REMOVING CODING & INTER PIXEL REDUNDANCY FOR IMAGE COMPRESSION

Abstract

Multimedia data has been growing incredibly every second owing to the development in multimedia applications and advancement in internet in all the fields including surveillance, entertainment, commercial, medical and education. In the past decade, the amount and dimensionality of multimedia data have grown larger and higher respectively, due to the advances of data storage and internet technology. Multimedia database systems are essential for the efficient usage of large collection of image data.

Visual information is of vital importance for mankind to perceive and understand the surrounding world. The saying "A picture is worth a thousand words" rightly expresses the amount of information contained in a single image. As the transmission and storage of every single bit in an image incurs a cost, the necessity of cost effective image compression technique plays an important role. The art of transforming an image to a digital format and its processing by digital computers is called Digital Image Processing. Digital image data is denser than the other information. All these digital data have to be stored and transmitted efficiently. At the present state of technology, the only solution is to compress the image data before its storage and transmission and to decompress it at the receiver end.

Image compression is the process of reducing the number of bits needed to represent an image by eliminating the redundancies. Statistical redundancy and redundancy using predictability are the two basic redundancies that appear in an image. Reducing or eliminating these redundancies from an image is called image compression which facilitates in bit rate reduction without affecting the visual quality.

Keywords: Multimedia data, Coding, Pixel, Redundancy.

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I. BACKGROUND STUDY

Digital images have significant redundancies. There are two basic data redundancies which can be identified and exploited in images: statistical redundancy and redundancy using predictability. Eliminating or reducing these redundancies results in compression. Compression can be lossy or lossless. Lossless image compression reproduces an identical image after decompression. Lossy compression yields perceptually equivalent but not identical image compared to the uncompressed image. Further, image compression can be achieved by representing images in the transform domain rather than in the spatial domain representation.

1. **Statistical redundancy (Lossless):** Lossless image compression reproduces the same image after decompression. Coding and inter pixel redundancy are two types of statistical redundancy.

2. **Coding redundancy:** Coding redundancy can be reduced by assigning minimum length code word for gray levels based on their probability of occurrences. Best example for coding redundancy is Huffman coding and arithmetic coding schemes.

3. **Inter pixel redundancy:** It defines the interdependency or correlation between nearest pixels of an image. Best example of inter pixel redundancy is run length coding.

4. **Redundancy using predictability (Lossy):** Lossy compression provides perceptually equivalent but not same image compared to the original image. Image redundancy represented by predicting the nearest pixel correlation or significance of the pixel intensity. This type of redundancy divided into two parts psycho visual and predictive neighborhood redundancy.
5. **Psycho visual redundancy:** According to the human visual system, some of the image information is considered as irrelevant information. Quantization scheme eliminates this irrelevant information.

6. **Predictive neighborhood redundancy:** Predictive coding is used to eliminate or reduce the neighborhood redundancy. Image data always related with their neighborhood. The intensity of a pixel is predicted from the intensities of its neighboring pixel.

II. STATEMENT OF THE PROBLEM

The objective of this research is to compress grayscale images using prediction and intensity based image compression methods. An Image compression technique minimizes the size in bytes of an image file without degrading the quality of the image to an unacceptable level. New image compression technologies which yield low bit rate while maintaining the fidelity of raw images are sought everywhere. When an image is compressed, it occupies less memory space. The reduction in file size allows more images to be stored in a given amount of disk or memory space. It also reduces the time required for images to be sent over the internet or downloaded from web pages. Hence, in long distance communication, transmission of compressed images saves time, cost and space. Image compression is achieved through the transformation, quantization and encoding procedures. This new frame work is designed by applying prediction and intensity based compression techniques to remove the coding and inter pixel redundancy in an image.

Motivation: The image transmission and storage are primarily motivated by the ease and flexibility of handling digital image information instead of the analog information. Transmission and storage capabilities are limited and expensive in nature. Image storage is required most commonly for educational and business documents, medical images used in patient monitoring systems and the like. Images consume more amount of storage. In addition to the extremely high storage and bandwidth requirements, use of uncompressed digital images will add significant cost to the hardware system that processes the images.

