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DCT Based Fast INTRA Mode Decision Method for HEVC Coding

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Abstract. *High Efficiency Video Coding (HEVC) can significantly improve coding efficiency by using 35 intra prediction modes, which lead to a substantial increase in coding complexity yet. In this paper, a fast intra mode decision method for HEVC based on DCT is proposed. The algorithm estimates the texture direction of the prediction block (PB) by using discrete cosine transform and reduces the number of candidate INTRA modes by using the texture direction of the PB. Experimental results show that in the high speed condition, the algorithm can achieve averagely 42.68% coding time saving, 2.89% BD-Rate increasing and 0.166dB BD-PSNR degradation; in the high quality condition, the algorithm can achieve averagely 24.69% coding time saving, 0.92% BD-Rate increasing and 0.0515dB BD-PSNR degradation.*
Keywords: DCT, HEVC, INTRA Prediction.

1. **Introduction.** The High Efficiency Video Coding (HEVC) standard, which was developed by the Joint Collaborative Team on Video Coding (JCT-VC), had been issued to deal with the growing demands of high resolution video services. Similar to the prior video coding standards, HEVC adopts hybrid video coding tools including INTER/INTRA prediction, transform coding and entropy coding, etc. Meanwhile, compared with H.264/AVC, HEVC adopts many new video coding techniques such as coding quadtree structure, transform quadtree structure, etc. These new coding tools enable HEVC to achieve about 50% bit-rate reduction with equal video quality in coding high definition videos [1].

In television stations, video editions such as program splicing are always demanded. As the HEVC INTRA coding doesn't demand frame re-ordering, many video editing softwares only compress video data by INTRA coding techniques so that the compressed video data can be easily edited. However, as the resolution of videos is becoming higher and higher and INTRA coding techniques of HEVC is complex, fast HEVC INTRA coding algorithms are highly desired by video editing softwares.

The software reference model of HEVC has adopted a fast INTRA prediction mode decision algorithm (named as HM algorithm in this paper) to reduce the coding computation. For the prediction unit (PU), Rough Mode Decision (RMD) and rate-distortion optimization (RDO) are applied to select the best INTRA prediction mode. Firstly, HM 12.0 determines the best n candidate modes selected by the Rough Mode Decision (RMD) process where all modes are caculated by Sum of Absolute Difference (SAD). The parameter n is set according to the size of PU. In addition, considering the fact that the neighboring prediction blocks (PBs) have strong correlations with each other, the Most Probable Modes (MPMs) derived from the neighboring blocks INTRA prediction modes are also added to the candidate set. Then, the rate-distortion optimization (RDO) process is utilized to derive the optimal INTRA prediction mode from the candidate set.

Apart from the fast algorithms of HM 12.0, other fast INTRA coding algorithms have been proposed by researchers. In Ref. [2], A regular spatial domain filtering technique is proposed to compute the dominant edge strength to reduce the possible INTRA prediction modes. In Ref. [3, 4, 5], the DCT coefficients of the PB are used to roughly extract the texture direction of the PB, then only several INTRA prediction modes are used to construct the candidate set. In Ref. [6], the CU texture complexity and the correlation between the current CU and neighbouring CUs are adaptively taken into consideration for the fast decision of the CU split and the CU depth search range. In Ref. [7], a fast bottom-up pruning algorithm based on the block structures of its sub-CUs is proposed to selectively skipped the mode decision at a large CU. In Ref. [8], a fast INTRA coding algorithm consisting of CTU depth range prediction, CU size decision and two-step mode decision is proposed. In Ref. [9], a fast mode decision algorithm, including motivating observations and implementation issues, is proposed to reduce the candidates in RDO process. It provides 20% and 28% time savings in high efficiency and low complexity cases respectively when it is compared with the default encoding scheme in HM 1.0.

Though lots of DCT based methods have been suggested to reduce the complexity of the INTRA coding of HEVC, some issues should be further explored to improve the performance. Firstly, as HEVC uses 35 INTRA prediction modes, the mapping relationships between the texture directions and the INTRA prediction modes need to be derived. Besides, current algorithms only support fixed PB size, so we need to find a way to support flexible PB sizes (such as 4×4, 8×8, 16×16, 32×32 and 64×64).

