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Lossy and Lossless Image Compression Schemes-An Experimental Study

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Abstract

Digital image processing is a famous and emerging field of application underneath computer science engineering. The applications of digital image processing are medical imaging, satellite imaging, and video in which the size of the image or image stream size is big and needs huge volume of storage space or else high bandwidth for communication in its real form. In such applications, Image compression methods are utilized efficiently. Image compression is broadly divided into two main types: lossless and lossy compression. Here, Lossy compression deals with compression schemes that have tolerance for some certain amount of error, that is, the compressed and the decompressed images may not be identical. Lossless image compression schemes keep the information with the intension that precise rebuilding of the image is probable from the compressed data. In this research work, previous lossless compression techniques are surveyed and then proceeds to analyze the merits and shortcomings of these methods. This research also provided experimental evaluation of various modern lossless compression algorithms that were reported in the literature. The experimental results are conducted and it is compared against each other to find the better approach under various performance measures such as Mean Square Error (MSE), Compression Ratio (CR), and Peak Signal to Noise Ratio (PSNR) for publicly available image data sets to analysis better technique.

Key Words: Digital image processing, image compression, lossy and lossless compression, transform coding, dictionary coding.

1.   Introduction

By means of the development of medical imaging amenities, a rising volume of data is presented in the recent image processing, and it results in a progressively extensive burden for data storage as well as transmission [1]. The large increase in the data lead to delays in access to the information required and this leads to a delay in the time. Large data lead to data units and storage is full this leads to the need to buy a bigger space for storage and losing money. Large data lead to give inaccurate results for the similarity of data and this leads to getting inaccurate information.

Image compression decreases the redundancies in image in addition signifies it in brief way [2] that could let more gainful consumption of storage capacity as well as network bandwidth. For that reason, the medical image compression acts a significant role in numerous applications. In the previous years, several and various image compression approaches [3-5] for a review and [6] were presented to compress the digital images. The benefits of image compression such as: 1. it enables a reliable cost of savings. 2. It is not only to decrease the requirements of storage but also decrease the entire time of execution. 3. It decreases the chances of the errors transmission as some bits have got transmitted. 4. It enables a degree of the security in contradiction of monitoring the unlawful Activities.

Image compression is categorized as lossless and lossy. In lossy compression technique [7], there is some information loss. And encoding is attained with a satisfactory amount of descent in the rebuilt image, with a superior compression ratio, for instance JPEG [8], JPEG2000 (9/7) [9]. On the other hand lossless technique is rescindable and this signifies an image signed with the least probable number of bits deprived of any information loss, and the compression ratio attained is very less [10], for instance LOCO-I [11], CALIC [12], JPEG-LS [13] and JPEG2000 (5/3) [14]. Applications such as medical image compression, satellite image compression, here data loss might bring about wrong identification or analysis, lossless compression approaches are utilized. For compressing the general-purpose digital images, Lossy compression approaches are utilized, here insignificant data loss is not a burden [15].

Lossless image compression is a major challenge for investigators whose aim of presenting an image in the least number of bits deprived of losing any information. According to the medical industry, and remote sensing and business documents, digital radiography to satellite imagery, all are inspired to offer improved error-free compression [16–18]. It is used for raster map compression as well as information hiding [19, 20]. Color images, particularly medical or satellite images, contain a higher resolution, and they desire lossless compression techniques. Such (lossless) techniques are based on redundancy amid image pixels that makes it very problematic for decreasing the image data size when conserving its quality. Normally, lossless methods are inclined to create a low compression as contrasted to the lossy methods. On the other hand,

images might be transferred to various domains previous to compression to improve redundancy.

Generally speaking, lossless compression can be categorized into three broad categories, namely: predictive scheme with statistical modeling, transform based coding and finally, dictionary based coding. The predictive deals with using statistical method to evaluate the differences between pixels and their neighbors, and performed context modeling before coding, however, it has computational complexity. Whereas in transform based compression, pixel are transformed using frequency or wavelet transformation before modeling and coding. The encoding scheme contains three encoding schemes such as Run Length Encoding, Huffman coding, Arithmetic coding. Dictionary based compression is the third category and it deals with replacing strings of symbols with shorter codes. It must be noted that dictionary based schemes are widely used for text compression [21], but compared to transform coding; it has been attained less results [22]. Many schemes have been presented to analyze the image compression. But, still high CR has been considered as a big issue in image compression. So, to solve this problem, here we surveyed some existing lossless image compression schemes and their demerits. The upcoming sessions explains the advantages and disadvantages of the current techniques in lossless image compression.

