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Probability based Fast Inter Mode Decision Algorithm for H.264/AVC

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Abstract: In this paper, a new probability based fast inter mode decision algorithm is proposed for H.264/AVC video standard. The main idea is to classify the inter modes into large and small modes category and determine which one is suitable for a macroblock (MB). Depending on this, the probability of each large mode corresponding to the initial Hadamard cost or the probability of each small mode corresponding to the initial Hadamard cost is determined. Then the best mode can be obtained from their probability characteristics. Thus, it is possible to determine the best inter mode only by calculating the Hadamard Transform (H-SAD) cost instead of rate distortion cost. Moreover, it avails the platform to determine the best mode without comparing the cost of each mode to other modes. As a result, this approach can avoid most of the complex computation processes like quantization, variable length coding, pixel reconstruction etc. The experimental results have shown that the proposed algorithm can reduce 60% to 65% of the total encoding time of H.264/AVC with negligible distortion in the rate distortion performance.

Keywords: Inter Mode Decision, Macroblock, Hadamard Transform, Rate Distortion Cost, H.264/AVC

1 Introduction

H.264/AVC [1], [2] is the latest video standard which has outperformed than previous video compression standard like MPEG- 1/2/3 ad H.261/263 in terms of video compression efficiency as well as video quality. This is why it has been used for different applications like video streaming, Blue-ray, real time communication etc.

It introduces many new techniques which include variable and hierarchical block transform, arithmetic entropy encoding including CABAC and CAVLC, directional spatial prediction for intra frame coding, multiple reference frame motions to outperform the previous standards. Among these features, one of the key ones is it uses seven variable blocks sizes for motion estimation and compensation which are 16×16, 16×8, 8×16, 8×8, 8×4, 4×8 and 4×4. Among these, large blocks (16×16, 16×8 and 8×16) are generally used for stationary image prediction with high coding efficiency and small blocks (8×8, 8×4, 4×8 and 4×4) are used for complex images for better prediction accuracy. The large blocks requires less computational time and has less accuracy than the small blocks. On the other hand, small blocks require more computational time and have more accuracy than the large blocks. Therefore, there is a trade of between the computational time and the prediction accuracy which plays a vital role for video quality is needed to decide which partition block size i.e. mode is the best one for motion estimation of a macro block (MB). This vital task is done by computing rate distortion costs of all available blocks and selecting the best partition block size i.e. mode that can provide relatively the best motion compensation with minimum computational time. This rate distortion cost calculation is also a highly complex that includes several processes like computation of integer transform, quantization and arithmetic entropy coding and pixel reconstruction process.

That is why this variable block technique involves lots of computational power. As a result, H.264/ AVC has limited applications in real time communication. In [3]-[11] different fast mode algorithms have been proposed applying which it is possible to reduce the computational complexity significantly enabling this video standard for real time application. For examples, in

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[3], Jing et al proposed mean absolute frame difference of a current frame and mean absolute difference of current MB to determine whether a MB is homogenous or not and decide the best mode among 16×16, 16×8 and 8×16. In [4], Kuo proposes the motion field distribution and correlation method for determining the best modes. In [5], Wei et al, proposes a mode decision algorithm where the mode of a MB is determined using the modes of adjacent MBs. Most of the algorithm proposes methods that skip some unnecessary modes, but need to calculate the rate distortion cost which needs high amount of computational time. In [7], to reduce the complexity of encoder, a novel fast inter-frame mode decision algorithm based on the statistical proportion of each encoding mode is proposed. In [8]-[11], probability based inter mode decision algorithms are proposed. In [9], Chiang proposes a H.264 encoding method based on statistical learning. Here, the best mode is determined using probability and statistic. In this paper, probability based fast inter mode algorithm is proposed which can decide the best mode without calculating the rate distortion cost maintaining a high rate distortion performance of the H.264/ AVC codec.

