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Secondary Prediction Mode Selection Algorithm Applied in Video Coding in wireless transmission system

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Abstract
Aimed at the higher coding efficiency of video compression, this paper proposes a novel concept named "Secondary Prediction" onto the traditional hybrid video coding scheme. To achieve higher efficiency of predictive coding, "Secondary Prediction" combins multiple high efficient prediction techniques together, thus enables a kind of spatio-temporal three-dimensional prediction into the hybrid coding scheme and can benefit from latest developments of both infra-prediction and inter-prediction technique.
Keywords: WIRELESS TRANSMISSION SYSTEM, MODE SELECTION ALGORITHM, VIDEO CODING

1. Introduction

Along with the detailed design and implementation of two sets of "Secondary Prediction" system,this paper provides innovative key techniques for the secondary prediction such as the non-squared intra-frame prediction, predictor of Most Probable Secondary Mode under directional criteria from imge predictor and the dynamic updating of mode indicator. Experimental results show significant BD bit rate saving among test sequences whose sizes are from QCIF to 720p, which is 2%-7% for different sequences and 4.05% (equivalent 0.14dB of BD PSNR gain) in average among high-definition (720p) test sequences for the proposed technique compared to H.264/AVC: At last, 17 potential development and optimization possibilities of the "Secondary Prediction" systems are listed and described for future work.

This paper made great development and creativity on two parts below:

As regards to the high computation complexity of H.264 video coding rate distortion optimization process, this paper puts forward the mode selection algorithm based on prediction of adjacent block, the H.264 frame prediction, using the spatial correlation of adjacent block prediction mode, adopts the mode MPM (Most Probable Mode) to replace mode DC (Direct Current) as the default candidate modes.

In order to further verify the correctness and validity of the proposed mode selection algorithm based on prediction of adjacent block, simulation experiment was conducted. As a consequence, the basic algorithm and improved algorithm, whose encoding time are reduced more than 50%, compared with JM18.0 full search method on luminance component frame prediction mode selection, having well maintained the coding performance at the same time. On 10 standard series tests, the luminance component kept same as the JM18.0 full search, the bit rate of basic algorithm rise by 2.361%, improved algorithm rate rise by1.477% on average. Experimental results show that in this paper, the basic algorithm and coding complexity are basically same, which achieved a significant lower level compared with full search way, maintained the coding performance well. Besides, the coding performance of improved algorithm is obviously superior to the classic algorithms.

2. Intra-frame Prediction

Intra-frame coding mode is an important part of video coding, which is mainly used in the following situations: (1) The first frame of the video sequence. Because the first frame of the video has no good encoded frame as the reference frame, intra-frame coding used as a solution. (2) The frame I coding method. (3) Some macro blocks of frame P and frame B. H.264 employs a macro block coding way, which will divide video into macro block and select the optimal prediction model according to the RDO value of macro block, therefore the macro block of frame P or B is likely to be chosen as intra-frame prediction model of encoding. (4) Error recovery. While by using inter-frame coding, errors appear in the process of transmission channel, the decoding end cannot get the information of reference block or get false information, so that the current macro block at the decoding end cannot correct decoding. However, in such cases the intra-frame coding approach can be adopted. H.264 frame prediction coding divided the predicted brightness into16*16 block and 4*4 blocks: 16*16 macro blocks prediction model is suitable for those with gentle change; 4*4 macro blocks applied to those containing many details; also the 8*8 block chromaticity prediction included. Furthermore, on brightness prediction model there are 9 kinds of to 4*4 blocks and 4 kinds to16*16 blocks. On prediction model of chromaticity, there are 4 kinds to 8*8 blocks. Figure 1 (a) the capital letters in A ~ M are the complied codes on the above and left of the 4*4 brightness blocks and the reconstruction of the pixel can be predicting reference pixel.

M	A	B	C	D
I	a	b	c	d
J	e	f	g	h
K	i	j	k	l
L	m	n	o	p

Figure 1. (a) Location of 4*4 block and its adjacent pixels

In H.264 standard, in order to get the optimal intra-frame prediction mode, RDO technique is often used, selecting minimum prediction model of the RDO calculation cost function as the prediction model of the current block. RDO function is below:

$$RDO_{\cos t} = SSD + \lambda_{\mathrm{mod}\,e} \times Rate \quad (1)$$

Among them, the SSD represents the sum of difference of squares for the primitive and reconstruction blocks pixels; λmode is for Lagrange Multiplier, which is related to Quantization Step QP and the frame type; Rate represents the number of bits used in the forecasting modes.

