Image Compression Algorithms for Satellite andMedical Images

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***Abstract*—Image being the visual representation of things is one of the most prominent modes of communication that is currently being studied. Image carrying information must be transmitted from one place to other place for further analysis. While transmission, noise gets added to signal. Thus, noisy image is enhanced as a pre - processing step. Performance parameters, SSIM and MSE are calculated for enhanced image. For transmission, bandwidth utilization and latency plays a crucial role, thus to minimize the resource utilization, the size of the image must be reduced. This reduction of image size is performed using Image Compression techniques. In this paper, a lossless LZW algorithm with bit - plane slicing and a lossy DWT algorithm is implemented for satellite and MRI brain medical images. The algorithms are evaluated by various performance metrics such as Compression ratio, entropy, PSNR and Mean Square Error.**

***Index Terms*—Lossless Image Compression, Bit Level Slicing, LZW coding, DWT coding, Contrast**

INTRODUCTION

Image processing is one of the most extensively used communication mode, where the information present in the image is stored, processed, transmitted at one end and received at another end. An image is a two dimensional array containing pixels as its basic element, which represents the data in it. When an image must be transmitted from one end to other, sufficient resource such as bandwidth, memory and capacity is required. Thus, to optimize the usage of resources, the data which is recurring and redundant can be reduced, thus reducing the size of the image[1]. This makes the transmission of image easy and consumes less memory. This technique of reducing the size of the image by removing redundant information is called Image Compression and corresponding techniques are called Image compression techniques. Image compression has wide scope in multimedia communication, remote sensing via satellites, various medical applications such as MRI, etc. Image compression is widely classified as Lossy Image compression technique and Lossless image compression technique. Lossy image compression technique is the one which can withstand the loss of data that has occurred during the compression process[1]. The main application is in multimedia applications and entertainment field, where a smallamount of loss of data does not affect the appearance of image.

The popular lossy compression techniques are Discrete Co- sine Transform (DCT), Fractal compression, Discrete Wavelet Transform, etc. Lossless image compression technique is the one which cannot afford to lose any information present in the image during compression as the whole data is informative and is required for further analysis. The main applications of lossless image compression are in satellite images, medical images, etc. The most popular lossless compression techniques are Lempel-Ziv-Welch, Run Length Coding, Huffman Coding, etc. Bit plane slicing is a technique, which extracts the information bit wise[2], MSB having highest information and LSB having least. It is one of the most widely used lossy compression technique.LZW coding is dictionary based lossless compression algo- rithm, known for its fast and simple reduction of repetitive data[3,4,5]. LZW algorithm is used for satellite interframe coding in [6] and for medical images in [7]. [8] has proposed a improved LZW method to increase the compression ratio of image. The objective assessment of medical lossless images is comparitively studied in [9]. Other algorithms such as Predictive coding for image compression are adopted in [10]. Also, Run Length Encoding (RLE), a lossless compression technique is implemented in [11]. A fast Huffman coding is studied in [12] and Adaptive Image compression is studied in [13] using adaptive Huffman and LZW coding. One of the most popular Discrete Wavelet Transform is used as image compression technique [14]. It uses HAAR DWT for filtering and scaling [15,16]. Real time satellite images are acquired by remote sensing from [17] and real time MRI brain image datasets from kaggle datasets [18].The parameters that are commonly used to evaluate the performance of different compression techniques are compres- sion ratio, Peak Signal to Noise Ratio (PSNR), Mean Square Error, Entropy measures. For Image enhancement, Structural Similarity Index Measure (SSIM), Mean Square Error and Entropy Measure. Compression ratio is defined as the ratio of original image bits to compressed image bits. Higher the compression ratio value, better is the compression technique. Mean Square Error parameter calculates square of mean of difference between original and compressed image. Lesser the mean square error, better is the compression technique, since
the error is minimum. Entropy is the measure of information present in the image. More the entropy value, more is the information bits present in the image. Peak Signal to Noise ratio calculates the SNR of image in decibels. This ratio is used as a quality measure of image. Higher the value of PSNR, better is the quality of compression. As a measure of image enhancement, Structural Similarity Index is used. Structural Similarity Index calculates the similarity between original and noise removed

enhanced image. More the SSIM value, higher is the similarity. Contrast is the measure of clarity of image with which objects or regions can be identified.

