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Image Compression Based On Adaptive Prediction And Block-Based Entropy Coding For Medical Image Sequences

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Abstract

In this paper, we purposed a near-lossless compression method for medical images to maintain the maximum error limit for each pixel this compression method has a better compression ratio than the lossless compression methods. Transmitting high resolutions data through a network leads to large storage space and Bandwidth. We approached the near-lossless compression method to preserve important diagnostic information for medical images. we purposed a threshold-based Resolution Independent Gradient Edge Detector (RIGED) to predict and decorrelate the image pixels for encoding we used block-based Run Length encoding that encodes the Predicted image into actual values and their numbers of occurrence. The actual image data values are separated from their runs and are stored in a vector array. To implement high compression and better quality of recovered images quantizer with an optimum q level is proposed. To remove inter-pixel redundancy the proposed method uses a resolution-independent gradient edge detector (RIGED) after quantization block-based encoding is used for removing coding redundancy. The proposed method is evaluated on volumetric 8-bit and 16-bit standard MR image data-set The performance of the proposed technique showed improvement over the existing techniques SPHIT, JPEG-LS, and JPEG 2000by 40.89%, 34.50%, and 22.36% respectively in terms of Bits per Pixel (BPP).

Keywords Near-lossless compression. Quantizer, Gradient edge detector. Run Length Encoding. Entropy coding.

1. Introduction

Medical imaging is commonly used in radiology to scan the internal structure of the human body. A recent development for medical diagnostics in doctor's offices creates a large amount of image data that is stored digitally. Telemedicine, which is characterized by the transmission of medical images between users, is one of the emerging fields of biomedicine as a large bandwidth is required to transmit medical images over the Internet, so there is a great need for effective compression techniques for their use Medical Image Compression is an effective technique to reduce redundancy and extraneous bits required to render an image in a better format A lossy compression technique is not preferred for image data compression, e.g. diagnostic information can lead to misdiagnosis, leading to diagnostic problems. The lossless compression is error-free and the compressed image is an exact copy of the original image. It allows the image to be compressed without delaying important information. The compression ratio is not very high in this case, which is limited by the entropy of the image. Lossless compression is used in the medical field, where data compression is performed in such a way that diagnostic capabilities are not impaired. Lossless compression limits the maximum error for each pixel to a certain given value. A nearly lossless compression technique is useful in remote sensing and telemedicine applications.

In the field of biomedical imaging, particularly volumetric magnetic resonance tomography and computed tomography, large amounts of medical image data are generated with a stack of 2D image layers. All image data generated is stored digitally and this large amount of data requires efficient storage. and transmission [1] It is very difficult for a hospital to store so much data, and this large amount of data requires a lot of bandwidth for transmission. Compression of medical imaging data is required to address these problems. Traditionally, lossless compression techniques are preferred for medical images. to avoid misdiagnosis, although the compression ratio (CR) achieved is quite low and, depending on the method used, is between 2 and 4 [2]. Loss of compression is an irreversible image compression technique that offers good compression efficiency but degrades image quality. This type of technique is unacceptable for medical imaging because a small deterioration in the critical diagnosis of Ostic information can lead to a false diagnosis, a radiologist is a big deal. However, to obtain a high CR, some distortion of the restored image is allowed, as reported by many researchers in the medical image compression community [3]. The loss of image compression is only justified if a critical diagnostic range with very little distortion is maintained to ensure a better quality of the compressed image [4]. Almost lossless compression limits the maximum error for each pixel to a certain specified value. Lossless compression potentially increases compression efficiency and consumes less bandwidth, while preserving the diagnostic information of medical imaging, useful in remote sensing applications.

In this article, we propose a near-lossless approach to high compression efficiency and image quality, the proposed technique is based on a predictive coding technique, RIGED is used to remove redundancy between pixels, and block-based coding is used to remove coding redundancy. For encoding, We used RLE Method to get Compressed images This document provides the elimination of psychovisual redundancy and an optimal q level for quantification. The determination of the optimal q-level is based on quantitative and qualitative analysis.

