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COMPARATIVE ASSESEMENT OF DIFFERENT TYPES OF DCT IN IMAGE COMPRESSION

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ABSTRACT
In this paper, we compare the different types of Discrete Cosine Transforms(DCT) techniques employed in Image and Video Compression along with aApproximate DCT..This new DCT employed is a multiplier free DCT which involves only addition operations. This new DCT employed will give low complexity and efficient throughput for operations.weanalyse the different types of DCT and their Performance.

INTRODUCTION
Like any Fourier related transform, DCT(Discrete Cosine Transform) exposes a function or a signal in terms of a sum of sinusoidsignals with different frequencies and amplitudes. In many situations, DCT operate as a function with a finite number of discrete datapoint as DFT(Discrete Fourier Transform).

DCT → uses only cosine transform
DFT → uses sine & cosine transform

8-point Approximation based technique were proposed for compressions[1][3].
Works with 16 point DCT approximations are also performed for some operations .[4][5].

The DCT,mainlythe DCT-II, is used in signal and image processing for lossless image compression, because it has a good "energy compaction" property:[1][2] most of the signal datas tends to be focussed in a low-frequency components of the DCT, considering the KLT transform for signals.KLT(karhunen-Loeve Transform) has a Linear and not separable property where full matrix multiplication is performed.

DFT is a linear,separable and has symmetric property where DCT has some better properties compared to DFT/KLT.DCT has fixed basis images and fast implementations are possible.DCT has better correlation characteristics and Energy compaction propertiesand are also widely used in solving partial differential equations ,where the different values of the DCT correspond to slightly different even/odd boundary conditions at the two ends of the array.

Incontrast, a DCT have*both* boundaries are even,so it produce a continuous extension at the boundaries (although the slope is generally discontinuous).Hence we are preferringDCTs, and in particular DCT types I, II, V, and VI (the types that have two even boundaries) generally perform better for signal compression than DFTs and DSTs. practically, a type-II DCT is usually preferred for such applications, for better operational convenience..

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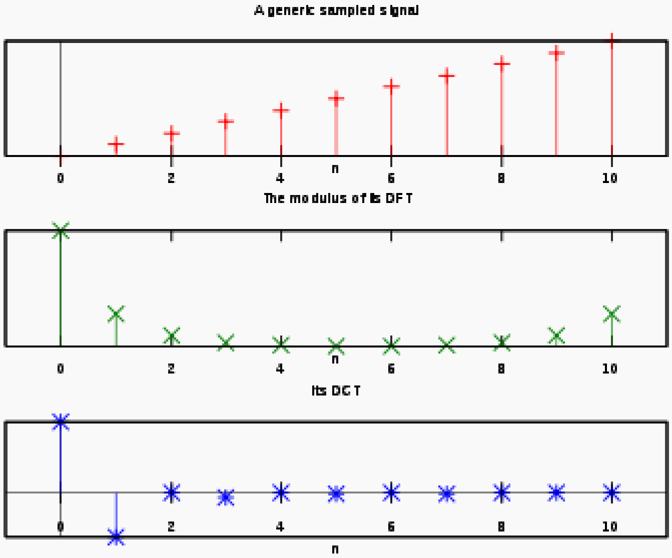

Fig(a)-DCT-II (bottom) compared to the DFT (middle) of an input signal (top).

The DCT is used in JPEG image compression, MJPEG, MPEG, DVvideo compression. The 2D DCT-II of N N blocks are computed and the results are quantized and entropy are encoded. In thefig(a), N takes the value 8 and the DCT-II formula is applied to each row and column of the block.

In the rest of the paper, we are comparing various types of DCT that are proposed and have the comparative Analysis of all the DCTs that are used.

ANALYSIS OF DCT

A. Fast multiplierless approximation of DCT

A Fast multiplier less approximations of the discrete cosine transform (DCT) with the lifting scheme called the bin DCT was introduced[3]. These bin DCT families are derived from Chen's and Loeffler's plane rotation-based factorizations of the DCT matrix, respectively, and the design approach can also be applied to a DCT of arbitrary size[6]. Two design approaches are presented. In the first method, an optimization program is defined, and the multiplier less transform is obtained by approximating its solution with dyadic values. In the second method, a general lifting-based scaled DCT structure is obtained, and the analytical values of all lifting parameters are derived, enabling dyadic approximations with different accuracies[3]. Therefore, the bin DCT can be tuned to cover the gap between the Walsh–Hadamard transform and the DCT. The corresponding two-dimensional (2-D) bin DCT allows a 16-bit implementation, enables lossless compression, and maintains satisfactory compatibility with the floating-point DCT. The performance of the bin DCT in JPEG, H.263+, and lossless compression is also demonstrated[6].