EXPERIMENTAL PROCEDURE

This work focuses on Image processing of satellite and medical images. First, the images are enhanced by removing noise present in the image, then image is compressed using compression algorithms. The complete steps are explainedbelow.

Image Enhancement

The process of removing unwanted signals from original image is known as Image enhancement. These unwanted signals are termed as noise component. They degrade the image, reducing the quality of image. In general, noise gets added during image acquisition and image transmission. Most commonly occurring noise in Satellite Image is salt and pepper noise. This noise can be removed using median filter. Medicalimages contain gaussian noise and can be removed using Gaussian filter.

Image Compression

Lempel Ziv Welch (LZW) and Discrete Wavelet Transform (DWT) compression techniques are implemented for com- pressing satellite and medical images.

LZW encoding: LZW is a lossless image compression algorithm widely used for compressing satellite and medical images. LZW is a dictionary - based algorithm [3,4,5], which looks for bits or symbols that occurs frequently and generates a table of frequently occurred bits and encodes it. Basically, it has 256 codes and goes on updating its table based on the sequence of bits occurred while scanning data. It is an adaptive efficient algorithm which results in providing good compres- sion ratio after LZW compression. By applying bit – plane slicing before giving the image to compression algorithm, it increases the compression ratio significantly. Any image is represented by 8 bits or 8 layers. 0^{th} bit is the Least Significant Bit (LSB) and 7th bit is the Most Significant Bit (MSB). Each image bit acts as a layer and can be extracted layer by layer. In an image, most of the information is contained in the MSB bit, thus by extracting MSB bit and is then given to LZW compression algorithm. Bit – plane slicing is the simplest lossy form of compression, thus LZW compression with bit plane slicing is lossy to lossless form of compression which outperforms simple LZW compression technique.*DWT encoding:* DWT being one of the most popular lossy technique, wavelets are the functions that are generated by dilations and translations from a single function, of which Haar Transform is the simplest one. The Haar transformation Matrix, denoted by T, having rows orthogonal to each other is an orthonormal matrix. TxT(transpose) gives the output of Haar wavelet image. With the help of filters, it distinguishes the higher and lower frequency components. Multiple levels can be performed by repeating filtering and decimation processon lowpass outputs.

After compression of image, the contrast of the compressed image is improved using power law transformation, which displays the image with good brightness and contrast.

RESULTS & DISCUSSION

The results obtained from implementation are explained in this section. Satellite image is taken from [17]. Medical image for analysis is taken from kaggle data-set [18]. MRI brain image is considered for medical image.

The performance evaluation parameters considered for im- age enhancement are Structural Similarity Index, Mean square Error and Entropy measure of original and enhanced image and that of compressed image are Compression ratio (CR), Peak SNR (PSNR), MSE, Entropy of compressed image and contrast of image.

Table I
Performance Evaluation of Image Enhancement

	Satellite Image	**Medical Image**
SSIM	0.7999	0.2800
MSE	176.1924	219.9999
Entropy (gray image)	7.0469	5.4028
Entropy (enhanced image)	6.8542	6.5087

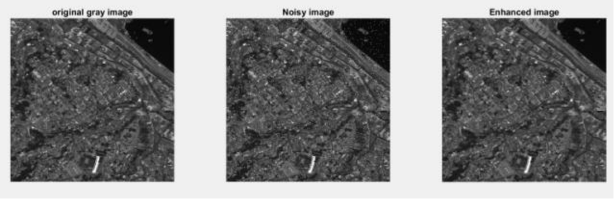

Fig. 1. Original, Noisy and Enhanced satellite image

The original gray image, noisy image and enhanced images of satellite and medical images are shown in Fig. 1 and Fig. 2 respectively. Table I shows the performance evaluation of image enhancement. It can be observed that for satellite image, the structural similarity is close to 1, hence significant noise has been removed using median filter.

