

Implementation of Modified Signed Discrete Cosine Transform

Ajit Kumar Patro, Deepika Patnaik, Sudhansu Sekhar Nayak

Abstract: One of the most important properties of Discrete Cosine Transform (DCT) is high power compaction, due to this property DCT is used for coding, image processing, image compression etc. The DCT application can be speed up by Signed Discrete Cosine Transforms (SDCT). The SDCT is the modification approximates of the DCT. In this paper by proposing signum function we proposed a flow diagram of algorithm and its architecture by considering 8 point transforms.

Index Terms: Discrete Cosine Transform, Signed Discrete Cosine Transform, Modified Signed Discrete Cosine Transform.

I. INTRODUCTION

Orthogonal transform are useful for many scientific application. Discrete Cosine Transform (DCT) has an important role in image processing. The use of DCT is growing explosively due to accessing the multimedia data through internet. Manipulation and transfer of digital images from digital cameras, requirement for storage have been growing rapidly but these files occupy a lot of memory and it consumes much time while downloading from internet. So it is quite necessary to develop efficient techniques for image compression. It gives high quality image in fewer amounts of data.

[1] The DCT is one of the essential mathematical tools in Digital Signal Processing (DSP). In recent years, the 8-point DCT is used in many video and image processing. Different frequency components are separated by DCT. It discards frequencies which are less important. The approximation based technique consist the Signed Discrete Cosine Transform (SDCT). Generally the entries of transformed matrix are obtained by approximation of DCT. SDCT is the modification transform of DCT, the elements of SDCT are represented by 0 or ± 1 , it does not require any multiplication. It retains the periodicity and spectral structure property of DCT. Only 24 additions are required to compute SDCT [2]. The main property of SDCT is to maintain good de-correlation and energy compaction. A number of algorithms have been suggested in papers [3-6].

II. MODIFIED SIGNED DISCRETE COSINE TRANSFORM

The DCT matrix, of order N is represented by T_{DCT} which is given by

$$T_{DCT}(m, n) = \begin{cases} \frac{1}{\sqrt{N}} & \text{for } m = 0, \quad 0 \leq n \leq N-1 \\ \frac{2}{\sqrt{N}} \cos \frac{\pi(2n+1)m}{2N} & \text{for } 1 \leq m \leq N-1, \quad 0 \leq n \leq N-1 \end{cases} \quad (1)$$

The SDCT matrix, T_{SDCT} is given by

$$T_{SDCT}(m, n) = \frac{1}{\sqrt{N}} \text{sign}\{T_{DCT}(m, n)\} \quad (2)$$

where signum functions given by

$$\text{sign}\{x\} = \begin{cases} +1 & \text{if } x > 0 \\ 0 & \text{if } x = 0 \\ -1 & \text{if } x < 0 \end{cases} \quad (3)$$

As the SDCT matrix does not requires multiplication or transcendental expressions and its elements are represented by 0 or ± 1 . The main characteristics of SDCT matrix are to maintain good de-correlation and energy compaction due to the periodicity and spectral structure of its originating DCT [2]. The 8x8 SDCT matrix is given by

$$T_{SDCT} = \frac{1}{\sqrt{8}} \begin{bmatrix} +1 & +1 & +1 & +1 & +1 & +1 & +1 & +1 \\ +1 & +1 & +1 & +1 & -1 & -1 & -1 & -1 \\ +1 & +1 & -1 & -1 & -1 & -1 & +1 & +1 \\ +1 & -1 & -1 & -1 & +1 & +1 & +1 & -1 \\ +1 & -1 & -1 & +1 & +1 & -1 & -1 & +1 \\ +1 & -1 & +1 & +1 & -1 & -1 & +1 & -1 \\ +1 & -1 & +1 & -1 & -1 & +1 & -1 & +1 \\ +1 & -1 & +1 & -1 & +1 & -1 & +1 & -1 \end{bmatrix} \quad (4)$$

