Lossless Image Compression using Adaptive Predictive Coding of Selected Seed Values

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ABSTRACT
In this paper, two proposed effective selection seed values techniques adopts to enhance the predictive coding efficiency.

Keywords
Data compression, redundancy, lossless, seed values and predictive coding

1. INTRODUCTION
In general, the multimedia field highly relied on data compression that implies image, audio and video. Thus, today data compressions become intensively research area that continuously constructs standard compression system like JPEG, MPEG, MP and H.265.

Basically, the data compression based on removing or eliminating the redundancy(s) as much as possible. In image case, the redundancy can be categorized into statistical redundancy and psychovisual redundancy, for the former this encompass the lossless image compression, while for the latter only or with the former this encompass the lossy image compression, for more details see [1-8] .

The predictive coding one of the well known image techniques still under the development that utilized the spatial domain efficiently that involving two steps of prediction (i.e., creating an approximate image to the original one) and differentiation (i.e., finding the residual between the original and the prediction image) [9]. The modelling concept is the core of the predictive coding that simply means formulate the embedded image redundancy (i.e., spatial redundancy) mathematically using the deterministic part (that required definition of the model order, model dependency form and model structure) and probabilistic part [9-16].

The predictive coding originally suffers from the seed value that corresponds to the initial modelling coding to construct the predicted image, that unfortunately reduced the compression efficiency of the technique [9,17-19].

In this paper, an efficient lossless image compression technique is adopted that effectively overcome the seed value problem that discussed in details in section 2, also the results and discussion illustrated in section 3.

2. PREDICTIVE CODING
The predictive coding techniques essentially use the seed values to create the predicted image where the spatial domain of the embedded correlation neighbours exploited. Two algorithms adopted to use the seed values efficiently/effectively for lossless image compression.

2.1 Seed Difference
The first technique based on partitioning the square input image (NxN) (uncompressed image) into fixed square block sizes (nxn), each segment lock utilized only the left and bottom seed values (i.e., initial condition does not include all the first row and column seed values but only selected values from them) to create the predicted values of the current pixel and the left bottom pixel based on the horizontal and vertical differences according to equations below (1-6), figure (1) shows the idea clearly.

$$HorizontalX\ \mathrm{P}redcurr = Xvalue - Left \quad \text{.....(1)}$$

$$VerticalX\ \mathrm{P}redcurr = Xvalue - Bottom \quad \text{.....(2)}$$

$$X\ \mathrm{P}redcurr = \begin{cases} HorizontalX\ \mathrm{P}redcurr & if\ (HorizontalX\ \mathrm{P}redcurr <= VerticalX\ \mathrm{P}redcurr) \\ VerticalX\ \mathrm{P}redcurr & else \end{cases} \quad \text{.....(3)}$$

$$HorizontalLeftBottom\ \mathrm{P}redcurr = LeftBottom - Bottom \quad \text{.....(4)}$$

$$VerticalLeftBottom\ \mathrm{P}redcurr = LeftBottom - Left \quad \text{.....(5)}$$

$$LeftBottom\ \mathrm{P}redcurr = \begin{cases} HorizontalLeftBottom\ \mathrm{P}redcurr & if\ (HorizontalLeftBottom\ \mathrm{P}redcurr <= VerticalLeftBottom\ \mathrm{P}redcurr) \\ VerticalLeftBottom\ \mathrm{P}redcurr & else \end{cases} \quad \text{.....(6)}$$

The predicted image depends on the lowest difference values of either horizontal or vertical difference values of the current pixel value and the left bottom value.

Lastly, the residual (residue) as the difference can be computed as a difference between the original image and the predicted one, reversely to reconstruct the image back adds the residual to the predicted image.

Left Bottom	Bottom
Left	Xvalue

Left Bottom Predictedvalue	Bottom known pixel value
Left known pixel value	XPredictedvalue

120	119
120	114

$HorizontalX\ \mathrm{P}redcurr = 6$
$VerticalX\ \mathrm{P}redcurr = 5$
$X\ \mathrm{P}redcurr = 119$

$HorizontalLeftBottom\ \mathrm{P}redcurr = 0$
$VerticalLeftBottom\ \mathrm{P}redcurr = 1$
$LeftBottom\ \mathrm{P}redcurr = 120$

120	119
120	119

2.2 Seed of Difference and Minimum Value

The second technique simply also starts from the original square image (NxN) that partitioned into the fixed square block of sizes (nxn), each segment lock utilized only the left and bottom seed values, the left bottom pixels predicted according to equations (4-6), while for the predicted values of the current pixel the horizontal and vertical differences calculated as in equations (1-2), if one of the differences is equal to zero then either the horizontal or vertical difference is applied , otherwise the lowest difference values of either horizontal or vertical difference values subtracted from the selected difference value of minimum difference value according equations(7), as illustrated in figure (2).

