FAST CONVERSION BETWEEN DCT AND WAVELET TRANSFORM COEFICENTS

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Abstract – This paper proposes and formulates a mathematical problem in the context of fast and multiplierless transform. On one hand, the cosine transform has been extensively applied to practical and real signals in order to obtain a decorrelated version. On the other hand, the wavelet transform achieves a sub-band decomposed version. Recently, in the video coding arena, both transforms have provided very close performance. It is therefore envisaged for the future the existence of fast transcoders from one domain to the other. This paper launches a challenge to find a joint conversion solution and its minimum bound in terms of number of operations.

Keywords – Fast DCT, Fast DWT, Joint Fast DC-DWT.

I. INTRODUCTION

The recent rapid growth of multimedia communications has efficiently allowed delivering different services, formats and contents. In video component based multimedia services, video compression plays an important role. During the last decade and with different goals, several video coding standards have been developed for video communications. These standards are MPEG-1 [1] for CD storage, MPEG-2 [2] for digital TV applications, H.261 [3] and H.263 [4] for video telephony/conferencing over ISDN and PSTN respectively. Later on, MPEG-4 [5] developed a new codec and baptized it as a generic visual codec standard with error resilience and high compression efficiency, making it suitable for robust communications. Recently developed, H.264/MPEG-4 AVC [6] presents higher compression than its antecessors and covers a broad range of applications. Despite its higher compression efficiency, H.264 demands greater complex coding implementation than MPEG-4 due to several new coding tools. One drawback in MPEG-4 is the 8x8 discrete cosine transform (DCT) which requires float implementation. The 4x4 DCT version used in MPEG-4 AVC/H.264 is an integer transform obtained by approximating the classical 4x4 float DCT and keeping the orthogonality.

Alternatively, discrete wavelet transform (DWT) has been applied to still image coding, and defined as the transform in MPEG-4 [5] and JPEG2000 [7].

More recently, wavelet based approaches in the context of scalable video coding [8,9] have shown good performance. Wavelet video schemes are able to provide flexible spatial, temporal, SNR and complexity scalability with fine granularity [10]. Besides, it avoids the effect of drifting usually occurring in the DCT based prediction loop. Nowadays, in MPEG, two groups are moving in parallel, one the Joint Video Team (JVT) working on scalable H.264 [11] and the other an Ad-Hoc group researching on wavelet video coding exploration [12]. As it is expectable to have a wavelet based video coding standard in the near future, this paper foreseen a need of heterogeneous transcoding, i.e. of converting from a wavelet video bit stream into a DCT video bit stream and vice versa. This is the main motivation to the problem to be formulated in the following section.

II. PROBLEM FORMULATION

For sake of simplicity, we will confine our problem formulation to 1D case but it can straightforward be extended to a multidimensional case. The wavelet transform can be expressed as a bank of filters [12]. Fig. 1 shows a two-band filter bank where $H_x(z)$ and $G_x(z)$ are the analysis and synthesis filters, respectively.

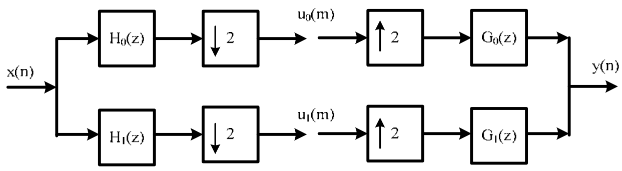

Fig.1 – Two-band filter bank.

For instance, the Haar filters are,

$$H_0(z)=\frac{1}{2}(1+z^{-1}) \tag{1}$$

$$H_1(z)=\frac{1}{2}(1-z^{-1}) \tag{2}$$

$$G_0(z)=1+z^{-1} \tag{3}$$

$$G_1(z)=-1+z^{-1}\,. \tag{4}$$

The FDCT is defined as,

$$C(k)=\alpha(k)\sum_{n=0}^{N-1}x(n)\cos\left[\frac{\pi(n+\frac{1}{2})k}{N}\right],0\le k\le N-1 \quad (5)$$

where

$$\alpha(k)=\begin{cases}\sqrt{\dfrac{1}{N}} & ,k=0\\ \sqrt{\dfrac{2}{N}} & ,1\le k\le N-1\end{cases}. \quad (6)$$

Several fast DCT solutions have been proposed in the literature [13,14]. Integer approximations were also published [15,16].

In this paper, we are looking for fast and integrated solutions, as well as, integer approaches for the synthesis (orthogonal or biorthogonal) wavelet filter bank (SFB) followed by the FDCT and the IDCT followed by the analysis filter bank (AFB) as depicted in Figs 2 and 3, respectively. It would also be very interesting to devise the mathematical complexity lower bound of the conversion.

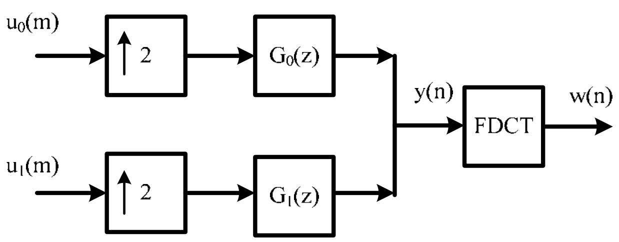

Fig.2 – Synthesis filter bank followed by forward DCT.

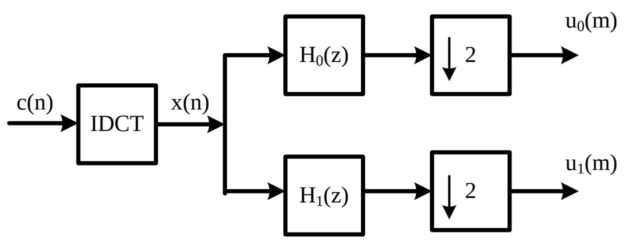

Fig.2 –Inverse DCT followed by analysis filter bank.

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