Fig. 2. Original, Noisy and Enhanced MRI medical image

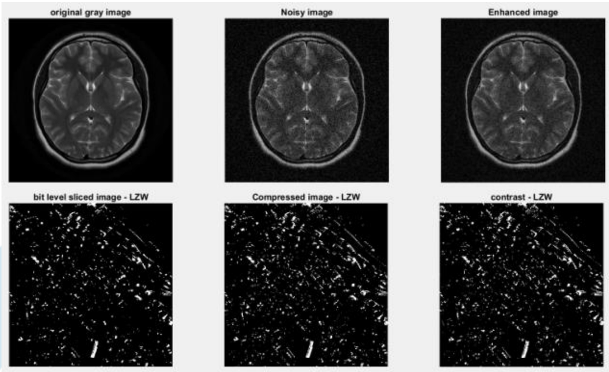

Fig. 3. LZW - Bit Level, Compressed and contrast improved satellite Image

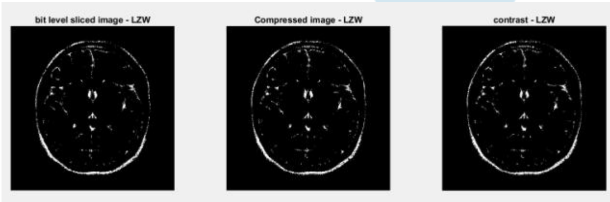

Fig. 4. LZW - Bit level, Compressed and contrast Improved MRI medical Image

Table II
Performance Evaluation of LZW with bit plane slicing Image Compression Technique

	Satellite Image	**Medical Image**
Compression Ratio	5.5581	8.9592
PSNR	10.8329	14.7383
MSE	5360	2180
Entropy (compressed image)	1.4808	0.7247
Contrast	255	255

Fig. 3 depicts the bit - level sliced, LZW algorithm based compressed and Contrast improved satellite image, which can be used for further analysis. Similarly fig. 4 depicts the bit - level sliced, LZW algorithm based compressed and contrast improved MRI medical image. The performance metrics of LZW compressed image is tabulated in Table II with respect to both satellite and MRI medical image.

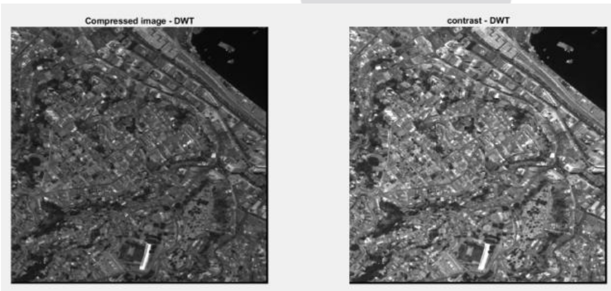

Fig. 5. DWT - Compressed and contrast Improved Satellite Image

Fig. 5 depicts the DWT algorithm based compressed and Contrast improved satellite image, which can be used for fur- ther analysis. Similarly fig. 6 depicts the DWT algorithm based

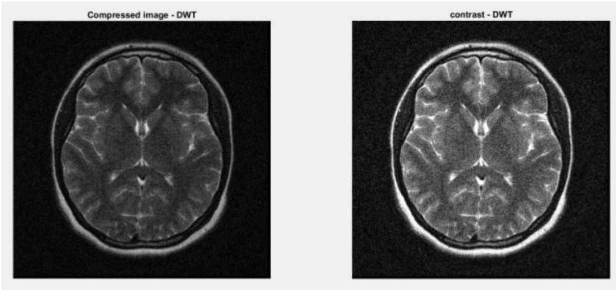

Fig. 6. DWT - Compressed and contrast improved MRI Medical ImageTable III
Performance Evaluation of DWT Image Compression Technique

	Satellite Image	**Medical Image**
Compression Ratio	1.0478	1.0253
PSNR	28.0748	22.8653
MSE	101.2985	336.1660
Entropy (compressed image)	6.8729	6.5069
Contrast	255	255

Compressed and contrast improved MRI medical image. The performance metrics of DWT compressed image is tabulated in Table III with respect to both satellite and MRI medical image. It can be observed from Table II and Table III that the lossless compression technique, LZW gives higher Compression ratio when compared with lossy DWT compression. It indicates that no loss of information happens in LZW algorithm. But when PSNR parameter is taken into consideration, lossy algorithm gives high ratio than that of lossless algorithm. As discussed, higher the PSNR, greater is the quality of the signal.

CONCLUSION

In this work, as a pre - processing step, degraded image is enhanced using suitable filters and its performance is evaluated. During transmission of image signal, the size of the image file plays a vital role. Thus reduction of image size for two critical applications namely satellite image and MRI brain image, using two different compression algorithms is discussed in this work. Thus it can be concluded that, when application requires higher compression ratio, LZW algorithm is preferred and when PSNR is the main parameter to be considered, DWT algorithm is preferred for compression. Compression for color images is one of the key area to be explored as future work. Also, other lossy compression techniques to achieve good compression ratio must be exploredfor future work.