2.   Literature Survey of Lossless Image Compression Schemes

In this segment, existing lossless compression schemes has been discussed. In 2017, Ayinde [23] proposed Zipper Transformation (ZT) exploits the conjugate symmetry property of Discrete Fourier Transformation (DFT). The proposed transformation is implemented using two different configurations: the interlacing and concatenating ZT. With the purpose of quantifying the efficacy of the presented transformation, we benchmark with Discrete Cosine Transformation (DCT) and Fast Walsh Hadamard Transformation (FWHT) in terms of lossless compression capability and computational cost. Numerical simulations show that ZT-based compression algorithm is near-lossless, compresses better, and offers faster implementation than both DCT and FWHT. Also, interlacing and concatenating ZT are shown to yield similar results in most of the test cases considered. But, it has computational complexity and less robust.

In 2017, Zhang & Tong [24] proposed a joint lossless image encryption and compression scheme based on Integer Wavelet Transform (IWT) and Set Partitioning in Hierarchical Trees (SPIHT) achieve lossless image encryption and compression simultaneously. Making use of the properties of IWT and SPIHT, encryption and compression are combined. Moreover, the proposed secure set partitioning in hierarchical trees (SSPIHT) via the addition of encryption in the SPIHT coding process has no effect on compression performance. A hyper-chaotic system, nonlinear inverse operation, Secure Hash

Algorithm-256(SHA-256), and plaintext-based key stream are all used to enhance the security. The analysis outcomes specify that the research techniques contain higher security as well as good lossless compression performance. But, it needs to improve the performance.

In 2016, Xiao et al., [25] introduced a novel algorithm, named improved Discrete Tchebichef. Transform (iDTT), to attain integer to integer mapping for effective lossless image compression. A sequence of experimentations are performed and outcomes prove that the presented iDTT algorithm consists of greater compression ratio compared to iDCT technique, as well as it is well-suited with the extensively utilized JPEG standard. The functioning of the research method is confirmed to be superior compared to that of iDCT based technique for gray and color image lossless compression. It is reasonable that iDTT could substitute iDCT in image in addition to video lossless compression because of its useful characteristics for instance energy compaction as well as information de-correlation.

A novel method for block-based lossless image compression was presented by, Masmoudi et al., in 2016 [26] by describing a novel semi parametric finite mixture model-based adaptive arithmetic coding. Traditional adaptive arithmetic encoders begin encrypting a series of symbols along with a uniform distribution, and they bring up-to-date the frequency of every symbol by incrementing its count subsequently it is encrypted. While encrypting an image block by block or row by row conventional adaptive arithmetic encoders give the identical compression outcomes. Moreover, images are generally non-stationary signals, that is to say that diverse regions in an image contain diverse probability distributions, and consequently traditional adaptive arithmetic encoders that give likelihoods for the entire image are not very effective. In the presented compression technique, an image is split into non-overlapping blocks of pixels that are distinctly encrypted with a suitable statistical model. Therefore, rather than beginning to encrypt every block with a uniform distribution, we present to begin with a probability distribution that is modeled by a semiparametric mixture got from the distributions of its adjacent blocks. The semi parametric model parameters are guesstimated via highest probability by means of the expectation–maximization technique with the intention of increasing the arithmetic coding efficacy. The outcomes of relative experimentations prove that we give important enhancements over traditional adaptive arithmetic encoders and the advanced lossless image compression standards. But, it has high time complexity due to the various processes.

A new Lossless image compression algorithm was presented by Babu et al., [27] in 2016. The research method of Improved Run-Length Coding (I-RLC) was utilized for obtaining a higher compression ratio. I-RLC model acquires the real image and transfers into a matrix format. The big-size matrix is split into an amount of non-overlapping minor size block matrix. The minor size blocks are performed to attain the compression ratio. This identical process replicates the complete image block size. I-RLC technique is used for diverse image formats to discover that technique provides improved outcomes as well as quality. I-

RLC algorithm is the significant tool to utilize for GIF, JPEG, TIFF and Textual files that encompasses best and compact code, on the other hand comparatively slow. The experimentation outcomes attain an improved compression ratio compared to any other approaches. On the other hand, an amount of files are uncompressed while they are stored.