III. REVIEW OF IMAGE COMPRESSION LITERATURE

As these research works is related to achieving image compression works and also initiate removal of coding and inter pixel redundancy. Review related to prediction and intensity based image compression is briefly discussed. Huffman Image Compression Incorporating Difference Pulse Code Modulation (DPCM) and Discrete Wavelet Transform (DWT) have been proposed [1]. Here the image is pre- processed by DPCM and after that the wavelet transform is applied to the output of the DPCM. Color Image Compression Using Hierarchical Prediction of Pixels has been proposed [2]. In this work the image pixels are predicted by ahierarchical prediction scheme and then the wavelet transform is applied to the prediction error. Image transformation scheme known as "J Bit Encoding" (JBE) has been proposed [3]. It can be noted, that image transformation means, rearranging the positions of the image components or pixels to make the image suitable for huge compression. In this work, the original data are divided into two matrices where one matrix is for original non-zero data bytes, while the other matrix is for defining the positions of the zero/non- zero bytes.

A novel scheme namely, "Two Way Mixing Model (TMW)" for image compression has been proposed [4]. This image control uses multiple probability distribution because inter dependency of each pixel is different from different part of the image. They also compared the results of Context based Adaptive Lossless Image Codec (CALIC). It provides better results than CALIC.

Edge based prediction technique for image compression has been proposed [5]. This proposed algorithm works on least square based method where the image is processed edge by edge instead of pixel by pixel. The experimental results proved that the new approach attains better performance compared to CALIC. "Lossless coding using variable block size" was developed during the year 2005 [6]. It shows that compression of image can be improved by quad tree based variable block size partitioning. Major objective of this research work is reducing the storage space & decreasing the band width requirements. Their experimental results show that the variable blocks works better than TMW.

DCT is one of the lossless Image compressions. Intensity based adaptive quantization has been proposed [7]. Here inverse DCT is performed only in the quantized blocks. The residual error sequences are obtained by subtracting two neighboring regions [8]. In their research work discussed about DCT based image compression. The error sequence is encoded by Arithmetic or Huffman encoding. Some kind of Image Compression algorithm studied from[9-15]

Wavelet based image compression has been proposed [16]. Lifting or bi orthogonal wavelet transform is used. [17] Taujuddin et al. have provided pixel to pixel evaluation to obtain the hard and smooth region for image compression. Oh et.al. [18] have provided Set Partitioning In Hierarchical Trees (SPIHT) limit the image energy to fewer coefficients. Intensity Based Adaptive Quantization Coding (IBAQC) [19] image is classified into high & low intensity blocks. High intensity encoding requires large quantization steps. Low intensity encoding does not need any quantization steps. Image classification and wavelet compression was developed [20]. They have converted an image into an array using Delphi image control tool. They conclude that in Huffman coding, the image uncompressed needs some specific knowledge of the symbol of probabilities in the compressed files and this need more bits to encode the file. Hyper spectral image compression for remote sensing applications was developed during the year 2016 [21]. A lossy hyper spectral image compression scheme based on intra-band prediction and inter-band fractal encoding was used. The hyper spectral image was firstly partitioned into several Groups Of Bands (GOBs). Intra-band prediction was applied to the first band in each GOB, exploiting spatial correlation, while inter-band fractal encoding with a local search algorithm was applied to the other bands in each GOB, making use of the local similarity between two adjacent bands. To improve the decoded quality, the prediction error and fractal residual were further transformed, quantized and entropy encoded.

Fractal image compression with the genetic algorithm has been proposed [22]. It includes the features of self-transformality property of the images. This algorithm is used to reduce the coding cost. A main demerit of this algorithm is it is a time consuming one.

IV. PROPOSED WORK

Although several image compression methods are available, the demand for user satisfied, significant bit rate reduction and image quality in many applications continues to outstrip the capabilities of existing technologies. Image Compression mainly aims at reducing the bit rates and improving the PSNR values. This research work specifically focuses on examining the prediction and intensity based image compression methods.

The research started with Prediction Based Image Compression (PBIC) that isOctagon Based Intra prediction (OBIP) method followed by N - Modulus Transformation Using Intra Prediction (NMT-OBIP). As the next stage in the research, applying IBIC, intensity based segmentation is done as pre-processing step to increase coding efficiency and data rate saving. In the final stage of research, an Integrated Encoder has been developed by blending PBIC & IBIC for reducing the bit rates and improving image quality. The efficiency of the four different schemes are analyzed and compared with JPEG 2000, Bayesian Model Averaging (BMA), TMW, JPEG – LS, Variable Block Size coding (VBS), Adaptive Predictive Coding (APC), Encryption Then Compression (ETC), 1-D Legendre Polynomials and 2-D Legendre Polynomials. Design principles are implemented in the MATLAB platform. The proposed method is analyzed using PSNR, compression ratio and bits per pixel as performance metrics. This research work uses six gray scale standard images for assessing the performance of all algorithms.

