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Developed a Method for Satellite Image Compression Using Enhanced Fixed Prediction Scheme

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A B S T R A C T

Image is widely used in modern life which produces huge amounts of data and that requirec
compression is the mechanism by which a digital image is effectively compressed to minimize
The images take huge space in the computers or servers, hence a long time during tran
compression method to reduce the store size and the cost of transmission using a fixed predictiv
redundancy between successive neighboring pixels since only a few information outcomes l
enhanced method to improve image compression of Satellite Images without missing data l
compresses image data without loss based on the fixed prediction technique. The Satellite Imag
by using six Satellite Images. The achieved results were very promising conducting a compres
tested to check the quality of the compressed images with a value =38.30.

MSC..

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1. Introduction

In recent days, people communicate and share information through the world of social media communication tools using tablets, smartphones, and computers, where images are the essence [1], but these images, unfortunately, consume memory and increase the cost of transmission channels. If used properly, this can be reduced, to reduce transmission and storage costs. Compression depends on redundancy and pixel correlations [2]. There is a growing interest in image compression in that the number of image data files is steadily increasing [3], in many disciplines, such as medicine, remote sensing, e-commerce, e-learning, and multimedia [4]. Nowadays, large-scale image technologies such as Huffman coding, computational coding, run-length coding, bit-level segmentation, block trimming, and vector scales are available as some standards such as JPEG (Joint Photographic Experts Group) and others are still under development such as predictive modular coding. Repetitive geometric. Where all techniques depend on the principle of exploiting repetition, within the image itself, within the representation of image information, and human perception (human visual system, HVS) [1].

The compression techniques are used widely in many fields to compress different types of multimedia including texts, images, audio, and video [5]. Predictive coding is still a new technique for image compression based on the use of modeling concepts for prediction and differentiation. The technologies are characterized by their accuracy and versatility, but they have poor compression efficiency; this debate aims to increase compression performance without sacrificing quality [16].

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The images take huge space in the computers or servers, hence a long time during transmission. This paper provides an enhanced compression method to reduce the store size and the cost of transmission using a fixed predictive scheme.

2. *Literature Review*

There are many different dominant image compression techniques used related to predictive coding or simply Differential Pulse Code Modulation (DPCM) as explained in related work below:

In [6] the scholars Introduced a method for compressing medical images that involves first preprocessing the image with a differential pulse code modulator (DPCM), then converting the DPCM output into waves, and eventually applying Hoffmann coding to the resulting parameters. The findings revealed that the compression ratios (CR) of DPCM-DWT-Huffman, DWT-Huffman, DPCM-Huffman, and Huffman algorithms are 6.4837, 4.32, 2.2751, and 1.235, respectively have been presented.

In [7], a hybrid lossless image compression technique called LPC-DWT-Huffman (LPCDH) technology has been proposed. The picture went through the LPC switch first. The LPC output is then subjected to the waveform transformation. Finally, Hoffmann notation is used to encode the wavelet parameters. The model is the maximum compression ratio as before, as compared to both Huffman and DWT-Huffman (DH) technologies.

In [8], some new strategies for improving lossless compression efficiency that incorporate accurate transformations with predictive coding were suggested. Pressure metrics such as gradient entropy and entropy are used to test the efficiency of the proposed techniques. Four different lossless medical image compression techniques were proposed, and these methods were put to the test using five different photographs from North Carolina State University and the University of Iowa's Medical Image Database. Lossless images are compressed using lossless predictive coding technologies with second-order projections and a right waveform transition using levitation technology. A technique for analyzing wavelet conversion into lift phases was built in the Daubechies process. Easy filtration measures with small filters, such as the Haar filter, are used to accomplish lifting have been presented.

In [9], a method for lossless binary and gray scale image encoding and secure storage. The compression is essentially lossless and is dependent on the SCAN language. Scanning is a 2D spatial access technique focused on vocabulary that can quickly define and produce a variety of scanning paths or fill-in-the-space curves. Before compression, a system based on information division is implemented to ensure safe image storage. Finally, the QR code is used to index protected images effectively. In comparison to one-dimensional barcodes, QR codes are two-dimensional barcodes that can hold a lot of information. The experimental results are analyzed using diagnostic photographs in the hopes of achieving greater results than those available in the public domain

3. Image Compression

Image compression is a form of data compression that is used to reduce the cost of storage and transmission of digital files. As opposed to general data compression techniques used by other digital data, algorithms can take advantage of the visual representation and statistical properties of image data to produce superior performance. It is either that photos are compact and misplaced, or that they are not lost at all. It is preferable to use lossless compression. Lossless compression is preferred for archival purposes and mostly for medical imaging and technical drawings. Corrupt compression methods, especially when used at low bit rates, exhibit compression defects. Resolution loss approaches are especially well adapted to natural images, such as pictures, where a minor (sometimes imperceptible) loss in resolution is appropriate in return for significant bit rate decreases. Non-lost pressure is described as pressure that causes minor variations without causing vision loss. [10]. Image compression may depend on different techniques like data redundancy, coding redundancy, inter-pixel redundancy, predictive and transform coding [11].