A block based lossless image compression algorithm utilizing Hadamard transform and Huffman encoding was presented in 2016 by Venugopal et al., [28] that is an easy technique with less complexity. Firstly input image is decomposed by Integer Wavelet Transform (IWT) and LL sub band is transferred by Lossless Hadamard Transformation (LHT) to eradicate the correlation inside the block. Additional DC Prediction (DCP) is utilized to eradicate correlation amid neighboring blocks. The non-LL sub bands are confirmed for Non-transformed block (NTB) dependent upon threshold. The key importance of this technique is it presents a modest DCP, efficient NTB validation and truncation. Dependent upon the outcome of NTB, encryption is performed unswervingly or subsequent conversion by LHT and truncated. Lastly each and every coefficients are encrypted by means of Huffman encoder to compress. According to the simulation outcomes, it is noticed that the research technique provides healthier outcomes in regard to compression ratio while matched up with previous lossless compression techniques for instance JPEG 2000. Most significantly the algorithm is assessed with normal non-medical images and set of medical images and gives ideal values of compression ratio and is fairly effective.

A technique was presented by Song et al., [29] in 2016, applies adaptive block size-based spatial prediction to foresee blocks unswervingly in the spatial domain as well as Lossless Hadamard Transform beforehand quantization for increasing the quality of rebuilt images. The block-based prediction breaks the pixel neighborhood restraint and gets benefit of the local spatial correlations identified in medical images. The adaptive block size assures a more rational partition of images and the enhanced usage of the local organization. The outcomes specify that the research method could resourcefully compress medical images and creates an improved Peak Signal-To-Noise Ratio (PSNR) underneath the identical pre-defined distortion compared to other near-lossless techniques however contains higher computational complexity.

A new lossless colour image compression technique was presented by Khan & Khan [30] in 2016, dependent upon a Reversible Colour Transform (RCT) and Burrows–Wheeler Compression Algorithm (BWCA). The research technique utilizes a two-pass Burrows–Wheeler Transform (BWT) for the individual source image colour planes to improve grey-level homogeneity in the 2-D space. Compression efficiency is matched up with numerous methods comprising the JPEG 2000 lossless compression technique and the formerly implemented kernel move-to-front transform-based BWCA (kernel BWCA). Validation is performed through small- and large-size images. The research technique utilizing RCT with bi-level BWT brings about greater compression by getting benefit of the redundancy in the grey levels taken by the YUV colour

space. For small-size images, it attains 45 and 126 percent more compression compared to the JPEG2000 lossless and kernel BWCA method, correspondingly. Amongst the diverse techniques compared, the research method attains on the whole finest performance and is well appropriate to small- and large-size image data compression. It contains computational complexity because of the greater error.

A novel method for a block-based lossless image compression utilizing arithmetic coding was investigated by, Masmoudi & Masmoudi [31] in 2015. The traditional arithmetic encoders encode and decode images pixel by pixel in raster scan order by means of a statistical model that gives likelihoods for the complete source symbols to be encrypted. On the other hand, in the research method, the arithmetic encoders encrypt an image block-row by block-row and block by block from left to right, and from top to bottom. The research method guesstimates the probability distribution of every block by exploiting the greater correlation amid adjacent image blocks. So, the probability distribution of every block of pixels is guesstimated by decreasing the Kullback–Leibler distance amid the precise probability distribution of that block in addition to the probability distributions of its adjacent blocks in causal order. The experimentation outcomes showed that the compression effectiveness of conventional AC is enhanced by an average of 15.5 and 16.4% in static and order-0 model, correspondingly. Moreover, this techniques yields improved outcomes compared to those got by conventional AC, for synthetic and natural images. It was extremely slow and wants heavy computations particularly for huge images.

A novel method for a block-based lossless image compression utilizing finite mixture models and adaptive arithmetic coding was presented by, Masmoudi et al., [32] in 2015. Conventional arithmetic encoders encrypt and decrypt images sample-by-sample in raster scan order. Furthermore, conventional arithmetic coding models give the probability distribution for entire source symbols to be compressed or transferred, comprising static and adaptive models. On the other hand, in the research method, an image is split into non-overlapping blocks and after that every block is encrypted distinctly by means of arithmetic coding. The research method gives a probability distribution for every block that is modeled by a combination of non-parametric distributions by exploiting the greater correlation amid adjacent blocks. The Expectation-Maximization technique is utilized for identifying the highest probability mixture parameters with the intention of increasing the arithmetic coding compression efficacy. The outcomes of relative experimentations prove that we give important enhancements over the advanced lossless image compression standards and techniques. Furthermore, experimentation outcomes prove that the research compression algorithm does better than JPEG-LS by 9.7 % while switching amid pixel and prediction error domains. However, the encoding algorithm was extremely slow.

