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A New Fast Intra Prediction Mode Decision Algorithm for H.264/AVC Encoders

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Abstract**—**The H.264/AVC video coding standard contains a number of advanced features. Ones of the new features introduced in this standard is the multiple intra-mode prediction. Its function exploits directional spatial correlation with adjacent block for intra prediction. With this new features, intra coding of H.264/AVC offers a considerably higher improvement in coding efficiency compared to other compression standard, but computational complexity is increased significantly when brut force rate distortion optimization (RDO) algorithm is used. In this paper, we propose a new fast intra prediction mode decision method for the complexity reduction of H.264 video coding. for luma intra prediction, the proposed method consists of two step: in the first step, we make the RDO for four mode of intra 4x4 block, based the distribution of RDO cost of those modes and the idea that the fort correlation with adjacent mode, we select the best mode of intra 4x4 block. In the second step, we based the fact that the dominating direction of a smaller block is similar to that of bigger block, the candidate modes of 8x8 blocks and 16x16 macroblocks are determined. So, in case of chroma intra prediction, the variance of the chroma pixel values is much smaller than that of luma ones, since our proposed uses only the mode DC. Experimental results show that the new fast intra mode decision algorithm increases the speed of intra coding significantly with negligible loss of PSNR.

Keywords**—**Intra prediction, H264/AVC, video coding, encoder complexity.

I. INTRODUCTION

THE emerging video coding standard H.264, which is jointly developed by ITU-T and MPEG, provides the state-of-the-art video coding technique to meet a wide range of applications[1,2,3]. H.264 offers a significant performance improvement over previous video coding standards such as H.263++ and MPEG-4 [4,5,6] in terms of better peak signalto-noise ratio (PSNR) and visual quality at the same bit rate [7]. This is accomplished mainly due to the consideration of variable block sizes for motion compensation, multiple reference frames, integer transform [an approximation to discrete cosine transform (DCT)], in-loop deblocking filter, context based adaptive binary arithmetic coding (CABAC), but also due to better exploitation of the spatial correlation that may exist between adjacent Macroblocks, with the multiple intra mode prediction in intra (P) slices [8].

The *H*.264 video coding standard supports intra prediction for various block sizes. For coding the luma signal, one 16*x*16 macroblock may be predicted as a whole using Intra-16x16 modes, or the macroblock can be predicted as individual 4*x*4 blocks using nine Intra-4*x*4 modes. In the profiles that support Fidelity Range Extension (*FRExt*) tools, a macroblock may also be predicted as individual 8x8 blocks using nine intra-8x8 modes [10]. Intra prediction for the chroma signal uses similar techniques as those for luma Intra-16x16 predictions.

The RD optimization (RDO) technique [11] has been employed in H.264 for Intra-prediction mode selection to achieve coding efficiency. However, the computational complexity of the RDO technique is extremely high since the encoder has to encode the target block by searching all possible modes exhaustively for the best mode in the RD sense [2], it makes *H*.264/*AV C* difficult for applications with low computational capability, such as mobile devices.

To reduce the complexity of *H*.264/*AVC*, various researches are currently being made to develop fast algorithms in motion estimation, intra mode prediction and inter mode prediction for *H*.264/*AVC* video coding [12,...,17]. In this paper, we present a new fast intra prediction mode decision method to improve the encoding speed without much sacrifice at RDO performance. This method based the idea that the prediction mode of each block is correlated with those neighboring prediction modes and the fact that the dominating direction of a smaller block is similar to that of bigger block. According to those ideas, we make the RD cost for only four mode of luma intra 4x4 block and the best mode of luma intra 4x4 is selected based a distribution of RD cost for those modes. So, the candidate modes of 8x8 blocks and 16x16 macroblock are determined by using the second idea. To justify the use of our proposed, the comparison results with JM encoder were examined based on the difference of the computational time, the PSNR and the bite-rate for various sequences. The experimental results show that our algorithm increases the speed of intra coding significantly with negligible loss of peak signal-to-noise ratio.