Rest of the paper is organized with rate distortion cost functions for H.264/AVC standard in section 2. The SKIP mode early termination algorithm is discussed in section 3. Then the proposed probability based fast inter mode algorithm is described in section 4. In section 5, results and discussion are analyzed comparing the standard and proposed algorithm.

2 Rate Distortion Cost Function for H.264/AVC Standard

The objective of using variable block size mode in H.264/AVC standard is to ensure precise motion prediction[12]. When a MB cannot be predicted well enough using a large block, it is suitable to divide it into small blocks and thus ensuring better motion compensation. But if it is possible to predict the MB with a large partition, there is no need for using smaller blocks because it introduces higher complexity calculating processing time. The general method to determine suitable partition size for a MB for best motion compensation needs to calculate rate distortion cost using the J_{SAD}, J_{SSD} or similar cost function. For J_{SSD}, sum of square of the difference of current MB and the predicted MB is calculated. In [9], rate distortion cost is define as Eq. (1).

$$J_{SSD}(S,C,Mode|QP) = SSD(S,C,Mode|QP) + \lambda.R(S,C,Mode|QP) \tag{1}$$

Where, λ is the Lagrangian multiplier and QP is the quantization parameter. The relation between Lagrangian multiplier and QP is found experimentally by Eq. (2):

$$\lambda = 0.85 \times 2^{\frac{(QP-12)}{3}} \tag{2}$$

The R in Eq.(1) can be written as

$$R = R_{header} + R_{motion} + R_{residual} \tag{3}$$

Where, R_{header}, R_{motion}, $R_{residual}$ are the number of bits needed to represent the header information, motion vectors and quantized residual block, respectively. $SSD(S,C)$ is the sum of the squared of the difference between the original blocks S and the reconstructed block C and it is defined as:

$$SSD(S,C) = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}(S_{ij} - C_{ij})^2 \tag{4}$$

Here, $S(i,j)$ is the (i,j) th element of the current block and $C(i,j)$ is the (i,j) th element of the reconstructed block. N is the image block size and equal to 4 for H.264. In equation (1) best mode is determined from a set of modes mentioned as :

$$Mode \in \{SKIP, Inter16\times16, Inter16\times8, Inter8\times16, Inter8\times8, inter4\times4, inter16\times16\} \tag{5}$$

Here, SKIP mode is an especial mode where no residual bit or motion is encoded. For J_{SAD} cost function, SAD value from the difference between the current MB and predicted MB is calculated. Here, J_{SAD} is defined as

$$J_{SAD} = \begin{cases} SAD(S,P) + \lambda_1.4K, & \text{if} \\ SAD(S,P), & \text{otherwise} \end{cases} \tag{6}$$

Where, $SAD(S,P)$ is the sum of absolute difference of the original block S and the predicted block P and defined as

$$SSD(S,P) = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1}(S_{ij} - P_{ij}) \tag{7}$$

Here, $S(i,j)$ is the (i,j) th element of the current block and $P(i,j)$ is the (i,j) th element of the predicted block. K is equal to 0 for probable mode and 1 for other modes and λ_1 is almost the square of λ and almost the exponential function of quantization parameter QP. Between these two cost function, SAD based cost function can save a lot of computation than the SSD based cost function because it does not need image reconstruction or variable length coding using CAVLC or CABAC like the SSD cost function. But this results a degradation of coding efficiency. To compensate that degradation, sum of absolute transformed differences (SATD) is widely used which uses frequency transform, usually H-SAD of the difference between the original blocks S and the reconstructed block C. It is complex method but takes less computation than SSD based cost function method and also have a better coding efficiency than SAD based cost function. Thats why H-SAD cost is considered for the proposed probability based fast inter mode algorithm.

3 Review on Skip Mode Early Termination

In most video sequence, some static and background images almost remain same. No motion or residual bits are encoded for these static portions of a video frame. This is called SKIP mode early termination. In mode of video sequences, substantial amounts of SKIP modes are present. In [13]-[14], a lot of work has been done to the SKIP mode prediction and states that SKIP mode can be considered as the best mode when the following conditions are satisfied.