An enhanced Medical Image Compression method dependent upon Region Of Interest (IMIC-ROI) was presented in 2015 by Zuo et al., [33]. Primarily, image

segmentation technique that is a region-based active contour model, is utilized to split the image into two fragments: ROI regions and non-ROI regions. JPEG-LS technique is employed to the striking region of ROI, and image restoration method and the lossy wavelet compression technique are used to the other region of the image. Consequently, the ROI regions are rebuilt deprived of any loss, and the non-ROI areas are compressed with greater compression ratio. Experimentation outcomes demonstrate that the research compression algorithm yields greater compression ratio and contains a fine detail, however with a minor data loss.

In 2015, Nandi & Mandal [34] presented two means to progress the compression ratio attained by Fractal image compression. For the period of sub partition of the input image into range as well as domain blocks, Adaptive Quadtree Partitioning is utilized. For the period of the final save, the parameters of the affine transforms of the fractal compressed images are losslessly compressed by means of two approaches-once by Modified Region Based Huffman (MRBH) coding, and another time by its variant, MRBHM. The research method provide superior compression ratios numerous time, maintaining PSNRs unaltered. On the other hand, compression time of the research methods is meaningfully beyond their counterparts.

An inventive technique was presented in 2015, by Alzahir & Borici [35] for lossless compression of discrete-color images, for instance graphics, map images, GIS, and binary images. This technique encompasses two key components. The primary one is a fixed-size codebook comprising 8×8 bit blocks of two-tone data in company with their equivalent Huffman codes and their comparative likelihoods of incidence. The likelihoods were got from a huge set of distinct color images that are utilized for arithmetic coding. The second component is known as the row-column reduction coding that would encrypt those blocks, which are not present in the codebook. The research technique is positively used on two main image types: 1) images with a predetermined number of discrete colors, for instance graphs, digital maps, and GIS images and 2) binary images. The outcomes prove that our technique compresses images from both types (distinct color and binary images) with 90% in various case and greater compared to the JBIG-2 by 5%-20% for binary images, and by 2%-6.3% for distinct color images on average. On the other hand, it contains computational complexity.

In 2015, Sumalatha & Subramanyam [36] the chosen area of the image is encrypted with Adaptive Multiwavelet Transform (AMWT) by means of Multi Dimensional Layered Zero Coding (MLZC). Experimentation outcomes proves that Correlation Coefficient (CC), Peak Signal to Noise Ratio (PSNR), Mean Structural Similarity Index (MSSIM) performance is greater and Mean Absolute Error (MAE), Root Mean Square Error (RMSE), values are less and Compression Ratio (CR) at greater Bits Per Pixel (BPP) while matched up with the integer wavelet and Multiwavelet transform, however the CR was low.

In 2014, Pogrebnyak et al., [37] presented a technique for tuning of lifting method wavelet filters to attain a greater image lossless compression. The research technique examines the image spectral features and output the suboptimal coefficients to get a greater compression ratio when matched up with the standard lifting filters. The investigation follows by spectral pattern recognition with 1-NN classifier. Spectral patterns are of a minor fixed length for the complete image letting therefore the enhancement of the filter coefficients for diverse imager sizes. The research technique was employed to a group of test images acquiring improved image compression outcomes when matched up with the standard wavelet lifting filters. It attained high compression ratio, but the computational complexity was high.

In 2014, Anusuya et al., [17] presented to develop a lossless codec by means of an entropy coder. 3D medical images are divided into 2D slices and related to 2D-stationary wavelet transform (SWT). The decimated coefficients are compressed in parallel by means of embedded block coding with enhanced truncation of the embedded bit stream. These bit streams are decrypted as well as rebuilt by utilizing inverse SWT. Lastly, the compression ratio (CR) is assessed to verify the proficiency of the proposal. By way of an improvement, the research method focusses on reducing the computation time by presenting parallel computing on the arithmetic coding phase since it handles numerous subslices. Conversely, the entire codeword should be received for the symbols to be decoded, and when a bit is corrupted in the code word, the complete message is turn out to be corrupt.

In 2014, Kim & Cho [38] presented a novel lossless color image compression technique, dependent upon the ordered prediction as well as context-adaptive arithmetic coding. For the lossless compression of an RGB image, it is primarily decorrelated by a rescindable color transform and at that point Y component is encrypted by a conventional lossless grayscale image compression technique. For encoding the chrominance images, we implement an ordered method, which facilitates the usage of upper, left, and lower pixels for the pixel prediction, while the conventional raster scan prediction approaches utilize upper and left pixels. A suitable context model for the prediction error is described and the arithmetic coding is used to the error signal equivalent to every context. For numerous groups of images, it is proved that the research technique decreases the bit rates when matched up with JPEG2000 and JPEG-XR. But, it has high cost of computational complexity.