The rest of this paper is organized as follows: Section 2 describes the intra mode decision in *H*.264/*AVC*. In Section 3, we propose a fast intra prediction algorithm in detail. Section 4 gives the Experimental results to show the performance of the proposed algorithm. Finally, the paper is concluded in

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section 5.

II. H.264/AVC Intra Mode Decision

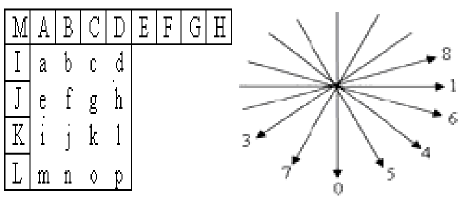
The H.264 standard exploits the spatial correlation between adjacent macroblocks/blocks for Intra prediction. In JV T, the current macroblock is predicted by adjacent pixels in the upper and the left macroblocks that are decoded earlier. For the luma prediction samples, the prediction block may be formed for each 4x4 subblock, each 8x8 block, or for a 16x16 macroblock. One case is selected from a total of 9 prediction modes for each 4x4 and 8x8 luma blocks, 4 modes for a 16x16 luma block and 4 modes for each chroma blocks. To take the full advantage of these modes, the H.264 encoder can select the best mode using the rate distortion optimization (RDO).

A. 4x4 Luma Intra Prediction Modes

In 4*x*4 Intra prediction modes, the values of each 4x4 block of luma samples are predicted from the neighbouring pixels above or left of a 4x4 block, and nine different directional ways of performing the prediction can be selected by the encoder as illustrated in Fig. 1 and Table I (and including a *DC* prediction type numbered as mode 2, which is not shown in the figure). Each prediction direction corresponds to a particular set of spatially-dependent linear combinations of previously decoded samples for use as the prediction of each input sample. For the purpose of illustration, Fig. 1(a) shows a 4*x*4 block of pixels a, b, c ...p, belonging to a macroblock to be coded. Pixels A, B, C ...H, and I, J, K, L, M are already decoded neighbouring pixels used in computation of prediction of pixels of current 4x4 block.

TABLE I
INTRA 4*X*4 PREDICTION MODES

Num	Intra 4x4 prediction mode
0	Vertical
1	Horizontal
2	DC
3	Diagonal-down-left
4	Diagonal-down-right
5	Vertical-Right
6	Horizontal-down
7	Vertical-left
8	Horizontal-up



(a) (b)

Fig. 1 Prediction directions

Fig. 1(b), shows of the nine 4x4 Intra prediction modes. For mode 2 (*DC*), all pixels (labelled a to p) are predicted by $(A+B+C+D+I+J+K+L)/8$. The mode 0 specifies the vertical prediction mode in which pixels (labelled a, e, i and m) are predicted from A, and the pixels (labelled b, f, j and n) are predicted from B, and so on. If Horizontal prediction is employed (mode 1), a, b, c, d are predicted by E, e, f, g, h by F etc. For mode 3 (diagonal down left), mode 4 (diagonal down right), mode 5 (vertical right), mode 6 (horizontal down), mode 7 (vertical left), and mode 8 (horizontal up), the predicted samples are formed from a weighted average of the prediction samples A-M. For example, samples a and d are respectively predicted by round $(I/4 + M/2 + A/4)$ and round $(B/4 + C/2 + D/4)$ in mode 4, also by round $(I/2 + J/2)$ and round $(J/4 + K/2 + L/4)$ in mode 8. The best prediction mode is selected for each block by minimising the residual between the encoded block and its prediction [1, 3, 4].

