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Hierarchical Fixed Prediction of Mixed based for Medical Image Compression

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Abstract: Imaging plays a critical role in health care system, but unfortunately exhausted lager bytes which affected both storage and communication, medical image compression reduce the amount of image data while keeping the image compressed identically to the original one that characterized by low compression ratio since where keeping all the information is prioritised. This paper is concerned with improving the performance of medical image compression of fixed prediction based, by incorporating the hierarchical scheme of even/odd based along the mixing prediction of quadrants. The test result indicates the superiority of the proposed system compared to the traditional fixed coding with preserving image identically.
Keywords: medical image compression, hierarchal coding and fixed prediction.

1. Introduction

Hospitals and medical centers produce an enormous amount of digital medical images every day, which are used for different purposes such as surgical and diagnostic plans. The ease of storing and transmission of digital medical images is a boon to patients and medical professionals. Due to the large volume of images, image compression is required to reduce the redundancies in image and represents it in shorter manner for efficient archiving and transmission of images [1]. Ideally, lossless image compression techniques with their total reconstruction fidelity (without loss of any information) are suitable for medical image compression [2], but unfortunately this comes with low compression ratio, to overcome this limitation either hybrid coding of lossy base incorporated or region of interest (ROI) concept exploited [3].

The core principle of hierarchal techniques, it is based on decomposition the image hierarchally from the root (original image) to the leaves (layers) by utilizing various concepts either of interpolation, or multi-layers representation, where basically it's aimed to improve the compression efficiency while maintain an acceptable image quality [4]. On the other hand, the fixed predictor of certain model efficiently exploited of to remove statistical redundancy of spatial base, due to highly dependency (correlation) between input medical image pixels.

The main challenge of medical image compression of lossless base lay on maximize the compression ratio to be suitable for medical applications, reviews of medical image compression techniques and a comparison among them can be found in [5-9]. Here in this paper we keen on medical image compression of hierarchal scheme and fixed predictor models representation, where the hierarchal scheme constructed using various methods, mostly the discrete wavelet transform (DWT) of multilayer decomposition utilized for medical images including [10-14], due to efficiently, simplicity and popularity. Also the other way of decomposition exploited for lossless image compression adopted by [15-18] based on utilizing the separation base that differentiated the image into two sub images, namely an even sub image and an odd sub image using the row and/or column representation. On the other hand, the fixed predictor resembles a pre-processing preliminary step that's clears up any unnecessary spatial redundancy embedded between neighbours, that adopted by [19, 20] to improve (enhance) image compression techniques.

This paper is concerned with improving the medical image compression performance of grey scale images losslessly, where the first part exploits various fixed predictors modalities, while the second part utilized the hierarchal scheme of even/odd decomposition with the same fixed predictor for each decomposed sub-image, and lastly the mixed predictors between decomposed sub-images.The rest of paper organized as follows, sections 2 and 3 contains comprehensive clarification of the proposed system; the results for the proposed system and the conclusions, is given in sections 3 and 4, respectively.

2. The Suggested System

This paper is concerned with compressing medical image losslessly using the hierarchal fixed predictor base, and extended into mixing along the quadrants using different fixed predictor models. The practical example is depicted in figures (1), and the following steps are applied:

Step 1: Load the original medical uncompressed grey image *I* of *BMP* format of size *N×N*.

Step 2: Decomposed the image (*I*) once or more into even and odd sub-images hierarchally, where the *I* resembling a root of tree that correspond to $layer_0$, and the sub-images corresponds to the leaf nodes of the tree correspond to next layer(s) [18], here the *I* is decomposed into four quadrants of even/odd base *IQuad* (i.e, *EvenEven, EvenOdd, OddEven, OddOdd*).

