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EXTENDED HIERARCHAL POLYNOMIAL CODING AND FIXED PREDICTOR OF LOSSLESS BASE

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Abstract: - This paper extended the hierarchal polynomial of coefficients based on even/odd scheme along the fixed predictor to compress the images losslessly where error free compression structure adopted, the test performance showed improvement more than twice compared to the hierarchal polynomial coefficients of one layer model.

Keywords: Image Compression, Lossless Base, Hierarchal Scheme, Polynomial Coding, and Fixed Predictor.

I. Introduction

Data compression is an old and eternally new research area, that implicitly means reduce expensive resources, such as storage memory or transmission bandwidth due to removing redundancy(s) [1]. In other words, data compression is still an interesting topic also because of the number of files/data keep growing exponentially [2], where image compression received increasing interest since the number of image data files keep growing exponentially, in many disciplines, like remote sensing, medicine, e-commerce, e-learning and multimedia [2]. Generally, Image compression techniques generally fall into two categories: lossless and lossy depending on the redundancy(s) type(s) exploited, where the former is also called information preserving or error free techniques, in which the image compressed without losing information that rearrange or reorder the image content, and are based on the utilization of statistical redundancy alone (i.e. exploits coding redundancy and/or inter pixel redundancy), while the latter which remove content from the image, which degrades the compressed image quality, and are based on the utilization of psycho-visual redundancy, either solely or combined with statistical redundancy. In other words, the distinctions between lossless and lossy lies on excluding and incorporating a quantization stage in the compression system for lossless and lossy respectively [3].

Polynomial coding is a modern image compression technique based on modelling concept to remove the spatial redundancy embedded within the image effectively. The basic idea of polynomial coding is the utilization of mathematical model to represent each non-overlapping partitioning block with a small number of coefficients of low error (residual) [4]. Much of the work attempts to enhance the traditional polynomial coding model of linear base and extended into non-linear base model; see [5-15].

The fixed predictor constitutes a pre-processing step eliminate the inherited redundancy [16], therefore, the design of predictor is compromised between efficiency and complexity, where the selected fixed predictor needs to be specified according to the order which is number of neighbour(s) used, the dependency form (causal or acausal), and the structure formula (1D or 2D), for more details see [17].

The hierarchal scheme generally categorized into four basic approaches, where all the techniques based on extension multi-layers representation. The first technique simply utilized the multi-resolution representation of wavelet transforms that decompose image into multi-layers, where each layer decomposed into approximation and detail sub bands (LowLowlayer, LowHighlayer, HighLowlayer and HighHighlayer) each of size (N/2×N/2), only the approximation sub-band (LowLowlayer) of preceding layer is exploited as an input to create the next extended layer [18], as illustrated in figure (1). This technique is characterized by high image quality with high compression ratios, due to exploits both the spatial and frequency correlation of data by contractions and translations of mother wavelet on the input data, supports the multi-resolution analysis of data and symmetric nature [18].
The second technique basically starts from the original image, representing the root, which corresponds to layer0, then implementing the traditional predictive coding (i.e., auto-regressive) AR method of any order with a selected model, where the AR coefficient constitutes the first layer (layer1); in order to construct the subsequent layer (s), the coefficients from the previous layer are regarded as an image and AR encoded in the current layer, and so on. The process continues iteratively until the correlation or redundancy embedded between the autoregressive coefficients is removed. As a result the top-down coding model is generated as a multi-layer or hierarchal modelling approach [3]. Figure (2) shows an example of the hierarchal fifth order causal 2-D model (i.e., 5th HARM model) providing an illustration of the idea clearly.

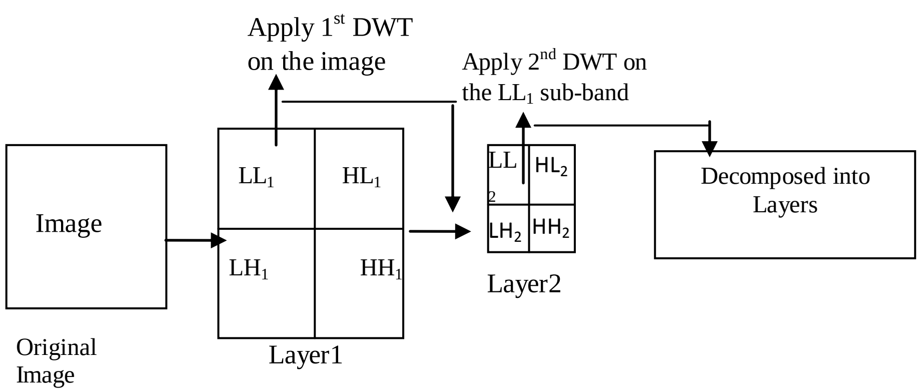

Fig. (1): The first hierarchal representation model using the multi-resolution base of wavelet transforms [19].

