HYBRID CODING OF IMAGE SEQUENCES BY USING WAVELET TRANSFORM

Dušan LEVICKÝ, Peter PETRULÁK
Peter RADOCZI, Marek ŠURIN
Dept. of Electronics and Multimedia Communication
Technical University of Košice
Park Komenského 13, 041 20 Košice
Slovak Republic

Abstract

In this paper a new method of hybrid coding of image sequences by using wavelet transform is proposed. The basic MPEG scheme with DCT has been modificated in sense of replacement DCT by wavelet transform. In the proposed method the motion estimation and compensation are used for motion vectors calculation and different frame between current frame and compensated frame is coded by using wavelet transform. Some experimental results of image sequences coding by using a new method are presented.

Keywords

MPEG, wavelet transform, DCT, motion estimation, motion compensation.

1. Introduction

In image sequences coding the interframe coding methods with the prediction of the objects motion are used. For simplification of implementation, motion compensation with motion estimation is generally performed by stepwise translation of objects in image. In first stage of coding, the displacement of object is estimated by using of motion estimation methods. The main methods of motion estimation are pel recursive techniques and block matching techniques [1],[2]. The result of this step is identification of block in the current frame with the most similarity in the previous frame. The offset between both blocks is the displacement vector for motion compensated prediction. Consequently, the prediction error and motion vectors for each of block has to be transmitted. For prediction error coding the DCT transform is used in MPEG or H.26X standards. Transformation coefficient of DCT are quantizated and coded by VLC method.

2. Block diagram of proposed method

The proposed method uses the same block as the MPEG standard with exception of prediction error coding (Fig.1).

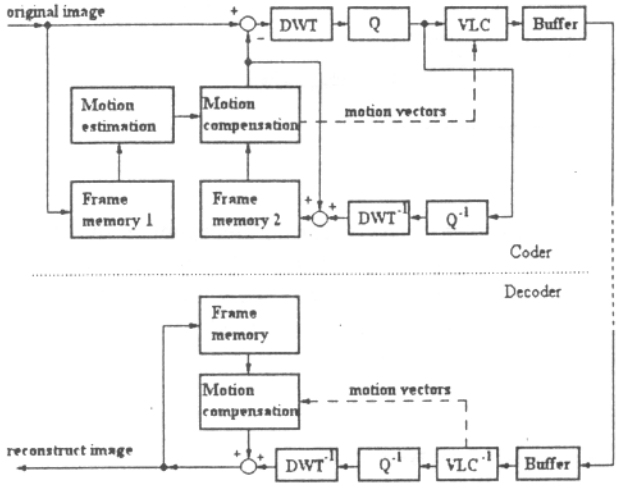

Fig. 1. MPEG coder - decoder

The current frame is stored in the frame memory 1 and previous (reconstructed) frame is stored in the frame memory 2. For motion estimation the three-steps method has been used. In block of motion compensation the motion vectors are computed.The difference between current frame and composed frame has been coded by using discrete wavelet transform. The transformation coefficients are quantized and coded by VLC coding. The reconstructed image at the decoder side can be obtained by using dequantization, inverse wavelet transform and motion compensation with motion vectors.

3. Reduction of temporal redundancy

In order to reduce temporal redundancy in video sequences many motion estimation techniques can be used. For simplification of implementation, most video coding schemes apply a simple block-matching algorithm [2]. The block-matching algorithm identifies for each reference block in the current frame the block with best match in the previous frame. The offset between both blocks specifies the motion vectors for motion compensated prediction (Fig. 2). In most cases the MSE criterion between the

block in current and previous frame is used as matching criterion.