In July, 2004, a new profile was added to *Hx*264 video coding standard, called the Fidelity Range Extensions (*FRExt*, Amendment 1), which demonstrates even further coding efficiency against *MPEG* - 2, potentially by as much as 3:1 for some key applications [10]. In the *FRExt* amendment, an additional intermediate prediction block size of 8x8 was introduced for spatial luma prediction by extending the concepts of 4x4 intra prediction in an effort to improve coding efficiency. For the 8x8 luma intra prediction, 9 prediction modes are used which are the same as that of 4x4 intra prediction. However, the computational complexity of the *H*.264 encoder is dramatically increased according to this feature of the new extended profile.

B. 16x16 Luma and 8x8 Chroma Intra Prediction Modes

The 16x16 luma intra prediction modes are selected in relatively homogeneous area, four prediction modes are supported as listed in Table II comprising of the dc, vertical, horizontal and plane prediction. These modes are specified similar to modes in Intra-4x 4 predictions except the plane prediction. In vertical prediction, each of the 16 columns (of 16 pixels each) of current macroblock are predicted using only 1 past decoded pixel each, similar to the case of prediction of 4 pixels of column by a single decoded pixel in the case of 4x4 intra prediction[3,4,5,6]. The horizontal prediction predicts an entire row of 16 pixels by a past decoded neighboring pixel, the process is repeated for each of the 16 rows. The dc prediction uses an average of past decoded row and column of pixels to predict all pixels of the 16x16 block. The planar prediction uses weighted combination of horizontal and vertical adjacent pixels. The neighbouring pixels used for prediction of 16x16 luminance component of current macroblock belong to neighbouring decoded macroblock. For the chrominance (chroma) components, there are 4 prediction modes that are applied to the two 8x 8 chroma blocks (U and V), which are very similar to the 16*x*16 luma prediction modes such as DC (Mode 0), horizontal (Mode 1), vertical (Mode 2), and plane (Mode 3). To take the full advantage of these modes, the H.264 encoders select the best mode using the rate distortion optimization (RDO) technique [11].

TABLE II
INTRA 16x16 PREDICTION MODES

Num	Intra 16x16 prediction mode
0	Vertical
1	Horizontal
2	DC
3	Plan

H.264/AVC encodes the MB by iterating all the luma intra decisions for each possible chroma intra prediction mode for the best coding efficiency. Therefore, the number of mode combinations for luma and chroma components in an MB is N8-chr*(N4*16 +N8*4+N16), where N8-chr, N8, N4, and N16 represent the number of modes for 8x8 chroma blocks, 8x8, 4x4 and 16x16 luma blocks, respectively. It means that, for an MB, it has to perform 4*(9*16 +9*4+ 4) = 736 different RDO calculations before a best RDO mode is determined [10, 14, 15]. As a result, the complexity of the encoder is extremely high. To reduce the encoding complexity with little RD performance degradation, a new fast intra-mode decision method is proposed in the next section.

III. Proposed Fast Intra Mode Decision

H.264/AVC standard checks all possible intra prediction modes of every block which belongs to P-frame as well as I-frame in order to achieve optimal coding efficiency. The Rate Distortion optimization (RDO) method used for mode decision in h.264 can achieve higher compression efficiency, but it also brings a bout a large computation complexity due to the transform and entropy coding for each mode. To reduce this complexity, few approaches have been proposed on fast intra prediction algorithm. In (Pan et al., 2003)[14,15], it is based on the local edge information, and thus adopts the edge direction to predict the possible mode. In (Jongho Kim* and Jechang Jeong, 2005)[17], the directional masks and mode information of neighboring blocks used to select the probable modes. In (Jun Sung Park, and Hyo Jung Song, 2006) [16], it is based on the idea that direction of a bigger block is similar to that of smaller block, the effects of fast mode decision is reduced. Therefore, as an alternative method, we propose a new fast intra-mode decision method based a fort correlation between adjacent modes prediction and the direction of a smaller block is similar to that of bigger block.

