ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Hybrid Image Compression Technique Based on NDWT and FBP

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Abstract:
This work introduces a new approach of compression through the use of Non-Decimated Wavelet Transforms (NDWT), Back Propagation Neural Network (BPNN), Fast Back Propagation (FBP) algorithm and Run-length Encoding (RLE). The approach proposed herewith suggests four steps: preprocessing as a first step, for the second step image transforms, followed by Zigzag Scan in the third and finally the hybrid compression as the final step. In the preprocessing phase, the image was resized into an 8x8 matrix and converted to a greyscale image. The NDWT was introduced in the transformation phase as it was used to transform the image in order remove the redundancy in the image. In theZigzagScan phase, the 2-dimensional matrix was transformed into a 1-dimensional matrix. As for the hybrid compression, Vector quantization was used by BPNN and FBP and the RLE lossless techniques. The results of this work provided a high compression ratio in comparison to other techniques used in the same process with a higher value of elapsed time also in comparison with the other the other techniques. The performance proved to be enhanced in according to the elapsed time period.

I. Introduction:

Compression is the technique of representing information in a compact form rather than its original or uncompressed form. While the data remains intact, it becomes diminished to the minimum possible form of it. Compression is a mean to ease the processing, storage and transferring of a large file which would otherwise require more resources [1].

There are two types of compression: Lossy and Lossless techniques. The Lossy compression technique is one where the data is compressed and decompressed but with a difference from the original file. However, the difference that happens is necessary for transferring files on the Internet and mostly in streaming media and telephony applications a lot faster. In the Lossy Compression, repeated compression and decompression of the file can eventually damage the quality of the file. Lossless compression retains the original data completely. When Lossy and Lossless compression techniques are compared with one another, Lossy data compression maintains the quality of the file as it is. However, with the lossless compression, the process becomes slower and would need more resources [2].

Non-decimated Wavelet Transform (NDWT), also known as stationary wavelet transform, is a wavelet transform designed to overcome the lack of translation-invariance of the DWT [3]. NDWT was first applied by Nason and Silverman in 1995. The calculation of the NDWT requires low and high pass filters to be applied to the data at each level of application to produce two sequences at the following level. No decimation happens during that transform as both sequences retain the same length as the original [4]. Vector Quantization (VQ) is one block-coding technique that uses blocks of data instead of single samples. It shows the correlation between the neighboring signal samples through quantizing them together. There are two main components within the VQ: the VQ encoder and the VQ decoder.

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At the encoder, the input image is portioned into a set of non-overlapping image blocks. The nearest code word in the codebook is then found for each image block. The corresponding index of each searched closest code-word is transferred to the decoder. Compression happens because the indices of the closest code words in the code book are sent to the decoder instead of the image blocks themselves [5]. VQ performs very well in rate-distortion. It uses a simple structure. Some efficient clustering algorithms are developed based on the VQ-like approach. However, the VQ algorithms still use a full-search method to find the best-matching code-words and they often require high computational requirements. It is for that reason that many research efforts were undertaken to simplify the search complexity for the encoding process [6, 7, 8, 9]. In this research a new expert scheme for hybrid compression of the researches images is suggested based on the NDWT, BPNN and FBP along with the VQ that results low computational complexity with no sacrifice in original file quality.

II. Background:

1. Non-Decimated Wavelet Transform:

The decimated wavelet transform is a wavelet transform algorithm, designed to overcome the lack of translation-invariance of the discrete wavelet transform (DWT) The NDWT is a fundamentally redundant scheme as the output of each level of the NDWT containing the same number of samples as the input – so for a decomposition of N levels there is a redundancy of N in the wavelet coefficients. The Non-Decimated Wavelet Transform (NDWT) W uses the filter bank (h,g) of a 1-D signal C_0 leads to a set W= $\{w_1, w_2 \ldots w_j, c_j\}$ where w_j are the wavelet coefficients at scale j and C_j are the coefficients at the grainiest resolution. The passage from one resolution to the next one is obtained using the "à trous" algorithm.

2. Back Propagation Neural Network:

BPNN algorithm aids in theelevation of the performance of the system and downgrade of the convergence time for the training of the neural network [10]. The BPNN architecture is used for both image compression and improving the VQ of images. A BPNN consists of three layers: the input layer, the hidden layer and the output layer as shown in[Figure 1]. The number of neurons in theinput layer is equal to the number of neurons in the output layer. The number of neurons in the hidden layer should be less than the number of neurons in the input layer. Input layer neurons represent the original file block pixels and output layer neuron represents the pixels of the reconstructed file block. The assumption in hidden layer neurons is that the arrangement is in one-dimensional array of neurons which represents the element of a code-word. This process produces an optimal VQ codebook. The source image is divided into non-overlapping blocks of pixels such as the block size equals the number of input layer neurons and the number of hidden layer neurons equals the code-word length. To design the codebook in the BP algorithm, the codebook is divided into rows and columns in which rows represent the number of patterns of all images and columns represents the number of hidden layer units [11].