To significantly improve the efficiency of lossless compression, we have re-examined the basics of lossless compression from the first step onwards: When capturing a new digital image, whether the image comes from a sensor in an optical camera or other frequency bands, or B. from an ordinary scanner or x-ray machine, or even from the calculations of certain acquired data such as medical CT and MRI images, etc., the intensity of the original images is continuous and is quantized to produce a digital output. is quantized, errors will occur and therefore the lossless scheme only applies to the quantized version, not the original signal, even if the quantization errors may be less than the noise in the original signal, encode the transformed domain, and then encode the lossless quantized coefficients, i.e. Use the lossy compression algorithm method. The proposed lossless system and the traditional lossless system m are equivalent. First, they all have losses, for the traditional lossless scheme the quantization is done in the signal domain, while for the proposed scheme the quantization is done in the transformed domain, if the transform is orthogonal and the input quantization noise levels are the same for both conditions then the PSNRs are the reconstructed images assigned to the two schemes are the same Second, both schemes are all lossless in the same direction, i.e. the original quantized version of the signal can be exactly reconstructed for both schemes. In the traditional lossless scheme, the exact reconstruction is in the quantized signal samples; whereas for the proposed lossless scheme the exact reconstruction takes place on the quantized transformed coefficient samples. There is only one chance in the waveform display area for the exact reconstructed version, and this exact reconstructed version is referred to as the "original" image after capture. However, the transformed representation is the most concise or powerful representation and therefore the most beneficial for compression. Note that the reversible integer transforms used in traditional lossless compression algorithms are very different from orthogonality; therefore, lower compression efficiency is expected.

2. Literature Survey

Novel Medical Image Compression Techniques based on Structure Reference Selection using Integer Wavelet Transform Function and PSO Algorithm, 2014, Gaurav Vijayvargiya et al suggested reducing an unstructured packet in the entire wavelet transform function. The repetitive structure of the carcass was collected using the particle swarm optimization algorithm. For the carcass structure era, the integer wavelet shift capability was used. Observation evaluation of PSNR and compression ratio. shows that the compression achieved is superior to other systems in the exploratory process. Searching for an excess packet structure consumes additional time and increases computing time.

Srikanth.S and Mehr S. (2013) - Compression efficiency for combining different embedded images In this work different families of wavelets were analyzed, a comparative study was also presented based on PSNRs and bit rates of these families, and these algorithms were tested on different images and it was observed that the results obtained by these algorithms were of good quality and quality. offers a high compression ratio compared to existing lossless image compression techniques. They used various wavelet-based image encodings that were integrated with Huffman encoders for further compression. In this article, they introduced the implementation of the SPIHT and EZW algorithms using Huffman coding.

Background Theory

Alert Coding Technique Predicting the pixel value of an image is a critical part of foreshadowing coding as it reduces the spatial excess of the image. Each pixel expectation is performed separately from a single circumstance (a collection of contiguous pixels) in the raster verification request. The remaining defect or image is detected by deriving an expected image from a single image. In contrast to the first clinical picture, the remaining one has a lower entropy estimate [3].

A basic schematic diagram of the prediction compression scheme is given in Fig. 1.

Predictor

The predictor eliminates interpixel redundancy from volumetric medical images that operate on a layer-by-layer basis. The selection of a highly efficient predictor is essential for the coding efficiency of the compression method. The efficiency of the predictor depends on how well you can reduce the entropy of the prediction error, which in turn depends on the precision of the predictor. A better reduction in the residual image's entropy will be the predictor's performance, which leads to better compression. The Gradient Adaptive Predictor (GAP) and the Median Edge Detector (MED) are two standard predictors for predictions [4]. it is computationally less complex compared to GAP, while the latter is more accurate. The combination of these two predictors is Gradient Edge Detection (GED), which uses MED and GAP's computational efficiency and prediction accuracy [5]. Predictor and selects a custom prediction threshold.

The predictor removes interpixel redundancy from volumetric medical images by operating slice by slice. The selection of a highly efficient predictor is essential for the coding efficiency of the compression method. The efficiency of the predictor depends on its ability to reduce the entropy of the prediction error, which in turn depends on the accuracy of the predictor. By decreasing the entropy of the afterimage, the predictor's performance is better, resulting in better compression. Adaptive Gradient Predictor (GAP) and Median Edge Detector (MED) are two standard predictors for prediction [24]. MED is less computationally complex than GAP, while the latter is more accurate. The combination of these two predictors is gradient edge detection (GED), which takes advantage of the computational efficiency and prediction accuracy of MED and GAP respectively [25]. GED is based on the threshold of the predictor and selects a threshold for the user-defined prediction.

