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*Classification: GJCST Classification: G.1.2, G.1.1*

A HYBRID IMAGE COMPRESSION TECHNIQUE USING WAVELET TRANSFORMATION - MFOCPN AND INTERPOLATION

*Strictly as per the compliance and regulations of:*

# A Hybrid Image Compression Technique Using Wavelet Transformation - MFOCPN and Interpolation

Dr.Anna Saro Vijendran[1], Vidhya.B[2]

*Abstract-* In this paper an interpolation method is proposed for compression technique. The method used is the localizing of spatial and frequency correlation from wavelets. Modified Forward Only Counter Propagation Neural Network (MFOCPN) is used for the classification and functional task. The wavelet based technique decomposes the lower sub band consisting of non significant coefficients and are eliminated. The significant smooth and sharp coefficients are found using interpolation methods. Here a new technique is proposed called the cosine interpolation, which is an alternative to the nearest neighborhood interpolation method. This methodology of interpolation proved to be an efficient approach for mapping all significant coefficients and thus resulting in improved quality. Hence the comparison is made between nearest neighborhood interpolation and cosine interpolation. The experimental results are tested on various standard images, where these results yield a better PSNR value compared with the existing nearest neighbor interpolation method.

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## I. Introduction

Digital Image Processing is defined as analyzing and manipulating images. Image Compression has become the most recent emerging trend throughout the world. Some of the common advantages image compressions over the internet are reduction in time of webpage uploading and downloading and lesser storage space in terms of bandwidth. Compressed images also make it possible to view more images in a shorter period of time [1].Image compression is essential where images need to be stored, transmitted or viewed quickly and efficiently. The benefits can be classified under two ways as follows: First, even uncompressed raw images can be stored and transmitted easily. Secondly, compression provides better resources for transmission and storage.

Image compression is the representation of image in a digitized form with a few bits maintenance only allowing acceptable level of image quality. Compression addresses the problem of reducing the amount of data required to represent a digital image. A good compression scheme is always composed of many compression methods namely wavelet transformation, predicative coding, and vector quantization and so on.

Wavelet transformation is an essential coding technique for both spatial and frequency domains, where it is used to divide the information of an image into approximation and detail sub signals [2].

Artificial Neural Networks (ANN) is also used for image compression. It is a system where many algorithms are used. The ANN is viewed as a graph with various nodes namely source, sink and internal [3].

The input node exists in the input layer and output node exists in the output layer whereas hidden nodes exist in one or more hidden layers. In ANN various learning method are used namely Unsupervised, Reinforcement learning and Back propagation.

Counter Propagation Neural Network (CPN) has become popular since it converges faster. A level of advancement in CPN is forward only Counter Propagation (FOCPN), where correlation based technique is used [4], [5],[6]. Modified forward only Counter Propagation (MFOCPN) is proposed where distance metrics are used to find the winner among the hidden layers neurons [7].

Some of the recent works have the combination of Artificial Neural Network and classical wavelet based approach which yields better compression ratio [8]. In this paper a new method is proposed using wavelet decomposition coefficients in MFOCPN by an interpolation. Two different interpolation methods are applied in MFOCPN and the results are compared. The Organization of this paper is as follows: Section II describes the existing methodology. Section III explains the proposed method with architecture. In Section IV the experimental results are compared and Suggestions are made In Section V.

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## II. Overview of Methodologies Used

1) *Wavelet Transforms*

A Wavelet is a foundation for representing images in various degrees of resolution. Wavelet transforms is just the representation of functions by a wavelet, which is a mathematical function, dividing the function into various frequency component matching the resolution. Wavelet transformation methodology has been used because of the disadvantages in Fourier Transformation [12]. A wavelet transformation has been classified as discrete wavelet transforms (DWTs) and continuous wavelet transforms (CWTs). A wavelet is represented as multi resolution level where each analysis is implemented through high pass and low pass filters, where each high pass filter is passed on wavelets and low pass filters is based on scaling functions. The wavelet transform function is based on the conversion of one dimensional function into two dimensional space involving translation and dilation parameters related to time and scale factors. Both the high and low frequency supports well for wavelet transform hence are well suited for image compression.