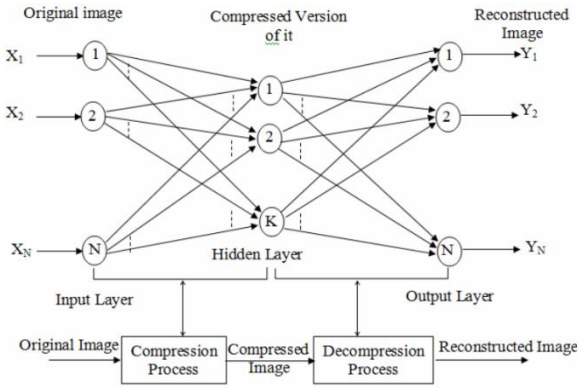

Figure 1 BPNN Image Compression System

3. Fast Back Propagation (FBP):

The FBP algorithm is used for the training of the designed BPNN in order to deduct the convergence time of the BPNN as much as possible. The FBP algorithm is based to minimize the objective function after the initial adaption cycles.

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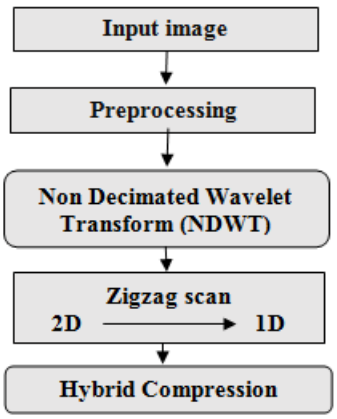
This minimization can be obtained through the reduction of lambda (λ) from unity to zero during the network training. The FBP algorithm is different from the standard BP algorithm in the development of alternative training criterion [12].

4. Run-length Encoding:

TheRun-length Encoding (RLE) compression is the most basic form of image compression technique in which data is in the form of runs. A runs is a sequence in which same data value occurs in many times consecutive data elements which are stored as a single data value and count, rather than as the original runs. It does not work well at all on continuous tone image like photographs [13].From the previous example, it is clear that the encoded version of data stream is 2 cells which is less than the original stream, saving about 11% of space required to store the image.

III. Proposed System:



Step 1: Preprocessing:

Input image
RGB to Gray (image_matrix)
For Each Pixel in Image_matrix {
Red = Pixel. Red Green = Pixel. Green Blue = Pixel. Blue
Gray = (Red + Green + Blue) / 3
Pixel. Red = Gray
Pixel. Green = Gray
Pixel. Blue = Gray
}
Return image gray_matrix
Output image

Step 2: Transformation:

The Non-Decimated Wavelet Transform is the second phase where the NDWT receives the resizable gray scale images and produces transformed images.

Step 3: Zigzag Scan:

Zigzag scan phase takes as an input the transformed images in 2D matrix and produced images in 1D matrix, so that the frequency (horizontal + vertical) increases in this order, and the coefficient variance decreases in the order shown in [Figure 2].

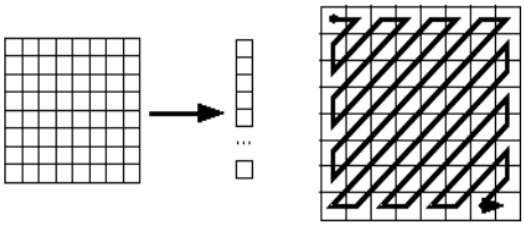


Figure 2 Zigzag Scan [14]

Step 4: Hybrid Compression:

In the Hybrid Compression step, two compression algorithms are used which are: the lossy compression and the lossless compression to provide the best results in terms of a high compression ratio and all while keeping the quality of the file. The techniques used are VQ by BPNN and FBP for lossy compression and RLE for lossless compression.

IV. EXPERIMENTAL RESULTS:

Table1 shows the results for the lossy and lossless image compression processes of the five images using the NDWT with the RLE without using the BPNN. It also shows the results using the BPNN and FBP. It shows that the Zigzag FBP has a larger value than the other techniques in the compression ratio. However, the elapsed time is more than other techniques.

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Table1 Hybrid compression based NDWT

Image used	NDWT, Zigzag Scan, FBP and RLE		NDWT, Zigzag Scan BPNN and RLE	
	CR	Time elapsed	CR	Time elapsed
Cameraman	41.94	3.08	33.23	4.43
Fruits	34.73	3.66	25.05	4.21
Lena	39.24	4.28	30.65	4.47
Tulips	40.32	5.52	32.53	3.85
White flower	46.68	1.99	31.71	3.18
AVERAGE	40.582	3.306	30.634	4.028

V. Conclusion:

This work presents a concise outline about image compression through the use of lossy and lossless compression techniques. It offers a comparison between the BPNN and FBP based on the NDWT. The results show that the FBP is better than the BPNN when the RLE is used in both the compression ratio and elapsed time.

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