

Image Compression Based On Octagon Based Intra Prediction

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Abstract: Recently image coding has been an important research area in many fields. Various compression algorithms have been developed in different ways for image compression. One of the ways in image coding is prediction based image coding. This paper proposes a novel technique for finding the prediction of a current pixel. Instead of traditional four mode prediction, this paper proposes an eight mode prediction scheme. The proposed method is tested with seven traditional images and compared with four recent methods. Experimental results substantially proved that the proposed method is better than recent methods.

Keywords: Intra Prediction, distortion, predictive coding, prediction residual

I. INTRODUCTION

In the digital world, the multimedia data contains the image, video and audio information stored by the computer using digital format. Multimedia data has been growing incredibly every second owing to the development in multimedia applications and advancement in internet in all the fields including surveillance, entertainment, commercial, medical and education. The art of transforming an image into a digital format and its processing by digital computers is called Digital Image Processing. Spatial prediction is one of the most important concepts in lossless image compression [1, 2]. Image compression is the process of reducing the number of bits needed to represent an image by eliminating the redundancies. Statistical redundancy and redundancy using predictability are the two basic redundancies that appear in an image. Reducing or eliminating these redundancies from an image is called image compression which facilitates in bit rate reduction without affecting the visual quality. Image storage is required most commonly for educational and business documents, medical images used in patient monitoring systems and the like. Images consume more amount of storage. Vector quantization (VQ) [3] is a lossy type image compressing technique because in VQ technique some information may be lost due to quantization. Visual Pattern Image Coding (VPIC) [4] and Visual Pattern Vector Quantization (VPVQ) [5] are extended versions of VQ. Md. Ahasan Kabir et al. has provided a "prediction-based transformation and entropy coding" [6] (PTEC) algorithm. The picture is divided hierarchically in the first stage of the PTEC method to estimate the current pixel using neighboring pixels. In the second point, two matrices are generated by predictive errors, where one matrix contains the absolute error value and the other contains the predictive error polarity. Finally, entropy coding applies to the matrices being generated. Intra prediction is only used in recent video coding standards such as H.263 [7] and H.264/AVC [8]. Intra - prediction method anticipated by Nokia [9], various prediction techniques are available there are DC prediction, directional extrapolation, and block matching. DC and directional prediction methods are comparable like H.264 intra prediction. [10]. Many lossless algorithms of image compression have been developed using this predictive coding method [12 - 14]. JPEG - LS is an example of an approach to predictive coding that works well with continuous - tone images [15, 16]. Section II describes the System architecture of the proposed encoder and decoder. Section III discuss about intra prediction. Section IV describes proposed octagon based prediction algorithm. Section V provides experiment results followed by conclusion.

II. System Architecture

The prediction process consists of a statistical estimation of future random variables from past and present observable random variables. The proposed encoder and decoder architecture are shown in Fig.1 and Fig.2. The Encoder consists of traditional steps like transformation, quantization and entropy coding. As the system is prediction based image coding, it includes inverse transformation and inverse quantization in the encoder itself. In addition to these steps, the proposed predictive image coding consists of intra prediction for finding predicted pixel in the neighboring blocks. The predicted pixel is calculated using the proposed octagon based intra

prediction scheme. The Prediction Error is calculated after finding the predicted pixel. Instead of encoding the current pixel, only the prediction error is encoded which reduces the coding. In the decoder, the traditional inverse transformation and inverse quantization steps are included. The prediction error is added with the predicted pixel to calculate current pixel in the intra prediction.