In 2014, Starosolski [39] presented RDgDb and LDgEb simple color space transformations for lossless image compression and a duo of their variants. We left from a outdated technique of building transformation for lossless image compression dependent upon transformation for lossy compression that is dependent upon Principal Component Analysis (PCA)/Karhunen–Loève transformation (KLT) for particular image set. RDgDb was presented dependent upon notification of real lossless ratios of individual image components got with easy transformations or untransformed, when LDgEb derives from the human

vision system. These transformations were assessed and matched up with conventional transformations comprising YCoCg-R RCT, and the optimal KLT for 3 groups of test images and for meaningfully diverse compression algorithms: predictive JPEG-LS, Discrete Cosine Transformation based JPEG XR and Discrete Wavelet Transformation based JPEG2000. The time complexity was high.

In 2013, Li [40] proposed an Improved Wavelet Lossless Compression Algorithm (IWLCA). It carries out classification rearrangement on low-frequency sub-band coefficient of wavelet image in line with Hilbert curve, however performs singular value truncating transform on high-frequency coefficient. At that point entropy encrypting was united to develop lossless image compression. Experimentation outcomes prove that IWLCA contains greater encoding efficacy that could efficiently decrease encoding bit rate of lossless image compression. While matched up with mainstream lossless algorithms for instance JPEG 2000 and JPEG-LS, the compression rate was meaningfully enhanced. It was not appropriate for huge image data.

In 2013, Yang et al., [41] proposed a low complexity Embedded Compression (EC) algorithm to improve Compression Percentage (CP) and decrease latency of encoding. In proposed algorithm, a simple and effective truncation for 2-D Lossless Hadamard Transformation (LHT) is utilized to decrease Dynamic Range (DR); and two different schemes are designed for subbands encoding: DC prediction for LL-subband; and Adaptive Transformation Method (ATM), for the non-LL subbands. The proposed algorithm aiming at archives high CP, low latency, and friendly implementation on hardware. Through experiments, we concluded that CP is improved compared with the former algorithm, but still lower JPEG2000. However, the latency and the complexity are deceased significantly, which suitable for engineering application.

In 2014, Moorthi & Amutha [42] proposed method is a novel hybrid medical compression scheme in a lossless manner for different medical modality. First partitioning the medical image in to region of importance (ROI) and region of non importance (RNOI) depending upon the selection using an improved K-Means algorithm. The region of importance (ROI) is compressed losslessly using the curvelet transform and differential pulse code modulation (DPCM) and the region of non-importance (RNOI) is compressed by using integer wavelet transform technique and set portioning in hierarchical tree SPIHT followed by adaptive arithmetic encoder. Finally, both the compressed outputs are fused together to give the final outcome compressed image. The storage and transmission of important medical data and imagery is made lucid using this model. The quality measures of proposed model are compared with different techniques. But, it doesn't suitable for large set of images.

In 2014, Hukkanen et al., [43] presented a lossless compression technique carrying out distinctly the compression of the vessels and of the residual part of eye fundus in retinal images that encompass beneficial info sources for numerous discrete medical diagnosis tasks, here the characteristics of interest could be for instance, the cotton wool spots in the eye fundus, or the capacity of

the vessels over concentric circular areas. It is supposed that one among the previous segmentation approaches given the segmentation of the vessels. The recommended compression technique transfers losslessly the segmentation image, and after that transfers the eye fundus part, or the vessels image, or both, conditional on the vessels segmentation. The self-regulating compression of the two color image segments is carried out by means of a sparse predictive technique. Experimentations are given over a database of retinal images encompassing manual and guesstimated segmentations. The code length of encrypting the complete image, comprising the segmentation and the image segments, verifies to be greater than the code length for the complete image got by JPEG2000 and other publicly existing compressors. But the computational cost was high.

In 2014, suganya et al., [44] presented colour medical image compression by means of Curvelet transform with lifting as well as Huffman coding. It proposes the decompression by means of inverse transforms and then the performance is examined by means of subjective as well as objective quality metrics. Most transforms however well appropriate to point singularities contains limits with orientation selectivity and don't signify two-dimensional singularities and smooth curves are not signified successfully. The Curvelet transform is appropriate for colour medical images that are usually containing curvy portions. Numerous medical images for instance CT, MRI, and so on are compressed for diverse image sizes and the outcomes are examined by means of PSNR, compression ratio, mean square error, bits per pixel value, normalized correlation, structural correlation and average difference. Computational speed was less.