3.*1 Fixed Predictor and Pulse Code Modulation (PCM)*

The fixed predictor is the most basic method of Pulse Code Modulation (PCM). It is used to eliminate high dependence (correlation) between input image pixels, which is where the majority of the resemblance is embedded, and it is the foundation of compression techniques. Since the predictor or fixed predictor that simulates a preprocessing phase removes inherited duplication, the predictor's architecture must balance efficiency and complexity [7].

The number of neighbors used, the dependence form, and the structure formula (1D or 2D) must all be considered when using a set predictor [9]. The below equations which is an example of one neighbor of causal dependency form of one–dimensional structure mapper/de-mapper respectively [13, 20].

$$Fp\,(i,j) = I\,(i,j) - I\,(i\text{-}1,j) \qquad (1)$$
$$I\,(i,j) = Fp\,(i,j) + I\,(i\text{-}1,j) \qquad (2)$$

Where Fp is the fixed predictor that eliminates the link inclusion by only keeping the distinction between the current pixel value and the value in the I previous row, as it kept the first row of the image to create the image again.

The prediction method entails the mathematical /estimation of predicted random variables from observed random variables in the past and present. A prediction of an image pixel or a group of pixels may be obtained from previously scanned pixels in an image compression scenario. The residual signal is obtained by subtracting the projected pixels from the original pixels. In general, the prediction is deemed accurate if the residual signal's energy is smaller than the initial signal's energy [21].

3.2 Compression Efficiency

The only guideline for the lossless case is the compression efficiency, since in this kind no distortion or deterioration occurred where the decoded compressed image content equals the original image [22]. The compression ratio (CR) of the initial size to the compressed size is the most apparent metric.

$$CR == \frac{Original\ Size\ in\ Byte}{Compressed\ Size\ in\ Byte} \qquad (3)$$

Where the original size is the pixel and the compressed size of the original image is the byte compressed information.

The reduction in size compared to the initial data size is also characterized by space savings:

$$SpaceSaving = (1 - \frac{Compressed\ Size\ in\ byte}{Original\ Size\ in\ byte}) \times 100\% \qquad (4)$$

4. Proposed System Design and Implementation

The proposed approach consists of the lossless use of standard predictive coding for fixed predictor coding and is generalized to a separator framework with hierarchical representation. The fixed predictor is a modeling technique to correlate intermediate redundancy, followed by the application of symbolic coding techniques to remove redundancy in the coding for fixed-length coding.

Apply fixed predictor to remove the spatial redundancy embedded from image I by exploiting one or more neighbor (s), here three fixed predictors of first orders adopted of (1D) of causality model utilized, where each predictor adopted separately, according to equations below.

$$FpL(i,j) = I(i,j) - I(i,j-1) \qquad (5)$$
$$FpB(i,j) = I(i,j) - I(i-1,j) \qquad (6)$$
$$FpLB(i,j) = I(i,j) - I(i-1,j-1) \qquad (7)$$

Where FpL, FpB, and FpLB correspond to the predictor image or differentiation (residual) image created due to removing the correlation embedded between neighbors to the left, bottom, and left bottom respectively. Also, I original image, i, j represents the ith rows and jth columns of image I.

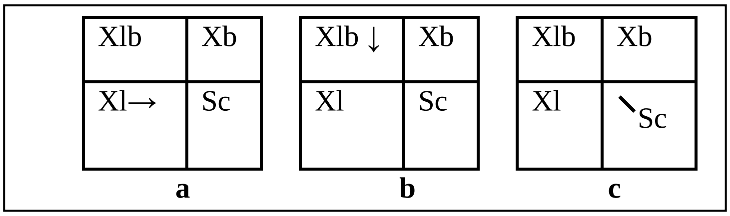
Apply symbol encoding techniques to remove the coding redundancy embedded within the Fp images either of the left, bottom, or left-bottom model, using Huffman coding along with the seed values (i.e., first row and/or first column).