Scheme I: Octagon Based Intra Prediction

OBIP is introduced for still gray scale lossy image compression, in which image compression is carried out in two search ranges square and octagon. In OBIP, intra prediction is defined as the prediction in which the image content of a particular region can be represented with other previously decoded region. Hence, in the intra prediction, decoding is done during encoding also. Here, the regions are termed as blocks. Theoctagon and square searching patterns are integrated and proposed a new OBIP searching algorithm for prediction based image compression. The search range of the OBIP algorithm is shown in Figure.1

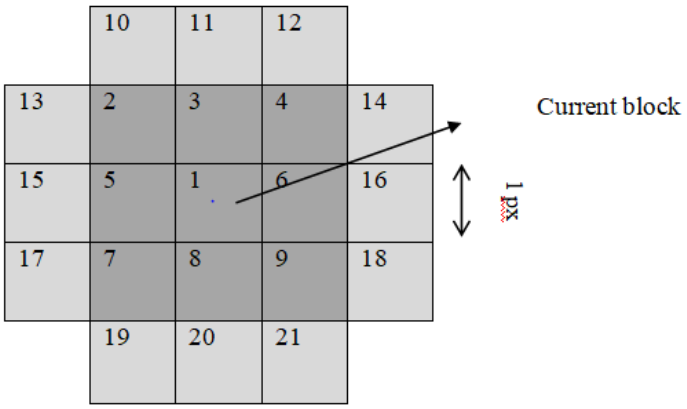

Figure 1: Octagon and square search

For an NxN block, intra prediction searches the predicted block in the neighboring blocks according to the search ranges specified. The inner square search range uses 9 blocks for intra prediction and shaded with dark gray while the outer octagon search range is shaded with light gray and it uses 12 blocks for intra prediction. Proposed algorithm uses totally 21 blocks for intra prediction.

The similarity of the blocks is measured using Block Distortion Measure (BDM). The block with the minimum BDM is selected as the predicted block. The candidate block with minimum BDM is the one that matches closest to the current block. The Octagon Based Intra Prediction Mode selection Algorithm is as follows:

Observations

OBIP employs new octagon based searching for still image compression which helps reducing the distortion there by improving the reconstructed image quality. In OBIP searching range of neighboring pixel is increased, in order to efficiently identify thepredicted block. Further, it has been observed that the higher the correlation the lower the distortion is. OBIP possess high correlation among the nearest pixels and also it maintains the high PSNR value.

Scheme II: N-Modulus Transformation Using Intra Coding

The proposed method NMT is used for still gray scale lossy image compression. The correlation between pixels is increased using modulus method. An intra coding fullydepends

on spatial redundancy, compression performance can be increased if the correlation between pixels is increased. In this method, the pixels in the image are changed to different values which are divisible by a common number, say N (N=2 to 9). Then by dividing the pixels by N, gives the pixels which are more correlated. Incorporating intra prediction coding after applying modulus transformation is carried out as the next step for further analysis. Since intra prediction is efficient if the neighbor blocks have same pixel values, NMT can be integrated with intra prediction and named as NMT-OBIP to improve the efficiency.

Observations

Proposed NMT-OBIP is done by the modulus operation. The modulus transformation is converted to a more general form to adapt the pixel value in the image. Since intra prediction is efficient if the neighbor blocks have same pixel values, NMT can be integrated with intra prediction called as NMT-OBIP to improve the efficiency.

Scheme III: Intensity Based Image Compression

IBIC is proposed for still gray scale lossy image compression. This scheme reveals the importance of high and low intensity pixels in compression. In this method, the pixels within the digital image are divided into low and high intensity which are compressed and decompressed separately using various existing algorithms.

The proposed method categorizes the image into high and low intensity components. After segmenting the image into HI vector and LI vector with pixel values based on threshold, the HI and LI pixels are processed separately using different existing algorithm. High intensity pixels are encoded using three compression methods viz Discrete Cosine Transform (DCT), Singular Valued Decomposition (SVD) algorithm and JPEG 2000 encoder. The best from the three algorithms for high intensity pixels is chosen. The low intensity pixels are encoded using another three different compression methods viz Arithmetic Encoding (AE), Quad-tree Decomposition (QD) algorithm and Vector Quantization (VQ). The best algorithm is chosen from each category and integrated together to build an efficient encoding algorithm which is depicted in Figure 2. It is named as IBIC Encoder.