REFERENCES

1. Dr. S Vimala, Mrs. Niranjana, “A Survey on recent Image Compression Techniques”, International Journal for Research in Science Engineering and Technology, pp. 23-28,vol. 2, Issue 9, pp. 23-28, 2015.
2. H Kikuchi, K Funahashi and S Muramatsu, “Simple bit – plane coding for lossless image compression and extended functionalities”, Picture Coding Symposium, pp. 1-4, 2009.
3. Negesse Tadesse, Abebe Alemu and Abhay Teshager, “Enhance the LZW Compression Ratio Through the Use of Image Preprocessing Techniques for Grey Scale Images”, International Journal of Material and Mathematical Sciences, pp. 22-42, 2021.
4. Srinivasa Rao Namburi, Praveen kumar Muvva, et.al, “A New Approach to increase LZW Algorithm Compression Ratio”, International Journal of Engineering Applied Sciences and Technology, vol. 4, Issue 10, pp. 141-144, 2020.
5. Md Ashraful Alam, Fakhrul Ahsan, et. Al, “Faster Image CompressiTechnique Based on LZW Algorithm Using GPU Parallel Processing”, 7th International Conference on Informatics, Electronics and Vision and 2nd International Conference on Imaging, Vision and Pattern Recognition, 2018.
6. Aseel M Mahdi, Faisal G Mohammed, “Lossless Compression Scheme for Satellite Images using Inter-Frame Coding with LZW Coding”, Australian Journal of Basic and Applied Sciences, 2017.
7. Sadhana Singh, Preeti Pandey, “Enhanced LZW Technique for Medical Image Compression”, 3rd International Conference on “Computing for Sustainable Global Development”, Mar. 2016.
8. Sawsan A Abu Taleb, Hossam M J Musafa, et.al, “Improving LZW Image Compression”, European Journal of Scientific Research, pp. 502-509, 2010.
9. Bona Kowalik-Urbanaik, Dominique Brunet, et.al, “The quest for “diag- nostically lossless” medical image compression: A comparative study of objective quality metrics for compressed medical images”, SPIE Medical Imaging: Image Perception, Observer Performance, and Technologyassessment, San Diego, CA, Proc. SPIE, vol. 9037, 2014.
10. Haider Al-Mohmood, Zainab Al-Rubaye, “Lossless Image Compression based on Predictive Coding and Bit Plane Slicing”, International Journalof Computer Applications, vol. 93, No. 1, 2014.
11. Hassan K. Albhadily, V Yu Tsviatkou, V K Kanapelka, “Grayscale Image Compression using Bit Plane Slicing and Developed RLE Algo- rithms”, International Journal of Advanced Research in Computer and Communication Engineering, vol. 6, Issue 2, 2017.

12. Rachit Patel, Virendra Kumar, et. al, “A Fast and Improved Image Com- pression Technique Using Huffman Coding”, International Conference on Wireless Communications, Signal Processing and networking, 2016.
13. Djuned Fernando Djusdek, Hudan Studiawan, Tohari Ahmad, “Adaptive Image Compression Using Adaptive Huffman and LZW”, International Conference on Information, Communication Technology and system, pp.101-106, 2016.
14. Amir Averbuch, Danny Lazar and Moshe Israeli, “Image Compression Using Multiresolution Decomposition”, IEEE Transactions on Image Processing, vol. 5, No. 1, 1996.
15. Hemalatha Kanagaraj, V. Muneeswaram, “Image compression using HAAR discrete wavelet transform”, 5th International Conference on Devices, Circuits and Systems, 2020.
16. Ahmed A Nashat, N M Hussain Hassan, “Image Compression Based upon Wavelet Transform and a Statistical Threshold”, International Conference on Optoelectronics and Image Processing, 2016.
17. R M Susilo, T R Bretschneider, “On the Realtime Satellite Image Com- pression of X - Sat”, Fourth International Conference on Information, Communications and Signal Processing, 2003.
18. Navoneel Chakrabarty, 2019, “Brain MRI Images for Brain Tumor Detection”.