Quantization

Original data are represented by a minimal loss of information with a good quantifier [6]. It is a lossy process and compression is achieved when the range of values is compressed into a single quantum value. Some distortion and bit loss in the medical image is allowed if no diagnostic information is lost in the reconstructed image, and nearly lossless compression limits the maximum error for each pixel to a given specified value.

Entropy Encoding

Entropy coding is used to remove statistical redundancy. Various coding techniques such as Huffman, run-length, dictionary, arithmetic, and bit-plane coding are described in the literature. Among other entropy coding techniques, arithmetic coding is an efficient coding technique. This coding technique does not separate the input symbol into component symbols but encodes the entire message into a single-bit string. Fewer bits are required to encode common characters and rare characters are stored in a higher number of bits, resulting in fewer bits overall.

Entropy coding is the step of the lossless image compression algorithm that performs the compression. The above steps remove the redundancy, but the encoder forms the last bitstream of a compressed image. Statistical redundancy refers to the ability to store an image in fewer spaces when using variable-length codewords instead of fixed-length codewords. Eliminating statistical redundancy in the process of taking advantage of the fact that some input values are more likely than others to occur. The most common input values are encoded with code words of minimal length, which saves memory space. When encoding grayscale images, the input values are the gray values. Entropy coders are referred to as a group of algorithms that can achieve bit rates at will.

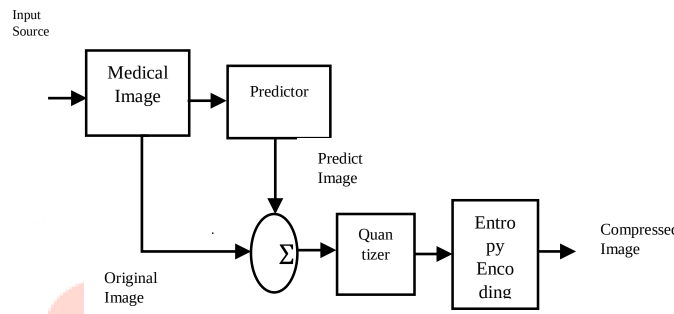


Fig1:Basic Schematic diagram of the predictive coding algorithm

3. PROPOSE METHODOLOGY

A schematic diagram of the proposed approach is represented in Fig. 2. Pixel prediction, quantization, and entropy encoding are the 3 primary steps of the proposed near-lossless predictive coding approach. The null speculation: Ho: The quantization of the picture introduces an irreversible error, which in flip adversely impacts the picture exceptional and its diagnostic functionality via way of means of the radiologist. H1: The null speculation turned into rejected.

The novelty of the proposed set of rules is to develop an advanced near-lossless predictive coding method with the optimal threshold, the optimal q-level, and block-based coding, eliminating redundancy between pixels, psycho-visuals, and coding, to attain excessive compression without dropping diagnostic information from doctors. Step I consists of the prediction for putting off spatial or inter-pixel redundancy from the image. In step II, the prediction error image or the residual obtained after the prediction is quantified to the optimal q level to eliminate psychovisual redundancy. Step III involves coding the quantized remainder after breaking it into small blocks to remove coding redundancy from the image.

Resolution Independent gradient Edge Detector (RIGED)

The efficiency of the predictor depends on the efficiency with which it can reduce the entropy of the residual image. The efficiency of the predictor can be improved by making it independent of modality and resolution. The proposed RIGED is independent of both modality and resolution. RIGED is an extension of the GED predictor, it is the best combination of a simple algorithm and efficient entropy performance. The existing GED is based on a threshold, ie user-defined and there is no particular method to select the prediction threshold [30].

For a perfect prediction, a certain threshold value must be selected to minimize the entropy of the residual image. The proposed RIGED is developed by selecting a common universal threshold that is optimal for different resolutions and imaging modalities. High bit depth images up to 16 bits deep, as advanced image scanning techniques generate higher resolution and higher bit depth images Threshold value for predicting different bit depths Medical images can be up to 2 bits deep. eliminated from the image by predictors. A common scheme for labeling causal neighbors in 2D predictors is shown in Figure 2.

The proposed algorithm is a common result for compressing different types of medical images with varying judgments, modes, and bit depths. The proposed Block Based RUN Length Encoding fashion using RIGED is a 2D contraction process applied to volumetric medical images containing frame-by-frame image sequences. Each image is predicted by RIGED and by abating the expected image slice from the original image, we get the relish with an entropy lower than the original image slice. A lower entropy relish is divided into optimally sized blocks, and the blocks are grouped grounded on the normal of the absolute error. Other different groups are independently entropy decoded by the computation encoder to gain a compressed image. For lossless contraction of a volumetric data set, the overall procedure is repeated for subsequent image slices and a weighted normal is calculated for the entire image set. The proposed armature isn't only applicable to medical data with low bit depth and t but also to medical images with high bit depth (16 bits/ pixel).

