Intra Prediction Mode Fast Decision Algorithm Research of H.264/AVC

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Keywords: H.264/AVC, prediction mode decision, DCT, rate distortion model.

Abstract. Intra prediction plays an important role in H.264/AVC. The mode fast decision is a significant factor for video coding efficiency in current video coding standard. Therefore, in this paper, the authors propose a method to choose the prediction mode quickly to save coding resource. According to the frame texture characteristics, the authors choose the block size and divide one intra_16×16 block into four intra_8x8 sub blocks with the algorithm. The sub blocks are transformed into frequency domain respectively. According to the number of zero, appropriate intra prediction mode can be decided. Furthermore, by taking advantage of direction relationship, the intra_4×4 sub blocks mode decision can be obtained. The experimental results demonstrate that the algorithm proposed in this paper can save coding time 30-50% while 0.04dB reduction of PSNR.

1. Introduction

With the advance of semi-conductor and access network technologies, multimedia communications become more and more popular in our daily life. For example, we can easily enjoy the videos hosted at famous video-sharing communities (such as Youtube, Hulu, Tudou, etc) through wired or wireless networks using personal computer or mobile devices. Multimedia video carries a large amount of information, and over 60 percent information is gotten by human visual sense. How to provide the high quality of service (QoS) or coding efficiency is a crucial problem for the success of video streaming application.

H.264/AVC standard is developed by the ITU-T in collaboration with ISO. It could provide better video quality compared with previous video coding standard. Intra prediction decision calculates all of the modes and gets the best one. Although the least error can be gained, the complexity is very large. So, the fast mode decision algorithm is always the hot spot in video coding research field.

Li proposed a low complexity algorithm for H.264 intra prediction[1]. In his algorithm, the texture feature of an MB was determined by calculating the luma differences between each pixel and its surrounding pixels and most probable mode was selected by computing the variation of each main prediction mode, then RDO(Rate Distortion Optimized) cost was calculated among the most probable mode, its two neighboring modes and DC mode. Liu proposed a fast intra mode decision algorithm based on spatial-domain energy which was used to represent the measurement of each 4x4 sub block[2]. Variances of the sixteen 4x4 sub blocks were calculated to measure the entire variance of the MB to determine the intra encoding type.Chen proposed a new hybrid fast mode decision method[3], in which the edge based on filters are applied to some samples distributed in the block and each directional mode is related to a filtering result. Kim proposed an efficient algorithm for intra prediction using an activity map for the pixel unit of respective prediction block in conjunction with specific thresholds to determine that the MB is more suitable for Intra_4×4 or 16×16[4]. Thierry proposed a learning method for the distortion calculation in fast intra prediction mode selection, using partial distortion sums on a selected sub-optimal search path of sample locations in a given macroblock[5]. Kau proposed a gradient intensity-adapted algorithm with adaptive selection strategy of prediction decision[6]. In his algorithm, he applied a gradient evaluation approach to evaluate the texture orientation inside the coding block, and due to the adaptive selection strategy a subset with a variable number of prediction modes was sent to RDO process.

In this paper, the authors propose a method to choose the prediction mode quickly to save coding resources. The experimental results demonstrate that the algorithm proposed in this paper can save a lot of time while decrease a little performance.

The rest of this paper is organized as follows. In section 2 the fast decision prediction mode algorithm is introduced. Section 3 is the coding complexity analysis. Experimental results are shown in Section 4 and finally conclusions are drawn in Section 5.

2. Fast prediction mode algorithm

According to the frame texture characteristics, the authors choose the intra_4×4 or 16×16 prediction mode. Intra_16×16 mode is applied to the smooth region, while intra_4×4 mode is used for abundant detail area. The selection of the two prediction modes depends on RDO cost function. The block whose size is 16×16 can be divided into sixteen intra_4×4 sub blocks. The enormous amount of computation cost on sixteen 4x4 sub-blocks will be avoided in the frame without too many details. While the frame with rich details which using intra_16×16 block prediction algorithm will increase the RDO cost function.

To solve the above problems, the authors propose a fast decision intra mode algorithm. According to high frequency component, intra_16×16 or 4×4 prediction mode is decided. Then the best prediction mode depends on the predicted direction relevance decision. The algorithm does not need RDO cost function to determine the coding type of macro block, and it reduces 4×4 sub block prediction range. It will reduce the intra prediction complexity.

Firstly, the authors divide a 16×16 macro block into four 8×8 sub blocks and do DCT for them. Then the coefficient matrix is quantified and the sum of zero value is counted. Lastly, we can decide the sub block is smooth or not by total number of zero. In this paper, the threshold is set to 52. If three of the four 8×8 sub blocks are smooth, the block can be considered smooth. Otherwise it will be regarded as texture complex.