Reconstruction rebuilds the compressed or decoded image which is identical to the original one I, the decoder, involve adding the decoded image Fp, and the fixed predictor model seed values, such as:

$$I(i,j) = FpL(i,j) - I(i,j-1) \qquad (8)$$
$$I(i,j) = FpB(i,j) - I(i-1,j) \qquad (9)$$
$$I(i,j) = FpLB(i-1,j) - I(i,j-1) \qquad (10)$$

4.1 Fixed Prediction Coding with Separator base Technique for Image Compression

The traditional fixed prediction coding is characterized by simplicity but unfortunately limited performance due to a negative number which exhausted a large number of bytes, Figure 1 shows an example of the fixed predictive of the first-order 1D left neighbor.



To overcome this complexity of negative numbers, the separator techniques adopted that based on creating or generating two matrices (images) A and B each of size NxN, where the possible values of matrix A are 0 or 1 or 2 depending on the value of Fp image. The matrix A is assigned a value of 0 where Fp (i, j) has a value of 0. Moreover, matrix A is assigned values of 1 and 2 where Fp (i, j) has a value greater than and less than 0, respectively. On the other hand, matrix B is assigned with the absolute value of Fp (i, j) followed by applying the symbol encoder techniques [12].

4.2 Hierarchal Separator Fixed Prediction Coding Technique for Image Compression

This is a fixed estimation coding strategy with two levels of separators. This method is focused on doing predictive coding several times while exploring the absolute matrices of the previous sheet. The method simply begins with the original image I, which represents the root and corresponds to layer 0, and then employs the previously discussed separator fixed predictive coding method to create the first layer (layer 1) of A and B matrices; to build the subsequent layer (s), the B matrices from the previous layer are treated as an image and the predictive coding technique is used to removed, Figure 2 show The layout of the hierarchal separator fixed predictor coding system of lossless based.

The steps of the hierarchal prediction method are illustrated in the algorithm below.

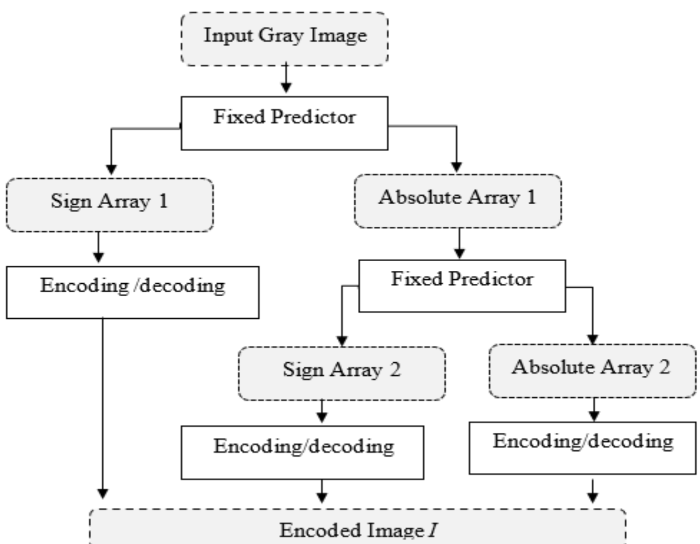


Fig. 2: The Layout Of The Hierarchal Separator Fixed Predictor Coding System

Algorithm1 : Fixed Predictor Algorithm

Input: GI //Array of Image
Output: Encoded Image I

Step 1: M← GetNoOfRows(GI) //Get Row
Step 2: N← GetNoOfColumns(GI)//Get Columns
Step 3: Assign Temp(1 to M,1 to N) equal to zeros // Initialize Temp. Array

Step 4: Temp(1, 1 to N)← GI(1, 1 to N) //Read First Row
Step 5: Temp(2 to M, 1)← GI(2 to M, 1) // Read Second Row
Step 6: RA(1, 1 to N)← GI(1, 1 to N) //Copy First row to the processing array
Step 7: RA(2 to M, 1)← GI(2 to M, 1)
Step 8: For i← 2 to M
Step 9: For j← 2 to N
Step 10: RA(i,j)← GI(I,j)-GI(i-1,j) //calculate the new value
Step 11: End For
Step 12: End For
Step 13: Applying LZW algorithm // LZW
Step 14: Applying Huffman Coding to find Encoding Symbols // Huffman Encoding
Step 15: Find Compression Ratio // Find CR
Step 16: Return Encoding Symbols // Output ES
Step 17: Return Compression ratio // Output CR

F1

F2

F3

F4

F5

F6

Fig. 3: Test Satellite Images

5. *Experimental Results*

Six satellite grayscale images, were used to measure the accuracy of constant prediction coding using the interval rule and the hierarchical diagram as shown in Figure 3, all of them are 800*600 pixels.

The enhanced method implemented using Matlab 2022 on PC with 2.1 GHz, 16 GB RAM on Windows 10 Operating System.

