Image and Video Compression by Improved 8-Point Approximate Dct without Multipliers

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Abstract: Video processing systems, for example, HEVC requiring low vitality utilization required for the interactive media market has lead to broad advancement in fast algorithms for the productive guess of 2-D DCT changes. The DCT is utilized in a large number of pressure guidelines because of its striking vitality compaction properties. Sans multiplier inexact DCT Changes have been suggested that offer prevalent pressure execution at low circuit multifaceted nature. Such approximations can be acknowledged in computerized VLSI equipment utilizing additions and Subtractions just, prompting noteworthy decreases in chip region and force utilization contrasted with customary DCTs and whole number changes. In this paper, we present a novel 8-point DCT guess that requires just 14 addition operations and no increases. The proposed DCT guess is a possibility for reconfigurable video norms, for example, HEVC. The proposed change and a few other DCT approximations are mapped to systolic-cluster advanced structures and physically acknowledged as computerized model circuits utilizing FPGA Spartan 3 and it are executed by verilog dialect.

Keywords: Video processing systems, 2-D DCT, VLSI equipment, DCT approximations.

I. INTRODUCTION

Image compression is vital for some applications, for example, interactive media, web and portable correspondence. Change based compression systems are generally utilized as a part of such applications. The discrete cosine change (DCT) is a crucial scientific apparatus in both picture and video coding. DCT is generally embraced in a few picture and video coding principles, for example, JPEG, MPEG-1,MPEG-2, H.261, and H.263. This is for the most part because of its great vitality compaction properties.

A discrete cosine change (DCT) communicates an arrangement of limitedly numerous information focuses as far as an entirety of cosine capacities swaying at various frequencies. DCTs are vital to various applications in science and building, from lossy compression of sound and pictures (where little high-recurrence segments can be disposed of), to otherworldly techniques for the numerical arrangement of incomplete differential conditions.

Utilization of cosine as opposed to sine capacities is basic in these applications: for compression, things being what they are cosine capacities are significantly more proficient (as clarified underneath, less are expected to rough a run of the mill signal), while for differential conditions the cosines express a specific decision of limit conditions. The paper introduces a new DCT approximation that possesses an extremely low arithmetic complexity, requiring only 14 additions. This novel transform was obtained by method for solving a tailored optimization issue aiming at minimizing the transform computational expense. Second, we propose Hardware implementations for several 2-D 8-point approximate DCT. The DCT approximation methods under consideration are the Cintra -Bayer (CB) approximate DCT, the modified CB approximate DCT.

II. PREVIOUS WORK

Some DCT approximations can absolutely dispose of the prerequisite for skimming point operations. All fig urings are performed over a fixed-point number juggling structure. All in all, these guess techniques utilize a change framework whose components are characterized over the set $\{0,\pm1/2,\pm1,\pm2\}$.

This infers invalid multiplicative many-sided quality, in light of the fact that the required operations can be actualized only by method for binary additions and shift operations. Such DCT approximations can give minimal effort and low-control outlines and viably supplant the definite DCT and other DCT-like changes. In fact, the execution attributes of the low unpredictability DCT approximations seem like the accurate DCT, while their partner equipment usage are efficient on account of the nonappearance of multipliers.

The diverse DCT approximate methods are clarified as far as its change lattices and the related fast algorithms acquired by matrix factorization systems.

1. BAS-2008 Approximate Method
It's a low-complexity approximate that was presented by Bougueze let al. This type of approximate is termed as BAS-2008 approximate. The BAS-2008 approximate C1has the following mathematical structure: $C_1 = D_1 . T_1$

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

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 factorization. Indeed, can be written as a product of three sparse matrices having $\{0, \pm 1/2, \pm 1\}$ elements as shown below:

$$T_1 = A_3 \cdot A_2 \cdot A_1, \text{ where,}$$

$$A_1 = \begin{bmatrix} I_4 & \bar{I}_4 \\ \bar{I}_4 & I_4 \end{bmatrix}$$

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

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

Matrices $\bar{I}_n$ and I_n indicate the identity and counter-identity matrices of request, individually. That is conspicuous about the matrix is the well-known decimation-in-frequency structure present in several fast algorithms.
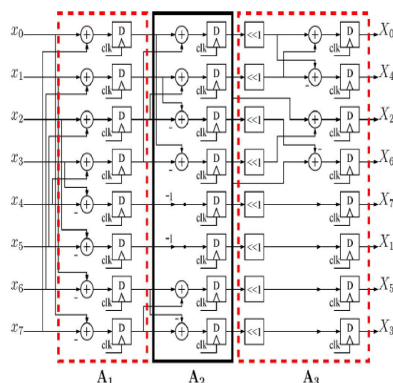

Fig.1 Digital architecture of BAS-2008.

