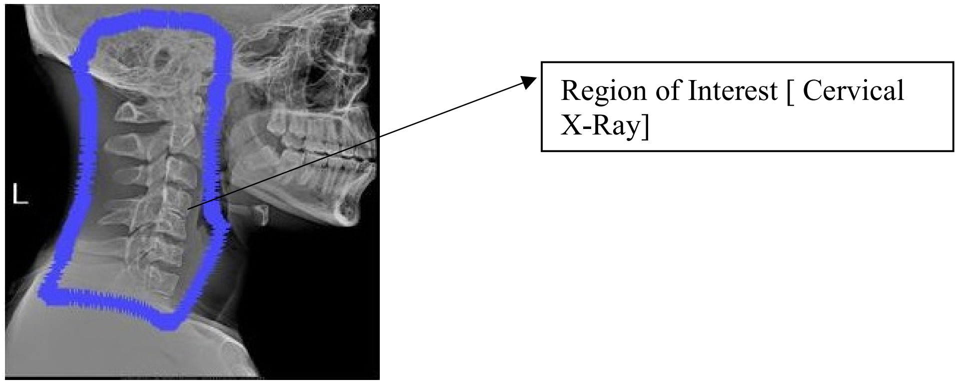


Fig: 4 Cervical X-Ray

The above figure depicts the lateral section of cervical x-ray, the selected blue area is termed as the ROI region and the other area of the image is the NROI region.

4.1.1 Proposed Compression Algorithm:

In this work, the compression algorithm for the medical images is presented. The presented algorithm uses the mechanism of Region of Interest in order to attain compression in a more appropriate form. This presented algorithm is the combination of a hybrid algorithm (DWT and DCT) and JPEG compression technique, with the influence of Region of Interest. The major steps of the ROI based Hybrid Compression algorithm in algorithm1.

Algorithm 1:		**ROI Based Hybrid Compression Technique for Medical Images**
Step 1	:	Select an input image and sort out its dimensions
Step 2	:	Select the Region of Interest.
Step 3	:	Segmenting the ROI and NROI regions from the image.
Step 4	:	Apply Hybrid of DWT and DCT over the ROI region of the image.
Step 5	:	Apply the JPEG technique over the NROI region of the image.
Step 6	:	Merge Both ROI and NROI images to get the rebuilt image.
Step 7	:	Compare the size reduction and the quality of the reconstructed image with the original input image by various measures.

4.2 Experimental Results:

In this division, we describe the data-based results of the ROI Based Hybrid Compression technique. In order that investigates the efficiency of our aimed algorithm, some medical modalities (X-ray, MRI, CT, Mammography and Ultrasound) are considered. The dimensions of these medical modalities are 256×256. Further, the effectiveness and efficiency of the algorithm is evaluated using MSE, PSNR, and CR. Here, the Matlab environment is used to implement the proposed technique and evaluate the results. The experimental ensues of the nominated ROI Hybrid Algorithm are equated with the other algorithm described in the literature (Shah et al.;). Here, the ensues of the aimed ROI Hybrid Compression algorithm and other compression techniques which is widely used for the compression of medical images is represented. Table 1 describes the result of the proposed algorithm over the MRI image in comparison to the technique presented in Shah et al.,

Table 3: Result of the purported algorithm over the MRI image.

Medical Modality	ROI Haar Compression (Level 3)			Proposed Technique (Level 3)		
	MSE	PSNR	CR	MSE	PSNR	CR
MRI	68.54	29.771	-	49.17	31.2475	2.27

Now in order to decide the overall efficacy of the proposed technique, we compare it with the other well-renowned compression algorithms in the field of medical images. Here, Table 2 represents the overall compression of the Purported technique with other popular techniques.

Table 4: Overall Comparison of Proposed Algorithm with other Proposed Algorithms.

Medical Modalities	DCT		DWT		JPEG		Hybrid (DCT and DWT)		Proposed	
	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR
X-Ray	34.2	32.82	9.39	38.39	13.97	36.71	35.57	32.65	37.58	32.4150
CT Scan	85.42	28.24	13.04	36.97	25.71	34.06	88.5	28.69	48.22	31.3320
Mammograph	15.42	36.28	7.97	39.11	28.86	33.56	17.71	35.68	21.90	34.7591

MRI	100.74	28.13	11.6	37.48	10.7	38.13	108.59	27.8	49.17	31.2475
Ultrasound	59.88	30.39	10.98	37.42	21.04	34.93	64.06	30.09	38.5403	32.3056

Table 2 demonstrates the experimental ensues of the aimed ROI Hybrid technique with another state of art compression techniques in the medical domain. In this study, five medical modalities X-ray, CT, Mammography, MRI and Ultrasound are considered. It is observed that ROI Hybrid Technique is much better than in term of the quality as well as in order to achieve higher compression ratio as compared to the algorithm proposed in Shah et al., and other popular compression techniques.