A new DCT based fast INTRA mode selection algorithm for HEVC is proposed in this paper, which uses DCT to estimate the texture direction of PBs and reduces the number of candidate INTRA modes. In Section 2, the mapping relationships between the DCT data of PB and INTRA modes is derived and detailed fast INTRA mode selection method is also presented. Then, Section 3 provides the experimental results of our proposed algorithm, and Section 4 concludes the paper.

2. **Proposed fast INTRA mode selection algorithms.** The 35 INTRA prediction modes of HEVC are constructed by 33 direction prediction modes (INTRA angular modes) and two special prediction modes (DC and Planar prediction modes), as shown in FIGURE 1. In order to find out the most optimal INTRA mode, all the prediction data of each mode should be generated and compared, but the complexity of such process is very high. Thus, if we can reduce the number of INTRA candidates, the computation complexity of the INTRA mode selection will decrease as well. As the DC and Planar prediction modes are direction irrelevant, these two modes can be excluded by the candidate set if we use the texture feature of PB data to select INTRA modes. In order to verify the effect of these two modes, we set up an analyzing experiment. Several test sequences were coded by the HM 12.0, and the percentages of PBs which were coded by using DC and Planar modes are shown in TABLE 1. TABLE 1 shows that averagely 40% of PBs use DC and Planar modes. Obviously, these two modes are very effective in INTRA coding. Thus, the candidate set of our fast INTRA mode selection method is initially constructed by

DC and Planar prediction modes, then the candidate set will extend with other INTRA angular prediction modes.

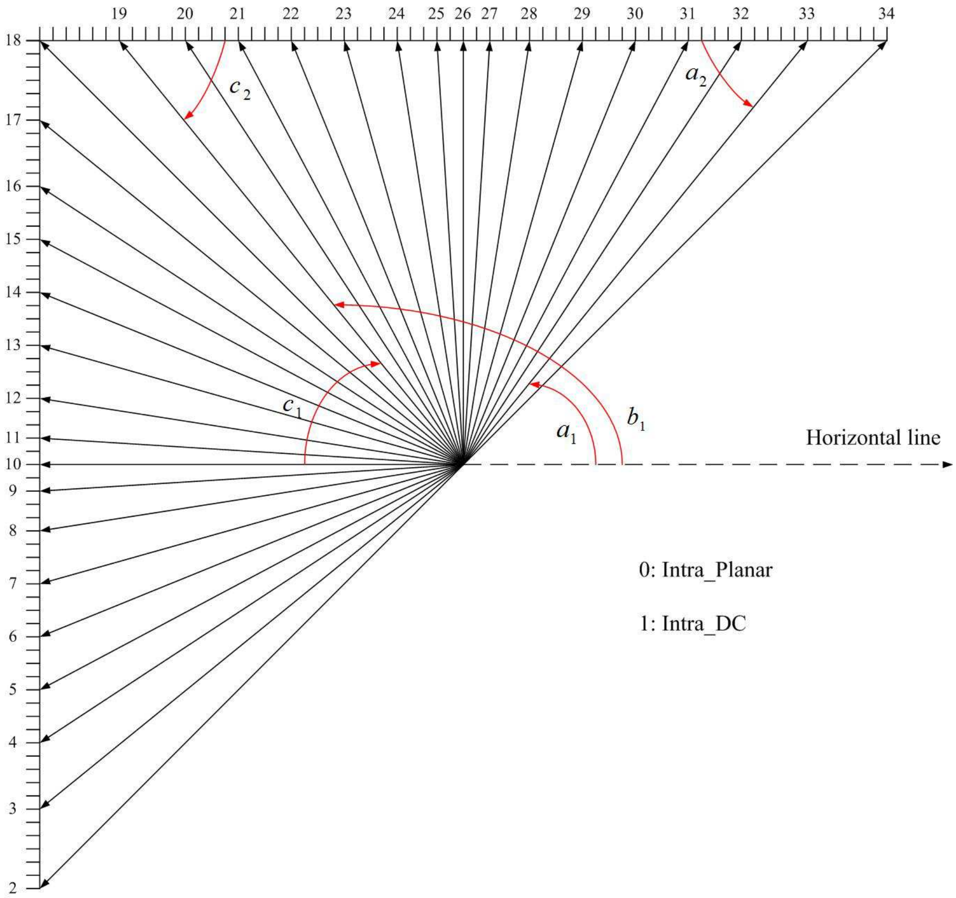

FIGURE 1. 35 INTRA prediction modes for luma component in HEVC.