In 2013, Sivasankari et al., [45] presented to inspect numerous compression methods dependent upon Region of Interest (ROI). In the analysis of retinal images, the important portion is detached out from the respite of the image by means of enhanced adaptive fuzzy C means algorithm in addition Integer multi wavelet transform is utilized for enhancing the visual quality in significant part. The region of minor importance are compressed by means of SPIHT algorithm and finally modified embedded zero tree wavelet algorithm is applied that utilizes six symbols was employed complete image after that Huffman coding is used to obtain the compressed image for transmission. The research method will provide superior quality, when the images utilized ROI when matched up with the other techniques. The performance outcomes indicate that the proposed method got improved outcomes while matched up with other techniques in regard to CR, PSNR and MSE. But the system reliability was not good due to the high computational time.

In 2013, Al-Khafaji & George [46] introduced a rapid lossless image compression technique for compressing medical images, it is dependent upon dividing the image blocks in keeping with its nature in the company of utilizing the polynomial estimate to decompose image signal subsequent to using run length coding on the remaining part of the image that signifies the error produced by using polynomial approximation. After that, Huffman coding is

used as a final phase to encrypt the polynomial coefficients and run length coding. The test outcomes specify that the recommended technique could bring about hopeful performance. But, the system reliability was not good.

Table 1: State-of-the-art among Various Lossless Image Compression Schemes

Authors	Methods	Advantages	Disadvantages
Ayinde (2017) [23]	Zipper Transformation (ZT) with Huffman encoding	It was near-lossless, compresses better, and offers faster implementation.	It has computational complexity and less robust.
Zhang (2017) [24]	Integer Wavelet Transform (IWT) and Set Partitioning in Hierarchical Trees (SPIHT)	It has high security and good lossless compression performance.	It needs to improve the performance.
Xiao et al., (2016) [25]	Improved Discrete Tchebichef Transform (iDTT)	It was suitable for video lossless compression due to its valuable properties such as energy compaction and information de-correlation.	The performance of this scheme was not good.
Masmoudi et al., (2016) [26]	block-based lossless image compression with Conventional adaptive arithmetic encoders	Significant improvements over conventional adaptive arithmetic encoders.	But, it has high time complexity due to the various processes of running.
Babu et al., (2016) [27]	Improved Run-Length Coding (I-RLC)	It was achieved a better compression ratio.	But, a number of files are uncompressed when they are stored.
Venugopal et al., (2016) [32]	Hadamard transform and Huffman encoding	It provides optimum values of compression ratio and is quite efficient.	Huffman coding removes the redundancy in each macro block but seems to be complex.
Zuo et al., (2015) [33]	Improved Medical Image Compression technique based on Region Of Interest (IMIC-ROI)	High compression ratio and has a good fine detail.	But with a slight loss of data.
Nandi & Mandal (2015) [34]	Modified Region Based Huffman (MRBH) coding	It offers much better compression ratios most of the time.	However, compression time of the proposed techniques is significantly more than their counterparts.
Anusuya et al., (2014) [17]	2D-stationary wavelet transforms (SWT).	It minimizing the computation time by introducing parallel computing on the arithmetic coding stage	However, the whole codeword must be received for the symbols to be decoded, and if a bit is corrupted in the code word, the entire message could become corrupt.
Yang et al., (2013) [41]	Lossless Hadamard Transformation (LHT)	It has high CP, low latency, and friendly implementation on hardware.	However, the latency and the complexity are deceased significantly.
Moorthi & Amutha (2014) [42]	improved K-Means algorithm and adaptive arithmetic encoder	The storage and transmission of important medical data and imagery is made lucid using this model.	But, it doesn't suitable for large set of images.
Sivasankari et al., (2013) [45]	Integer Multi Wavelet Transform with Huffman en coding (IMWT-HE)	The performance results show that the presented scheme attained better results	But the system reliability was not good due to the high computational time.

3.   Performance Evaluation

In order to assess the efficacy of the lossless image compression approach, it has run several experiments. In this segment, some lossless compression schemes performance has been evaluated by using two datasets. The dataset 1 contains five benchmark grayscale images in Fig 1 were used. The dataset 2 considered 3-D medical image data samples are: scan 1 [47], scan 2 is a 3D MRI image of the circle of willis and other cerebral arteries [48], and scan 3 is the axial T2-weighted MR image of a normal brain at the level of the lateral ventricles , lena color image and messidor retinal color image . These images are depicted in Fig. 2a, b, and c correspondingly. The dataset 3 in Fig. 3 which comprises of popular benchmark images are utilized to show the efficiency of the presented heuristics.