RDO technology of H.264 standard will iterate over all prediction modes to get the optimal one That is to say, after forecasting, transforming, quantization, coding with every mode, coding bit number (Rate) can be obtained. Then images are reconstructed by inverse quantification and inverse transformation, so as to get distortion degree (SSD) of the original and reconstructed blocks. Therefore, RDO calculation is complicated and time-consuming. In reference procedures JM, the number of RDO calculation to each macro block is C8*(L416+L16), in which C8 represents chromaticity number of 8*8 blocks mode, L4 is the number of brightness in 4*4 blocks prediction mode, L16 represents the brightness number of 16*16 blocs prediction mode. In conclusion, getting a macro block needs compute 4*(9*16+4) = 592 times to obtain the optimal prediction mode, so mode selection algorithm of the H.264 standard is of very high complexity.

3. Mode Selection Algorithm Based on Prediction of secondary

3.1. Mode selection model

In order to reduce the encoding complexity, it intends to construct an encoding performance estimation model of low complexity based on intra-frame mode selection algorithm of filtering, screening out coding modes with poor performance prior to RDO, so as to reduce the R - D cost calculation and lower the encoding complexity. This paper adopts direction gradient as the direction of the prediction mode coding performance estimation model to conduct mode selection. The direction gradient of direction prediction model is defined as the mean absolute deviation between current block pixels and its maximum weighted reference pixel in the predicted direction.

$$G(dir) = \frac{1}{n} \sum_{x \in R, x \in C, Xx // dir} |P_X - Ix| \quad (2)$$

dir is the prediction direction; R and C are respectively reference pixel and the sampling subset of current block pixel; Xx / /dir represents consensus of lining between the sampling reference pixel X and the current block pixel X and that in forecasted direction; n is the number of sampling pixels; Px and Ix are respectively the reconstruction value of the reference pixel X value and the original value of the current block pixel X. In function (2), G (dir) is reference pixel in prediction direction and direction gradient of the current block, whose value refers to the edge strength in orthogonal direction of predicted one. Meanwhile, G (dir) is also approximation of prediction residual mean absolute value of the current block in predicted direction, prediction residual energy information included. Therefore, combination of texture direction of image with context the in direction gradient defined by function (2) and the current block prediction residual, indicates the good estimation on coding performance of prediction mode.

3.2. Gradient computation

In order to simplify the calculation, only give direction gradient with a few typical prediction pixel and reference pixel computational prediction model. The paper sample the number of pixels in power of 2 as the direction of gradient, transforming the division as operation shift to speed up calculation, with I4MB sampling of four pixels, I8MB sampling eight pixels, I16MB sampling 16.

Figure 2 (a) ~ (d) sample the gradient direction calculation method of I4MB in four direction prediction modes, among which dark pixels said of reference pixels and the current block pixels involved in calculation.

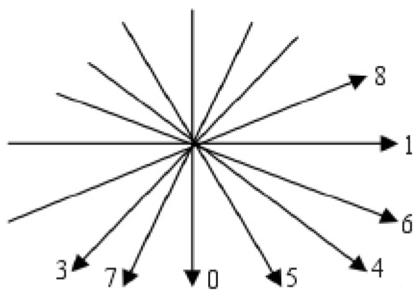

Figure 2. (b)Prediction direction of 4*4 block

As the figure 2 (a) shows, in the vertical prediction mode of I4MB, the current block is forecast by reference block pixel A ~ D, and gradient direction was calculated by the function (3) as below:

$$\begin{cases} G(A) = |P_A - I_c| + |P_A - I_m| \\ G(C) = |P_C - I_g| + |P_C - I_o| \\ G(ver) = (G(A) + G(C)) \gg 2 \end{cases} \quad (3)$$

PA, PC, respectively, are on behalf of the reconstruction value of the reference pixel of A and C; Ie, Im, Ig, Io are respectively the original value of the current block pixels m e, g, o; G (A) and G (C) are gradient of reference pixel A and C to the current block; G (ver) is the direction gradient of the vertical prediction mode (mode 0).

In the 4MB horizontal forecast mode, the predicted value of each line's pixel of current block is equal to its reconstruction value of the reference pixel I ~ L, which is shown in figure 2 (b), and the direction gradient calculated by function (4):

$$\begin{cases} G(I) = |P_I - I_b| + |P_I - I_d| \\ G(K) = |P_K - I_i| + |P_K - I_l| \\ G(hor) = (G(I) + G(K)) \gg 2 \end{cases} \quad (4)$$

PI, PK, respectively, are on behalf of the reconstruction value of the reference pixel of I and K; Ih, Id, Ii, Il are respectively the original value of the current block pixels m e, g, o; G (I) and G (K) are gradient of reference pixel I and K to the current block; G (hor) is the direction gradient of the vertical prediction mode (mode 1).

