*Siddharth Pande Int. Journal of Engineering Research and Applications*www.ijera.com
ISSN : 2248-9622, Vol. 5, Issue 5, (Part -1) May 2015, pp.87-90

RESEARCH ARTICLE OPEN ACCESS

Modified approximate 8-point multiplier less DCT like transform

Siddharth Pande*, Shyam Pankhaniya**
Department of Electronics & Communication Engineering, School of Engineering, RK University, Rajkot.

ABSTRACT
Discrete Cosine Transform (DCT) is widely usedtransformation for compression in image and video standardslike H.264 or MPEGv4, JPEG etc. Currently the new standarddeveloped Codec is Highly Efficient Video Coding (HEVC) orH.265. With the help of the transformation matrix the computational cost can be dynamically reduce. This paper proposesa novel approach of multiplier-less modified approximate DCT like transformalgorithm and also comparison with exact DCT algorithm and theapproximate DCT like transform. This proposed algorithm willhave lower computational complexity. Furthermore, the proposedalgorithm will be modular in approach, and suitable for pipelinedVLSI implementation.
***Keywords*–**Approximate DCT, DCT, JPEG, HEVC, Multiplier-less DCT transform

I. INTRODUCTION

Discrete cosine transform proposed in [1] is a very widely used transformation method for compression in the field of Digital Image and Video Processing. After the first introduction in the 1974, it has evolved and has become one of the important component of video and image processing standards. DCT of type-II [2] is generally used for various compression techniques. Different approaches based upon theoretical mathematics have be publish in the past to reduce the architecture where by maintaining the integrity and the functionality of the original DCT which can be found in [6-8],[10]. The DCT has maintained its durability in the compression work-flow by its simple and low bit transformation criteria, still many new algorithms have come up from time to time related to DCT. Image and Video standards like H.264 or MPEGv4 [3], JPEG [9] etc. have implemented DCT as the compression tool. The most recently released Codec HEVC or H.265 [4] for video processing uses the Chen’s architecture [5] for computing the DCT. The JPEG standard [9] which is widely used Codec for image storage also uses DCT for the Image compression. The implementation of [1] requires huge amount of multipliers and adders at the hardware level, which turns out to be costly with respect to the size and power consumption. DCT is widely popular for mostly because it is effective in transforming the image data into an easily compressible form and this can efficiently be implemented both in software and hardware. This papers gives a comparison of the work proposed by [10] with [1] on the basis of quality of image. Also a modified work is proposed and compared with [10] and [1] respectively. The paper has two sections the first gives the mathematical model from [10] and the second gives the proposed work and the related comparative analysis done.

II. REVIEW OF APPROXIMATE DCT METHOD

Novel approaches from the past literature can be found for minimizing the computational complexity. In [10], A fast algorithm is proposed which minimize the floating point operations by means of approximate transforms which deals with a minimum cost argument of the transformation matrix:

$$T = arg\ min\ cost(T) \qquad (1)$$

Where, T has Coefficients

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\ 1 & 0 & 0 & -1 & -1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 \end{bmatrix}$$

In a JPEG like image compression mostly the higher frequency components are discarded by the quantization matrix. In the depth analysis the amount of data to be preserved in the matrix is given by a number r were by coefficients of rows and columns ≥ r are made zero. Using the matrix T from (1), the orthogonal matrix C can be obtained by using the equation

$$C = D \cdot T \qquad (2)$$

Where, C is the obtained orthogonal transformation matrixand D is the diagonal matrix containing the weight of theCosine Factors:

$$D = diag\left(\frac{1}{\sqrt{8}}, \frac{1}{\sqrt{2}}, \frac{1}{2}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{8}}, \frac{1}{\sqrt{2}}, \frac{1}{2}, \frac{1}{\sqrt{2}}\right) \qquad (3)$$

The 8 × 8 input matrix A is converted into *2-D* DCT output matrix B by:

$$B = C \cdot A \cdot C^T \qquad (4)$$

Where, ^{T} denotes the Transpose of matrix C

III. PROPOSED TRANSFORM

JPEG like image compression deals with the Zig-zag transmission of the data from the matrix there by sending the lower frequency components first [9]. Also the Higher frequency components are discarded as mentioned in [10], the upper left half of the Matrix *B* has almost all the data of the image block including the DC signal and the lower frequency component.