Here, the Proposed technique is compared with other well-known compression techniques and their PSNR values and the compression ratio has been plotted in Fig 3 and Fig 4: in order to see how well the functioning of the proposed technique. In fig 5 the images of the certain stages of the experimental implementation are depicted in order to understand the experimental process in an effective manner.

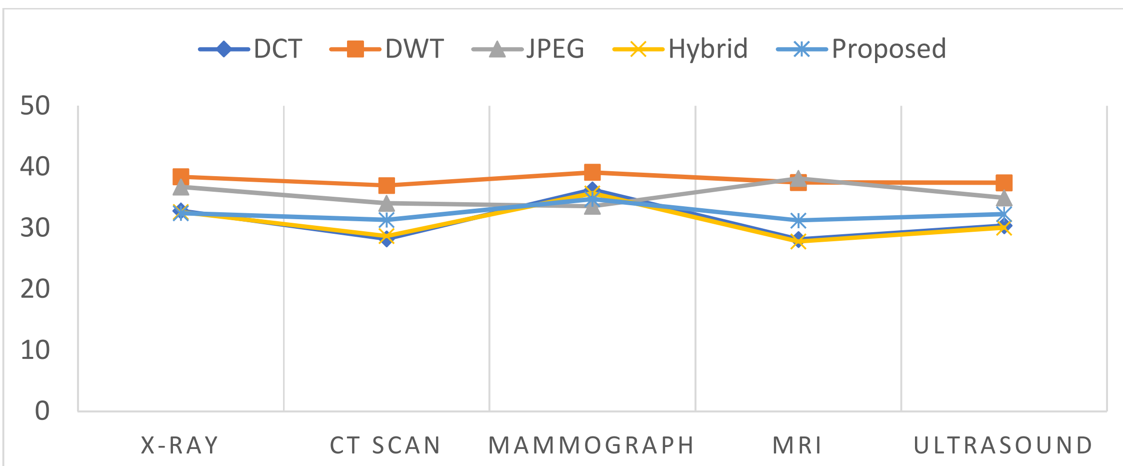


Fig 5: PSNR Comparison of Proposed Technique

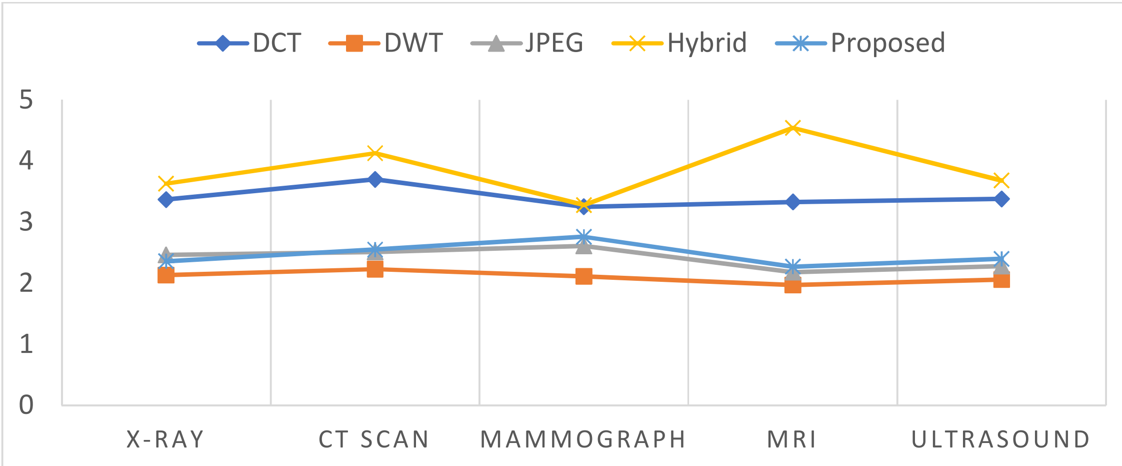
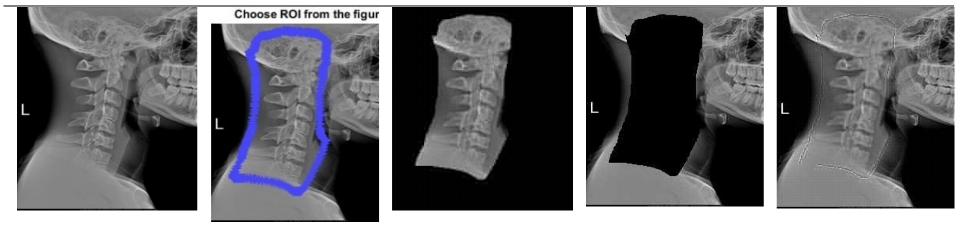
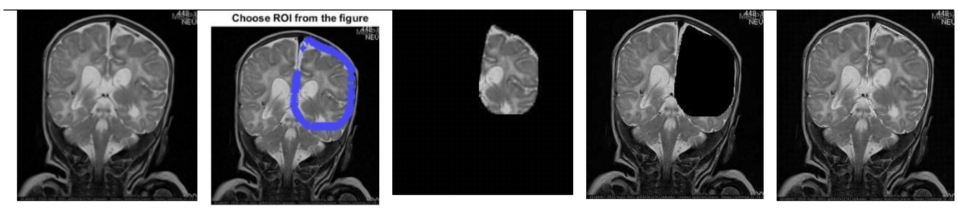