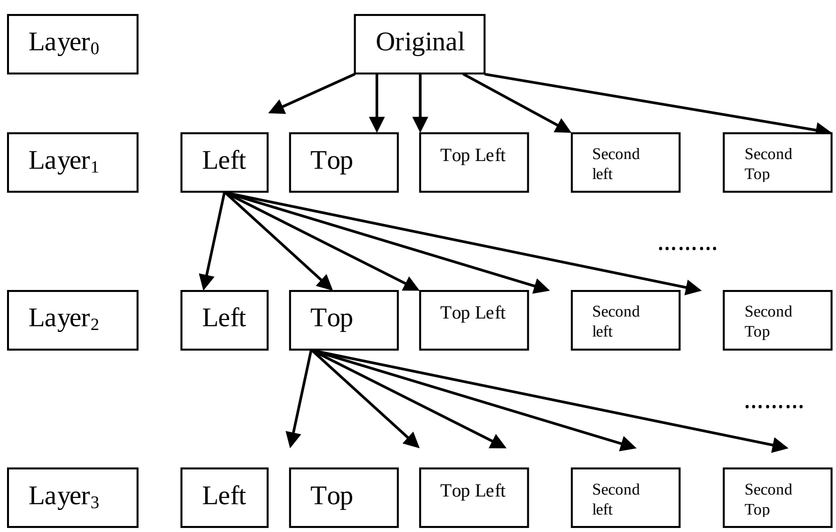

Fig (2): The second hierarchal representation model; we start from the image and each time we work on the parameter estimated from the layer above [3].

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The third technique exploited the geometric transformation to construct a multi-resolution scheme through shrinking base (i.e., nearest neighbour, linear, bilinear) of interpolation techniques, in other words, create shrinked resolution images each of half size of proceeding up layer. The interpolation refers to the guessed intensity values at the missing locations, for each transformed non-integer values assign the closest pixel (in distance) to it by using the rounding operation where the nearest neighbour is a very fast and simple method [20]. Figure (3) illustrates this technique obviously.

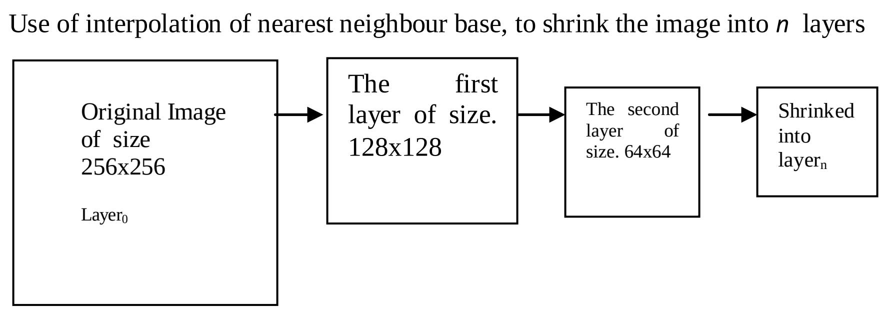

Fig (3): The third hierarchal representation model using the interpolation base [19].

The last technique used the subdivided principle into odd and even sub-images based on the row(s) and/or column(s) representation recursively [19], as shown in figure (4), which is adopted in this paper.

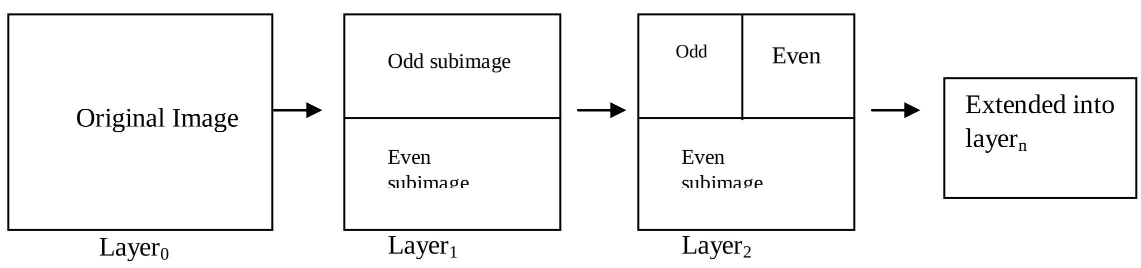

Fig (4): The fourth hierarchal representation model using the subdivision base [19].

This paper is concerned with exploiting the polynomial coding, hierarchal scheme of even and odd decomposition along the fixed predictor base that efficiently improve the compression performance of lossless (error free) base compression system. The rest of paper organized as follows, section 2 contains comprehensive clarification of the proposed system; the results for the proposed system and the conclusions, is given in sections 3 and 4, respectively.