3.1. Mathematical Model

Keeping in mind the constraints mentioned to create *T* matrix in [10] a new modified matrix T^* is proposed which is:

$$\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & -1 & 0 \\ 1 & 0 & 0 & -1 & -1 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

In the process of modification due care was taken to preserve the *C* matrix orthogonality, Also some of the diagonal matrix elements are removed so as to reduce the computational complexity with the T^* matrix the Orthogonal matrix *C**canbe obtained by:

$$C^* = D^* \cdot T^* \quad (5)$$

Where, The diagonal matrix D^* is:

$$D = diag\left(\frac{1}{\sqrt{8}}, \frac{1}{\sqrt{2}}, \frac{1}{2}, \frac{1}{\sqrt{2}}, 0, 0, 0, 0\right) \quad (6)$$

And the 2D DCT of the input block A can be calculate as:

$$B^* = C^* \cdot A \cdot C^{*T} \quad (7)$$

B^* is the output 8 x 8 block for the input *A*, Here the *2-D* DCT is calculated using *1-D* DCT on the Column matrix followed by *1-D* DCT on the row Matrix.

3.2. Analysis

Quality of the Transformed Image is checked by the PSNR values with depth control and the values are compared to the original DCT process. Here while doing the depth analysis, up-to 4, considering only the 16 coefficient and discarding the rest, PSNR value obtained and compared,It is found that PSNR values after $r \geq 4$ are found to be almost constant for the Proposed T^*.

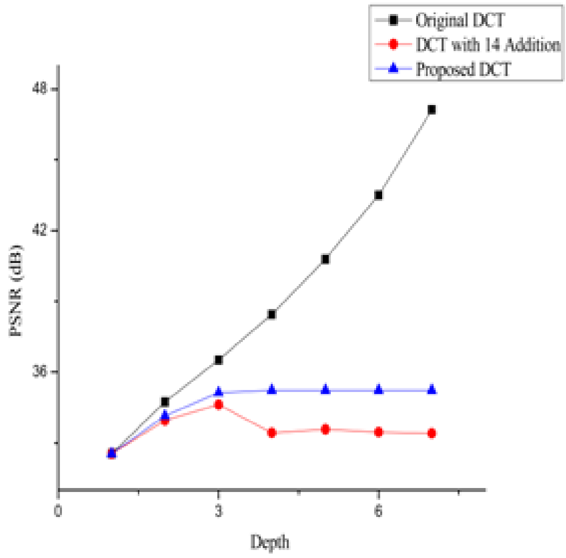

Fig1. Graph of PSNR vs Depth(r)

Fig. 1 shows the graph of the quality analysis according to the depth control factor *r*.

(a) Input Image after grayscale conversion

(b) PSNR 38.45 dB

(c) PSNR 33.43 dB

(d) PSNR 35.23 dB
Figure 2. (a) shows the Input 512 × 512 image Lena, (b), (c) are the output images obtained after decompression. (d) Shows the output image using proposed *T**. Here *r*=4.

It can be observed that the removal higher frequency components from the matrix produced better PSNR ratings. Accordingly this new transformation matrix $T^*$is proposed satisfying the constraints mention in [10]

IV. RESULTS

The transform matrix *T* from [10] and the equation from [2] are used to make test model in *Matlab*™ script and the PSNR values according to [11] are measured for different values of r and are compared. The famous Lena image of size *512 × 512* is used, the image is broken into *8 × 8* block for processing using the transform matrix T from [10], while the regular equation based approach is used and a model code is made to process *8 × 8* block for [1]. The study of the transformed matrix block shows mostly the upper left corner of the matrix holds the compressed transformed data.