This diagram represents the digital signal flow graph of CB201 approximate DCT. This Transformation matrix contains only 22 additions and there is no shift and multiplications are performed here.

2. Modified CB-2011 Approximate
This transform is obtained by replacing elements of the CB-2011 matrix with zeros. The resulting 8-point approximation matrix is orthogonal and contains only elements in$\{0, \pm 1\}$. Clearly, it possesses very low arithmetic complexity. Mathematical structure of the Modified CB-2011 is given by:

$$C_2 = D_2 \cdot T_2$$

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

Where,
D3 = diag(1/√8,1/√2,1/2,1√2,1/√8,1/√2,1/2,1/√2).
The matrix T2= P2 · A6 ·A7 ·A1
Matrix P2 has permutation: (1)(2 5 8)(3 7 6 4).

$$A_6 = \text{diag}\left(\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}, -1, I_5\right)$$

$$A_7 = \text{diag}\left(\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & -1 & 1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}, -I_3, 1\right)$$

This Modified CB-2011 approximate require least no of components compared to the old CB-2011 method. Thus, requiring only 14 additions.
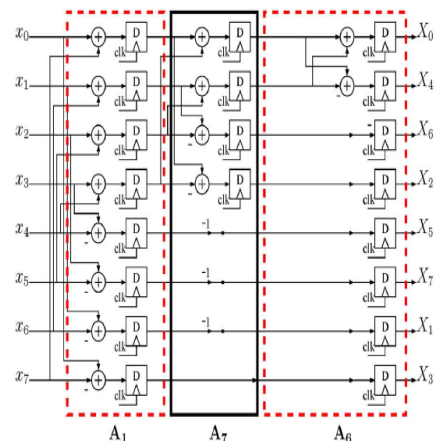

Fig.2 Digital architecture of Modified CB-2011 approximate

III. PROPOSED METHOD

The aim at deriving a novel low-complexity approximate DCT. For such end, we propose a search over the 8×8 matrixspace in order to find candidate matrices that possess low computationcost. Let us define the cost of a

transformation matrix as the number of arithmetic operations required for its computation. One way to guarantee good candidates is to restrict the search to matrices whose entries do not require multiplication operations. Thus we have the following optimization problem:

$$T_P = \arg\min_T \text{cost}(T)$$

Where, T_P is the sought matrix and $\text{cost}(T)$ returns the arithmetic complexity of T .Additionally, the following constraints were adopted:

1) Elements of matrix T must be in $\{0, \pm 1, \pm 2\}$ to ensure that resulting multiplicative complexity is null.
2) We impose the following form for matrix T. Matrix T·TT must be a diagonal matrix to ensure orthogonality of the resulting approximation.

An important parameter in the image compression routine is the number of retained coefficients in the transform domain. For considering 8×8 image blocks, in image compression using support vector machine, only the first 8–16 coefficients were considered. We adopted the number of retained coefficients equal to 10. The following DCT approximation is proposed.

$$C_P = D_P \cdot T_p$$

$$C_p = D_p \cdot \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ 1 & 0 & 0 & -1 & -1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 0 & 0 & 0 & 1 & -1 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 1 & -1 & 0 \\ 0 & 0 & 1 & 0 & 0 & -1 & 0 & 0 \end{bmatrix}$$

Where D=diag$(1/\sqrt{8}, 1/\sqrt{2}, 1/2, 1/\sqrt{2}, 1/\sqrt{8}, 1/\sqrt{2}, 1/2, 1/\sqrt{2})$.
Matrix T_p has entries in $\{0, \pm 1\}$ and it can be given a sparse factorization according to:

$$T_P = P_4 \cdot A_{12} \cdot A_{11} \cdot A_1, \text{ where,}$$

$$A_{11} = \text{diag}\left(\begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 1 & 0 \\ 0 & 1 & -1 & 0 \\ 1 & 0 & 0 & -1 \end{bmatrix}, I_4 \right)$$

$$A_{12} = \text{diag}\left(\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}, -1, I_5 \right)$$

and P_4 is the permutation (1)(2 5 6 8 4 3 7).