Step 3: Apply the fixed predictor coding to the decomposed quadrants results from step 2 above, where each quadrants use the same predictor models, where the predictor exploiting one or more neighbour(s), here eight fixed predictors of different orders (fist, second and third) adopted as shown in table (1) and figure (2), where each predictor adopted separately.

$$FpQuad = IQuad(i, j) - FpM(o, d, s) \text{......................} (1)$$

Where *FpQuad* is the fixed predictor image or differentiation (residual) image created due to removing the correlation embedded between neighbors, *FpM* is a function defining a neighborhood of fixed predictor model of (*o*rder, *d*ependency, *and s*tructure), where all the models utilized of causality base but with different order and structure.

Step 3: Apply symbol encoding techniques to remove the coding redundancy embedded within the *FpQuad* images, using Huffman coding along the seed values (i.e., first row and/or first column).

Step 4: Reconstruct or rebuild the compressed or decoded image which is identical to the original one *I*, by reconstruct each quadrants independently then use the rebuild quadrants to construct the compressed identical image, namely adding the decoded image *FpQuad*, and the fixed predictor model seed values, such as:

$$IQuad(i,j) = FpQuad(i,j) + FpM(o,d,s)................(2)$$

S_q	S_c	S_b	S_d
S_f	S_a	S_x	

Fig (2): Local neighboring pixels where the predictors are designed according to table (3.1) where S_x refers to the current predicted pixel, using S_a,……S_d predictor pixels [21].

Table (1): The fixed predictor models [21].

No	Description	Predictor
1	**S_a**(Left neighbour)	**FM**(1,cusal,1D)=P(*i*,j-1)
2	**S_b**(Bottom neighbour)	**FM**(1,cusal,1D)=P(*i*-1,j)
3	**S_c**(Left -Bottom neighbour)	**FM**(1,cusal,1D)= *P(i-1,j-1)*
4	(S_a+S_b)/2 (**average**)	**FM**(2,cusal,2D)=*P((i,j-1)+P(i-1,j))/2*
5	(**Maximum value**) of Sa, Sb,and Sc	**FM**(3,causal,1D)=Max(Sa,Sb,Sc)
6	(**Minimum value**) of Sa, Sb,and Sc	**FM** (3,causal,1D)=Min(Sa,Sb,Sc)
7	**(Mode values**) of Sa,Sb,Sc, Max, and Min	**FM**(3,causal,1D)=Mode(Sa/Sb/Sc,Max,Min)
8	(**Median values**) of Sa,Sb,Sc, Max, and Min	**FM**(3,causal,1D)=Mode(Sa/Sb/Sc,Max,Min)