2) *Modified Forward Only Counterpropagation Neural Network (Mfocpn)*

The counter propagation network is a hybrid network, and called to be a self organizing loop, having the characteristic of both self organizing map (SOM) and feed forward neural network. The variants of CPN are of two types forward counter propagation and full counter propagation. The CPN has three layers namely input, instar and outstar is given in Fig (1).

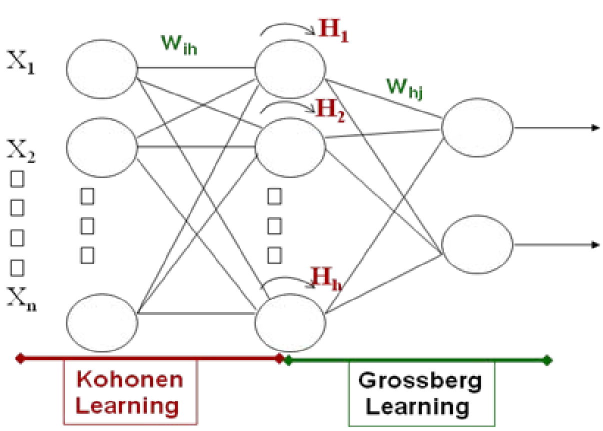


*Fig.1 CPN Architecture*

The input and the instar layer is said to have a competitive connection where only one neuron is considered as winner. The instar and outstar are connected by as feed forward networks. Thus in CPN each layer is considered and trained separately enabling the network as a good classification model. The learning in CPN is classified as the learning Process is given in two phases. The Kohonen learning (unsupervised) phase and the Grossberg learning (supervised) phase [7], [8].

3) *Thresolding*

The combination of both wavelets along with MFO-CPN provides a better compression. In Fig (2) a classical wavelet based compression is shown where the DWT is used then it is passed to Quantizer where the pixels are only reduced, where as in Fig (3) a wavelet along with CPN model is used to obtain a significant pixels [13]. Discrete wavelet transform (DWT) is done to reduce the inter pixel redundancy.