II. The Proposed System

This technique is an extension to the hierarchal scheme polynomial coefficients based that discussed in [15, 19] that shown in figure 5, but with extended into two layer polynomial coefficients even/odd decomposition along with applying fixed predictor of each sub-image separately, where the fixed predictor utilized as in the JPEG of Dc's values that illustrated in figure (6).

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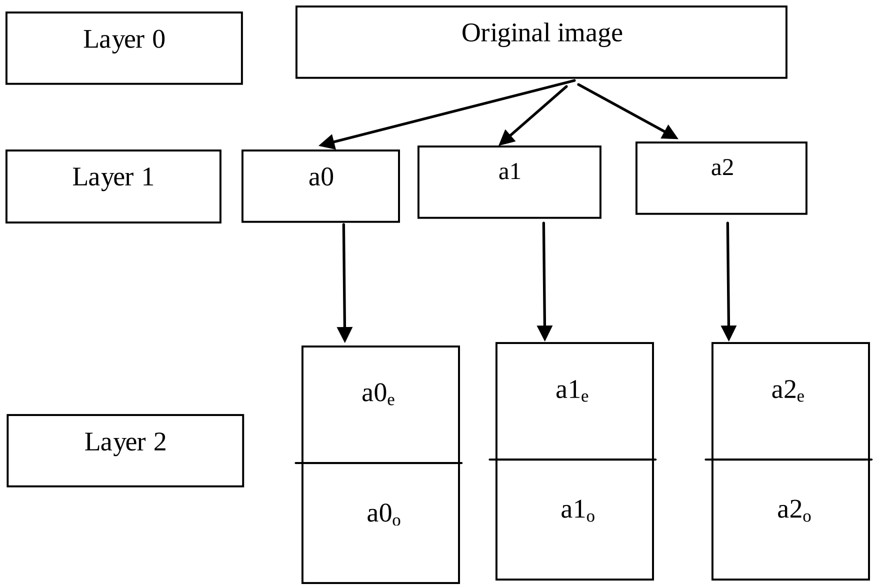

Fig.(5): The polynomial coefficients that decomposed into even and odd sub-images of multilayer scheme [19].