In I4MB lower left diagonal's prediction mode, the current block pixels predicted by B ~ H, among which the reference pixels E, D, F involved in forecasting weight more. Moreover, predicted pixel g, m, F, k, don't close to each other, to a certain extent, which reflect the change of brightness values, so that we choose them to do direction gradient calculation, as shown in figure 2 (c) and function (5):

$$\begin{cases} G(E) = |P_E - I_g| + |P_E - I_m| \\ G(D) = |P_D - I_i| \\ G(F) = |P_F - I_K| \\ G(diag\_left) = (G(E) + G(D) + G(F)) \gg 2 \end{cases} \quad (5)$$

PE, PD, PF are the reconstruction value of the reference pixels E, D, F; Ig, Im, If, Ik are the original value of pixels g, m, f, k; G(E), G(D), G(F) are direction diagonal of the current block for E, D, F; G (diag__left) is the direction gradient in the lower left diagonal prediction mode (mode 3).

For I4MB right diagonal mode, choose M, I, A with more prediction pixels and weight; meanwhile use the corresponding prediction pixels f, g, j, p to do direction gradient calculation, as shown in figure 2 (d) and function (6) :

$$\begin{cases} G(M) = |P_M - I_f| + |P_M - I_p| \\ G(I) = |P_I - I_j| \\ G(A) = |P_A - I_g| \\ G(diag\_right) = (G(M) + G(I) + G(A)) \gg 2 \end{cases} \quad (6)$$

PM, PI, PA are the reconstruction value of the reference pixels M, I, A; If, Ig, Ij, Ip are the original value of pixels f, g, j, p; G(M), G(I), G(A) are direction diagonal of the current block for M, I, A; G (diag_right) is the direction gradient in the lower right diagonal prediction mode (mode 4).

3.3. Mode Selection Algorithm

Direction gradient of prediction mode contains texture direction, edge strength and residual energy information between reference pixel and the current block, and can be used as mode estimation on coding performance before simplifying mode. However, the direction gradient can not demonstrate modes' coding performance completely accurately. Mode with minimum gradient is the much better prediction mode, not the best during the actual coding process. At the same time, in the H.264 mode DC is taken as boundary prediction, which is of superior performance in plain area. Therefore, the prediction model is not directly the mode of smallest gradient direction but the mode DC and those with smaller direction gradient as candidates for rate distortion optimization.

As Table 1 shown, in the sequences Foreman. qcif and Tempete. cif, all100 frames use I4MB mode, selecting the mode DC and the minimum direction gradient in 1 ~ 7 kinds direction prediction mode for luminance component prediction to have RDO performance test. Results showed that the mode number more, the performance of coding better; select mode DC and direction mode with three gradient modes can be well achieved encoding time and the balance with coding performance. Other sequence and experiment using I8MB gained similar consequence. Based on this observation, for the I4MB and I8MB, we have chosen three direction mode with minimum gradient direction and mode DC as a candidate for RDO, taking mode of minimum R - D cost as the optimal prediction mod 4*4 sub-block and 8*8 sub-block l. Whereas for I16MB choose the smallest one among the only three direction modes, selecting direction mode of smallest direction gradient and mode DC as a candidate for RDO, taking the prediction mode with less R - D cost as its optimal one. Then, accumulate of R - D price of in the optimal prediction mode, 4*4 sub-block of I4MB, all 8*8 blocks of I8MB to calculate out R - D cost of macro blocks for I4MB, I8MB

Table 1. Performance Comparison of I4MB by Different Modes (Full Frame I Coding)

Number of Direction modes	Tested Performance of Sequence Foreman. qcif			Tested Performance of Sequence Tempete. cif		
	⊿PSNR/dB	⊿BR/%	⊿Time/%	⊿PSNR/dB	⊿BR/%	⊿Time/%
1	-0.716	10.445	-72.53	-0.601	8.194	-73.87
2	-0.344	4.860	-62.27	-0.368	4.948	-61.84
3	-0.250	3.502	-51.65	-0.237	3.173	-50.90
4	-0.178	2.490	-41.76	-0.161	2.148	-39.09
5	-0.117	1.624	-31.14	-0.096	1.257	-27.21
6	-0.047	0.645	-20.15	-0.051	0.666	-15.33
7	-0.032	0.446	-6.96	-0.017	0.220	-3.67

and I16MB macro block, which are the best prediction mode's R - D price respectively. Finally, among these three modes by three ways, choose R - D minimum cost of macro blocks as the optimal to predict, and adopt the best method of each sub-block in the optimal prediction mode to do intra-frame prediction. Therefore, under such an advanced grade the times of calculating of luminance component with each macro block is 4 * 4 * 4 + 4 * 2 * 2 + 2 = 82. R - D cost calculation, without chrominance component mode, times of R - D cost calculation of macro block is reduced to 4*82 = 382.