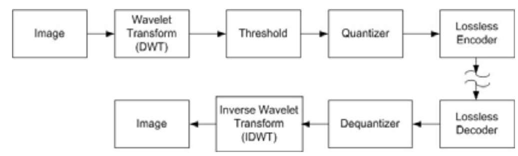


*Fig.2 Block Diagram for Classic Wavelet based Image Compression*

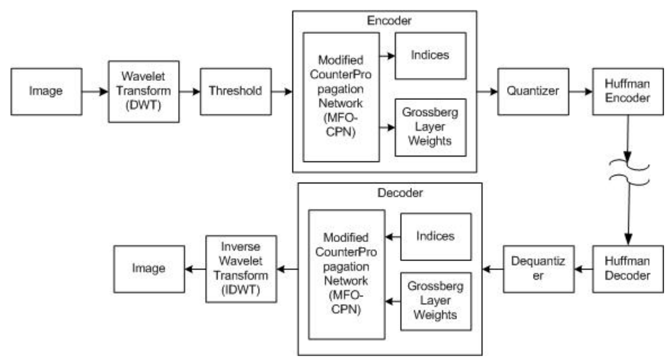


*Fig.3 Block Diagram for Wavelet–CPN based Image Compression*

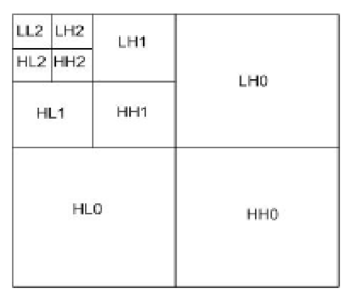


*Fig.4a Multi-resolution wavelet representation*

*Fig(4 b) Boat image*

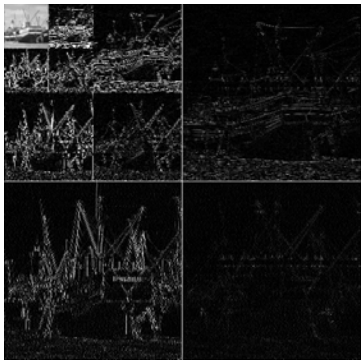

*Fig.4c WT in 3 levels*

The DWT provides multi resolution system, where the coefficients are quantized along with MFO-CPN where each wavelet level and sub band is trained on the basis of thresolding. An image decomposed with wavelet transformation can be reconstructed with desired resolution. A three level wavelet decomposition allows to transform coefficients. The wavelet sub band decomposition has the non-significant values at the lower level. In the Fig(4 a) the notation L and H represents low pass and high pass filters respectively and the LLi, LHi, HLi,HHi, are the filters where first letter denotes the vertical order (i.e.) the filter applied to rows and second letter denotes the horizontal order (i.e.) the filter applied to columns. The advantage of high pass component is that it reduces the computational time. The levels of decomposition make the compression efficient. Quantizer reduces the number of bits needed to store the transformed coefficients. It is considered as many to one mapping.

The thresolding parameter is chosen based on experimentation or based on visual effect of reconstructed image. The universal thresolding parameter is λ [13],[10] which has the number of total coefficients and standard deviation of coefficients. The Fig(4 b) and Fig(4 c) show an boat image with its wavelet transformation having three levels.

In this approach it is experimented to find the direction of significant coefficients across various sub bands of decomposition. Here an adaptive hard thresolding approach is applied for finding the significant wavelet coefficients. The thresolding parameter has been tuned for each level of image after several experimentations based on the quality of the reconstructed image.

## III. Proposed Methodology

The proposed methodology is explored with the MFO-CPN networks along with cosine interpolation to obtain the wavelet coefficients for image compression. Discrete Cosine Transform (DCT) was widely used in image compression, but due to various disadvantages as mean weighting defect and noise weighting so on a DWT method is only used. Hence wavelet based transforms are better compared to DCT. The classical wavelet based coding along with MFO-CPN is used where only significant wavelet coefficients are passed after wavelet transformation is applied, instead of passing the whole pixel value.

### 1) *Interpolation For Spatial Location Of Siginificant Wavelet Coefficient*

The quantization methods help in significant mapping of coefficient along with the positional information to reconstruct the image. The interpolation is a method of adding or removing a pixel while resizing or compressing an image. An interpolation is of different kinds but basically it is divide into two groups namely adaptive and non adaptive. Adaptive methods are used to interpolate among sharp edges and smooth texture whereas nonadaptive methods treat all pixels equally [14]. Various interpolation methods are nearest neighborhood, bilinear, bicubic, spline, and cosine and so on. In our proposed method a nearest neighborhood interpolation is already taken and cosine interpolation method is newly constructed and a comparison is made. Nearest neighbor is the common approach method that requires only least processing time because it considers only the one pixel that is nearby to the interpolated. In other interpolation method it takes four pixels or eight pixels that are surrounded for the interpolated point.

Thus in Fig.(5) a nearest neighborhood interpolation curve is given, which shows a sharp edges are only taken for the interpolated point, hence the considerations for nearest neighbor is less computational technology.

The disadvantage of using linear interpolation is it results in discontinuities. A cosine interpolation is the other simplest methods and tends to provide a smooth transition between adjacent segments. In Fig (6) the curve gives a clear view of cosine interpolation graph where cosine gives a smooth transition curve. Hence both the methods are taken into account and compared on the same metric.