A. Intra-Modes Decision for 4x4 Luma Blocks

Instead of performing the nine RDO for each luma 4x4 block, the proposed algorithm only selects half of the candidate modes. For each block, the prediction mode is correlated with two neighbor modes. From this observation, we calculus the RDO modes prediction of a 4x4 block from the horizontal mode (mode 1), the vertical mode (mode 0), the diagonal down right (mode 4) and the diagonal down left (mode 3) to obtain the directional information. The candidates set of most probable intra prediction modes is selected which depend a location of two modes with minimum cost as summarized the following rules:

1) If a mode vertical (mode 0) is a minimum cost and mode diagonal down right (mode 4) is the second minimum, candidate mode of the 4x4 block are mode vertical (mode 0) and mode vertical left (mode 7). Else, if a mode diagonal down right (mode 4) is a minimum cost and mode vertical (mode 0) is the second minimum, candidate mode of the 4x4 block are mode diagonal down right (mode 4) and mode horizontal down (mode 6).
2) If a mode diagonal down right (mode 4) is a minimum cost and mode horizontal (mode 1) is the second minimum, candidate mode of the 4x4 block are mode diagonal down right (mode 4) and mode vertical right (mode 5). Else, if a mode horizontal (mode 1) is a minimum cost and mode diagonal down right (mode 4) is the second minimum, candidate mode of the 4x4 block are mode horizontal (mode 1) and mode horizontal up (mode 8).
3) If a mode vertical (mode 0) is a minimum cost and mode diagonal down left (mode 3) is the second minimum, candidate mode of the 4x4 block are mode vertical (mode 0) and mode vertical right (mode 5). Else, if a mode diagonal down left (mode 3) is a minimum cost and mode vertical (mode 0) is the second minimum, candidate mode of the 4x4 block are mode diagonal down left (mode 3) and mode vertical left (mode 7).
4) If a mode diagonal down left (mode 3) is a minimum cost and mode horizontal (mode 1) is the second minimum, candidate mode of the 4x4 block are mode diagonal down left (mode 3) and mode vertical left (mode 7). Else, if a mode horizontal (mode 1) is a minimum cost and mode diagonal down left (mode 3) is the second minimum, candidate mode of the 4x4 block are mode horizontal (mode 1) and mode horizontal down (mode 6).
5) If a mode horizontal (mode 1) is a minimum cost and mode vertical (mode 0) is the second minimum, candidate mode of the 4x4 block are mode horizontal (mode 1) and mode horizontal up (mode 8). Else, if a mode vertical (mode 0) is a minimum cost and mode horizontal (mode 1) is the second minimum, candidate mode of the 4x4 block are mode vertical (mode 0) and mode vertical left (mode 7).
6) Else, the candidate mode of the block is mode 2 (DC) and mode with minimum cost.

According to the criteria described above, we can determine the candidate groups as shown in Table III.

TABLE III
CANDIDATE MODES FOR 4X4 INTRA PREDICTION

Minimum cost modes	Second Minimum cost modes	Candidate modes
Mode 0	Mode 4	Mode 0,7
Mode 4	Mode 0	Mode 4, 6
Mode 0	Mode 3	Mode 0, 5
Mode 3	Mode 0	Mode 3, 7
Mode 1	Mode 4	Mode 1, 8
Mode 4	Mode 1	Mode 4, 5
Mode 3	Mode 1	Mode 3, 7
Mode 1	Mode 3	Mode 1, 6
Mode 0	Mode 1	Mode 0, 7
Mode 1	Mode 0	Mode 1, 8

B. Intra-Modes Decision for 8x8 Luma Blocks

The FRExt amendment initiative was motivated by the rapidly growing demand for coding of higher-fidelity video material, especially in application areas like professional film production, video post production, or high-definition TV/DVD. In this amendment, an intermediate prediction block size of 8x8 was introduced for spatial luma prediction by extending the concepts for 4x4 intra prediction, but with a prediction block size that is 8x8 rather than 4x4 and with low-pass filtering of the predictor to improve prediction performance.