Table 1: Compression Ratio% of fixed prediction coding

Tested Images	Bottom based	Left based	left- bottom based
F1	79.13	79.34	79.89
F2	79.33	79.72	80.67
F3	79.23	79.49	80.43
F4	79.36	79.73	80.16
F5	79.23	79.75	80.42
F6	79.14	79.63	80.74

The results are shown in Tables 1, illustrate the implementation of the enhanced method on the six test satellite grayscale images F1-F6, grayscale images of size 469 KB, and diminutions of 800x600 pixels.

The achieved results showing that the compression ratio is up to about 79-80% for both bottom and left based technique, while it is increased up to 80% for the left-bottom technique.

The traditional fixed predictor coding is simple to implement with high compression performance. Also, the results vary according to the fixed predictor model adopted and image details (characteristics).

The results of all models nearly converged with each other, and the bottom predictive coding was adopted for the separator and hierarchal techniques.

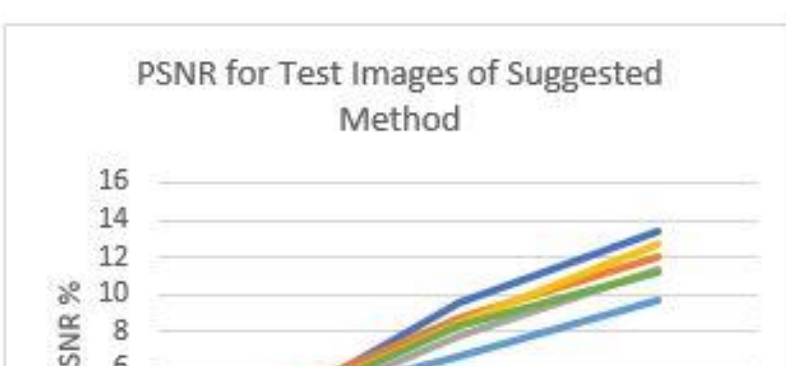
The results show that this technique of hierarchal base is of higher performance compared with other models, which implicitly means removing spatial (interpixel) redundancy efficiently while overcoming the negative numbers problem that the predictive coding suffers from. The results are shown graphically in Fig. 4.

Peak signal-to-noise ratio (PSNR) is an important measurement to check the similarity of the decompressed images with the original images to find whether they are

identical or not. Table 2 shows the values of PSNR for the test images for the different techniques of the suggested method. The results of PSNR for the suggested method are shown graphically in Fig. 5.

Table 2: The PSNR (dB) For The Suggested Method

Image	Bottom based	Left based	left- bottom based
F1	3.37	9.56	13.44
F2	4.06	8.71	11.99
F3	3.22	7.83	11.30
F4	3.43	8.51	12.64
F5	4.22	8.83	11.42
F6	3.56	7.93	11.48



Another important measurement test is Mean Square Energy MSE which is used to calculate the difference between original image and the decoded image. The results in Table 3 showing that the MSE is very low and that means that the suggested method has a very good ability to keep the quality of images high after decoding them.

Table 3: MSE of Test Images

Image	Bottom based	Left based	left- bottom based
F1	2.55	1.30	0.92
F2	2.82	1.37	0.90
F3	2.94	1.32	0.94
F4	2.87	1.34	0.88
F5	2.84	1.32	0.92
F6	2.92	1.31	0.93

Table 4: Comparison Of Suggested Method With References Methods

Image	CR%	MSE	PSNR
[6]	36	5.00	16.50
[7]	58	15.00	10.00
[8]	40	9.00	11.00
[9]	65	18.00	8.00
Suggested Method	80	2.11	3.52-11.24

The suggested method has compared with some literature references to find the efficiency according to the compression ratio CR, MSE, and PSNR. The comparison showing the suggested method if fairly good in compare with the other developed methods. Table 4 showing the comparison between the suggested method and literature references.

6. Conclusion

In this paper, an enhanced method was developed to compress satellite grayscale images using the prediction coding technique. The enhanced predictive coding increased the compression ratio up to 79-80%. The proposed method for improving system performance can be developed, through the use of adaptive predictor instead of static predictor, using other hierarchical representation techniques (even / odd), or exploiting other DWT filters (dub aches, Coif let, EZW), using other prediction models with conditionally High-level, different dependency and causation scheme, expanding the system to compress 3D color medical images with variable sizes of images, and using the concept of the area of interest (ROI) to separate the image areas according to their importance, where each region is compressed differently. For future work, it would be more effective to apply the suggested method on the bit plane slices of binary and grayscale images with RLE algorithm to achieve a high compression ratio.

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