$$X\ \mathrm{P}redcurr = \begin{cases} HorizontalX\ \mathrm{P}redcurr - Bottomif\ (HorizontalX\ \mathrm{P}redcurr <= VerticalX\ \mathrm{P}redcurr) \\ VerticalX\ \mathrm{P}redcurre - Leftlse \end{cases} \quad \text{.....(7)}$$

Left Bottom	Bottom
Left	Xvalue

Left Bottom Predictedvalue	Bottom known pixel value
Left known pixel value	XPredictedvalue

Original image block

120	119
120	114

$HorizontalX\ \mathrm{P}redcurr = 6$
$VerticalX\ \mathrm{P}redcurr = 5$
$X\ \mathrm{P}redcurr = 119 - 5$

$HorizontalLeftBottom\ \mathrm{P}redcurr = 0$
$VerticalLeftBottom\ \mathrm{P}redcurr = 1$
$LeftBottom\ \mathrm{P}redcurr = 120$

Predicted image block

120	119
120	114

Fig. (2): Seed difference and minimum technique

Also the reconstructed image based on the predicted along with the residual images.

3. EXPERIMENTAL AND RESULTS

Lossless techniques efficiency based on quantitatively measuring of compression performance only, the compression ratio (which is the ratio of the original image size to the compressed size) is generally adopted; also here six tested standard square gray scale images selected as shown in fig (3) that implies of natural and medical images.

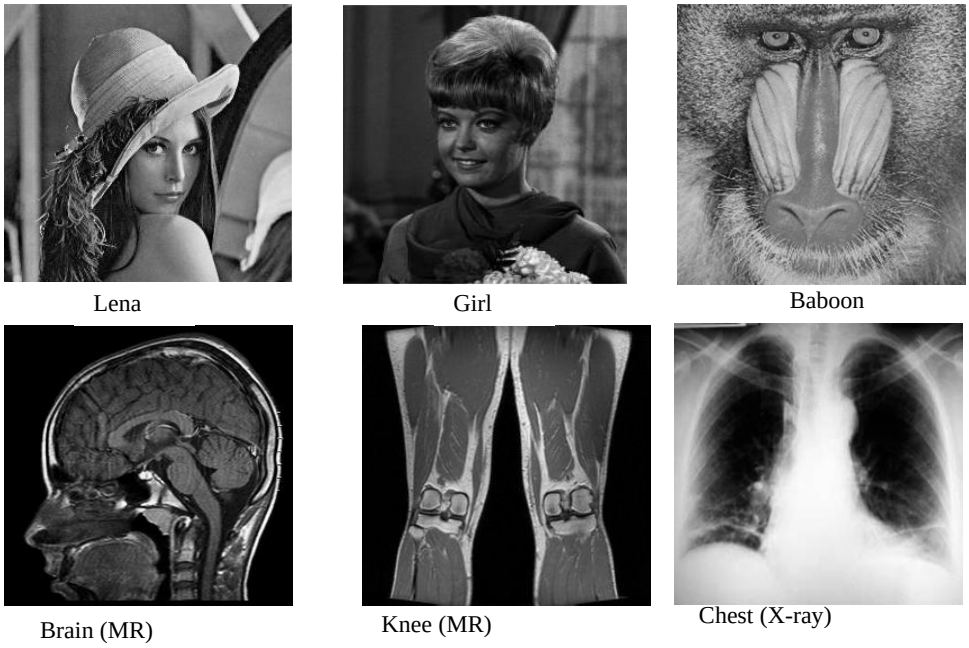

Fig. (3): Tested images gray scale images of size 256×256.

The results shown in table (1)illustrates clearly the superior performance of the second suggested techniques of Seed of Difference and Minimum Value compared to the first technique of Seed Difference, due to high prediction image quality that resemble the original image leading to small prediction error (residual). In other words, the compression ratio directly affected by the way of selected the seed values, since less residual error required efficient selected seed values.

Lastly, the results also showed that there is a trade-off between the technique efficiency or the compression performance (i.e., compression ratio) and the image structure (image details and variation), where high compression ratio of medical images of small image details and low variation compared to natural images of high details and large variation.

Table 1: Compression ratio of the two proposed techniques of the tested images using (2x2) block sizes.

Tested Image	***Seed Difference***	***Seed of Difference and Minimum Value***
	Compression Ratio	Compression Ratio
Lena	7.5642	9.7263
Girl	8.8431	11.2740
Baboon	6.6406	8.3977
Brain (MR)	9.1800	11.4674
Knee (MR)	10.1954	13.9201
Chest (X-ray)	11.2142	13.1546

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