3.4. Algorithm Improvement

Image's spatial correlation not only exists between brightness and chromic value of adjacent pixel, but also manifest in its texture structure. Many areas in natural images between secondary owns similar edge characteristics and same texture direction, and the best prediction mode of these neighboring blocks tend to be the same, which means there also exists certain spatial correlation between adjacent block's prediction mode. Taking advantage of this feature, using the mode MPM as a candidate of RDO mode can effectively improve coding performance of mode selection algorithm.

The most possible mode MPM of I4MB and I8MB in H.264 is defined as the minimum number of prediction mode of the current block on the left and upper secondary, and those not on the left and upper take mode DC as the MPM. I16MB has no definition on MPM. Figure 3 manifests the percentage between the block of the best prediction model of MPM under the multiple sequence search mode and mode DC with all blocks, figure 3 (a) and (b) respectively account for I4MB and I8MB mode. Obviously, frequency of both I4MB and I8MB under MPM as the best mode is much higher than that of mode DC. So we improved the basic algorithm that adopting I4MB and I8MB mode in MPM to replace DC mode as the default candidate. Under I4MB and I8MB candidate mode selection, calculating the direction gradient for each block in the direction mode, choose three kinds of modes with smallest direction gradient under I4MB and I8MB as a candidate. If MPM mode gathers the candidates, those in DC mode also join the MPM to candidate mode. I16MB candidate mode selection and the basic algorithm are in the same. Due to the same number of RDO with candidate in the mode, so the complexity of basic algorithm and the improved algorithm are basically the same.

4. Experimental Simulation and Analysis

4.1. Experimental Comparison Algorithm

After compared with the performance of algorithm proposed in the paper, in the best current algorithm DES and SDD use block segmentation to detect texture strength, which did not provide the brightness component I8MB mode selection method. However, we set the size of the 2*2 sub-block as 4*4 and then referring to I4MB mode to extend the two algorithms. In addition, DES algorithm provides an option of exiting, which is when all the direction gradient values are greater than a threshold, perform full search. But considering the validity of the experiment method, this option is cancelled. In the book «A fast mode decision algorithm and its VLSI design for H.264 intra – prediction «, while algorithms detect edge information without the direction, a full search is also performed. It is a selection branch of algorithm. In order to keep the integrity of algorithm, the implementation is maintained. Algorithm the paper researched does not perform full search in all conditions. At the same time, for the chrominance components of prediction is relatively simple, all comparative experiments don't conduct UV component prediction mode selection algorithm.

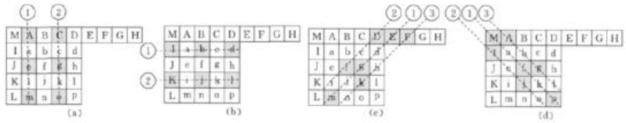

Figure 3. Direction Gradient Calculation of I4MB Prediction Mode

4.2. Coding Parameters and Evaluation Index

Experiments evaluate methods performance based on JM18.0 full search strategy. Evaluation indexes include the luminance component PSNR of coding performance index, losses Δ PSNR (dB) of bit rate (BR), and reduced percentage Δ Time relative to JM18.0 encoding time. Δ PSNR (dB) and Δ BR (%) are respectively coding performance loss of fast algorithm relative to JM18.0 under mode PSNR (no loss rate) and code rate mode (no loss of PSNR). Bjontegaard method is under the four quantitative parameters to convert the PSNR verse bit rate and the average fitting. Test sequence includes five standard 4:2:0 sequences of qcif, cif. Each sequence is encoded with100 frames and other key parameter settings are below:

(1) Quantization parameter (QP) are 28, 32, 36 and 40;

(2) Frame frequency is 30.0;

(3) All frames adopt frame prediction;

(4) Utilize distortion optimization (RDO);

(5) Entropy code with CABAC;

(6) Encode advanced level (high profile).