Each INTRA angular mode corresponds to a certain texture feature of the PB data. For example, when the INTRA prediction mode is 34, PB size is 4×4, as shown in FIGURE 2, the pixels in the PB are projected to the reference line along the right upper diagonal direction, and the INTRA prediction data is assigned by the corresponding pixels. The detailed method to calculate the corresponding prediction direction angle of each INTRA mode is shown in equation (1). The prediction directional angle θ means the angle between its prediction direction and the positive horizontal axis, and d of equation (1) is a parameter related to the INTRA angular prediction mode. Obviously, if the projecting direction of one INTRA angular mode is consistent with the texture feature of the PB, this INTRA angular mode will get good prediction performance. Thus, if the texture feature of the PB is used to select the INTRA modes, the complexity of INTRA mode selection can be reduced. So we have to get the texture feature of each PB first.

$$\theta = \begin{cases} \arctan \frac{32}{d}, & AngularModes26to34 \\ \arctan \frac{d}{32}, & AngularModes2to10 \\ 180^\circ - \arctan \frac{32}{-d}, & AngularModes18to26 \\ 180^\circ - \arctan \frac{-d}{32}, & AngularModes10to18 \end{cases} \tag{1}$$

DCT of image data is an effective method to derive the texture features. After applying DCT on PB data, every DCT coefficient represents a basis image with specific texture

Table 1. Percentage of PBs coded by using DC and Planar modes

Test Sequences	PU Size	DC (in %)	Planar (in %)	DC and Planar (in %)
BasketballDrill 832×480	64	2.56	78.39	80.95
	32	6.58	44.87	51.45
	16	10.49	16.99	27.48
	8	12.28	10.09	22.37
	4	17.62	9.57	27.19
RaceHorses 416×240	64	20.37	75.93	96.3
	32	24.54	53.48	78.02
	16	22.31	34.87	57.18
	8	22.93	18.38	41.31
	4	25.73	15.26	40.99
vidyo1720p 1280×720	64	23.48	48.33	71.81
	32	23.60	23.94	47.54
	16	23.53	10.67	34.2
	8	24.08	9.97	34.05
	4	26.75	8.44	35.19

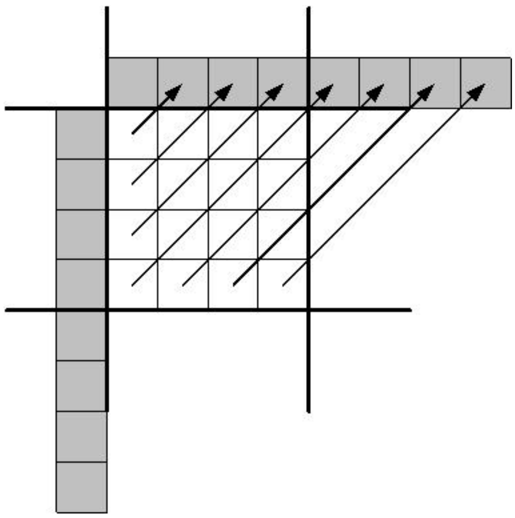

Figure 2. Example of generating a predicted PB by using corresponding reference pixels when the INTRA prediction mode is 34.

features. Moreover, the absolute value of one DCT coefficient can reflect the similarity of the texture feature between the PB and the corresponding basis image. For example, the basis images of the DCT coefficients in the first row have the vertical direction tendency. Similarly, the basis images of the DCT coefficients in the first column have the horizontal direction tendency. If we use E_v and E_h to denote the horizontal and vertical features of the PBs respectively, these two parameters can be estimated as:

$$\begin{cases} E_v = \sum\limits_{v=0}^{N-1} |F(0,v)| \\ E_h = \sum\limits_{u=0}^{N-1} |F(u,0)| \\ \theta = \arctan \frac{E_v}{E_h} \\ \delta = F(1,0) \times F(0,1) \end{cases} \tag{2}$$