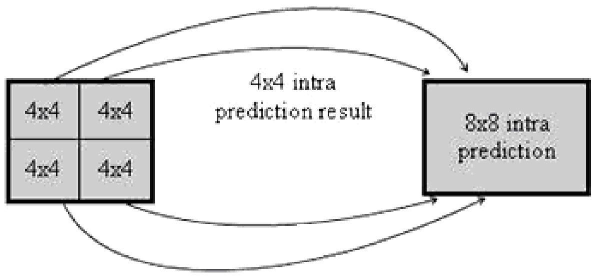


Fig. 2 The scheme of applying 4x4 intra prediction modes result

The RD optimization process of 8x8 intra modes is quite complex. To solve this problem, we can reduce the computational complexity by cutting down the number of candidates for the best intra prediction mode. In our experiments, we observe that the dominating direction of a smaller block is similar to that of bigger block. As in Fig. 2, the best prediction mode of 4x4 luma block within 8x8 blocks has the same direction as that of 8x8 luma block. From these observations, for each 8x8 luma block, the resultant modes selected with the four 4x4 luma blocks constructed these 8x8 luma blocks, are the candidate modes of the 8x8 luma intra prediction mode. Thus, for each 8x8 luma block, the number of candidate modes can be reduced from nine to a number between four and one modes. The algorithm is described as follows and is illustrates in Fig. 3:

Step 1: for each 8x8 luma block, obtain the modes of each 4x4 luma block constructed this block, those modes are the candidates mode of 8x8 luma block.

Step 2*:* calculus the RD cost of the mode with modes already selected in step 1, proceed to the next candidate intra prediction mode.

Step 3: if all candidate intra prediction modes are examined, carry out step 4. Else, if the candidate mode intra prediction is the same as one which is already calculated, proceed to the next candidate intra prediction mode and carry out step 2, else, carry out step 2.

Step 4*:* decide the best intra mode for 8*x*8 luma block with minimum cost.

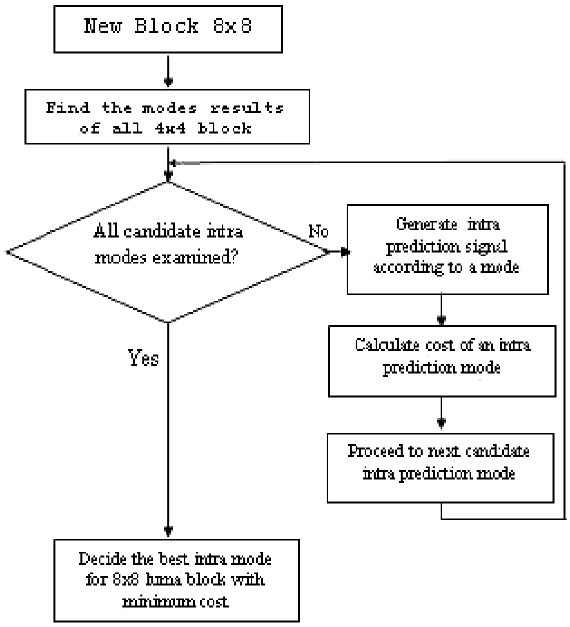


Fig. 3 Flow chart of proposed 8x8 intra prediction mode decision method

C. Intra-Mode Decision for 16x16 Luma Macroblocks

In *H*.264/*AVC* standard video coding, the 16x16 luma intra prediction modes are selected in relatively homogeneous region. Therefore, for 16x16 luma macroblocks, there are only 4 directional modes, different from the case of 4*x*4 luma blocks, such as horizontal, vertical, DC and plane mode. So for fast intra prediction mode decision, we have implemented the fast 16x16 intra-mode prediction algorithm based on modes of 8x8 luma blocks make this macroblock. This algorithm is composed of two steps as shown below.

Step 1: for each 16x16 luma macroblock, obtain the modes of each 8x8 luma block constructed this macroblocks.

Step 2: in this case, with modes of 8x8 luma block already selected in step 1, the candidate set of most probable 16x16 intra prediction modes is selected that results are summarized in Table IV.

