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Research and Improvement of Selection Algorithm Based on the H. 264 Intra-prediction Model

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Abstract. Intra prediction is an important part of H.264. However, in order to determine the optimum model,it usually costs too much time to compare each performance mode. Therefore, the computational complexity becomes the bottleneck of the H.264 intra-frame coding. This paper presents a fast mode decision algorithm based on the analysis of characteristics of H.264 intra-frame prediction algorithm. By using the texture characteristic of the image itself, the preset threshold will separate the Intrn16 × 16 and 4 × 4 prediction mode. A rapid computation using the relevance between adjacent blocks and adjacent direction prediction model will be made under 4 × 4 mode. The experimental results showed that, by the premise of guarantee of image quality, the algorithm can effectively improve the encoding speed of H.264.

Keywords: H.264; Intra Prediction; Mode Selection;

1. Introduction

H.264 / AVC is a new generation standard of video coding. In order to enhance the coding efficiency, h.264 introduced the algorithm of intra frame prediction. Taking full advantage of the relevance between adjacent macro blocks, it just encodes the difference between the predicted values and the actual value, and thus can operate with fewer bits to represent the information of the macro. H.264 can save 64% of the transmission streaming on average in the same picture quality compared with the previous coding standard MPEG-2 and save 39% of the transmission streaming compared with mpeg-4 ASP. It reduced the data throughput greatly on the condition of guaranteeing video quality. Therefore, the intro frame prediction was regarded as the important factor of success of H.264 standard.

Howecer, in order to determine the best intro frame prediction model of H.264, it required too much time to compare the performance of various patterns, so the computational complexity is the main factor of limiting the intra frame forecast. In order to meet the needs of practical application and achieve best coding effect with the least bit rate, we must choose fast algorithm to reduce the complexity of operation of the intra frame prediction.

2. The algorithm of H.264 intra-prediction model

2.1. The basic concepts of intra-prediction coding

An image is composed of many dots called pixel. In same image, there have strong correlations between pixels, called spatial correlation. The correlation is stronger when the two pixel space is closer, which means small probability of mutation of the value between two adjacent pixels.

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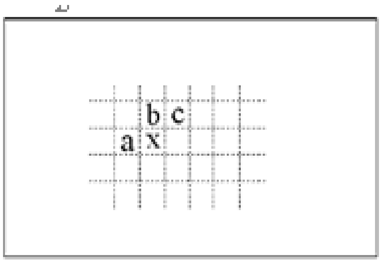


Fig. 1. (a) first picture

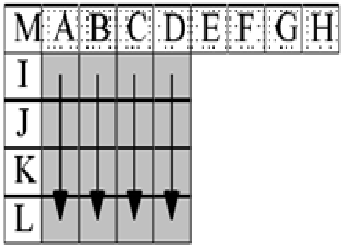
In Fig 1, x is the transported signal, a, b, c are adjacentpixels which are called reference pixels. During transmission, the decoding recovery value of the actual pixel x was obtained by subtracting the reference pixel from the actual pixel x which means only difference value signal was transferred, and then add the received difference signal to the reference pixels on the receiving end. Compared to the actual signal, the amount of data of the difference signal was greatly reduced, and the video signal was compressed. This kind of compression based on spatial correlation called intra frame prediction coding.

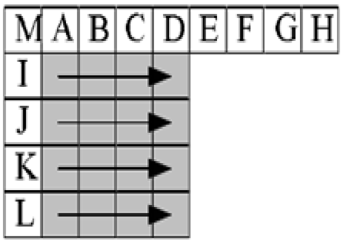
2.2. Intra-prediction Coding

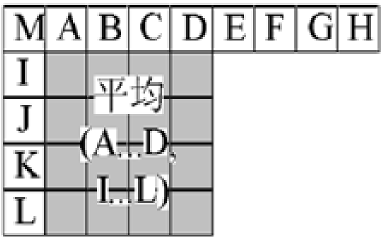
The previous compression algorithms, based on the direct transform coding on all the macroblocks, is likely to yield a greater coefficient, resulting in large quantization distortion during quantization. H.264 can predict the current block directly by using adjacent pixels. Therefore, the correlation between adjacent blocks can be effectively avoided and the coding efficiency of intra prediction can be improved. In H.264 intra prediction, the luminance blocks include 4 × 4 blocks and 16 × 16 blocks, the chrominance has 8 × 8 chroma blocks. For the luminance component, the prediction blocks can be four 4 × 4 sub-blocks or one 16 × 16 macro block. For each 4 × 4 sub-block, its expectative value is determined by the predict ion of the 13 adjacent pixels (Fig 2).