1. The best motion compensation block size for this MB is 16×16.
2. The best reference frame is previous frame,
3. The best motion vector is the predicted motion vector.
4. The transform coefficient of the 16×16 block size is all quantized to zero.

The problem is that only the last three conditioned can be checked and this may miss predict the SKIP mode early termination. In the following section proposed probability base fast inter mode decision is explained and it is combined with skip mode to improve the coding efficiency.

4 Proposed Probability based Fast Inter Mode Decision Algorithm

It is seen from observation and rigorous simulations that, when a current MB is homogeneous by nature, the H-SAD cost between the current MB and the predicted MB is very small. On the other hand, for a homogeneous MB a large portion block is more suitable than the smaller one for motion prediction. Again, when the MB is non-homogeneous, the H-SAD cost between the current MB and the predicted MB increases depending on the complexity. As the complexity increases, the prediction cost also increases. In these cases, a small partition block is more suitable than a large one for better motion prediction. So, it can be said that when the H-SAD cost of a MB is small, the suitable modes are the large ones and for larger H-SAD cost the suitable modes are the smaller ones

4.1 Determination of large and small modes

As there are seven inter modes of different sizes and shapes including 16×16, 16×8, 8×16, 8×8, 8×4, 4×8 and 4×4 supported by H.264/AVC. There is also a SKIP mode which is employed to encode some static objects and background that remain almost same in adjacent frames. Modes 8×8, 8×4, 4×8 and 4×4 are considered as sub modes and are classified under Inter P 8×8 modes where $Interp8 \times 8 \in \{Inter8 \times 8, Inter8 \times 4, inter4 \times 8, inter4 \times 4\}$. Here we

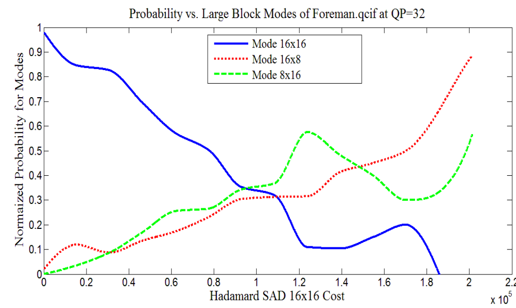


Fig. 1: Probability Characteristic Curve of Large modes for Foreman QCIF Video Sequence at QP=32.

have classified these 7 modes into two categories; Large modes and Small modes where, $Largemodes \in \{Inter16 \times 16, Inter16 \times 8, inter8 \times 16, inter16 \times 16\}$ and $Smallmodes \in \{Inter8 \times 8, Inter8 \times 4, inter4 \times 8, inter4 \times 4\}$

To determine the best mode for a MB, we first calculate the Hadamard cost of that MB. Then, we divide the MB into four 8×8 sub block and calculate Hadamard cost for each block to find Hadamard which is defined as

$$SSD_{P8\times8} = \sum_{i=0}^{3} SAD_{S8\times8} \quad (8)$$

where, i is the ith sub block of the MB. If the cost Hadamard $SAD_{16\times16}$ is equal or less than $SAD_{P8\times8}$ then we choose the large modes, otherwise we choose the small modes.

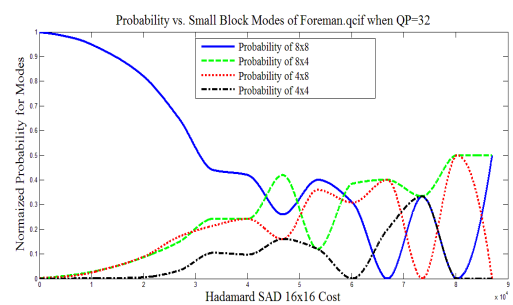
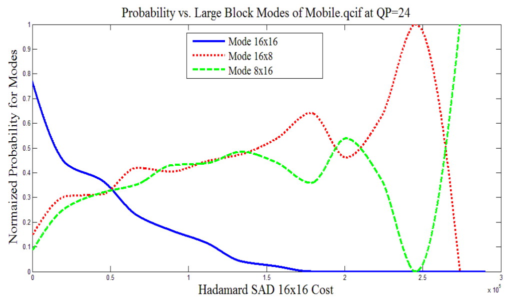