The SDCT is Invertible but it is not orthogonal. The computation of SDCT requires 24 additions [2]. Another SDCT T_1 is introduced in [7]

$$T_1 = \frac{D_1}{2\sqrt{2}} \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & -1 & -1 \\ 1 & 0.5 & -0.5 & -1 & -1 & -0.5 & 0.5 & 1 \\ 0 & 0 & -1 & 0 & 0 & 1 & 0 & 0 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & 0 & 0 & 0 & 0 & 1 & -1 \\ 0.5 & 0 & 0 & -0.5 & -0.5 & 0 & 0 & 0.5 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix} \quad (5)$$

where

$$D_1 = \text{diag} \left(1, \sqrt{2}, 2\sqrt{\frac{2}{5}}, 2, 1, \sqrt{2}, 2\sqrt{\frac{2}{5}}, 2 \right) \quad (6)$$

The matrix T_1 contains only (0, ± 0.5 , ± 1), which is obtained by approximating the elements of SDCT matrix T.

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The compression capabilities and power compactions of the transform are very high which has been shown in [7]. 17 additions and two shifts are required for the computation of the transform. In the matrix $T_1 T_1^T$ two nonzero non-diagonal entries have negligible effect. The transform in [7] is not proper orthogonal.

An efficient Modified Signed Discrete Cosine Transform (MSDCT) [8] results from applying the signum function operator to the transform in [7] provided in equation 5. The matrix T_p is given by

$$T_p = DT \tag{7}$$

where

$$T = \text{sign}\{T_1\} = \begin{bmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 0 & 0 & 0 & -1 & -1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 0 & 0 & -1 & 0 & 0 & 1 & 0 & 0 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & -1 & 0 & 0 & 0 & 0 & 1 & -1 \\ 1 & 0 & 0 & -1 & -1 & 0 & 0 & 1 \\ 0 & 0 & 0 & -1 & 1 & 0 & 0 & 0 \end{bmatrix} \tag{8}$$

and

$$D = \frac{1}{\sqrt{TT^T}} = \text{diag} \left(\frac{1}{\sqrt{8}}, \frac{1}{2}, \frac{1}{\sqrt{8}}, \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{8}}, \frac{1}{2}, \frac{1}{2}, \frac{1}{\sqrt{2}} \right) \tag{9}$$

In the matrix of MSDCT have 24 zeroes of (5) and ± 0.5 elements have been approximated to ± 1 . It does not require any shift operator. The MSDCT satisfies orthogonal property and it maintains good power of compaction of its originating transform [8]. Only 17 add operations are needed for the FAST Implementation of MSDCT is shown Fig-1.