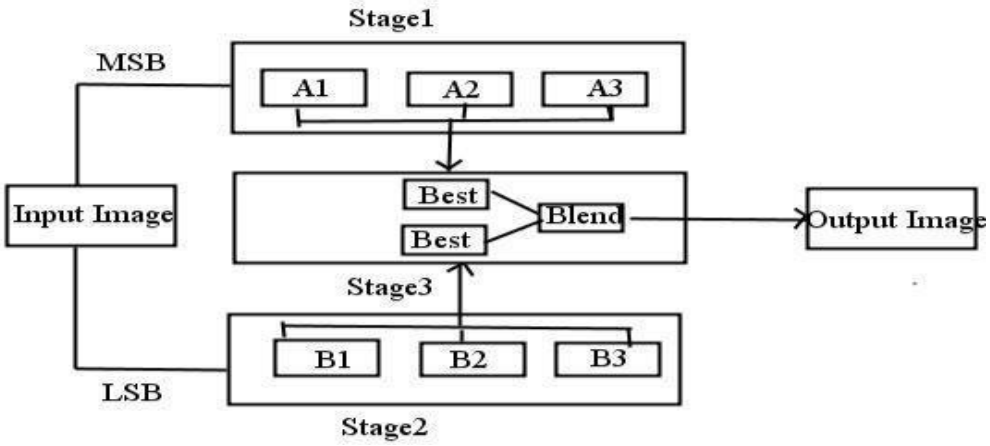

Figure 2: IBIC System Architecture

A1-Discrete Cosine Transform, A2 – Singular value decomposition, A3 – JPEG 2000 B1 – Arithmeticencoding, B2 - Quad-tree Decomposition, B3 - Vector Quantization

Observations

Methods used to encode HI components are DCT, SVD and JPEG 2000. Amongthe three methods, JPEG 2000 provides better result than reported techniques. While considering AE, QD and VQ, AE provides better result for low intensity pixels. From the experiments, it is analyzed that the high intensity pixels are efficiently encoded using JPEG 2000 encoder. Similarly the low intensity pixels are efficiently encoded using Arithmetic encoding. Hence these two methods are integrated into a single encoderIBIC.

Scheme IV: Proposed Integrated Encoder (PBIC+IBIC)

In this Scheme, the image is divided into high and low intensity pixels. Both PBIC and IBIC are integrated together to form a proposed encoder. From the proposed IBIC method, efficient encoders are chosen for encoding HI and LI components. These encoders are combined with NMT-OBIP codec to design a novel codec. The proposed integrated codec is carried out in two approaches. The encoder used in each approach is shown in Table 1.

Table 1: Encoder used in approach1 and 2

Approaches	ComponentEncoder	ComponentEncoder
Approach 1	JPEG 2000	NMT-OBIP
Approach 2	NMT-OBIP	AE

In Approach1, the HI components are encoded using JPEG 2000 encoder and LI components are encoded using the proposed NMT- OBIP encoder. In Approach2, the HI components are encoded using the proposed NMT-OBIP encoder and LI components are encoded using AE encoder. Approach 1 embeds JPEG 2000 with proposed NMT-OBIP to facilitate improving its performance.

Observations

Finally, the two approaches of the proposed integrated encoder are analyzed. The proposed Integrated Encoder – Approach1 gives an average compression ratio of 13.94667 leading to 0.081 average bit rate and also it maintains the average PSNR value of 55.21833 dB. Approach 2 gives an average compression ratio of 12.54 leading to 0.14 average bit rate and also it maintains the average PSNR value of 50.005dB. It is clear that Approach 1 is finds to be efficient, it is considered further for comparison in the next section.

V. SUMMARY OF PROPOSED WORKS

The performance of four proposed methods is compared with well known JPEG 2000 image compression standard. JPEG2000 is the standard image compression standard for several years. Hence, it is necessary to compare the proposed methods with JPEG2000. The resulting average performance measures such as for considered images are recorded inTable 2.