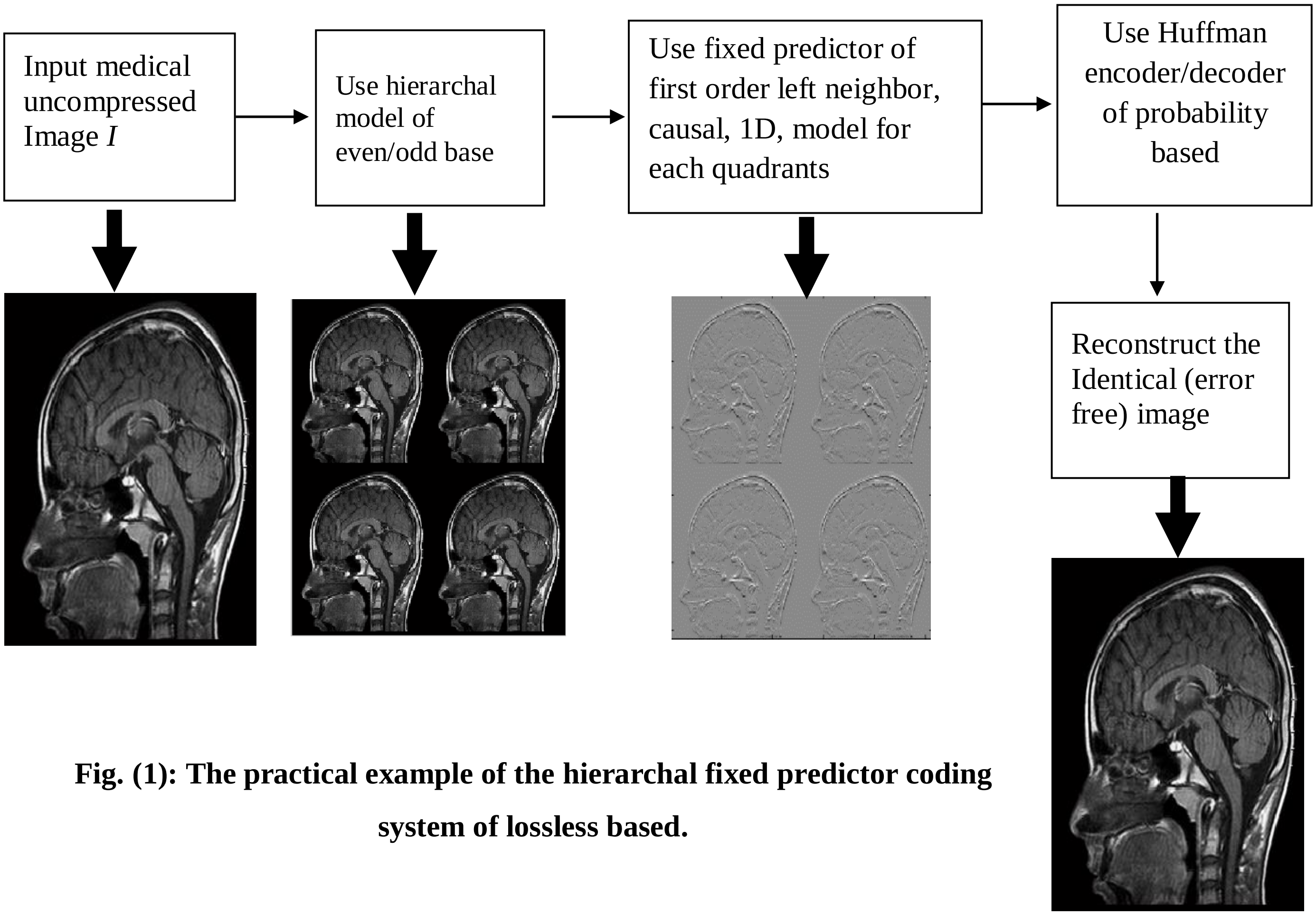

Fig. (1): The practical example of the hierarchal fixed predictor coding system of lossless based.

This technique can be extended into different predictor models utilized instead of using the same predictor of all quadrants, namely for each quadrant exploit a predictor model to improve the compression performance.

3. Experimental Results

In order to test the performance of the fixed prediction coding using the hierarchal scheme of independent models and mixed based, three standard medical *MRI* images adopted as in figure (3), where all the images of 256 grey levels (8 bits/pixel) square of size 256×256, also the compression ratio (*CR*) utilized as criteria (measure) of lossless performance system base (i.e., ratio of original size to the compressed information size in bytes), and the programs written in *Mathlab* (2008) programming language. Table (2) show the tested images using the fixed prediction coding techniques,

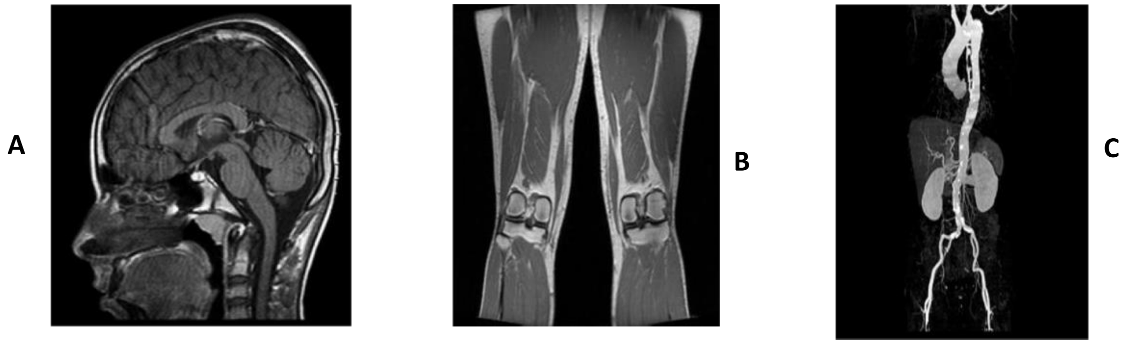

Fig. (3): The MRI tested medical images of size 256×256, grayscale images, (a) Brain, (b) Knee, and (c) Tummy.