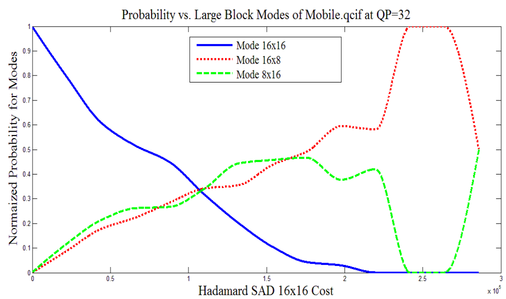
Fig. 2: Probability Characteristic Curve of Small modes for Foreman QCIF Video Sequence at QP=32.

4.2 Finding the best mode from large and small modes

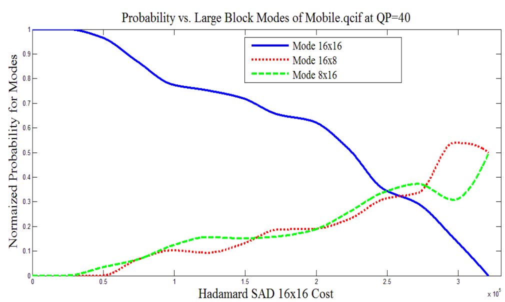
To determine the best mode from large modes we first take the Hadamard $SAD_{16\times16}$ cost of a MB. Then we find out which mode is the best for that cost for general cases. When a set of the Hadamard $SAD_{16\times16}$ costs are taken and their corresponding best mode is plotted in a curve an interesting characteristic of large modes is found. A characteristic curve for Foreman QCIF video sequence is shown in Figure 1.



(a)



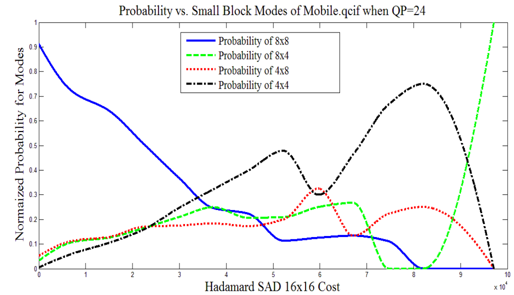
(b)



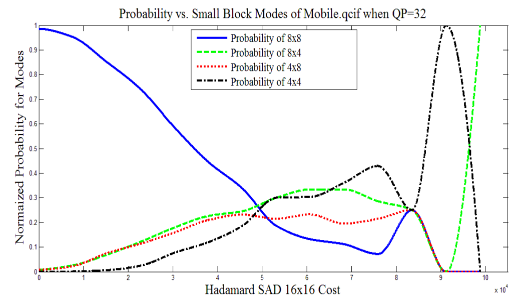
(c)

Fig. 3: Probability characteristic curve of Large modes for News QCIF Sequence at QP = 24, 32, 40. (a) QP=24. (b) QP=32. (c) QP=40.

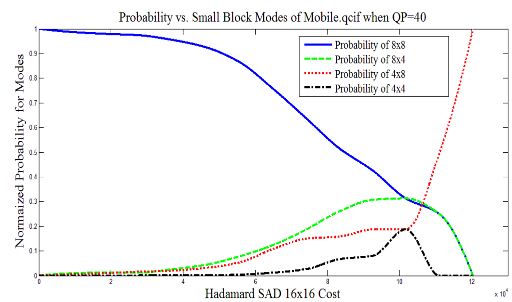
This is a normalized probability curve where it can be seen that a particular mode has a better probability of occurrence at a certain cost. To simplify this thing, we divide the data set into small chucks and find out the dominating mode with best probability. The range at which a certain mode dominates is marked with a threshold value. For three large modes (16×16, 16×8 and 8×16) two thresholds are enough to distinguish among them.