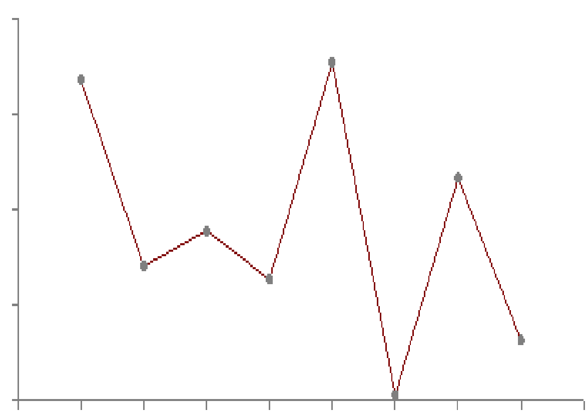

*Fig.5 nearest Neighborhood Curve*

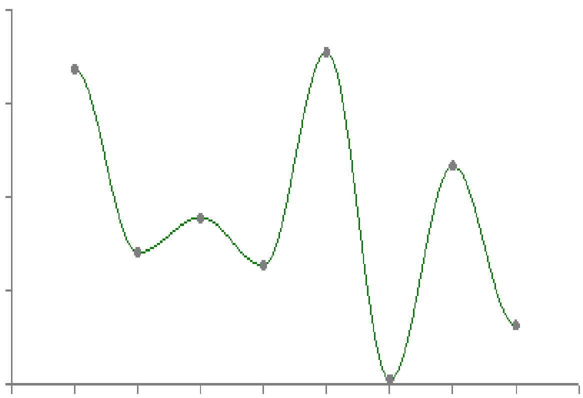

*Fig.6 Cosine Interpolation Curve*

Initially an image is taken of size M X N, where an wavelet decomposition is done at any level, then thresolding is used along with the MFOCPN by applying VQ to obtain the significant values, where the Cosine Interpolation is used to obtain smooth coefficients, and then decoder along with the inverse wavelet transform is used to obtain the reconstructed image. Algorithm coding explains the process.

***Algorithm-coding***

***Step 1***. Wavelet decomposition of image for level k, and assign count c = k.

***Step 2.*** Single level wavelet decomposition of $LL_{(c-1)}I$ and apply thresholding on obtained three subbands HL, HH, LH.Find significant coefficient (after thresholding on three subbands) and apply VQ using MFOCPN for coding.

***Step 3***. Cosine Interpolate the reconstructed $LL_c$ to the size $(M/2^{c-1})$ x $(N/2^{c-1})$ to get $LL_{(c-1)}I$ .

*Step 4*. Decode HL, HH, LH using MFOCPN decoder.

***Step 5***. Take $LL_c$ and HL, HH, LH from Step 3 and apply inverse wavelet transform (IDWT) with these four subbands and obtain image I of size $(M/2_{c-1})$ x $(N/2_{c-1})$.

***Step 6***. Change c = k-1 and $LL_c$ = I (from Step 5) and if c = 0 go to Step 6 else go to Step 3.

***Step 7***. Stop.

## IV. Results and Discussions

The simulation results are given in the table. This gives a comparison between the Nearest neighbor and cosine interpolation methods.

Simulations are done as follows:

a) Standard image is taken.
b) Wavelet decomposition and thresolding is taken.
c) Along with the thresolding quantization table is constructed.
d) Wavelet decomposition with the two variants of interpolation method is done using Algorithm-coding in the place of MFO-CPN.
e) Comparison results are displayed in the table.

The interpolation method used is the cosine and nearest neighbor method. Wavelet decomposition is also done; codebook is done using MFO-CPN. Here the results are compared for various standard images and the output of the Lena image is displayed. in the table(1) a comparison result of Lena, cameraman and mandrill image of various sizes namely 128, 256, 512 are taken in all those the PSNR value for the Cosine Interpolation yields a higher value compared with the nearest neighborhood interpolation. From the below table it is seen for the gray scale image using Lena of size 128 X 128 the PSNR value by the Nearest Neighbor is 15.9025 (i.e.) it is 5 times greater increase with the previous value and with Cosine is 20.0200 that Cosine Interpolation PSNR is increased from 5% to 10% than the Nearest Neighborhood Interpolation.