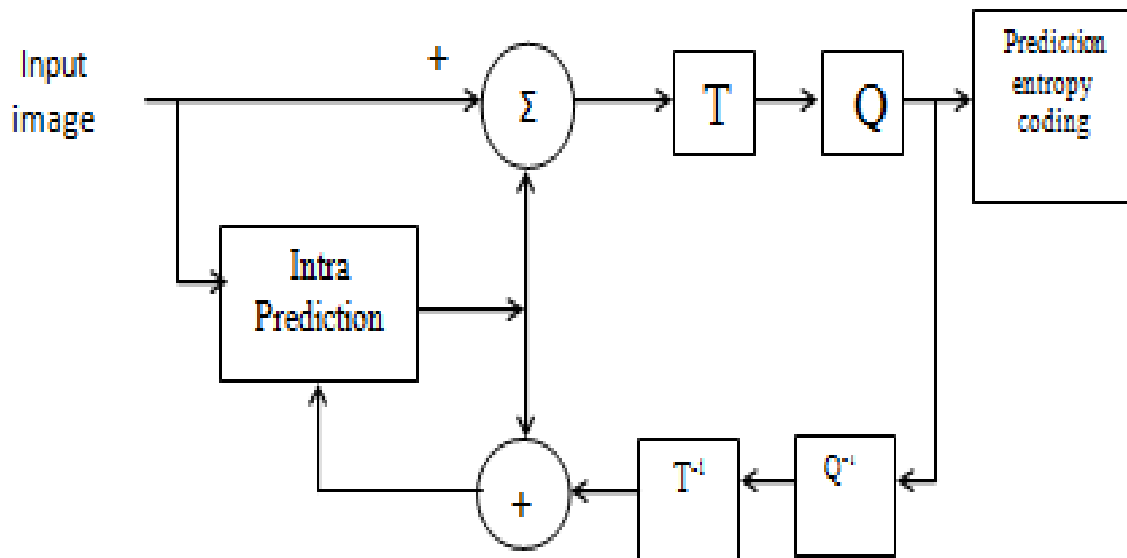


Fig. 1 Proposed Encoder Architecture

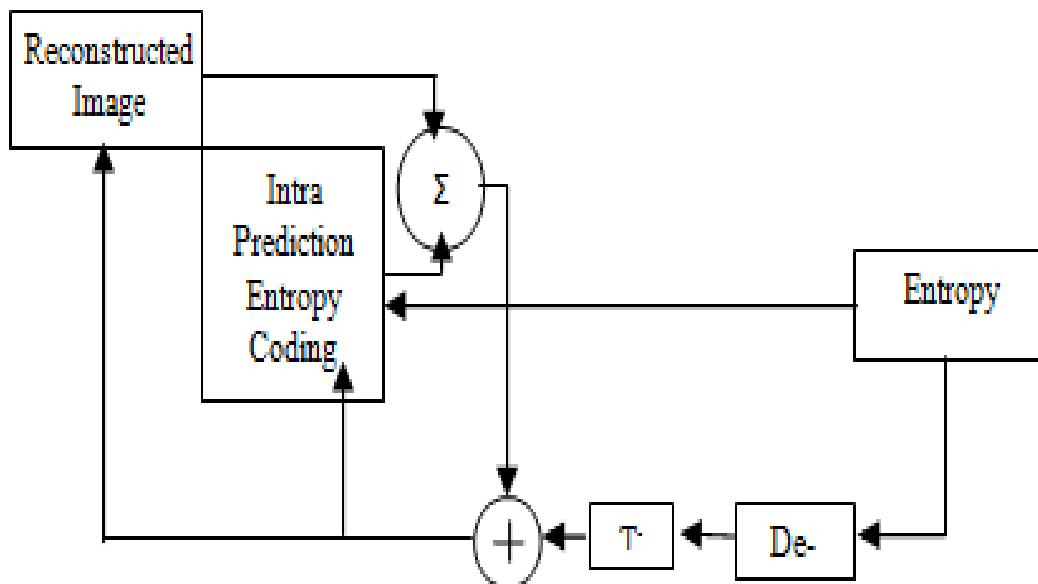


Fig. 2 Proposed Decoder Architecture

III. Intra Prediction

In video coding, intra prediction is mostly used. A prediction signal is obtained from previously coded samples for the coding unit and it is subtracted from the original coding unit to create a residual signal that has much less data than the obtains the same prediction signal using previously decoded samples, decodes the residual signal and adds them together to reconstruct the coding unit [11]. In intra prediction each unit is predicted by using the neighboring pixels of the same image. Intra coding is helpful in coding homogeneous regions where neighboring pixels of the block has comparable value as the pixels within the block.