Vertical gradient: Av=|NW-W|+|NN-N|

Horizontal gradient: Ah=|WW-W|+|NW-N|

if A v -A h>T, then PX=W;

if the difference between vertical and horizontal gradients is greater than a threshold, then the predicted pixel direction is west.

else if A v -A h< -T, PX=N;

if the difference between vertical and horizontal gradients is less than a threshold, then the predicted pixel direction is north, else P X= N+W-NW, (2)

where T=Threshold and Av and Ah are Vertical and Horizontal Gradients

T= 44 (Common threshold for every modality and resolution of 8-bit depth medical image) T=768 (Common threshold for every modality and resolution of 16-bit depth medical image)

3.3.2. Block-Based Encoding Using RLE

The predictive coding technique is the major in Encoding the residual image. Because of that, divided the Residual image into Blocksafter that easily Separately encode each block Before Applying RLE to the Residual Image it is Divided into Non-overlapping Blocks because to encode the residual image it provides compression in the form of BPP based on mean absolute error image segmentation is done using a Fixed size of 8 x 8 blocks are classified into different groups.

3.3.3 Architecture of RLE Employing RIgED Predictor for 8-bit and 16-bit Depth Images

The proposed RLE technique employing RIGED is a 2D compression process applied to volumetric medical images containing image sequences on a frame-by-frame basis.

To obtain a residual image we apply RIGED to predict images from volumetric datasets

Each frame is predicted by RIGED and by subtracting the predicted image slice from the original image we obtain the residual image with a lower entropy as compared to the original image slice. A lower entropy residual image is divided into optimal size blocks and blocks are grouped based on the average of absolute error. Further different groups are separately entropy-encoded by the arithmetic encoder to achieve a compressed image. For lossless compression of a volumetric dataset, the overall procedure is repeated for the next image slices and a weighted average is calculated for the complete image set. The proposed architecture is not only applicable to low-bit depth medical datasets but also to high-bit depth (16 bits/pixel) medical images.

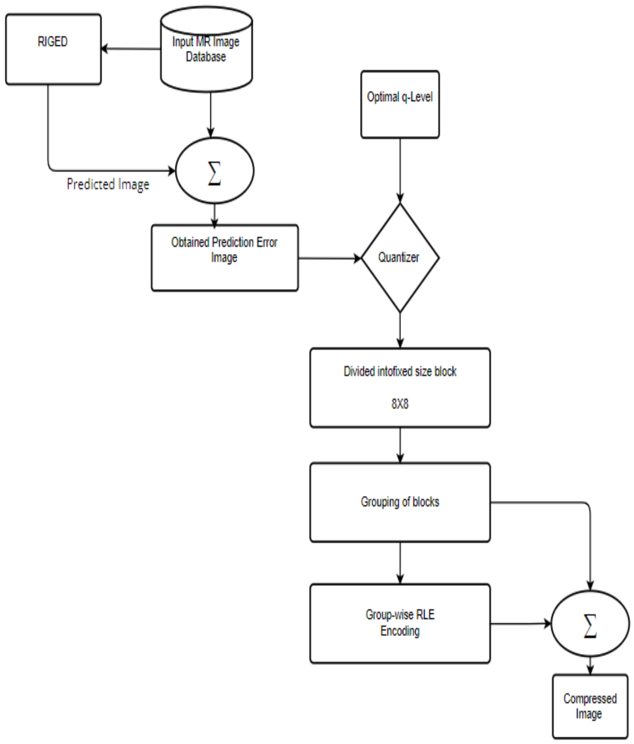


Fig 2: Block Diagram of Image compression of RLE Encoder

To vary the resolutions and bit depth of medical images a new algorithm is proposed for medical image

3.4. Run Length Encoding Technique

It can perhaps be said that run-length encoding (RLE) is the most straightforward common compression technique. It is a 'lossless' algorithm and can function by searching for 'runs' of the same value bits, bytes, or pixels and encrypting the run's length and value. Therefore, RLE produces the best results with pictures with large contiguous color areas, especially monochrome pictures. The run-length encoding technique is one of the most widely used encoding methods in lossless compression techniques. It supports most bitmap file formats, such as BMP, PCX, and TIFF, and is an elementary form of lossless compression algorithms. This technique is suitable to compress any data irrespective of its content. However, the data content affects the RLE compression ratio. Without losing important information, the RLE technique can compress medical images. Meanwhile, medical images can be compressed into a single data sequence with a long continuous sequence. Black and white images can mainly compress with run-length encoding, and better results can be obtained from image compression. In the present study, lossless compression of the medical image using RLE was obtained.