(a)



(b)



(c)

Fig. 4: Probability characteristic curve of Small modes for News QCIF Sequence at QP = 24, 32, 40. (a) QP=24. (b) QP=32. (c) QP=40.

To determine the best mode from the small ones Hadamard $SAD_{S8\times8}$ cost is calculated first for every sub-block and the probability of occurrence of each small mode to the value is found. Similar process can be applied to select the best sub mode. As there are four modes, three thresholds values are required to distinguish them. Characteristic curve for small modes of Foreman QCIF video sequence is shown in Figure 2.

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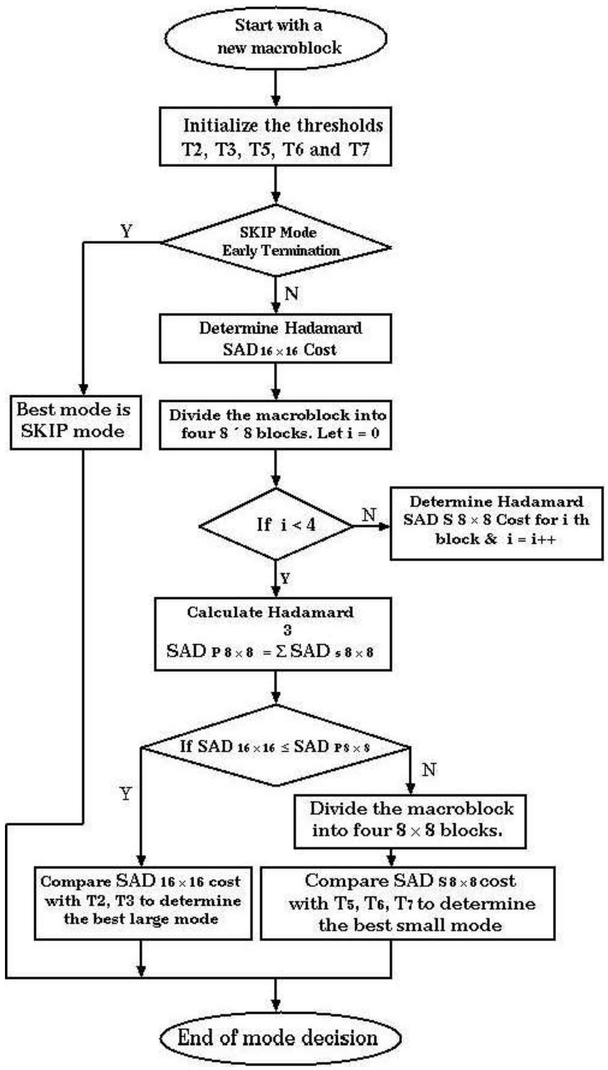


Fig. 5: Flow chart of proposed probability based Fast Inter Mode decision algorithm.

modes, three thresholds values are required to distinguish them. Characteristic curve for small modes of Foreman QCIF video sequence is shown in Figure 2. Finally, this algorithm is combined with SKIP mode early termination process to make it even faster.

4.3 Thresholds determination for each mode

There are seven inter modes of different sizes and shapes including 16×16, 16×8, 8×16, 8×8, 8×4, 4×8 and 4×4 supported by H.264/AVC. In this paper, these seven block sizes are classified into two categories i.e. Large Blocks (16×16, 16×8, and 8×16) and Small Blocks (8×8, 8×4, 4×8 and 4×4). At first, a MB is taken and its Hadamard $SAD_{16\times16}$ Transform cost calculated. Then the

Table 1: Thresholds T_2, T_3, T_5, T_6, and T_7 found by observation from the simulated probability versus 16×16 costs