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

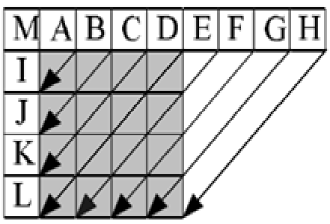
Fig.2. Each 4 × 4 block has 9 selectable prediction mode

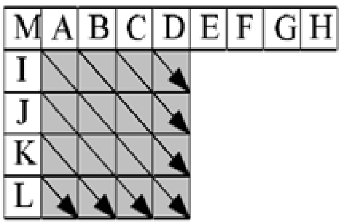


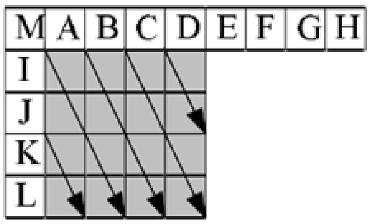




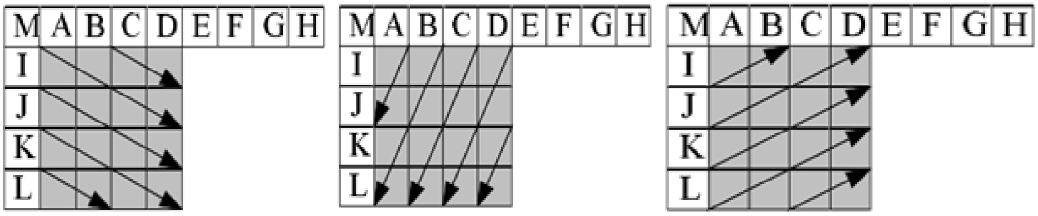
mode0(Vertical prediction) mode1(level prediction) mode2(DC prediction)







mode3(Left-down diagonal prediction) mode4(Right lower diagonal prediction) mode5(Vertical right prediction)



mode6(Horizontal downward prediction) mode7(Vertical left prediction) mode8(Horizontally prediction)

Fig.3

The 16 × 16 luminance block is the integral prediction of the intensity components of a macro block. Similar with the 4 ×4, 16 ×16 requires 33 surrounding pixels as reference pixel, and has 4 kinds of prediction modes. (Fig 4)

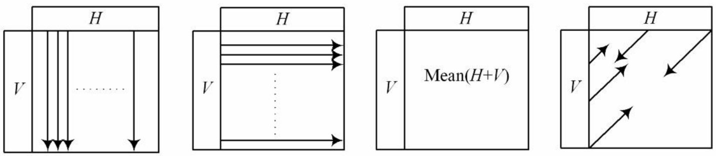


Fig 4.

For the 8 × 8 chroma prediction mode, it is very similar to16 × 16 luma block prediction mode, where only the pattern order is different, in which DC is mode 0, the horizontal mode is mode 1, the vertical mode is mode 2, and the Plana is mode 3.

In order to make full use of the predictive model, the H.264 encoder determines the final prediction model based on the global RD optimization model J. The distortion optimization model for the full-search rate is as follows:

$$J = D + \lambda R$$

where D is the coding distortion value, λ is the Lagrange parameter, R is the encoding rate corresponding to the encoding mode. The best prediction model is the coding mode which made the rate-distortion cost J smallest. During the prediction, a macro block demands N8 ×(N4 ×16 + N16) = 592 times mode calculations totally ((N8, N4, N16 are 8 ×8,4 ×4 and 16 ×16 chroma blocks, respectively) to determine the optimum intra prediction mode. The large amount of computation made it impossible to be applied to timing video encoding. Therefore fast computation method is necessary.

3. Fast Algorithm for Intra Prediction Mode

3.1. The algorithm ideas

By analysing the original algorithm of H.264, we found that both the texture of the image and the directivity of the 4 ×4 block could be used to reduce the number of intra prediction times. In this paper, we come up with a new algorithm by combining the two methods, which can greatly reduce the computation times.

Pre-sentence of the texture of the macro bloc, that is, determining whether the block has obvious texture and its rough texture characteristics. The less probable prediction mode was abadoned, and only the model with large possibility was used for RDO calculation, reduced the complexity of the algorithm. According to the literature [6], Intra16 ×16 and 4 ×4 prediction mode can be separated by the threshold T. For Intra16 ×16 prediction mode, it can be used directly for the flat and clear macro blocks, while for Intra4 × 4 mode, the rapid prediction mode should be introduced to reduce the complexity of the algorithm, which will be discussed later.

The flatness of macro block can be measured by the SAD which is the absolute value of residual of a macro blocks prediction.

$$SAD = \sum_{x,y \in MB} \left| PE(x,y) = O(x,y) - P(x,y) \right|$$

where O (x, y) is the original value of the block of pixels, P (x, y)is the predicted value of the block pixel, PE (x, y) is the residuals of block prediction.

$$\begin{cases} QP \le 20, T=500 \\ QP > 20, T=1000 \end{cases}$$

The pixel of T depends on the quantization parameter QP. when SAD <T, the macro block is flat, and the 16 ×16 mode can be used directly.