IV. Proposed Octagon Based Intra Prediction (OBIP) Algorithm

Intra prediction plays a vital role in recent video coding standards. One among them is block-based intra prediction technique which is used for efficient spatial redundancy exploitation. In this paper, a research is made in image compression by incorporating intra prediction coding to improve the efficiency. Intra Prediction is defined as the prediction in which the image content of a particular region can be represented with other previously decoded region in the image. Hence, in the intra prediction, decoding is done during encoding also. Here, the regions are termed as blocks. Initially, the image is divided into blocks. Intra predicted blocks are generated based on the pixels of the previously encoded and reconstructed blocks. There are some prediction modes for identifying predicted block. These prediction modes are defined for square block sizes from 4×4 up to 32×32 . The encoder tests all the available intra prediction modes and signals the best mode to the decoder. The decoder must generate an identical prediction block, based on the reconstructed pixels from the previously encoded neighboring blocks. The reconstructed reference samples used in the prediction process belong to the neighboring blocks. For an $N \times N$ block, intra prediction searches the predicted block in the neighboring blocks according to the search ranges described next. It is shown in Fig. 3. The proposed algorithm uses 20 neighboring blocks for intra prediction. The search range of the OBIP algorithm is shown in Fig.4. The inner square search range is uses 8 blocks for intra prediction and shaded with dark gray while the outer octagon search range is shaded with light gray and it uses 12 blocks for intra prediction. Proposed algorithm uses totally 20 blocks for intra prediction. The similarity of the blocks is measured using Block Distortion Measure (BDM). The block with the minimum BDM is selected as the predicted block.

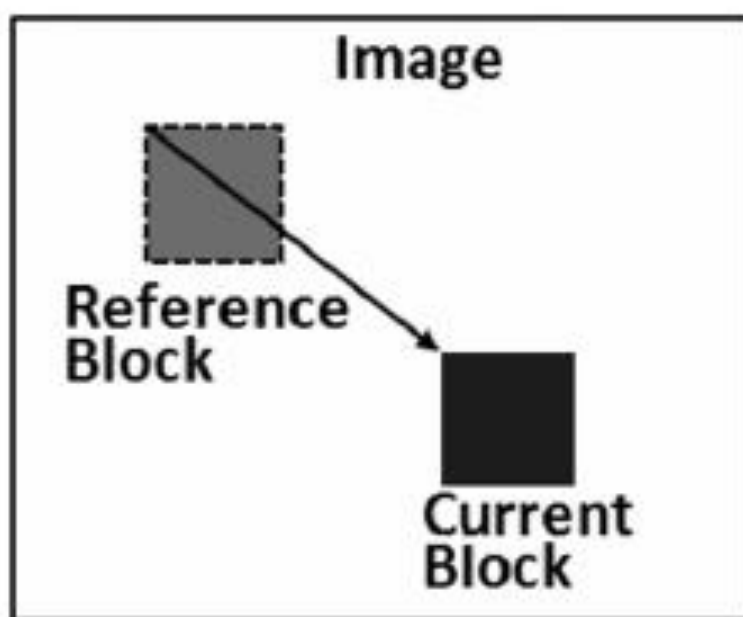


Fig. 3 Illustration of Intra prediction

Mode Selection Algorithm is as follows:

Algorithm 1: Octagon Based Intra Prediction Mode Selection

Input: Current Block

Output: Predicted Block, Prediction Error

Steps:

1. For each current block, calculate BDM for the 8 neighboring blocks in the square range. If minimum BDM is zero in any of the neighboring blocks, Predicted block is found. Stop the search. Go to step 5.
 2. Calculate BDM for the 12 blocks in the octagon range.
 3. Calculate minimum BDM obtained from the above two steps.
 4. The block with minimum BDM obtained in the previous step is selected as Predicted block.
 5. Calculate prediction errors using the current block and the predicted block.
 6. Stop the process.
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Matching of one block with the other is based on the output of the BDM. The candidate block with minimum BDM is the one that matches closest to the current block. Among the various cost functions, the one that is less computationally expensive is the Mean Absolute difference (MAD) and is given by the formula:

$$MAD = \frac{1}{MN} \sum_{i=0}^{M-1} \sum_{j=0}^{N-1} |C_{ij} - R_{ij}| \quad (1)$$

Where M and N is the size of the block, C_{ij} and R_{ij} are the pixels being compared in current block and reference block, respectively.