Sequence		Large Blocks (Main Modes)		Small Blocks (Sub Modes)		
	QP	T_2	T_3	T_5	T_6	T_7
News	20	170300	20910	59400	14430	21540
	24	181500	52260	73690	21910	54710
	28	155900	62690	94940	26640	79920
	32	164100	112200	68650	39430	NAN
	36	187200	268300	114900	66410	NAN
	40	247500	267800	97100	71235	NAN
	QP	T_2	T_3	T_5	T_6	T_7
Foreman	20	122800	23350	36450	56740	16780
	24	147000	23220	39240	60100	23140
	28	151500	57860	48000	60800	37260
	32	148500	94910	58630	43580	NAN
	36	162400	191900	82630	72140	NAN
	40	231000	218500	79000	NAN	NAN
	QP	T_2	T_3	T_5	T_6	T_7
Mobile	20	148900	39690	60640	40320	32890
	24	194300	51060	91550	51320	33990
	28	212400	67450	39330	62330	41150
	32	164300	107200	48950	73110	83440
	36	201900	164900	67540	82680	87480
	40	277200	249700	101900	106500	NAN

characteristic curve of the probability of large modes vs. Hadamard $SAD_{16\times16}$ Transform cost of that MB is plotted. In this research, the probability of modes and vs. the initial MB cost characteristic curves of Mobile.qcif video sequence(100 frames) for different quantization parameter (QP=20, 24, 28, 32, 36, 40) are analyzed. Figure 3 and Figure 4 shows the characteristic changes between Large Modes and Small modes for different quantization parameters. From large modes probability characteristic curve, it has been observed that the range of domination of 16×16 mode increases as the quantization parameter increases. Similar scenarios are found from the small modes characteristic curves. Therefore, it is necessary to determine some thresholds for each mode to determine their range. But as the range for each mode varies with quantization parameter, the thresholds should be adaptive with quantization parameters.

4.4 Parameters Selection

In this paper, the proposed algorithm first determines whether the large modes are suitable or the small modes for a MB. Then, the large mode from the large modes category or the small mode from small mode category is selected as the best mode. As there are 3 large blocks, therefore, two thresholds T_2 and T_3 has been introduced to distinguish among them. 16×8 block is considered as the best mode if the initial cost is greater than T_2. If the initial

Table 2: Optimized thresholds T_2, T_3, T_5, T_6, and T_7 found using polynomial curvature theorem on the data

Sequence		Large Blocks (Main Modes)		Small Blocks (Sub Modes)		
News	QP	T_2	T_3	T_5	T_6	T_7
	20	170320	23320	64200	14372	21550
	24	181151	55551	81637	21776	54722
	28	154735	66892	107351	26384	79934
	32	161443	117202	87152	38990	NAN
	36	182092	273798	141461	65703	NAN
	40	238640	273240	108200	96021	NAN
Foreman	QP	T_2	T_3	T_5	T_6	T_7
	20	122784	24600	38680	56820	16780
	24	146980	25189	42422	60274	23140
	28	151475	60920	52330	61121	37260
	32	148470	99543	64313	44120	NAN
	36	162365	169207	89880	72992	NAN
	40	230960	228200	88040	NAN	NAN
Mobile	QP	T_2	T_3	T_5	T_6	T_7
	20	146000	39084	55520	40152	33700
	24	191714	50373	82839	50981	35041
	28	210708	66709	25576	61740	42468
	32	164257	106443	28392	72172	85050
	36	204472	164174	38073	81279	89406
	40	283600	249068	61040	104504	NAN

Table 3: RD and encoding time reduction of probability based inter mode decision algorithm