B. *B*ouguezel-Ahmad-Swamy Approximate DCT

In [3], a low-complexity approximate was introduced by Bouguezel et al. We refer to this approximate DCT as BAS-2008 approximation. The BAS-2008 approximation has the following mathematical structure:

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$$C_1 = D_1.T_1 = D_1.\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & -1 & -1 \\ 1 & \frac{1}{2} & -\frac{1}{2} & -1 & -1 & -\frac{1}{2} & \frac{1}{2} & 1 \\ 0 & 0 & -1 & 0 & 0 & 1 & 0 & 0 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & 0 & 0 & 0 & 0 & 1 & -1 \\ \frac{1}{2} & -1 & 1 & -\frac{1}{2} & -\frac{1}{2} & 1 & -1 & \frac{1}{2} \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix}$$

Where D1=diag(1/√8,1/√4,1/√5,1/√2, 1/√8,1/√4,1/√5,1/√2).A fast algorithm for matrix T_1 can be derived by means of matrix factorisation .Indeed, T_1 can be written as a product of three sparse matrices having (0,+_*1/2,+_1)elements as shown*

$$A_2 = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 & 0 & 0 \\ 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1 & 1 \\ 1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 0 & 0 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 1/2 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -1 & 0 & 1/2 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Matrices I_n and $\overline{I_n}$ denote the identity and counter-identity matrices of order n,respectively.it is recognizable that matrix A1 is the well-known decimation-in-frequency structure present in several fast algorithms[3][6]

C. CB-2011 Approximation

By means of judiciously rounding-off the elements of the exact DCT matrix,a DCT approximation was obtained .The resulting 8-point approximation matrix is orthogonal and contains only elements in(0,+_1).clearly,it possesses very low arithmetic complexity.The Matrix derived transformation matrix C_2 is given by:

$$C_2 = D_2.T_2 = D_2.\begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 0 & 0 & -1 & -1 & -1 \\ 1 & 0 & 0 & -1 & -1 & 0 & 0 & 1 \\ 1 & 0 & -1 & -1 & 1 & 1 & 0 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & 0 & 1 & -1 & 0 & 1 & -1 \\ 0 & -1 & 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & -1 & 1 & -1 & 1 & -1 & 1 & 0 \end{bmatrix}$$

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Where D2=diag(1/√8,1/√6,1/√2,1/√6, 1/√8,1/√6,1/√2,1/√6).An efficient factorisation for the fast algorithm for T2 was proposed . T_2= P_2.A_6.A_5.A_1 whereA5=diag

$$\left(\begin{bmatrix}1&0&0&1\\0&1&1&0\\0&1&-1&0\\1&0&0&-1\end{bmatrix}.\begin{bmatrix}-1&1&-1&0\\-1&-1&0&1\\1&0&-1&1\\0&1&1&1\end{bmatrix}\right)$$

D. Approximation DCT

A low-complexity approximate DCT is proposed with the 8 ×8 matrix space and a candidate matrices that possess low computation cost is proposed. Here the cost of a transformation matrix is defined as the number of arithmetic operations required for its computation. One of the main advantages is to restrict the search to matrices whose entries do not require multiplication operations. Thus we have the following optimization problem.

$$T = \begin{bmatrix}a_3&a_3&a_3&a_3&a_3&a_3&a_3&a_3\\a_0&a_2&a_4&a_1&-a_6&-a_4&-a_2&-a_0\\a_0&a_2&a_0&a_2&a_2&a_2&a_2&a_2\\a_0&a_2&a_2&a_2&a_2&a_3&a_1&a_3\\a_3&a_3&a_2&a_3&a_3&a_2&a_1&a_2\\a_2&a_2&a_3&a_2&a_2&a_2&a_2&a_2\\a_1&a_1&a_2&a_1&a_2&a_1&a_1&a_1\\a_1&a_1&a_1&a_2&a_1&a_1&a_2&a_2\end{bmatrix}$$

where is the sought matrix and returns the arithmetic complexity .