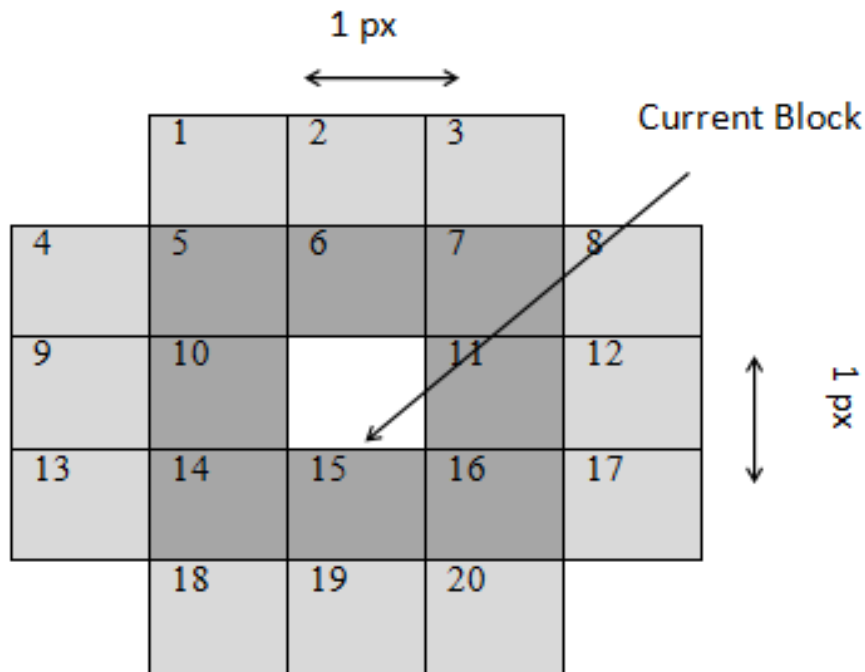


Fig. 4 Search range of proposed algorithm

Fig.5 shows BDM calculation of square and octagon ranges in which we consider B_{18} to have min BDM in square range and B_6 to have min BDM in octagon range. Initially, the BDM of blocks in the square range (8 neighboring blocks) is calculated. If minimum of BDM is zero, then prediction block is found. Otherwise, the BDM of blocks in the octagon range (12 neighboring blocks) is calculated. Minimum of BDM is calculated from the square and octagon range. The block which has the minimum BDM is selected as the predicted block.