4.3. Performance Comparison

Figure 3 and figure 4 compares the Paris, cif sequence JM18.0 and the R - D curve and encoding time of fast mode selection algorithm. Figure 3 shows that the improved algorithm R - D curve in this paper is much closer to the JM18.0 full search curve. The performance points of the quantitative parameters are in the top left of the algorithm, and reconstructed video quality and compression performance are better than comparison algorithm. Although algorithm's coding performance in the document [12] is similar to basic algorithm in this paper, its encoding time is significantly higher than the basic algorithm and improved algorithm in this paper as shown in figure 5. Figure 5 shows, frame coding time in the document [11, 13] is close to the algorithm in the paper, but obvious gap of coding performance can be seen from the figure 4 with two algorithms in this paper.

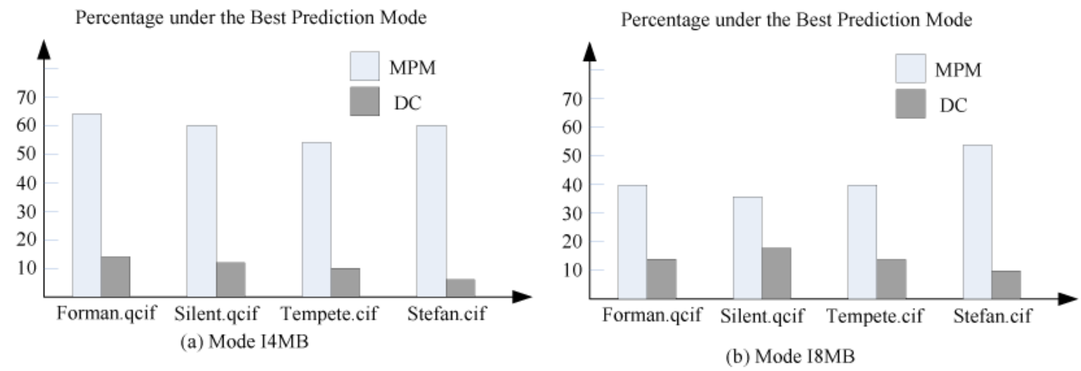

Figure 4. Comparison of MPM as Best Prediction Mode with Mode DC

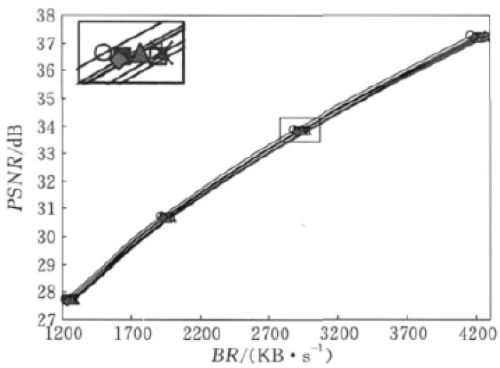

Figure 5. R - D Curve Comparison of Paris, cif Sequence

5. Conclusion

For high computation complexity of H.264 video coding rate distortion optimization process, the paper puts forward the adjacent block prediction mode selection algorithm. Using direction gradient to detect texture direction and edge strength of the current block and its neighborhood, screening out the prediction mode with larger direction gradient in advance, the thesis puts forward the mode selection algorithm based on prediction of adjacent block, fully utilizing the spatial correlation of adjacent block prediction mode, replacing mode DC with the mode MPM as the default candidate mode, the basic algorithm greatly improved.

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Service Oriented CSOMA Model for Risk Evaluation of Cloud Computing System

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Abstract
Virtualization asks for safer and better quality to service-oriented cloud computing system suppliers. Most of the traditional researching is focus on the risk assessment of the information system and DDoS, but lacking of researching on cloud computing in deep. So that the service-oriented cloud computing system risk evaluation researching is very essential. In this paper, we build a service-oriented cloud computing system risk assessment framework that using distributed dynamic status monitoring of virtual machine system and making risk prediction value to summarizing the final risk assessment level of the system as a whole. The model can be used in monitoring, identifying, predicting and evaluating for cloud computing security risk that is having effect on the risk evaluation of virtual machine node and whole cloud system.
Keywords: SLA, QOS, RISK EVALUATION, CLOUD COMPUTING, DDOS.

1. Introduction

Cloud computing platform, which mainly provides a multi-tenant-oriented environment with web services, is an integration of extensible application service access which can be obtained through frequently-used communication protocols on the Internet. Cloud computing service relies on a large-scale data center and mostly uses virtualization server to run web application programs and web services [1]. The service-oriented cloud computing system presents the following characteristics in three aspects:

(1)Large-scale and extensible design of service layer. It refers to a complex distributed-load balancing technology, and uses a dynamic and elastic on-