Table 2: Summary of results obtained-Average Values compared with JPEG 2000

Average Values					
Performance Measures	**OBIP**	**NMT-OBIP**	**IBIC**	**Integrated Encoder**	**JPEG 2000**
CR	5.6325	14.52738	13.54225	13.94667	10.9699
PSNR	56.7008	52.285	54.84865	55.21833	51.7718
Bits Per Pixel	0.1923	0.090917	0.5930333	0.081	0.7337

It is perceived from the results (Table 2), that on an average the OBIP Encoder gives a compression ratio of 5.6325 leading to 0.1923 bit rate and it also maintains the PSNR value of 56.7008dB. In similar line, NMT-OBIP Encoder achieves an average of 14.52738 compression ratio leading to 0.090917 bit rate and it also maintains the PSNR value of 52.285 dB. IBIC Encoder gives an average compression ratio of 13.54225 leading to 0.5930333 bit rate and it also maintains the PSNR value of 54.84865 dB. Integrated Encoder achieves with an average of 13.94667 compression ratio leading to 0.081 bit rate and it also maintains the PSNR value of 55.21833 dB. JPEG 2000 Encoder gives an average compression ratio of 10.9699 leading to 0.7337 bit rate and it also maintains the PSNR value of 51.7718 dB.

OBIP gives better PSNR value but compared to other proposed methods it gives very low compression ratio. On the report of three performance measures all the four proposed methods have enhanced PSNR and bit rate values than JPEG2000. IBIC Encoder gives nearly equal PSNR value compared to Integrated Encoder but its bit rate values are inappreciable than Integrated Encoder. From the observed results it is clear that improved compression ratio yields better bit rate value.

Observations

Among the four proposed methods, two compressive approaches are proposed for prediction based image compression that is OBIP and NMT-OBIP. IBIC is proposed for intensity based image compression. PBIC and IBIC are blended together to form an Integrated Encoder. To accomplish bit rate reduction, octagon based intra prediction is introduced in OBIP and also because of applying octagon based intra prediction, the proposed OBIP attain greater PSNR value. NMT-OBIP uses N-Modulus transformation for enhancing pixel correlation. Octagon based intra prediction is also embedded with NMT to improve its performance. It is clearly seen that when applying modulus transformation and octagon based intra prediction, the compression ratio and bit rate values have improved. IBIC and Integrated Encoder enhances the performance of JPEG 2000 by including different phases in it. IBIC & Integrated Encoder maintains the quality of JPEG 2000 with a little increase in PSNR and CR value. From this performance evaluation, it is found that Integrated Encoder outperforms the other reported techniques. It is observed that the combination of both prediction and intensity based image compression produce good results.

Average PSNR, CR, bit rate and storage space saving of all the proposed methods are found to be good. JPEG 2000 is a widely used standard compression method so that the

proposed methods are compared with JPEG 2000. It is observed from the results that the proposed method IBIC and Integrated Encoder which embed JPEG 2000 produce good results than JPEG 2000. Proposed Integrated Encoder bit rate value is also compared with other encoders which yield good results.

VI. CONCLUSION

The main challenge in still image compression is minimizing the size in bytes of an image file without degrading the quality of the image and also reducing the storage and bandwidth cost requirements. This research work addresses these issues by introducing four new still gray scale lossy image compression techniques. Among the four proposed methods, two compressive approaches are proposed for prediction based image compression that is OBIP and NMT-OBIP. IBIC proposed for intensity based image compression. PBIC and IBIC are blended together to fabricate Integrated Encoder.

The following are the findings of this research work:

1. From the proposed PBIC and IBIC methods, it is observed that the combination of prediction and intensity based image compression encoding technique produce improved results.
2. In IBIC, all the stages are implemented and observed that the High Intensity pixels are efficiently encoded using JPEG 2000 and the Low Intensity pixels areefficiently encoded using Arithmetic Encoder
3. IBIC & Integrated Encoder is embedded with JPEG 2000. It is found that these proposed methods which embedded JPEG 2000 produced good results than JPEG 2000.

Benefits of the Proposed work

1. Applying the Octagon based search pattern, searching range of neighboring pixel has been increased which in turn efficiently identifies the predicted blocks. Octagon based search pattern introduced in prediction based image compression improves the compression efficiency.
2. The correlation between pixels has increased by employing NMT-OBIP. The higher the correlations, the lower the distortion which in turn leads to bit rate reduction.
3. Reduction in bit rate leads to higher compression ratio and more memory space saving.
4. Integrated Encoder is an efficient encoder designed in this work that has achievedgood bit rate savings

VII. LIMITATIONS OF THE PROPOSED WORK

1. The proposed approaches are suitable only for gray scale images.
2. Proposed encoder's execution time is higher than JPEG 2000, since it embeds JPEG 2000 in it. Space saving being an impact factor so as to time consumption, can be negligible.

VIII. FUTURE SCOPE

1. All the proposed methods can be tested on RGB or some other color images.

2. The proposed methods can be implemented in small video sequences.
3. Several other metrics such as MSE can be used to analyze its performance.
4. It can also be tested on real-time images.