The performance of the proposed technique is evaluated by entropy and BPP values. Entropy is calculated after RIGED prediction and the overall compression performance in terms of BPP is calculated after block-based encoding. Entropy describes the total number of bits required to represent image information [31]. The overall compression performance is calculated and the data size of a compressed image depends on BPP and image resolution. A smaller number of bits required to store the compressed image shows a high compression efficiency. The compression ratio (CR) is inversely related to BPP values [32], [33].

4. Results and Explanation

All experiments carried out in this research work are carried out with MATLAB 2018 on different volumetric MRI images from different sources. For experiments, publicly available datasets with more than 15 medical images with 8-bit depth, seven sets of 16-bit depth datasets collected from local hospitals with 12 images, and two sets of depths 16 bits collected from publicly available datasets. The proposed algorithm is also compared to other existing algorithms based on performance evaluation parameters.

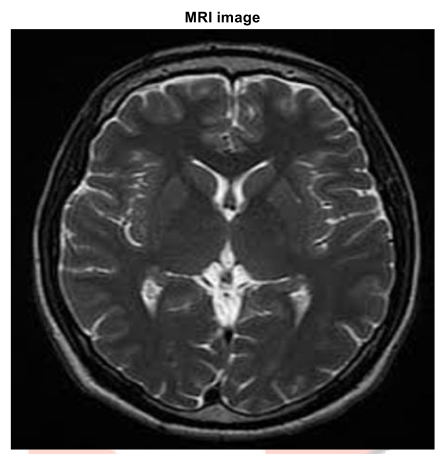


Fig 3: Input image

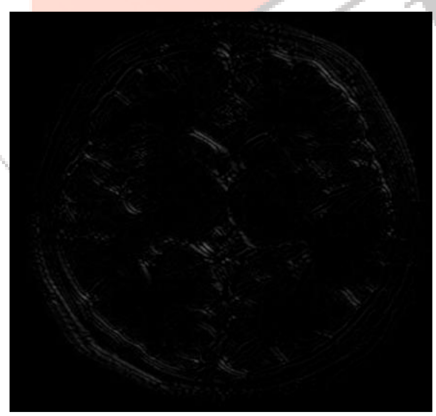


Fig 4:RIGED Image

Fig 5: Residual image

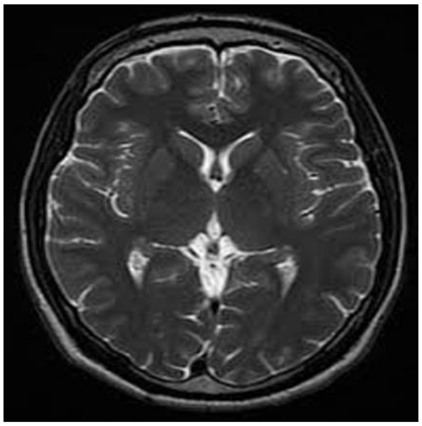


Fig 5: Recovered Image

4.1 Analysis of the proposed technique

The performance of the proposed technique is anatomized in terms of different performance criteria such as BPP, PSNR, quality index, etc. The performance of the proposed technique is checked at varying probabilities to identify how important image regions affected by pathology can be detected by our proposed method.

The proposed calculation is investigated for pressure execution of different 8-bit and 16-cycle profundity volumetric pictures. The unique picture is at first anticipated by RIGED at the ideal edge as an incentive for productive forecast and afterward, the forecast blunder picture is quantized and recuperated at various q-levels of 2, 4, 6, 8, 10, 12, 14, 16, and 18. For the close lossless procedures, as q-level builds, quality reductions quickly. To meet the prerequisites of recuperated picture quality, quantization (q-level) is constantly set to be little to keep up with the great alongside high CR. Images are recuperated at various q-levels and approved by the radiologist for the ideal worth of the q-level at which the picture is recuperated with practically no deficiency of analytic data.