Smooth macro block mode selection is simple, so this paper will not repeat them. 16x16 macro block with complex texture need to be divided into 16 intra4×4 sub block to accurately reflect the texture.

The first five prediction modes are used with high frequency. This paper selects 0-4 mode as basic modes. The other 4 are secondary prediction mode.

We calculate the RDO function of basic modes and sort the results. If the minimum RDO is DC, it will be selected as the best mode. If the intersection angle between the smallest and second smallest RDO is 45 degree, the mode between them is an alternative mode. If the angle is 90 degree, the alternative mode is between the first and third smallest RDO. Compare the smallest and alternative mode, the mode with smallest RDO value is the optimal mode.

3. Complexity analysis

In H.264/AVC intra coding, RDO is used to calculate the optimal intra coding mode. It is calculated with the function:

$$J = SSD + \lambda \times R \tag{1}$$

SSD is the sum of squared differences between the current block and its reconstruction, λ is the Lagrange multiplier and R is the bitrate.

For intra mode decision, the times of RDO cost function is calculated to measure the complexity of the algorithm. In H.264 the chroma mode is the outer loop, in order to scan all the modes of luma mode.

The calculation number is:

$$N = Mode8 \times (Mode4 \times 16 + Mode16) \tag{2}$$

Mode4 and Mode16 present the number of prediction mode of 4×4 and 16×16 luma block, respectively; Mode8 presents the number of prediction mode of 8×8 chroma block. That means the best mode of a macro block is obtained by calculating $4\times(16\times9+4)=592$ RDO cost functions.

The algorithm in this paper needs to calculate 4 RDO cost functions to intra_16×16 prediction mode. The luma and chroma prediction need not to calculate with RDO cost function, so just calculate 4 times. If the macro block is divided into sixteen intra_4×4 mode, the 8×8 complex texture block needs to calculate about $4\times5=20$ to $4\times6=24$ times with RDO cost function while 5 or 6 with RDO cost function if it is smooth. The 8×8 block number of a macro block is 0,1,2 by calculating about $4\times20=80$, $4\times24=96$, $5+3\times20=65$ to $6+3\times24=78$, $10+2\times20=50$, $12+2\times24=60$ times respectively. The luma and chroma block are mutual independent, so the macro block needs to calculate $4\times50=200$ to $4\times96=384$ with RDO cost function. It reduces the complexity of the encoding greatly.

4. Experimental results

We use six test sequences to compare the performance of the proposed algorithm and the original one. The test platform is JM 8.6 and the results are shown in the following table.

Table1. H.264 fast decision intra mode performance

Sequences	Tims(s)		PSNR(dB)		BR(kbits/s)	
	org	74.524	org	40.99	org	387.98
claire	opt	37.142	opt	40.97	opt	415.26
	Save	50.16%	Decrease	0.02	Increase	7.03%
	org	87.070	org	39.06	org	486.38
mother-daughter	opt	53.450	opt	39.01	opt	521.17
	Save	38.61%	Decrease	0.05	Increase	7.15%
	org	90.594	org	39.68	org	567.46
akiyo	opt	52.312	opt	39.66	opt	604.02
	Save	42.26%	Decrease	0.02	Increase	6.44%
	org	105.225	org	38.18	org	697.91
foreman	opt	71.584	opt	38.15	opt	744.54
	Save	31.97%	Decrease	0.03	Increase	6.68%
	org	133.005	org	36.89	org	951.54
coastguard	opt	92.896	opt	38.85	opt	971.26
	Save	30.16%	Decrease	0.04	Increase	2.07%
	org	211.950	org	35.43	org	2032.58
mobile	opt	150.288	opt	35.35	opt	2057.26
	Save	29.03%	Decrease	0.08	Increase	1.22%

The result shows that the coding time can be saved 30-50 percent, PSNR is decreased 0.02-0.08 and bitrate is increased 1-7 percent. The algorithm proposed in this paper decreases the coding complexity greatly by decreasing PSNR and increasing bitrate slightly.

5. Summary

In this paper, the authors propose a fast decision Algorithm to save coding resource. One 16×16 block is divided into four 8×8 sub blocks. The sub blocks are transformed into frequency domain respectively. According to the number of zero, appropriate intra prediction mode can be decided. Furthermore, by taking advantage of direction relationship, the 4×4 sub blocks mode decision can be

obtained. The experimental results demonstrate that it can save coding time greatly while take bitrate and PSNR as small price.

Acknowledgement

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