REFERENCES

[1] Abo-Zahhad, M., Gharieb, R.R., Ahmed, S.M. & Abd-Ellah, M.K., 2015, 'Huffman image compression incorporating DPCM and DWT', Journal of Signal and Information Processing, 6(02), p.123.
[2] Kabir, M. & Mondal, M., 2018, 'Edge-based and prediction-based transformations for lossless image compression', Journal of Imaging, 4(5), p.64.
[3] Suarjaya, I.M.A.D., 2012, 'A new algorithm for data compression optimization', arXiv preprint arXiv:1209.1045.
[4] Meyer, B. & Tischer, P., 1997, 'TMW-a new method for lossless image compression', ITG FACHBERICHT, 2, pp.533-540.
[5] Li, X. & Orchard, M.T., 2001, 'Edge-directed prediction for lossless compression of natural images', IEEE Transactions on image processing, 10(6), pp.813-817.
[6] Matsuda, I., Ozaki, N., Umezu, Y. & Itoh, S 2005, 'Lossless coding using variable block-size adaptive prediction optimized for each image', In 2005 13th European Signal Processing Conference (pp. 1-4). IEEE.
[7] Al-Azawi, S., Boussakta, S. & Yakovlev, A., 2011, 'Image compression algorithms using intensity based adaptive quantization coding', American Journal of Engineering and Applied Sciences, 4(4), pp.504-512.
[8] Mandyam, G., Ahmed, N. & Magotra, N., 1997, 'Lossless image compression using the discrete cosine transform', Journal of visual communication and image representation', 8(1), pp.21-26.
[9] Anitha, S. "Comparison of Compression Techniques." International Journal of Advanced Research in Computer Science 5.1 (2014).
[10] Anitha, S. "Lossless image compression and decompression using Huffman coding." International Research Journal of Engineering and Technology 2 (2015): 240-247.
[11] Anitha, S. "An Overview of Image Compression." International Journal of Advanced Research in Computer Science 5.5 (2014).
[12] Anitha, S. "Image Compression Based On Octagon Based Intra Prediction." Turkish Journal of Computer and Mathematics Education (TURCOMAT) 12.10 (2021): 6144-6151.
[13] V.Lakshmi Praba, R.S. Rajesh, S. Anitha, "An Image Compression: - A Survey", International Journal of Computer Sciences and Engineering, Vol.07, Special Issue.08, pp.79-82, 2019.
[14] "Removing Coding and Inter Pixel Redundancy in High Intensity Part of Image", International Journal of Engineering Technologies and Innovative Research,ISSN: 2349-5162,Vol.6,Issue 2,page no.1172-1177,February-2019.
[15] V.Lakshmi Praba, R.S. Rajesh, S. Anitha, "An Image Compression: - A Survey", International Journal of Computer Sciences and Engineering, Vol.07, Special Issue.08, pp.79-82, 2019.
[16] Munteanu, A., Cornelis, J. & Cristea, P., 1999, 'Wavelet-based lossless compression of coronary angiographic images', IEEE transactions on medical imaging, 18(3), pp.272-281.
[17] Taujuddin, N.S.A.M., IBrahim, R. & Sari, S., 2015, 'Progressive pixel-to-pixel evaluation to obtain the hard & smooth region for image compression', In 2015 6th International Conference on Intelligent Systems, Modelling & Simulation (pp. 102- 106). IEEE.
[18] Oh, H., Bilgin, A. & Marcellin, M.W., 2012, 'Visually lossless encoding for JPEG2000', IEEE transactions on image processing, 22(1), pp.189-201.
[19] Serra-Sagristà, J. & Aulí-Llinàs, F., 2008, 'Remote sensing data compression', In Computational Intelligence for Remote Sensing (pp. 27-61). Springer, Berlin, Heidelberg.
[20] Sune, M.P.M., & Prof. Vijaya K. Shandilya, 2013, 'Image Compression Techniques based On Wavelet and Huffman Coding', International Journal of Advanced Research in Computer Science and Software Engineering, 3(4).
[21] Zhao, D., Zhu, S. & Wang, F., 2016, 'Lossy hyperspectral image compression based on intra-b& prediction and inter-band fractal encoding', Computers & Electrical Engineering, 54, pp.494-505.
[22] Grinstead B., Sari-Sarraf H., Gleason S. & Mitra S. 2000, 'Content based compression of mammograms for telecommunication & archiving', 13th IEEESymposium on Computer Based Medical Systems, pp. 47-52.