Table (1) Comparison results of various standard images.

| Name of the picture | Method | PSNR | CR | MSE | Elapsed time in sec |
|---|---|---|---|---|---|
| Lena 128 | Nearest neighbor | 15.9025 | 3.78643 | 639.2694 | 91.375000 |
| | Cosine | 20.0200 | 3.8925 | 647.2577 | 84.546000 |
| Lena 256 | Nearest neighbor | 19.0147 | 4.9368 | 299.4961 | 495.000000 |
| | Cosine | 23.0640 | 4.9309 | 321.1307 | 959.750000 |
| Lena 512 | Nearest neighbor | 21.7657 | 4.6669 | 152.8454 | 1764.766000 |
| | Cosine | 25.5205 | 4.6642 | 182.4042 | 3505.953000 |
| Cameraman128 | Nearest neighbor | 12.1849 | 3.9196 | 685.8150 | 91.922000 |
| | Cosine | 19.6627 | 4.3505 | 702.7516 | 60.453000 |
| Cameraman256 | Nearest neighbor | 11.9751 | 5.3142 | 534.2036 | 481.844000 |
| | Cosine | 20.9323 | 5.4073 | 544.6225 | 572.640000 |
| Cameraman512 | Nearest neighbor | 13.6512 | 5.6194 | 426.0196 | 4685.750000 |
| | Cosine | 24.3799 | 5.5758 | 430.1840 | 2008.76000 |
| Mandrill 128 | Nearest neighbor | 10.0539 | 3.5295 | 758.3493 | 99.906000 |
| | Cosine | 19.2166 | 3.4406 | 778.7846 | 57.016000 |
| Mandrill 256 | Nearest neighbor | 12.0395 | 3.4549 | 428.1329 | 287.31300 |
| | Cosine | 21.8586 | 3.4438 | 439.8592 | 384.875000 |
| Mandrill 512 | Nearest neighbor | 15.2378 | 3.6857 | 611.2921 | 2973.797000 |
| | Cosine | 20.1747 | 3.4024 | 624.6178 | 2135.484000 |

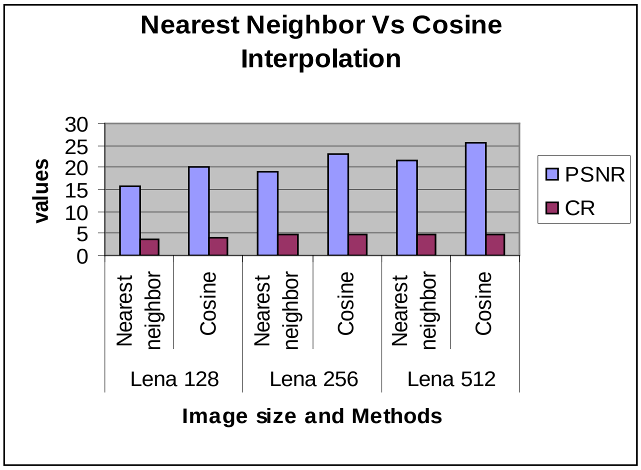


*Fig.6 Comparison Graph of nearest neighbor and Cosine Interpolation*

*Fig.7 (a) Original image*

*Fig.7 (b) Wavelet decomposition*

*Fig.7(c) Distorted image*

Fig.7 (d) Restored image

The output of the Lena image is given in Fig7 (a) to Fig7 (d), which clearly shows that the visual quality is subjectively good and the clarity is higher than the nearest neighbor interpolation method The graph of the Fig(6) gives a comparison of Lena image of various sizes with the Nearest neighbor and Cosine Interpolation where the cosine method PSNR is higher is all the image sizes.

## V. Conclusion

The methodology of using various interpolations proved to be an efficient approach for mapping all the significant coefficients yielding an acceptable compression ratio. The proposed method gives a new approach for various new interpolation methods, in this paper a vector quantization along with MFO-CPN is used instead of conventional VQ which gives better results. This method can be applied for the color

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images, where it is transformed to YCbCr color space. The Y component inversion is done using interpolation method .The interpolation method in Y-Component maps the coefficient from CbCr component. As a future works other interpolation methods such as bilinear, bicubic, spline interpolation methods can be explored to produce a significant map. MFOCPN, part for VQ, can further be extended with other similarity measures apart from higher order distance metrics for more efficient code book design.

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