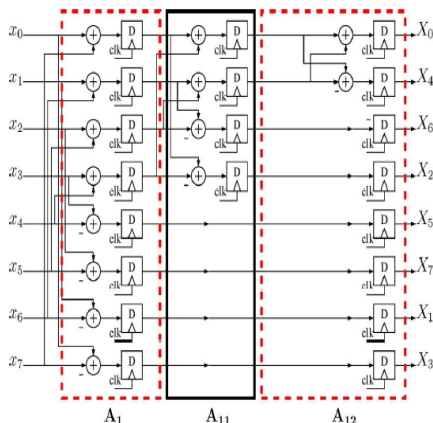Fig.3 Digital architecture of the Proposed Transform.

Method	Multiplication	Addition	Shift	Total
BAS 2008	2	18	8	28
CB 2011	3	14	0	17
Proposed Transform	0	14	0	14

Table.1 Arithmetic complex analysis

The table gives the information of the number of components that are needed in each of these transformations.

IV. TEST RESULTS

Circuit is simulated using ModelSim, which is a hardware simulator tool for simulating many electronic circuits. In this section we show the simulated outputs that are obtained by ModelSim regarding the imposed technique.
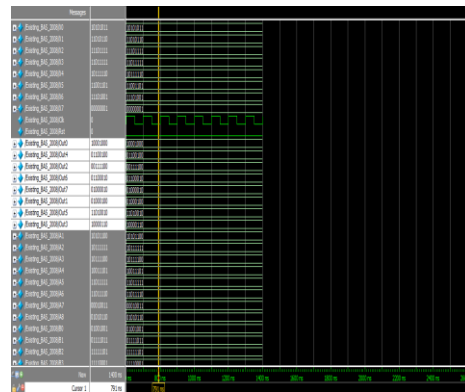

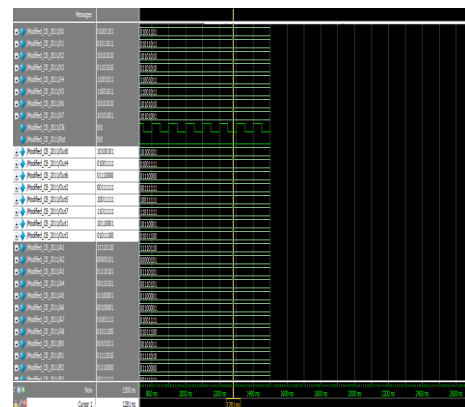Fig.4 Simulated Result of the Existing BAS 2008.

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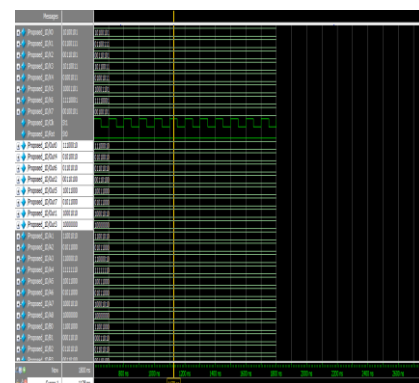
Fig.5 Simulated result of Modified CB-2011.

Fig.6 Simulated Result of the Proposed Transform.

Below tables will describe the Device Utilizations of the transform techniques that have been described in this paper. These tables will give the clear insight on the circuitry complexity.

Logic Utilization	Used	Available	Total Utilization
Number of slices	128	704	18%
Number of slice flip-flops	168	1408	11%
Number of 4 input LUT's	140	1408	9%
Number of Bounded IOB's	122	108	112%
Number of GCLK's	1	24	4%

Table.2 Device Utilization of BAS-2008

Logic Utilization	Used	Available	Total Utilization
Number of slices	128	960	19%
Number of slice flip-flops	168	1920	8%
Number of 4 input LUT's	140	1920	7%
Number of Bounded IOB's	122	108	112%
Number of GCLK's	1	24	4%

Table.3 Device Utilization in Modified CB-2011.

Logic Utilization	Used	Available	Total Utilization
Number of slices	119	960	12%
Number of slice flip-flops	190	1920	8%
Number of 4 input LUT's	112	1920	6%
Number of Bounded IOB's	122	108	112%
Number of GCLK's	1	24	4%

Table.4 Device Utilization of the Proposed Transform

V. CONCLUSION

The 8-point approximate DCT method is proposed for image compression. Simulated results gives you the clarity on computation process and the device utilization by these transform shows that the Proposed system has the advantage of using this method is that it gives low computational complexity in terms of algorithm complexity. Also the proposed DCT approximation is a candidate for reconfigurable video standards such as HEVC.

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