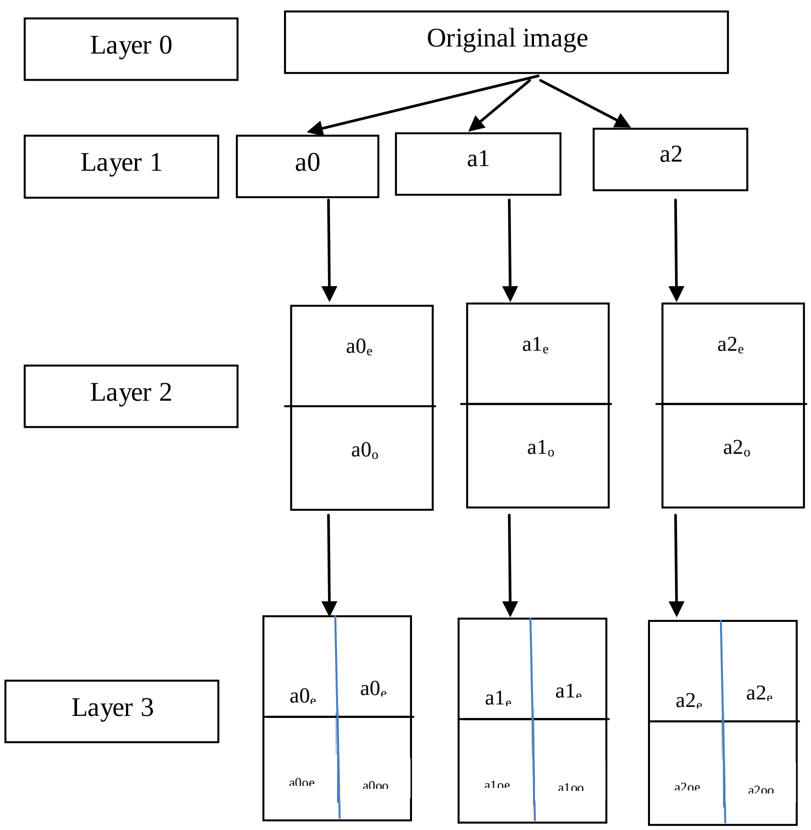

Fig.(6): The proposed compression system

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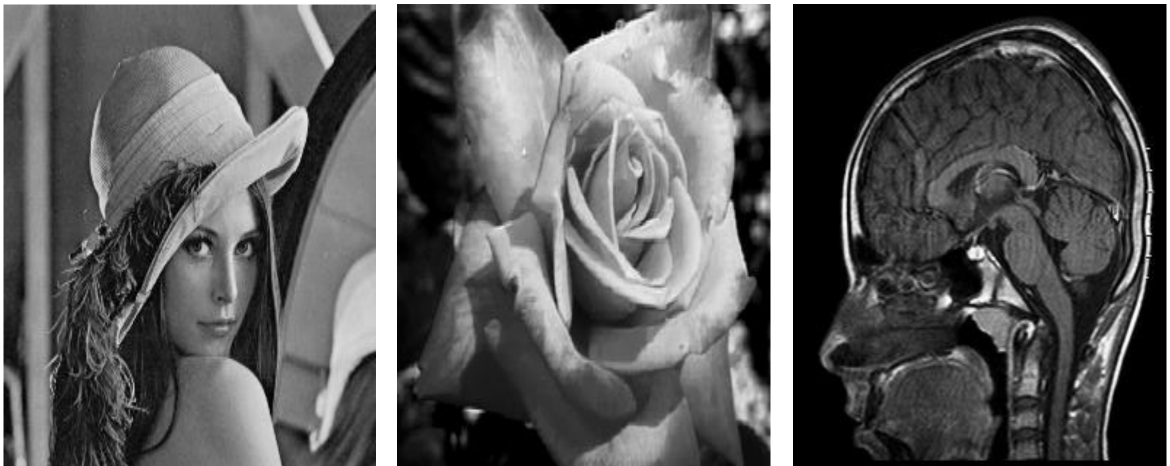
III. Experimental Results

In order to test the performance of the suggested compression system and compare it with the hierarchal polynomial of coefficients based adopted by [15,19], we use the same standard gray scale images(256 gray levels or 8 bits/pixel), square (256×256) of varying details (see figure 7), with utilizing the compression ratio which is the ratio of the original image size to the compressed size, was adopted as performance measure of lossless base systems.



a **b** c

Fig. (7): The three tested images of size 256×256, gray scale images, (a) Lena (b) Rose and (c) Brain.

Table (1) and figure (8) shows the results of comparison between the two mentioned techniques in terms of compression ratio of the three tested images.

Table 1: Comparison performance between hierarchal polynomial coding of block based and proposed system for the tested images using block size of 4x4.

Tested images	**Hierarchal polynomial coding of coefficients based [15,19]**	**Proposed system**
	Compression Ratio	***Compression Ratio***
Lena	2.5984	6.8012
Rose	3.0490	7.1235
Brain	2.9176	9.1582

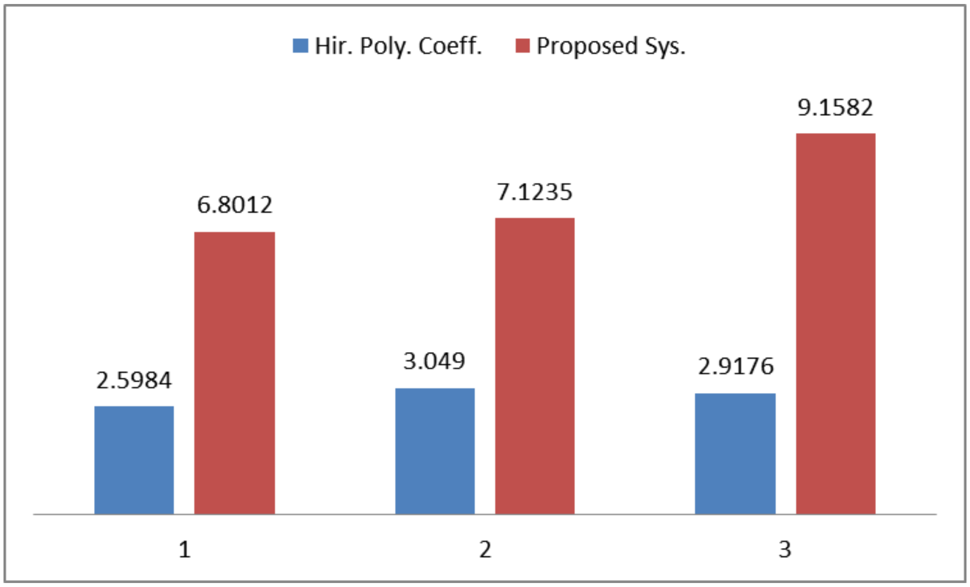


Fig. 8: Compression ratio of the two compression systems for the three tested images.

Clearly the proposed technique improved the compression ratio about more than three times on average compared to techniques adopted by [15,19] that vary according to image details (characteristics), where for complex (highly detailed images) more than twice while for MRI brain image of fixed background more than four times.

IV. Conclusions

The proposed compression system extended the hierarchal representation of polynomial coefficients values into two layers of even/odd separation along the fixed predictor to remove the redundancy efficiently.

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