TABLE IV
CANDIDATES 16X16 MODES ACCORDING TO 8X8 MODE

8x8 modes	Candidate 16x16 modes
Modes 7, 0, 5, 2	Modes 0 (vertical)
Modes 8, 1, 6, 2	Modes 1 (horizontal)
Modes 0, 1, 3, 4, 2	Modes 2 (DC).
Modes 0, 1, 3, 2	Modes 3 (plane).

D. 8x8 Chroma Intra Prediction Modes

The chroma intra prediction mode of *H*.264 consists of four modes: *DC*, horizontal, vertical, and plane mode. These modes are the same as for the luma component in *Intra*-16x16 macroblocks. So, the statistical characteristics of luma and chroma components are very different. The variance of the chroma pixel values is much smaller than that of the luma ones. The luma pixel values gradually change according to the angle between the direction of the source light and the surface of the object. On the other hand, the chroma pixel values in a certain area change very little [18]. With the uses of the characteristic of chroma and the subject to reduce the complexity with better quality, we use only the DC mode for chroma intra prediction.

E. Analysis of Computational Complexity

Table V summarizes the number of candidates selected for *RDO* computation by the proposed method. As can be seen from Table V, the encoder with the fast mode decision algorithm would need to perform only 1* (5*16 + 1) = 81 if the 8x8 intra prediction mode not used. In case that the 8x8 luma block for *H*.264/*AVC FRExt* is applied, the mode combination complexity is reduced to a number 1*(5*16 + 1*4 + 1) = 85 with our algorithm. Thus our proposed algorithm reduces number of *RDO* calculation significantly compared to the 1*(4*16 + 4*9 + 4) = 104, 2*(4*16 + 9*4 + 2) = 440 and 4*(9*16 + 9*4 + 4) = 736 modes that are used in the current *RDO* calculation in *H*.264/*AVC FRExt* video coding with (J. S. Park and H. J. Song 2006), (F. Pan, X. Lin,..2005) and Full search method of H.264 respectively.

TABLE V
COMPARISON OF THE NUMBER OF THE CANDIDATE MODES

	Block size	Total number of modes	Number of candidates
Luma (Y)	4x4	9	5
Luma (Y)	8x8	9	1 to 4
Luma (Y)	16x16	4	1 to 4
Chroma(U,V)	8x8	4	1

IV. EXPERIMENTAL RESULTS

To evaluate the performance of the proposed method, our proposed method was implemented into H.264/AVC reference software *JM*10*:*1 [19] and tested with various Quantization Parameters *Qp*. The system platform is the Intel Pentium 4 Processor of speed 1.8GHz, 512MB *DDR RAM*, and Microsoft Windows XP. The test conditions are as follows: (1) *MV* search range is 16 pixels for *QCIF*, *CIF*; (2) RD optimization is enabled; (3) Reference frame number equals to 5; (4) *CABAC* is enabled; (5) GOP structure is *IPPPP* or I-frame only; (6) the number of frames in a sequence is 100. Comparisons with the case of exhaustive search were performed with respect to the change of average *PSNR* (Δ*PSNR*), the change of average data bits (Δ*Bit*), and the change of average encoding time (Δ*Time*), respectively.

In order to evaluate the timesaving of the fast intra mode decision algorithm, the following calculation is defined to find the time differences. Let *TJM* denote the coding time used by JM10.1 encoder and *TFI* be the time taken by the fast intra mode decision algorithm, and is defined as:

$$\Delta Time = \frac{T_{FI} - T_{JM}}{T_{JM}} * 100\% \tag{1}$$

Table VI shows the simulation results of the proposed algorithm with *JM*10.1 for various sequences with *IPPP* type. The quantization parameter set was chosen to be [10,14,18,...42,46]. We also show the simulation results for *I-frame only* type sequences in Table VII. It can be seen that the proposed algorithm achieves very high encoding time saving (up to about 76%) with a little loss of *PSNR* and increment of *bit-rates*.

