A Time-Recursive DCT and DST Parallel Lattice Structure for VLSI Implementation [1]

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Abstract

In this paper, a new scheme employing the time-recursive approach to compute the discrete cosine transform (DCT) and discrete sine transform (DST) is presented. Using such approach, parallel lattice structure that can dually generate the DCT and DST simultaneously is developed. The resulting architecture is regular, module, and without global communication and can be applied to any transform size N.

1. Introduction

Due to the advances in ISDN network and high definition television (HDTV) technology, high speed transmission of digital video signal becomes very desirable. The discrete cosine transform (DCT) has shown very effective performance for data compression in image processing [1, 2]. The performance of the discrete sine transform (DST) closes to that of the KLT signal with low correlation coefficients [3], the DST also has specific applications in the siganl processing. A parallel structure to efficiently perform these transforms is strongly demanded.

2 Dual Generation of DCT and DST

A new time-recursive parallel lattice structure for efficient computation of the DCT and DST simultaneously is presented. Since data arrive serially in digital signal transmission, we consider the orthogonal transforms from a time-recursive point of view instead of the whole block of data. Denote $X_c(k,t)$ and $X_s(k,t)$ as the DCT and DST (defined in [1, 3]) of a data sequence $[x(t), x(t+1), ..., x(t+N-1)]$. The time-recursive relations for the new transforms $X_c(k,1)$ and $X_s(k,1)$ as well as the previous transforms $X_c(k,0)$ and $X_s(k,0)$ are given by

$$X_c(k,1) = \left\{X_c(k,0) + \left[-x(0) + (-1)^k x(N)\right]\left(\frac{2}{N}\right)\cos\left(\frac{\pi k}{2N}\right)\right\}\cos(\frac{\pi k}{N})$$
$$+\left\{X_s(k,0) + \left[-x(0) + (-1)^k x(N)\right]\left(\frac{2}{N}\right)\sin\left(\frac{\pi k}{2N}\right)\right\}\sin(\frac{\pi k}{N}), \quad (1)$$

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and

$$X_s(k,1) = \left\{ X_s(k,0) + \left[-x(0) + (-1)^k x(N)\right] \left(\frac{2}{N}\right) \sin\left(\frac{\pi k}{2N}\right) \right\} \cos(\frac{\pi k}{N})$$
$$- \left\{ X_c(k,0) + \left[-x(0) + (-1)^k x(N)\right] \left(\frac{2}{N}\right) \cos\left(\frac{\pi k}{2N}\right) \right\} \sin(\frac{\pi k}{N}). \quad (2)$$

The lattice module manifesting this approach is shown in Fig. 1, where $k = 1, 2, ..., N-1$. The simplified module for $k = 0$ in the DCT and $k = N$ in the DST is plotted in Fig. 2. The resulting parallel lattice structure is shown in Fig. 3. Here we have seen that the transform domain data $X(k,t)$ have been decomposed into N disjoint components that have the same lattice modules with different multipliers coefficients in them. This structure requires $6N - 4$ multipliers and $5N - 1$ adders; the total computational time is N clock cycles.

3 Conclusion

From the above disscusion, it is important to notice that the transformed data of subsequent input vector can be generated per clock cycle. Since there is no global communication and the structure is modular and regular, it is suitable for practical VLSI implementation. The most fascinating result is that this architecture can be applied to any number of N. From this point of view, it is more attractive than most existing algorithms. In addition, this lattice structure reveals some interesting properties between the DCT and DST. The DCT and DST can be dually generated simultaneously. Since the DCT is near the optimal tranform KLT in highly correlated signal, while the DST approaches the KLT in low correlation coefficient, as we are able to obtain the DCT and DST at the same time, this lattice structure is very useful especially when we do not know the statistics of the incoming signal. It is obvious that the design complexity of this structure is relatively low compared with other algorithms. The charteristics of this algorithm are suitable for processing series input data. Therefore, it is very attractive to high speed applications such as HDTV signal coding and transmission.

References

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