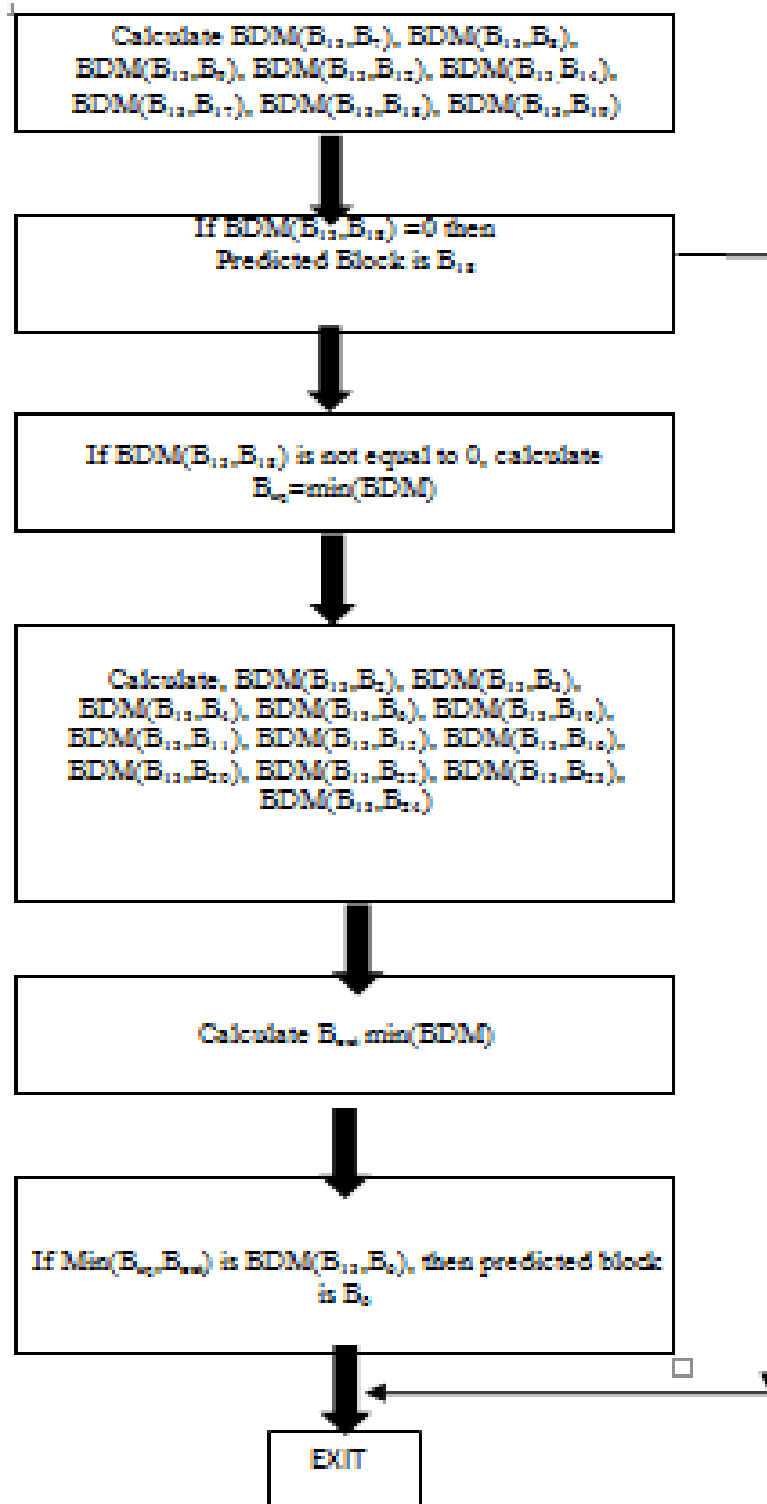


Fig. 5 Work flow of calculating prediction block

V. Experimental Results

The proposed method is analyzed using PSNR, Compression ratio and bits per pixel. The image types and its sizes are listed in Table 1. The proposed method is compared with JPEG2000 and recent methods in terms of PSNR, Compression ratio and bits per pixel.

Table 1 Test Image and its size

Image	size
Cman.tif	256x256
Baboon.tif	256x256
Barbara.png	512x512
Boat.gif	512x512
Lena.png	512x512
Peppers.png	512x512
Lifting.png	256x256

Compression ratio is used to specify the reduction in data-representation size. CR is calculated by using the following formula.

$$\text{Compression Ratio} = \frac{\text{Uncompressed Size}}{\text{Compressed Size}} \quad (2)$$

$$MSE = \frac{1}{MN} \sum_{i=0}^{m-1} \sum_{j=0}^{n-1} \|I(i, j) - K(i, j)\| \quad (3)$$

The PSNR is defined as

$$PSNR = 20 \log_{10} \left(\frac{MAX_I}{\sqrt{MSE}} \right) \quad (4)$$

Signal-to-noise is defined as the ratio between a signal and the background noise:

$$SNR = \frac{\sum_{i=0}^{m-1} \sum_{j=0}^{n-1} K(i, j)^2}{\sum_{i=0}^{m-1} \sum_{j=0}^{n-1} I(i, j) - K(i, j)^2} \quad (5)$$



Fig. 6(a) Input Image (b) After Block subdivision (c) Output obtained by the proposed method of Lena Image

Table 2 Results obtained by the proposed method OBIP

Method/ Image	Compression Ratio	PSNR (dB)	Bits per Pixel
Cman	5.0221	59.1147	0.1991
Baboon	3.2408	49.1767	0.3086
Barbara	5.1885	58.2644	0.1927
Boat	5.4346	57.2197	0.1840
Lena	7.9194	60.3744	0.1263
GoldHill	6.9896	56.0549	0.1431
Average	5.6325	56.7008	0.1923

Table 2, illustrates the result of OBIP. The proposed method achieves average PSNR value 56.7008 dB average bits per pixel value 0.1923.

The proposed method is compared with JPEG 2000, Variable Block Size coding (VBS) [17], Adaptive Predictive Combination (APC) [18] and Encryption Then Compression (ETC) [19]. It is shown in Table 3. Proposed OBIP achieves average bits per pixel value 0.165. It provides better result than JPEG 2000 and recent methods.

Table 3 Bits per pixel Comparison of the proposed method with JPEG2000 and recent methods

Method/ Image	JPEG 2000	VBS (2010)	AP C (2013)	ETC (2014)	Proposed
Barbara	4.600	3.18 15	3.75	1.223	0.1927
Lena	4.684	4.28 0	3.45	0.766	0.1263
GoldHill	4.603	4.20 7	4.20	1.137	0.1751
Avg.	4.629	3.88 95	3.75	1.042	0.165

VI. Conclusion

An effective compression technique named as Octagon based intra prediction has been developed for still gray scale lossy image compression, which helps reducing the distortion thereby improving the reconstructed image quality. To speed up the Octagon search pattern is morphologically decomposed into square search pattern. It uses minimum number of search points to achieve the lowest error and the fastest search speed. The proposed method achieves PSNR ranges from 49.1767db to 60.3744db and bits per pixel ranges from 0.1263 to 0.3086. It saves 85% bit rate.

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