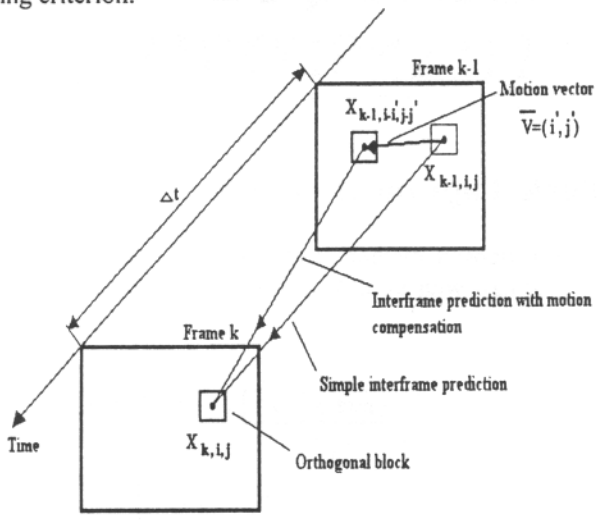

Fig. 2

Ones of more favorite search algorithm is the three step algorithm [2], which searchs the blocks with best match in previous frame in three steps. This algorithm is very effective from point of view good performance and low computation complexity.

4. Wavelet transform

The wavelet transform is relatively a new concept of linear transforms that generalized the properties of the Haar transform [4],[5],[6]. There are equal approaches in both continuos and discrete domains with orthogonal or biorthogonal basis functions as well as generally nonorthogonal basis. The continuos wavelet transform of function f(t) is defined in the form

$$W(a,b)=\frac{1}{\sqrt{|a|}}\int_{-\infty}^{\infty} f(t)\psi^{*}\left(\frac{t-b}{a}\right)dt \qquad (1)$$

where a,b are parameters of wavelet function ψ .

For image processing the discrete or fast wavelet transform is used [6]. The wavelet decomposition of original image is shown in the Figure 3. The original image is decomposed by the lowpass (LP) and highpass (HP) filters followed by downsampling first of rows and then of colums. The results of wavelet decomposition is aproximation of original image and three detail signals (horizontal, vertical and diagonal). Process of wavelet decomposition can be expressed in the following form

$$cA_j = cA_{j+1} + cD_{j+1}^{(h)} + cD_{j+1}^{(v)} + cD_{j+1}^{(d)} \qquad (2)$$

where j is level of decomposition
A_j is original image.

The next step is decomposition of cA_{j+1} and so on. This components in each level can be used for image compression or transmission. The reconstruction of original image is shows on the right side of Fig. 3.

5. Experimental results

The aim of experiments was testing of wavelet transformation in image sequences coding by proposed scheme from several point of view. First was testing of reconstructed image in sense of PSNR that can be calculated in the form

$$PSNR = 10\log_{10}\left\{\frac{(255)^2}{MSE}\right\}[dB] \qquad (3)$$

Second was the compression ratio comparison of proposed method and MPEG with DCT transform. Compresion ratio C_r can be expressed in the form

$$C_r = \frac{\text{Number of bits in original image}}{\text{Number of bits in image code}} \qquad (4)$$

In wavelet transform the several types of wavelets were used (SYM5 - Symlets wavelet number 5, HAAR - Haar wavelet,COIF3 - Coifman wavelet number 3, BIOR 3.7 - Biortogonal wavelet number 3.7) [3]. In both experiments the wavelet coefficients have been thresholded in the same range of threshold values. In the Tab.1 the evalution of the reconstructed image quality after coding by proposed method is shown. In this table we can see that for low threshold values the image quality for proposed method (DWT with HAAR wavelet) is better than for DCT coding method.For the threshold value greater than 100 DCT coding method is better. The experimental result in sense of compression ratio are shown in Tab.2. In this table we can see that for low threshold values (up to 10) the COIF3 wavelets is the best, for threshold values greater than 10 is DCT better with some exceptions (threshold value 150 and 250). The quality of reconstructed image from point of view subjective evaluation can be visible in the image Talking man (Fig.4). In the Fig.4 we can see the reconstructed image by using of MPEG coding with DCT and in the Fig. 5 is reconstructed image by using MPEG with DWT. The subjective better reconstruction of original image visible in Fig. 5 has been reached because DWT is not block method. Therefore side effect of implementation of DWT is filtration effect of original image after coding. The DCT is typical blocks transformation and creates the "blocking effect" than can by visible mainly for higher compression ratio.