When SAD> T, 4 × 4 model is the selection. 4 × 4 luma block has 9 kinds of prediction modes. The computing complexity can only be reduced when these 9 kinds of models were used selectively. By using the correlation between the adjacent blocks and the adjacent direction prediction models, the selection steps could be described as follows: First, the four prediction models with strong orientation were measured, namely, vertical (mode 0), horizontal (mode 1), diagonal to the left (mode 3), Diagonal to the lower right (mode 4). Then, the candidate forecasting models can be selected from the results. Comparing with directivity of the current block, if they are the same the candidate model, the best model could be determined accordingly, otherwise, the model of Intrn4 ×4 2 should be choose as the optimal model.

4. The Process of Algorithm

Based on the analysis above, we come up the fast process of algorithm as follows:

Calculate the SAD value of the macro block according to the original algorithm of H.264;

$$\begin{cases} QP \le 20, T=500 \\ QP > 20, T=1000 \end{cases}$$

compare,If SAD <T, jump to (d);If SAD> T, the 4 ×4 block prediction mode is the choice. The total variance of the vertical, horizontal, diagonal to left, diagonal to lower right could be calculated according to the correlation of prediction mode of adjacent direction. Compare the 4 total variances, the smaller the total variance is the greater the possibility is;

Select the optimum model;

5. Simulation and Results Analysis

JM Series model is the official testing source code of H.264, and was coded completely in accordance with the H.264 standard. JM reference model cited a variety of new features to improve coding performance, but ignored the encoding complexity, resulting in high coding complexity, low efficiency and poor practicality.

In order to achieve the optimization algorithm above, we improved the JM86 model. 4 different basic video sequences (qcif format) were processed, by adopting the intra prediction mode entirely. The basic experimental environment is as follows:

CPU:IntelT6600,2.1GHz;RAM:2.00G

OS:Windows7 Encoder: Visual C + +6.0

Table 1.Comparison between the Foreman sequence fast algorithm and the original algorithm

QP	ΔPSNR/dB	ΔBit/(%)	ΔTIME/（%）
10	-0.18	+1.62	-69.9
16	-0.09	+1.53	-68.8
24	-0.03	+2.05	-70.2
28	-0.01	+2.14	-69.0
36	+0.02	+2.11	-69.0

Table 2.Comparison between the Ackiyv sequence fast algorithm and the original algorithm

QP	ΔPSNR/dB	ΔBit/(%)	ΔTIME/（%）
10	-0.22	+1.76	-72.4

16	-0.17	+2.10	-69.7
24	-0.08	+2.76	-72.9
28	-0.02	+2.33	-70.7
36	+0.00	+2.23	-66.8

Table 3.Comparison between the Carphone sequence fast algorithm and the original algorithm

QP	$\Delta_{PSNR/dB}$	$\Delta_{Bit/(\%)}$	$\Delta_{TIME/(\%)}$
10	-0.30	+1.85	-62.4
16	-0.18	+2.10	-69.7
24	-0.07	+2.88	-79.9
28	-0.02	+2.96	-75.5
36	-0.01	+3.22	-58.5

Table 4.Comparison between the Bus sequence fast algorithm and the original algorithm

QP	$\Delta_{PSNR/dB}$	$\Delta_{Bit/(\%)}$	$\Delta_{TIME/(\%)}$
10	-0.22	+1.99	-58.4
16	-0.12	+2.75	-66.7
24	-0.25	+2.88	-67.9
28	-0.18	+3.30	-55.5
36	-0.04	+3.22	-59.5

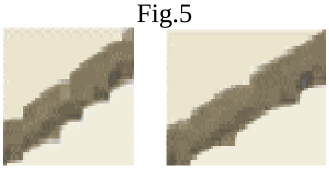
with the adoption of the fast algorithm, the encoding speed is 68.5% higher than the original algorithm of H1264/AVC on average. Meanwhile, the code rate just increased about 2.5%, where the SNR is almost unchanged.

6. Conclusion

With the analysis of the technology of H.264 intra prediction and the consideration of the computational complexity of selection algorithm as the main disadvantage of the h.264 reference code, we presented a fast algorithm. It took advantage of using the characteristics of the texture image itself exactly, and reduced the calculation complexity of the intra prediction, with the help of directional characteristic of the adjacent macro blocks. The image effect of the details are in perfect range after the image was enlarged.(Fig 5) without affecting the the effect of image(Fig6) .

Original image Images obtained by the algorithm in this pape

Fig.5



original Details The details obtained by the algorithm in this paper

Fig 6

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