The approaches are suggested to evaluate the dataset as follows

- Zipper Transformation (ZT) with Huffman Encoding (HE)
- Integer Wavelet Transform (IWT) and Set Partitioning in Hierarchical Trees (SPIHT)
- Improved Discrete Tchebichef. Transform (iDTT) with huffman encoding
- Improved Run-Length Coding (I-RLC)
- Hadamard Transform and Huffman Encoding (HT-HE)
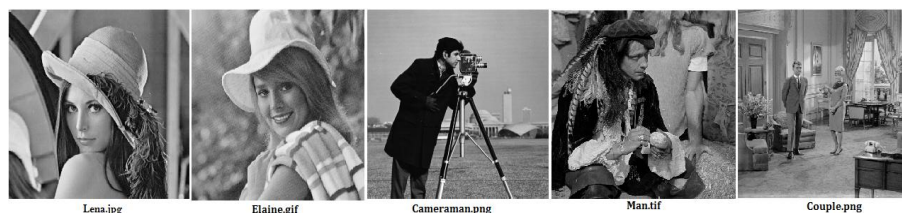- Integer Multi Wavelet Transform with Huffman en coding (IMWT-HE)
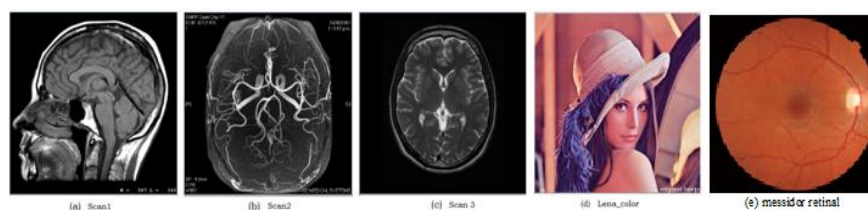

Fig. 1: Images of Dataset 1

Fig. 2: Images of Dataset 2

Fig. 3: Images of Dataset 3

Compression Ratio (CR)

The CR is an important criterion in choosing a compression scheme. This criterion is used to compare different compression paradigms, and is defined as:

$$CR = \frac{original\ size\ of\ image}{compressed\ size\ of\ image} \qquad (1)$$

Mean Square Error (MSE)

It is known as the aggregate squared error amid the trampled and the real image. The formula is as follows

$$MSE = \frac{1}{MN} \sum_{y=1}^{M} \sum_{x=1}^{N} [I(x,y) - I'(x,y)]^2 \qquad (2)$$

Here I(x,y) is known as the real image, I'(x,y) is called the estimated version (i.e. the decompressed image) and M,N are known as the magnitudes of the images. A lesser value for MSE signifies less error, and as considered from the inverse relation amid the MSE and PSNR, this turns to a greater value of PSNR.

Peak Signal to Noise Ratio (PSNR)

It is generally utilized as a degree of quality of rebuilding of image. A greater PSNR will generally point to that the rebuilding is of greater quality.

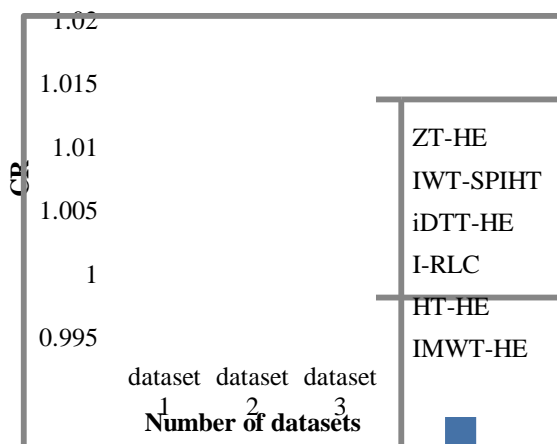$$PSNR = 20 * log10 (255 / sqrt(MSE)) \qquad (3)$$

Fig. 4: CR Compression among Three Datasets

From the Fig 4, it can be observed that the comparison of CR for all datasets. In x-axis the amount of datasets is taken and for y-axis CR is taken. The ZT-HE, IWT-SPIHT, iDTT-HE, I-RLC and HT-HE methods are evaluated. The ZT-HE, IWT-SPIHT, iDTT-HE, I-RLC, HT-HE and IMWT-HE methods achieved higher CR result of 1.016, 1.0063, 1.0076, 1.0051, 1.0061 and 1.0035 respectively. It concludes that the ZT-HE method has shown superiority results
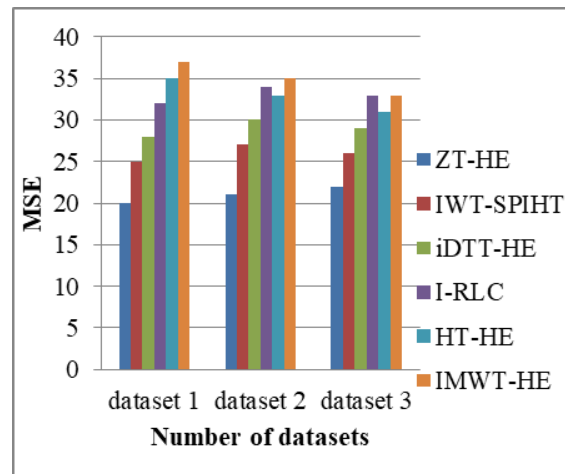
for all given datasets.