Fig. 2 (a) shows the Input *512 × 512* Lena Image in grayscale, (b) shows the output of the exact DCT by [1], (c) shows the output by the Transformation matrix presented in [10] and (d) shows the output of the proposed transformation matrix T^*. It is seen that after maintaining the depth of 4, i.e. round 16 coefficient of the upper left corner contains most of the image data in the compressed form, so the rest of coefficient related to higher frequency data of the image block are discarded which is shown by the proposed T^*. Table-1 shows the comparison between methods used. For the purpose of comparison one more quantity UQI [12] is taken into consideration. Result shows that this proposed T^* has better PSNR and UQI for same value of *r* as compared to *T*. Original DCT has better values but it consumes more hardware architecture as compared to the other two. Hence on the basis of this two parameters of comparison, the proposed T^* can be used in place of (1).

V. CONCLUSION

The proposed transform matrix could be used as a modified approximate 8-point DCT matrix, the proposed transformation matrix only has values of $\{0, \pm 1\}$ which are only addition and subtraction, there are no shifting operations and multipliers to compute the transformation coefficient as in [5], [6], [7], and [8].

TABLE- 1: Comparative results on the basis of PSNR and UQI

	Depth (r)	PSNR (dB)	UQI
Original DCT [1]	4	38.45	0.8209
Approximate DCT [10]	4	33.43	0.5511
Proposed DCT	4	35.23	0.6698

The future work is to implement this on a hardware platform so that a new IP based core for 8-point DCT can be proposed. This work can be used to model a hardware DCT core which can implemented on upcoming standards like HEVC [4] and also can be used with the present standards of image and video processing Codec and tools.

REFERENCES

[1] N. Ahmed, T. Natarajan and K. R. Rao, ”Discrete Cosine Transform,” *IEEE Trans. Computers*, *vol. C-23*, *no. 1*, 90-93 January1974.

[2] V. Britanak, P. Yip, and K. R. Rao,” *Discrete Cosine and Sine Transforms* (New York, NY, USA: Academic, 2007)

[3] International Telecommunication Union, *ITU-T Recommendation H.264 Version 1: Advanced Video Coding for Generic Audio-Visual Services ITU-T*, (Tech. Rep., 2003)

[4] G. J. Sullivan, J. R. Ohm, W. J. Han and T. Wiegand “Overview of the high efficiency video coding (HEVC) standard,” *IEEE Trans. Circuits System Video Technology, vol. 22, no. 12*,1649-1668, Dec. 2012.

[5] W-H. Chen, C. H. Smith and S. C. Fralick, “A fast computational algorithm for the discrete cosine transform,” *IEEE Trans. Communications, COM-25, No. 9*, September 1997.

[6] B. G. Lee, “A new algorithm for computing the discrete cosine transform,” *IEEE Trans. Acoustic., Speech, Signal Process., vol. ASSP-32*,1243-1245, December 1984.

[7] S. Bouguezel, M. O. Ahmad, and M. N. S. Swamy, “Low-complexity 8×8 transform for

image compression," *Electronics. Letter, vol. 44, no. 21*, 1249-1250, 2008.

[8] R. J. Cintra and F. M. Bayer, "A DCT approximation for image compression," *IEEE Signal Processing Letter, vol. 18, no. 10*, 579-582, Oct. 2011.

[9] W. B. Pennebaker and J. L. Mitchell, "*JPEG Still Image Data Compression Standard*," (New York, NY, USA: Van Nostrand Reinhold, 1992).

[10] U. S. Potluri, A. Madanayake, R. J. Cintra, F. M. Bayer, S. Kulasekera and A. Edirisuriya, "Improved 8-point approximate DCT for image and video compression requiring only 14 additions," *IEEE Transactions on Circuits and Systems I, Vol. 61, No. 6*, June 2014.

[11] A. Ichigaya, M. Kurozumi, N. Hara, Y. Nishida and E. Nakasu, "A Method of Estimating Coding PSNR Using Quantized DCT Coefficients," *IEEE Trans. Circuits System Video Technology,Vol. 16, No. 2,* Feb. 2006.

[12] Z. Wang and A. Bovik, "A universal image quality index," *IEEE Signal Processing. Letter, vol. 9, no. 3*, 8184, 2002.