Table (2): The fixed prediction coding of compression ratio for tested images using different fixed predictor models

No Pre	*Orginal Image size in Bytes*	*Brain Test Image*		*Knee Test Image*		*Tummy Test Image*	
		Compressed Image Size in Bytes	*CR*	*Compressed Image Size in Bytes*	*CR*	*Compressed Image Size in Bytes*	*CR*
1	65536	42100	1.5567	34534	1.8977	25010	2.6204
2	65536	42668	1.5360	40788	1.6067	26082	2.5127
3	65536	45254	1.4482	42492	1.5423	26744	2.4505
4	65536	41312	1.5864	37742	1.7364	26058	2.5150
5	65536	42672	1.5358	37598	1.7431	26462	2.4766
6	65536	41630	1.5742	37096	1.7667	24250	2.7025
7	65536	41896	1.5643	38206	1.7153	24530	2.6717
8	65536	43126	1.5196	40592	1.6145	25840	2.5362

There are a number of highlight issues need to be mentioned according the above results of fixed prediction coding:

1- Obviously, the fixed predictor model simple to implement of low compression performance, that because of the limitation on capturing image details due to insufficient model flexibility, since the image features or characteristics cannot usually be fully described by a model where the details vary from part to part.

2- The results directly affected by image details (characteristics), where for tummy image high compression achieved, due to large background size compared to image details.

Table (3), illustrates the comparison between the fixed predictor and hierarchal fixed predictor. The results clearly show improvement in performance due to ability to capture details efficiently in these quadrants compared to the whole image.

Table (3): The hierarchal fixed prediction coding of compression ratio for tested images using different fixed predictor models

No Pre	*Orginal Image size in Bytes*	*Brain Test Image*		*Knee Test Image*		*Tummy Test Image*	
		Compressed Image Size in Bytes	*CR*	*Compressed Image Size in Bytes*	*CR*	*Compressed Image Size in Bytes*	*CR*
1	65536	6274	10.4456	6388	10.2592	3496	18.7460
2	65536	6298	10.4058	7154	9.1607	3508	18.6819
3	65536	6332	10.3500	7160	9.1531	3574	18.3369
4	65536	6336	10.3434	6870	9.5394	3594	18.2348
5	65536	6338	10.3402	6892	9.5090	3580	18.3061
6	65536	6196	10.5771	6766	9.6861	3342	19.6098
7	65536	6220	10.5363	7022	9.3330	3392	19.3208
8	65536	6290	10.4191	7044	9.3038	3478	18.8430

Finally, table (4) shows to results related to the last experiment discuss it in this chapter of mixed quadrants of hierarchal prediction coding, which implies four predictors (i.e., median, maximum, minimum, averaging) choose them according best test results due to difficulty to select a measure to choose a predictor since all the quadrants details approximate to each other. The results illustrate high performance due to selectively choosing the approximate model of each quadrant.

Table (4): The mixed hierarchal fixed prediction coding of compression ratio for the three tested images.

Tested images	*Orginal Image Size in Bytes*	*Compressed Image Size in Bytes*	*CR*
Brain	65536	4484	14.6155
Knee	65536	4892	13.3966
Tummy	65536	2528	25.9241

4. Conclusions

The fixed predictor coding techniques is a simple predictive coding representation that based on exploiting the embedded correlation between neighboring pixels, characterized by low compression performance. By incorporating the hierarchal scheme of even/odd base, the performance improved according to image details or features. Also the mixed between quadrants rather than using one predictor model, effectively enhance the results.

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