Sequence		Performance data					
Foreman	QP	20	24	28	32	36	40
	BIT Rate %	-8.722	-9.57	-8.50	-5.7	-2.4	-0.31
	PSNR-db	0.057	0.013	0.028	0.08	0.13	0.17
	Encoding Time (%)	63.70	58.62	11.28	39.7	40.0	43.66
News	QP	20	24	28	32	36	40
	BIT Rate %	-19.92	-21.46	-22.3	-6.0	-4.8	-3.58
	PSNR-db	0.218	0.175	0.175	0.09	0.10	0.071
	Encoding Time (%)	51.717	78.50	82.57	77.9	74.1	69.53
Mobile	QP	20	24	28	32	36	40
	BIT Rate %	-2.6087	-3.85	5.71	-6.7	-5.7	-3.69
	PSNR-db	0.102	0.11	0.068	0.05	0.09	0.078
	Encoding Time(%)	58.340	49.30	48.91	53.3	54.9	59.15

cost is greater than T_3 then 8×16 mode is selected. Otherwise, 16×16 mode is considered as the best mode.

Similarly, as there are 4 small modes, three thresholds T_5, T_6, T_7 are introduced to distinguish among them. For a greater value than T_5, T_6, T_7 8×4, 4×8 and 4×4 modes are considered as the best mode respectively. Otherwise, 8×8 mode is considered as the best sub mode. The threshold values for each mode are taken very carefully for different quantization parameters, QP = 20, 24, 28, 32, 36 & 40. Table 1 shows the thresholds for different video sequences for different quantization parameters obtained by observing and analyzing the mode vs. cost characteristic curves. To find out the optimized thresholds, polynomial curvature fitting theorem has been applied. Thus, optimized thresholds values of Foreman, News and Mobile QCIF video sequence for each quantization parameter are obtained which are shown in Table 2. Therefore, it is possible to use the data from Table 2 to get the thresholds values for determining the best inter mode.

4.5 Proposed Algorithm with Flowchart

The proposed probability based fast inter mode algorithm can be represented with the following steps:

Step 1: Initialize the thresholds T_2, T_3, T_5, T_6 and T_7 for a specific QP value.

Step 2: Select a macroblock and determine its Hadamard $SAD_{16\times16}$ cost.

Step 3: Check if the MB is suitable for SKIP mode, if not go to Step 4, if yes select skip mode as the best mode.
Step 4: Divide the macroblock into four 8×8 sub blocks and determine Hadamard $SAD_{S8\times8}$ cost for each block and calculate them to find Hadamard $SAD_{P8\times8}$ cost.
Step 5: If Hadamard $SAD_{16\times16}$ cost is less or equal to Hadamard $SAD_{P8\times8}$ cost choose large modes category, otherwise small modes category.
Step 6: If Large mode category is chosen, compare the Hadamard $SAD_{(16\times16)}$ cost with the T_2 and T_3 to determine the best Large mode (16×16, 16×8 and 8×16).
Step 7: If small mode category is chosen, compare the $SAD_{(s8\times8)}$ of a sub block with the T_5, T_6 and T_7 to determine the best small mode (8×8, 8×4, 4×8 and 4×4).

The flow chart of the proposed algorithm is shown in Figure 5. Based on this algorithm it is possible to determine the best inter mode without calculating the rate distortion cost function.

5 Results and Discussion

Proposed probability based mode decision algorithm was tested using the first 100 frames of different kinds of video sequences of QCIF format. Among them Foreman has medium motion changes with dominant luminance changes. News has a low spatial details and changes in motion. Mobile has a complex horizontal and vertical motion with slow zooming and panning. The experiment has been carried out in the JVT 18.2 encoder and the parameters are listed as below:

– CABAC enabled;
– GOP structure is IPPPP;
– Maximum search range for motion estimation is 32;
– QP values are 20, 24, 28, 32, 36 and 40.

The thresholds values are determined by the experiment varied very slightly for different kinds of video sequences. Compared to the original H.264/AVC video encoder, proposed algorithm has reduced the computational time significantly by around 60% to 65% for different QP values which are shown in Table 3. Though the bit rate increases and PSNR has reduced slightly, but the degradation of video quality for is very low and considered almost negligible.Therefore, the proposed algorithm is applicable for real time applications where reducing computational time is preferable compensating the video quality with negligible distortion.