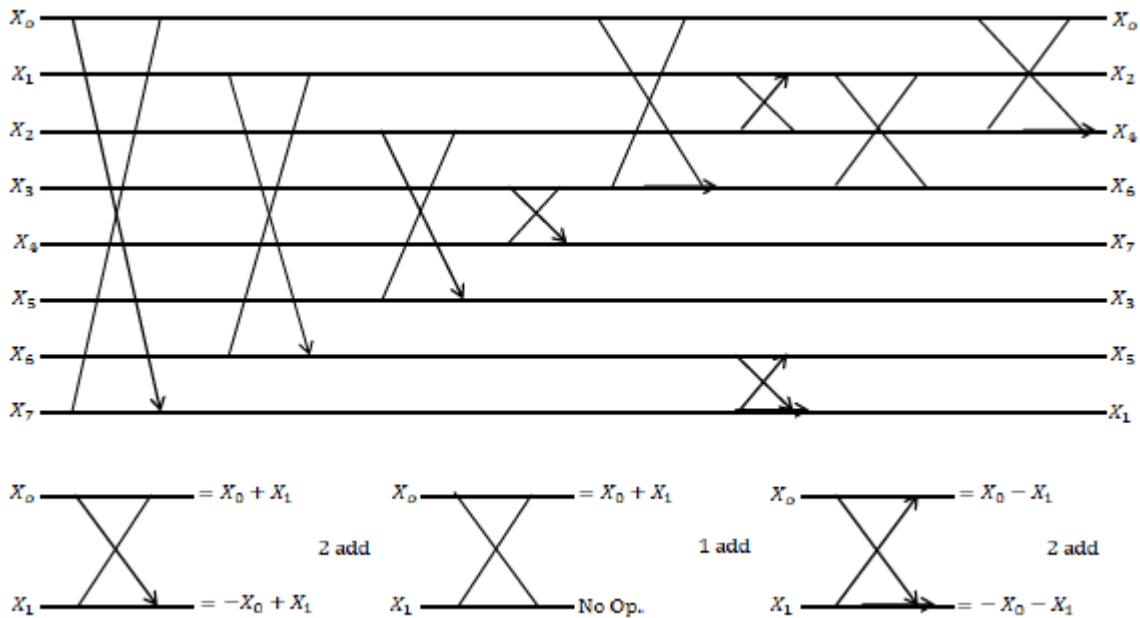


Fig. 1: Flow Diagram for the Fast Implementation of the Algorithm

TABLE 1 COMPUTATIONAL REQUIREMENT FOR 8x8 TRANSFORMS

Transform	Adds	Shifts	Multiplications	Total
BAS [6]	28	0	4	32
SDCT [2]	24	0	0	24
Proposed Transform	17	0	0	17

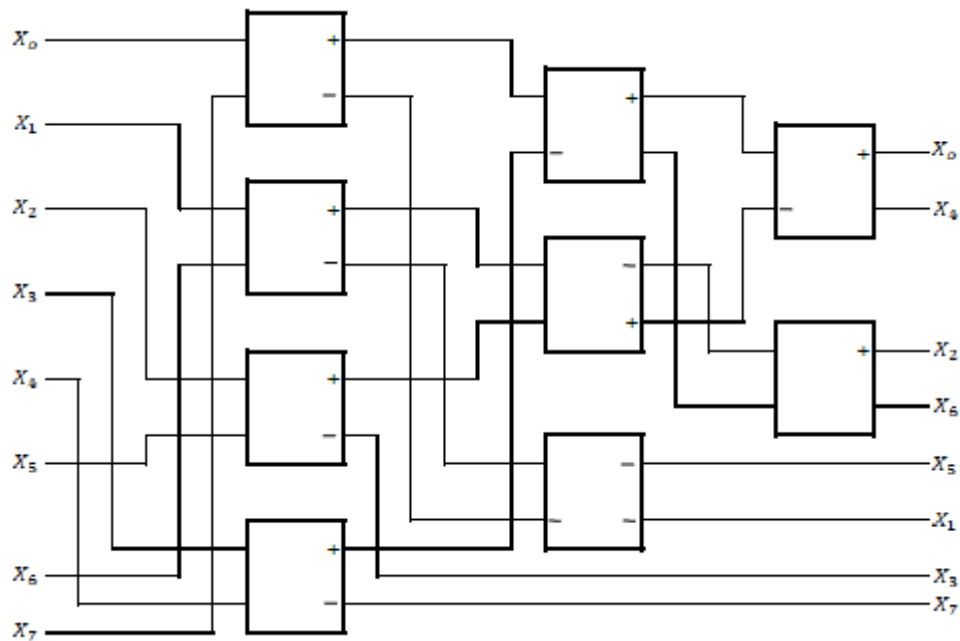


Fig. 2: Architecture for Execution of the Algorithm

III. CONCLUSION

It is required to store and transmit efficiently images. So image compression is highly essentially. DCT is very useful for efficient transmission and storage of images. The core of image processing like image compression and coding is used as DCT. The computational requirements for various 8×8 transforms are given in table-1 MSDCT has to lowest complexity.

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