Additionally, the following constraints were adopted

1. Elements of matrix must be in to ensure that resulting multiplicative complexity is null;
2. All rows of are non-null;
3. Matrix must be a diagonal matrix to ensure orthogonality of the resulting approximation [6]

PERFORMANCE ANALYSIS

A. Arithmetic complexity:

Table-[1] Arithmetic Complexity Analysis

Method	Mult	Add	Shifts	Total
Exact DCT[1]	64	56	0	120
Fast multiplilerless approximation[3]	0	29	2	31
BAS 2008 [6]	0	18	2	20
CB 2011[9]	0	22	0	22
Approximate DCT[8]	0	14	0	14

Here, the arithmetic complexity refers for the computational complexity. The arithmetic complexity consists of the number of elementary arithmetic operations (additions/subtractions, multiplications/divisions, and bit shift operations) that required to compute a given transformation.

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Because all considered DCT approximations have null multiplicativecomplexity, we resort to comparing them in termsof their arithmetic complexity assessed by the number of additions/subtractions and bit-shift operations. Table I displays theobtained complexities. We also include the complexity of all the DCT included (i) Fast Multiplierless DCT[1][6].

i. BAS-2008 Approximation[9][10].
ii. CB-2011 Approximation[1][8].
iii. Improved Approximation DCT requiring only 14 Additions.[2][8].

Improved Approximation DCT has the same very low-complexityexhibited by the Modified CB-2011 approximation [5].According to the survey,To the best of our knowledge these are DCT approximations offering the lowest arithmetic complexity.

B. Comparision of PSNR:

Fig. 1 presents the resulting average PSNR relative to the DCT, for r=2,3,……20., i.e., for high compression ratios [3][8]. The Approximation DCT could perform the Modified CB-2011 approximation for , i.e., when 84.38% to 76.56% of the DCT coefficients are discarded. Such high compression ratios are employed in several applications [1], [2]–[8].Average PSNR and UQI measures are presented for all considered images at a selected high compression ratio. The approximate transform proposed in [8] could out perform remaining methods in terms of proximity measures(total energy error and MSE) when compared to the *exact* DCT.

It also furnished good image quality measure results (average dB). However, at the same time, it is the most expensive approximation measured by its computational cost asshown in Table I.

On the other hand, the transforms with lowest arithmetic complexities are the Modified CB-2011 approximation and Approximation DCT requiring14 additions. The new Approximation DCT could out perform the Modified CB-2011 approximation as an image compression tool as indicated by the PSNR andMSE values.
Table [2] shows a comparative report for the different types of DCT showing MSE,

Table-[2]:Comparative analysis

Types of DCT	MSE (dB)	Efficiency η	PSNR
Exact DCT [1]	0.000	93.991	28.336
Fast multiplierless DCT [3]	7.102	85.380	26.902
BAS 2008 [6]	2.378	86.863	27.245
CB-2011 [9]	0.980	87.432	27.369
Approximate DCT [8]	7.899	80.897	25.726

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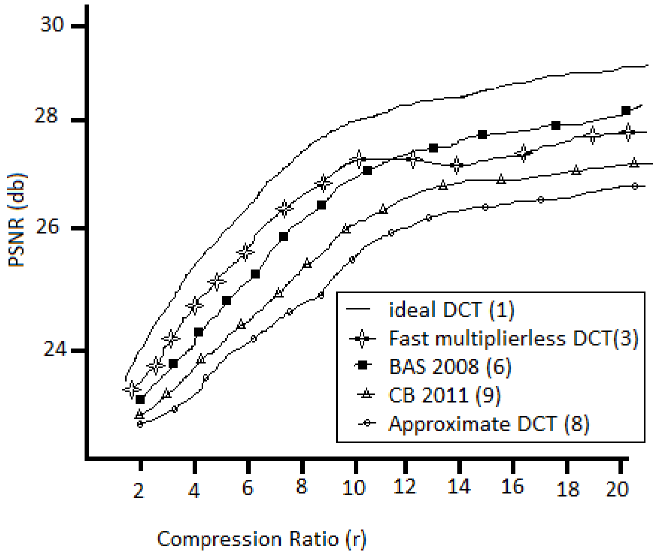

fig-(1):compression ratio vs average PSNR

CONCLUSION

In this paper, we compared a low-power 8-point DCT approximation that require only 14 addition operations to computations which has all good advantages compared to the other DCTs that are proposed in this survey and hardware implementation for all the transform including other prominent approximate DCT methods, including the designs by Bouguezel-Ahmad-Swamy DCT perform very close to the ideal DCT. However, the modified CB-2011 approximation and the 8-point Approximate DCT possess lower computational complexity and are faster than all other approximations under consideration.

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