Table For PSNR For Different Q Levels Image Compression

Methods		Q=2	Q=8	Q=14	Q=18
8-Bit Data Set Predictor	MRI	68.26	59.07	56.09	54.8
16-Bit Data Set Predictor	MRI	84.87	78.13	75.64	72.9
8-Bit RLEData Set	MRI	88.76	84.56	79.23	76.54
SPHIT	MRI	54.92	48.14	46.9	42.87
JPEG-Ls	MRI	36.69	34.08	30.06	28.84

Table1: PSNR values obtained for medical image dataset at varying of q-Level

Summary first-class appraisal of MRI image assessments of converting piece profundity is confirmed through a radiologist. The visual nature of the photograph is appraised by way of the radiologist based on evaluation and place. A quantization level of 8 is good at which an image is recuperated proficiently without dropping any statistics as indicated using the radiologist. The presence of pathology may be identified as much as q-Level of 18 and assessment of pathology is potential till q-stage of 8 for MRI. The selected q-Level ought to be perfect as a long way as lucidity and dwindled bending of the remade image. Alongside these lines, in this work, a q-Level of 8 is chosen for quantization of MR image tests, at which location and assessment are performed accurately. Investigation of recuperated Images is achieved at different levels from 2 to 18 but because of space hindrance, MRI images recuperated at q-Level of 4, 8, 12, and sixteen are displayed in Fig eleven. Outwardly absolutely recuperated images at diverse q-tiers are the same. The appraisal through the radiologist offers a q-Level of eight-bit to be best for evaluation.

Fig. 11. Sample of recovered MRI. (a) original image, (b) q=4, (c) q=8, (d) q=12, (e) q=16.

Table For BPP For Different Q Levels Image Compression

Methods		Q=2	Q=8	Q=14	Q=18
8-Bit Data Set Predictor	MRI	3.526	3.07	2.59	2.48
16-Bit Data Set Predictor	MRI	3.62	3.313	3.24	2.93
8-Bit RLEData Set	MRI	3.86	3.56	3.23	3.14
SPHIT	MRI	3.12	2.74	2.59	2.47
JPEG-Ls	MRI	3.09	2.58	2.46	2.04

Table2: BPP values of MR image at varying of q-Levels

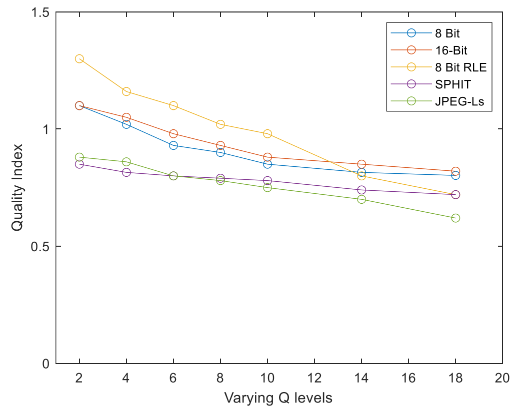


Fig 12. Quality index values at varying q-Levels

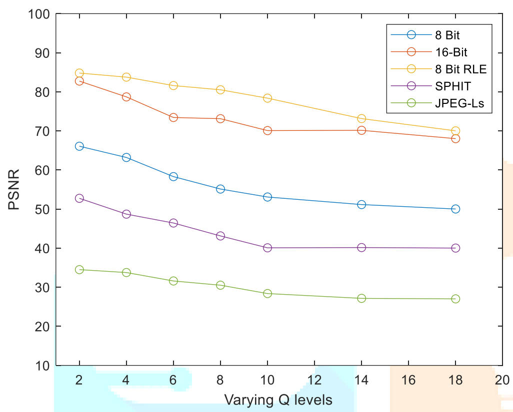


Fig. 13. PSNR values at varying q-Levels.