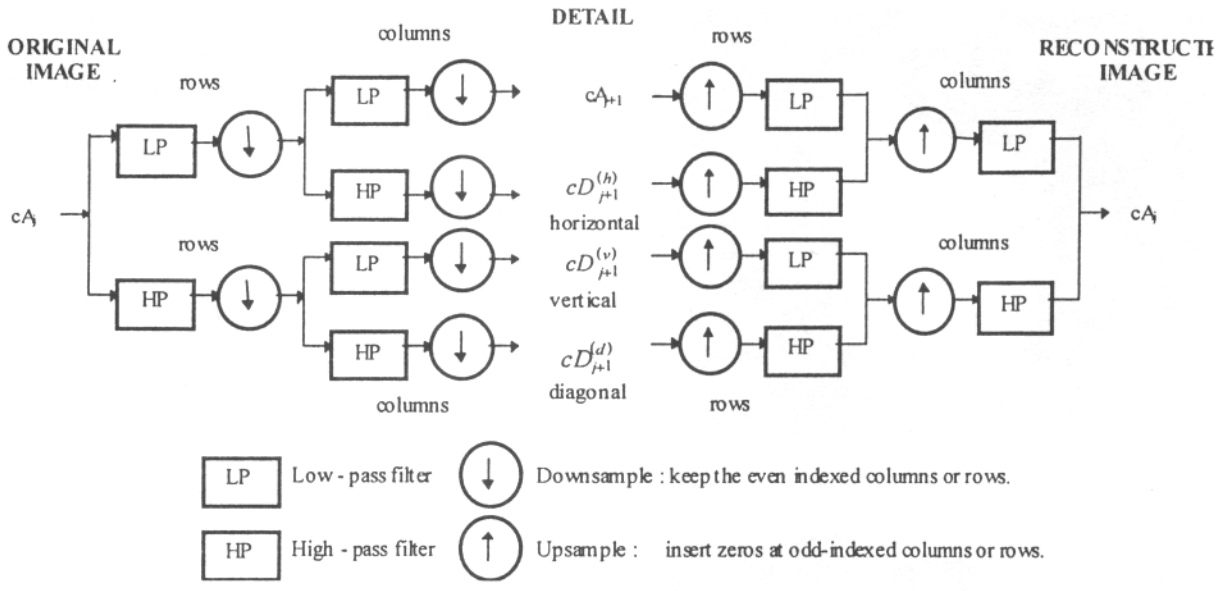

Fig. 3

Tab. 1

W \ T	1	2	3	4	5	6	7	8	9
SYM5	59,790	51,261	46,593	43,595	41,569	40,115	39,020	38,144	37,459
HAAR	60,951	52,912	48,222	45,943	43,854	42,261	41,110	40,231	39,542
COIF3	59,890	51,237	46,590	43,563	41,554	40,070	38,929	38,090	37,418
BIOR3.7	55,899	48,111	44,365	42,149	40,676	39,541	38,679	37,981	37,411
DCT	59,879	51,240	46,575	43,633	41,568	40,046	38,986	38,112	37,468
W \ T	**10**	**20**	**30**	**40**	**50**	**100**	**150**	**200**	**250**
SYM5	36,887	34,189	32,944	32,092	31,439	29,876	29,374	29,308	29,269
HAAR	39,009	36,436	35,256	34,490	33,862	32,243	29,560	29,398	29,268
COIF3	36,878	34,241	32,961	32,076	31,440	29,935	29,418	29,268	29,268
BIOR3.7	36,927	34,355	33,184	32,325	31,720	30,451	29,993	29,724	29,502
DCT	36,933	34,320	33,153	32,355	31,811	30,227	29,768	29,421	29,334