6 Conclusion

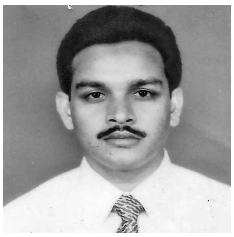
In this paper, a new probability based fast inter mode decision algorithm is proposed for H.264/AVC. A suitable macroblock is determined by classifying the inter modes of H.264 into large and small modes. Comparing with the initial Hadamard cost, the probability of each large and small mode is determined. Then the best mode can be obtained from their probability characteristics. Thus, it is possible to determine the best inter mode only by using this cost function rather than using rate distortion cost. Moreover, it avails the platform to determine the best mode without comparing the cost of each mode to other modes.Experimental results demonstrate that the proposed algorithm can reduce 60% to 65% of the total encoding time while the RD performance is almost the same as the original H.264/AVC encoder. The developed algorithm is very efficient and applicable for further hardware implementation.

References

[1] I. E. G. Richardson, H.264 and MPEG-4 video compression; video coding for next generation multimedia. John Wiley and Sons,(2003).
[2] T. Wiegand, G. J. Sullivan, G. Bjontegaard, and A. Luthra, Overview of the H.264/ AVC video coding standard, IEEE Trans. Circuits Syst. Video Technol.13,560-576(2003).
[3] X. Jing and L. P. Chau. Fast approach for H.264 inter mode decision. Electron, Lett.40,1051-1052(2004).
[4] T. Y. Kuo and C. H. Chan, Fast variable block size motion estimation for H.264 using likelihood and correlation of motion field. IEEE Trans. Circuits Syst. Video Technol.16,1185-1195 (2006).
[5] Z. Y. Wei, K. N. Ngan, A Fast Macroblock Mode Decision Algorithm for H.264. Proceedings of the IEEE Signal Processing.1,243-246(2005).
[6] Y. M. Lee, Y. T. Sun, and Y. Lin, SATD- Based Intra Mode Decision for H.264/AVC Video Encoding, IEEE, Trans. on Circuits and Systems for Video Technology,20,463-469,(2010).
[7] Shimei Su, Bing Zhou, Xueli Huang, A Novel Fast Inter Mode Decision Algorithm for H.264/AVC, Journal of Mulmedia, 6,285-292(2011).
[8] I. Choi, J. Lee, B. Jeon, Fast coding mode selection with rate-distortion optimization for MPEG-4 Part-10 AVC/ H.264. IEEE Trans, Circuits Syst, Video Technol.16,1557-1561(2006).
[9] Chen- Kuo Chiang and Shag-Hong Lai, Fast H.264 Encoding Based on Statistical Learning, PCM 2010, Part II, LNCS 6298, 179-189(2010).
[10] Ma, W. , Yang, S. Gao L., Pei, C., Yan, S. , Fast Mode Selection Scheme for H.264/ AVC Inter Prediction Bsed on Statistical Learning Method, IEEE International Conference on Multimedia and Expo. ICME (2009)
[11] Y. H. Kim, J. W. Yoo, S. W. Lee et al., Adaptive mode Decision for H.264 encoder, Electron. Lett.40,1172-1173(2004).
[12] Pengyu Liu , Kebin Jia, A Fast Mode Decision Scheme with Variable Block Sizes in H.264/AVC, International Conference on Intelligent Systems Design and Applications.3,368 371(2008).

[13] Liquan Shen, Zhi Liu, Tao Yan, Zhaoyang Zhang, Ping An, Early SKIP mode decision for MVC using inter-view correlation Journal of Signal Processing-image Communication - SIGNAL PROCESS-IMAGE COMMUN.25,88-93(2010).

[14] Pei Tao, Guang Jiang, Wei Li An adaptive early termination algorithm of fast mode decision for multiview video coding, International Conference on Audio, Language and Image Processing (ICALIP),201 205(2012).



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