TABLE VI
SIMULATION RESULTS FOR IPPP SEQUENCES

sequences	Y-PSNR (dB)	UV-PSNR (dB)	Bitrate (%)	Time(%)
Claire	-0,255	-0,162	+2,70	-72,42
silent	-0,185	-0,043	+0,76	-74,03
news	-0,164	-0,072	+2,75	-72,75
grandma	-0,193	-0,053	+1,36	-71,25
salesman	-0,227	-0,084	+0,68	-74,22
Mthrdotr	-0,256	-0,110	+0,43	-72,97

TABLE VII
SIMULATION RESULTS FOR I-FRAME-ONLY SEQUENCES

sequences	Y-PSNR (dB)	UV-PSNR (dB)	Bitrate (%)	Time (%)
Mobile	-0.167	-0.022	+2.54	-76.33
Silent	-0,120	-0,016	+3,95	-74,98
news	-0,080	-0,040	+4,38	-73,15
vectra	-0,061	-0,026	+4,92	-73,20
salesman	-0,111	-0,070	+4,07	-75,05

Tables VIII and IX show the tabulated performance comparison of our proposed with the full search method for different image sequences described below. Note that in the tables, positive values mean increments and negative values mean decrements. Experimental results of the proposed method show a significant reduction of computation in between 71.51%, and 78.25%, a slight increase in bit rate in between 1.94% and 4.63%, and similar *PSNR* in comparison with full search method.

Figs. 4,5,6 shows the RD performance and the computation time for the two sequences ”news”. It can be seen from these figures that the two RD curves, one from the original full search and the other from the proposed algorithm, are almost overlapping each other. It means that the performance of the proposed algorithm is almost similar to that of the original full-search. From Fig. 6 we can observe that the encoding time with fast intra modes decision is distinctly less than that of without full search under the same test conditions.

V. Conclusion

In this paper, a fast intra prediction mode decision method for *H.*264 video coding is proposed based on the directional information and the observation that the dominating direction of a smaller block is similar to that of bigger block. With our method, the number of mode combinations for *luma* and chroma blocks in an MB that takes part in *RDO* calculation has been reduced significantly from 736 to as low as 81. From the experimental results, we can see that the proposed method can achieve a considerable reduction of computation complexity while maintaining similar bit rate and *PSNR*.