Tab. 2

W \ T	1	2	3	4	5	6	7	8	9
SYM5	1,387	1,810	2,400	3,196	4,200	5,405	6,815	8,482	10,330
HAAR	1,227	1,584	2,068	2,791	3,687	4,895	6,349	8,061	10,019
COIF3	1,594	2,084	2,753	3,668	4,800	6,205	7,927	9,843	11,953
BIOR3.7	1,546	2,002	2,543	3,161	3,822	4,567	5,357	6,190	7,077
DCT	1,260	1,638	2,178	2,893	3,843	5,074	6,458	8,189	10,030
W \ T	**10**	**20**	**30**	**40**	**50**	**100**	**150**	**200**	**250**
SYM5	12,413	38,466	74,050	122,49	190,09	610,46	883,37	915,64	927,07
HAAR	12,102	39,220	76,828	125,54	195,61	1091,71	5952,3	16393	66661
COIF3	14,211	39,502	70,357	108,06	146,39	264,75	296,26	301,32	301,39
BIOR3.7	7,988	19,428	33,340	49,59	68,63	168,49	255,03	305,89	337,66
DCT	12,080	39,650	78,860	136,53	207,39	1337,42	4369,1	21845	65535

Where : T - Threshold level
W - Type of wavelet

Fig. 4. Original image

Fig. 5. Reconstructed image: MPEG with DCT

Fig. 6. Reconstructed image: MPEG with DWT

6. Conclusion

The proposed method of image sequences coding uses discrete wavelet transform for coding of prediction error instead discrete cosine transform. The main advantages of the proposed method are block effect removing, higher speed of coding and decoding processes as speed of discrete cosine transform coding and noise removing in image after coding and image reconstruction. The weakness of proposed method is lower compresion ratio for higher threshold values.

References

[1] MUSMANN,H.G.-PIRSCH,P.-GRALLERT,H.J.: Advances in Picture Coding, Proceedings of the IEEE,Vol.73, No.4, April 1985, pp.523-548.

[2] KOGA,T. *et al.*: Motion compensated interframe coding for video conferencing, in *Proc. Nat. Telecommun. Conf.* (New Orleans, LA), Nov. 29-Dec. 3, 1981, pp. G5.3.1-5.3.5.

[3] Image processing Toolbox for MATLAB Reference Giude,Mathworks, Inc.1997

[4] ANTONINI,M.-BARLAUD,M.: Image coding using wavelet tranform, IEEE Transactions on image processing, Vol.1, No.2, April 1992, pp. 205-220.

[5] DEDERA,Ľ.-CHMÚRNY,J.: The wavelet transform and its aplications. Journal of Electrical Engineering, Vol 45, No. 11, 1994, pp. 401-406.

[6] LEVICKÝ,D.-MATÚŠ,E.-KRÁL,P.: Wavelet transforms Analysis - Synthesis algorithms. Journal of Electrical Engineering, Vol 47, No. 11-12, 1996, pp. 281-286

About authors ...

Dušan LEVICKÝ (Prof., Ing., CSc.) was born in Slanec, Slovak Republic, in 1948. He received the Ing. (MSc.) degree and CSc. (PhD.) degree from the Technical University in Košice and he is now professor at the Department of Electronics and Multimedia Communications, Faculty of Electrical Engineering and Informatics in Košice. His research interest includes digital image processing, multimedia communications and cryptography.

Peter PETRULÁK was born in 1975 in Košice, Slovakia. He received Ing. (MSc.) degree at the Faculty of Electrical Engineering and Informatics of Technical University of Košice in 1999.

Peter RADOCZI was born in 1976 in Košice, Slovakia. He received Ing. (MSc.) degree at the Faculty of Electrical Engineering and Informatics of Technical University of Košice in 1999. In this time he is PhD. student at the Department of Electronics and Multimedia Communications.

Marek ŠURIN was born in 1975 in Stropkov, Slovakia. He received Ing. (MSc.) degree at the Faculty of Electrical Engineering and Informatics of Technical University of Košice in 1999.