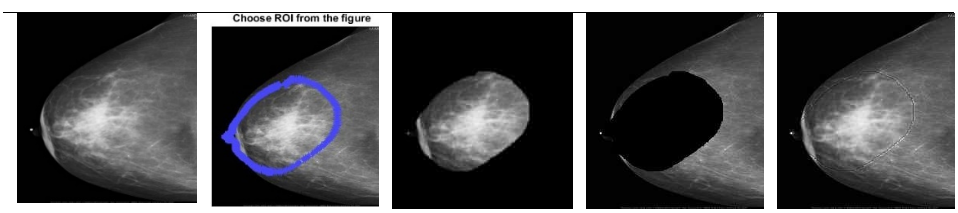
Fig 6: Compression ratio Comparison of Proposed Technique



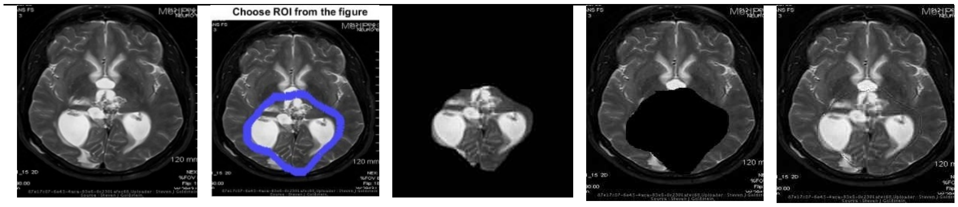
X-Ray (20.2 kb)	Marked ROI Region	Compressed ROI Section	Compressed NROI Section	Final Image (8.53 kb)



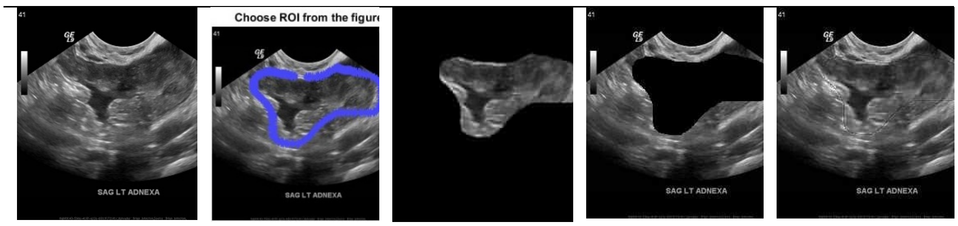
CT image (26.3 kb)	Marked ROI Region	Compressed ROI Section	Compressed NROI Section	Final Image (10.3 kb)



Mammograph (17.2 kb)	Marked ROI Region	Compressed ROI Section	Compressed NROI Section	Final Image (6.23 kb)



MRI Image (25.3 kb)	Marked ROI Region	Compressed ROI Section	Compressed NROI Section	Final Image (11.1 kb)



Ultrasound Image (20.8 kb)	Marked ROI Region	Compressed ROI Section	Compressed NROI Section	Final Image (8.66 kb)

Fig 7: Images of Certain Stages in Experiment.

CHAPTER 5

5. Conclusion:

This report illustrates some of the compression techniques which are used to compress the medical images and these techniques are able to solve the storage and bandwidth limitation problems. After reviewing the literature, it is concluded that the performance of the compression algorithms totally relies upon the CR. Higher the CR of the technique, better is technique. Here, it is kept in mind that there should be no loss of critical information. In this work, an ROI based Crossbreed compression technique is demonstrated for the effective compression of the various medical modalities. The main ideology of the proposed technique relies upon the concept of selection of Region of interest (ROI) by a trained physician. The efficiency of the aimed technique is examined by using five different modalities. Further, MSE, PSNR and Compression Ratio (CR) are used as the performance parameters. It is showed from the model results that the purported technique gives healthier results than the other compression techniques. It is evaluated that the presented technique is much efficient, effective and robust for the compression of medical images.

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