Fig. 5: MSE Compression among Three Datasets

From the Fig 5, it can be observed that the comparison of CR for all datasets. In x-axis the amount of datasets is taken and for y-axis MSE is taken. The ZT-HE, IWT-SPIHT, iDTT-HE, I-RLC, HT-HE and IMWT-HE methods are evaluated. The ZT-HE, IWT-SPIHT, iDTT-HE, I-RLC and HT-HE methods achieved less MSE result of 22, 26, 29, 33, 31 and 33 respectively. It concludes that the ZT-HE method has shown superiority results for all given datasets.
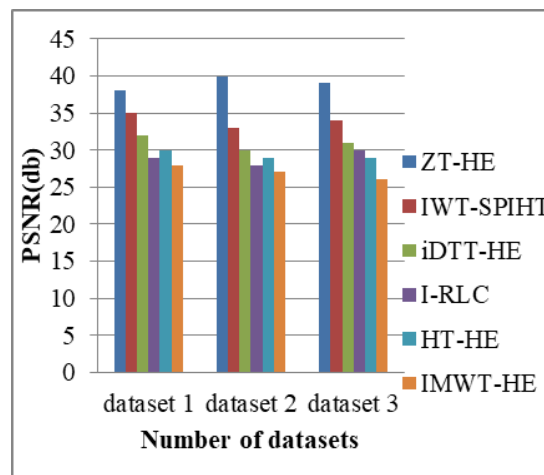

Fig. 6: PSNR Compression among Three Datasets

From the Fig 6, it can be observed that the comparison of CR for all datasets. In x-axis the amount of datasets is taken and for y-axis PSNR is taken. The ZT-HE, IWT-SPIHT, iDTT-HE, I-RLC, HT-HE and IMWT-HE methods are evaluated. The ZT-HE, IWT-SPIHT, iDTT-HE, I-RLC and HT-HE methods achieved higher PSNR result of 39, 34, 31, 30, 29 and 26 respectively. It concludes that the ZT-HE method has shown superiority results for all given datasets.

Inference from the Analysis

Therefore, we might state that the constructed Huffman codes are near-ideal. As well provided the disposed to- incorrect-probabilities component of RLC and the greater compression outcomes of the research technique, we prove that for practical applications the presented Huffman coding method must be the desired compression choice.

All things considered, the entire significance of the theoretical and empirical observations postulated in [49,50] is that Huffman coding is usually more vigorous compared to RLC that could expose emphatic benefit in unusual cases. However, Huffman algorithm has required prior knowledge of the incoming source sequence to improve the compression ratio compared than RLC.

As well as, the researchers [51] have not much attention in medical imaging compared to other applications. In medical imaging, lossy compression can sometimes achieve a minute compression before a good percentage of information is dropped. More compression can be achieved if some visible losses can be tolerated for clinical task purposes. There are still a lot of controversies as to what the real life applications of lossy compressions are, especially in the medical domain.

Nowadays, a Diabetic retinopathy is the foremost reason of blindness in the adult population. With the intention of efficiently recognize patients distress from the disease, mass-screening efforts are underway for the period of which digital images of the retina are captured and after that evaluated by an ophthalmologist. With the aim of recognizing features for instance exudates and microaneurysms, that are extremely small in extent, retinal images are captured at high resolutions. This signifies big file sizes and, taking the archival of thousands of records, a high demand on computational resources, in specific storage space. Therefore, the lossless image compression is needed for compression of retinal images.

4. Conclusion

Image Compression is an important field of research due to its wide range of application in image processing area. Much classic and modern loss less image compression algorithms work well on public data sets, but degrade sharply when they are used in a real compression system. In this research, the comparison results of popular methods suggested for lossless image compression. Those research methodologies are discussed along with their benefits and drawbacks in the detailed manner to find the effectiveness of every algorithm. The research works has been compared with each other based on their resultant metrics to find the better approach for preceding the further research scenario. Although many algorithms and techniques exist but still there is some scope for improvement in order to get better results for lossless image compression. Since the previous method has issues with huffman coding

performance when large number of images which leads less compression ratio results. In future work, these concepts will be examined through efficient proposed huffman encoding and hybrid transformation techniques with medical messidor retinal database.

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