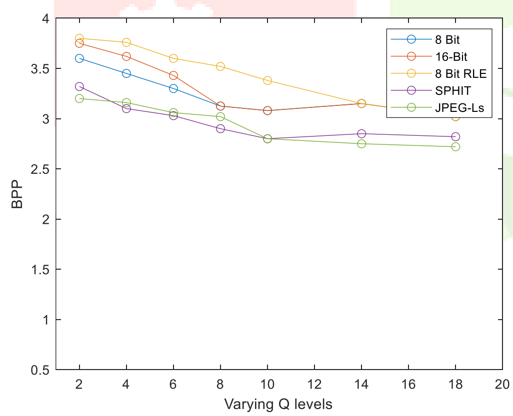
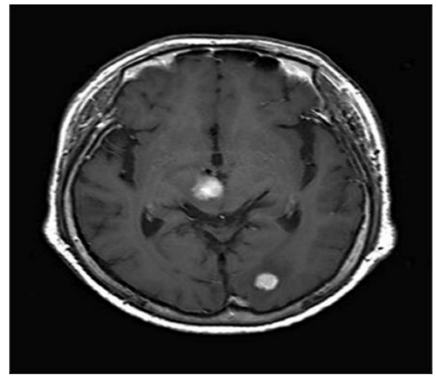
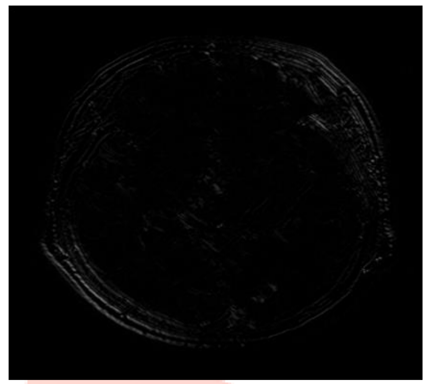


Fig 14.Entropy values at varying q-Levels.

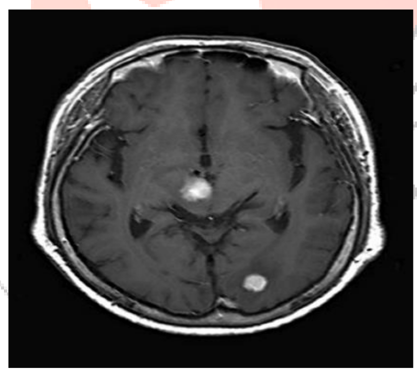
FUTURE SCOPE AND ITS Experimental Results



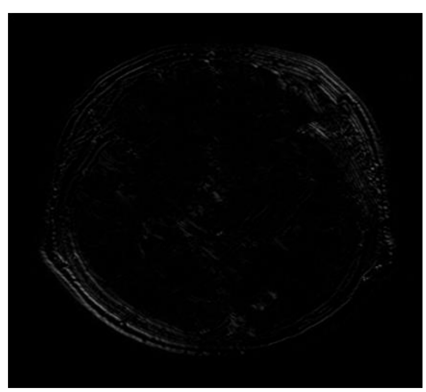
(a)



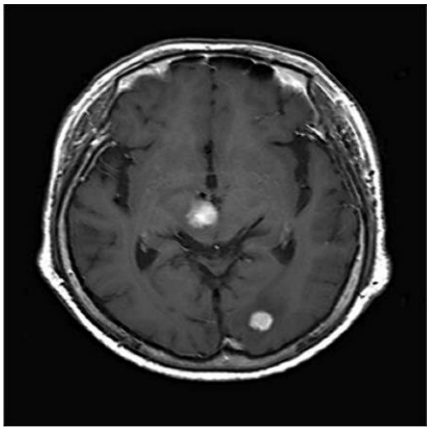
(b)



(c)



(d)



(e)

Fig:6 Image slice of volumetric brain MRI. (a) Original image, (b)Textured Image, (c) Predicted image, (d) Residual image, (e) Recovered image.

Conclusion

By considering calculations Properties of Medical images, a Predictive Encoding Algorithm for Near Lossless Medical images has Sensitive Diagnostic information. The Proposed method uses RLE Encoding, Quantizer, Block based encoding to provide Non-overlapping Blocks for the Predicted image .it achieves a high level of Compression Efficiency for quantization of optimal Q-Level of Residual image. The surest q-value for the quantification is obtained through analyzing the qualitatively and quantitatively obtained images possible up to level q of 8 Level 8 is the most desirable q stage at which each estimation and detection may be achieved without dropping the diagnosis Achieved compressed image without losing Diagnosis information after quantification is obtained images are possible up to level Q is 8. The novel RIGED most desirable threshold predictor is used within the proposed technique to cast off redundancy between pixels. The compression efficiency becomes analyzed in BPP, fine index, and PSNR. The overall performance of the proposed method in terms of PSNR for popular 8-bit record sets and general sixteen-bit statistics sets is 51.70 dB and 73.73 dB, respectively.

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