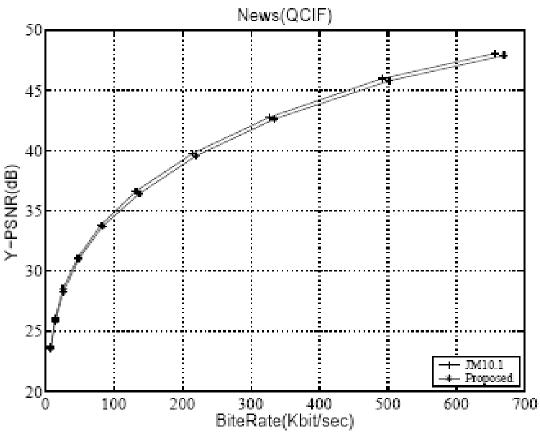


Fig. 4 Comparison of PSNR-Y and bit-rate for the sequences News

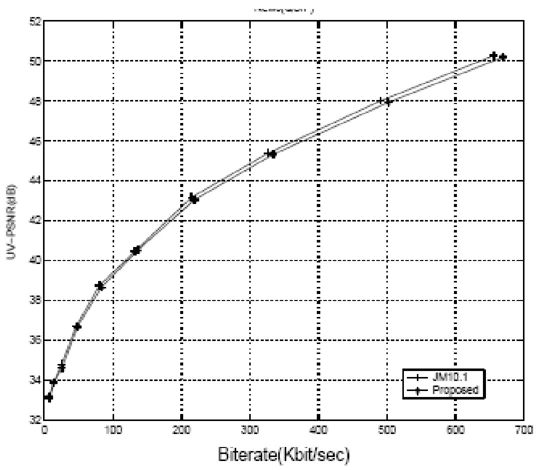


Fig. 5 Comparison of PSNR-UV and bit-rate for the sequences of News

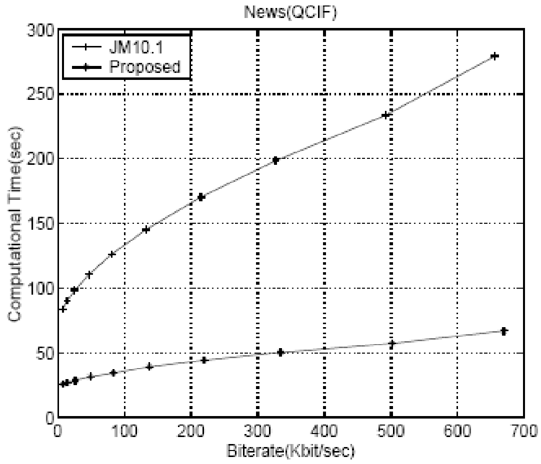


Fig. 6 The computational time comparison of News sequence

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TABLE VIII
RESULTANTS ON QCIF TEST SEQUENCE "MOBILE"

Qp	Method	Y-PSNR(dB)	U-PSNR(dB)	V-PSNR(dB)	Biterate(Kbit/sec)	complexity
10	FS	51,34	51,44	51,39	4054,75	443,612
	Proposed	51,19	51,4	51,34	4144,86	96,507
	ΔImproved	-0,15	-0,04	-0,05	+2,22%	-78,25%
18	FS	44,1	44,37	44,31	2353,67	332,701
	Proposed	43,9	44,33	44,26	2411,51	73,811
	ΔImproved	-0,2	-0,04	-0,05	+2,46%	-77,81%
26	FS	36,42	37,26	37,26	1430,9	245,981
	Proposed	36,26	37,28	37,13	1458,73	55,907
	ΔImproved	-0,16	-0,02	-0,13	+1,94%	-77,27%
34	FS	29,27	31,48	31,77	809,36	178,518
	Proposed	29,1	31,41	31,84	830	42,546
	ΔImproved	-0,17	-0,07	-0,07	+2,55%	-76,17%
42	FS	22,91	27,76	27,55	362,16	127,263
	Proposed	22,78	27,78	27,64	372,63	33,077
	ΔImproved	-0,13	-0,02	-0,09	+2,89%	-74,01%

TABLE IX
RESULTANTS ON QCIF TEST SEQUENCE "SALESMAN"

Qp	Method	Y-PSNR(dB)	U-PSNR(dB)	V-PSNR(dB)	Biterate(Kbit/sec)	complexity
10	FS	51,62	51,45	51,63	1714,05	307,684
	Proposed	51,47	51,52	51,56	1750,62	66,918
	ΔImproved	-0,15	-0,07	-0,07	+2,13%	-78,25%
18	FS	44,82	45,89	46,24	1021,08	223,236
	Proposed	44,65	45,84	46,18	1046,51	50,892
	ΔImproved	-0,17	-0,05	-0,06	+2,49%	-77,20%
26	FS	37,89	40,69	41,42	508,55	156,43
	Proposed	37,8	40,62	41,34	528,11	37,423
	ΔImproved	-0,09	-0,07	0,08	+3,85%	-76,08%
34	FS	31,89	37,81	38,42	209,34	112,615
	Proposed	31,78	37,63	38,35	218,85	28,954
	ΔImproved	-0,11	-0,18	-0,07	+4,54%	-74,29%
42	FS	26,97	36,01	36,38	65,36	86,703
	Proposed	26,91	35,95	36,19	68,45	24,7
	ΔImproved	-0,06	-0,06	-0,19	+4,63%	-71,51%