$F(u,v)$ is the DCT coefficient in the ith row and jth column of the DCT data matrix, and θ represents the angle estimation of the PBs texture direction. Because each of the 33 angular modes corresponds to one prediction direction, the mapping relationships between the 33 angular modes and the prediction directional angles can be derived. As shown in TABLE 2, the prediction directional angle means the angle between its prediction direction and the positive horizontal axis. Take the INTRA prediction mode 33 as an example, as shown in FIFURE 1, its prediction directional angle is a_1. The angle $a_2 = \arctan(32/26) = 50.91°$. According to the parallel lines theorem, the angle a_2 is equal to a_1. Thus, $a_1 = a_2 = \arctan(32/26) = 50.91°$. For another example, the prediction directional angle of the mode 19 is b_1, whose complementary angle is c_1, and the parallel angle of c_1 is c_2. According to the property of the isosceles triangular, c_2 is equal to a_2.

As θ in equation (1) always gets a positive value, the prediction directional angles of the mode 33 and 19 correspond to the same θ. In addition, we use δ to further refine the corresponding mode. If $\delta \geq 0$, the modes in the first column of TABLE 2 are selected as the corresponding modes of θ, otherwise, the modes in the second column are selected. Furthermore, we also extend each texture angle to an angle range, so that an arbitrary θ whose range between 0° to 90° can be mapped with one of the 33 INTRA prediction modes. Take the mode 13 as an example, its directional angle is 15.71°, and its neighbors are the mode 12 and mode 14, then we set the up/down angle range (R_{13}^{up}/ R_{13}^{dn}) for the mode 13 by:

$$\begin{cases} R_{13}^{up} = ((Angle_{12}) + (Angle_{13}))/2 = 12.30° \\ R_{13}^{dn} = ((Angle_{13}) + (Angle_{14}))/2 = 18.91° \end{cases} \tag{3}$$

Applying similar method to INTRA prediction modes, the θ ranges can be derived as the forth column of TABLE 2. For an arbitrary θ, it will be fitted in one of the ranges shown in TABLE 2, and one INTRA mode in the first or second column of TABLE 2 will be selected as the corresponding mode of the θ.

However, as only one INTRA mode will be selected by θ and the texture feature of the PB may not be strictly identical with it, the selected INTRA mode is always suboptimal. Thus, we need to extend the θ to a reasonable range so that the optimal INTRA mode can be included. We carried out statistic experiments to find out the proper extending range, and the following conditions were used in our statistic experiments:

1. The HM 12.0 configured as high efficiency was used as the reference HEVC encoder. Test sequences were PeopleOnStreet (2560×1600 Class A), Kimono (1920×1080 Class B), RaceHorses (832×480 Class C), BlowingBubbles (416×240 Class D), Vidyo4 (1280×720 Class E), the quantization parameter was set as: 22, 27, 32, 37, and the test sequences were coded as all INTRA frame.

2. In order to compensate for the error of our calculation formulas for the texture direction, we gradually extended the angle range with up/down directions to include more INTRA modes of TABLE 2 into the INTRA mode candidate set. Once the encoding

Table 2. Relationships between the angular prediction modes and texture directions of PB data

$\delta \geq 0$	$\delta < 0$	Mode Angle	Range of θ
10	10	0°	[0.00°, 1.79°)
11	9	3.58°	[1.79°, 6.23°)
12	8	8.88°	[6.23°, 12.30°)
13	7	15.71°	[12.30°, 18.91°)
14	6	22.11°	[18.91°, 25.05°)
15	5	27.98°	[25.05°, 30.63°)
16	4	33.27°	[30.63°, 36.18°)
17	3	39.09°	[36.18°, 42.05°)
18	2/34	45°	[42.05°, 47.96°)
19	33	50.91°	[47.96°, 53.82°)
20	32	56.73°	[53.82°, 59.38°)
21	31	62.02°	[59.38°, 64.96°)
22	30	67.89°	[64.96°, 71.09°)
23	29	74.29°	[71.09°, 77.71°)
24	28	81.12°	[77.71°, 83.77°)
25	27	86.42°	[83.77°, 88.21°)
26	26	90°	[88.21°, 90.00°]

quality of the candidate set reached the same quality as the reference encoder in condition of the bitrate difference less than 0.5%, and PSNR difference less than 0.01dB, we considered that the optimal INTRA mode had been included by the candidate set.

We set two constant parameters m and n. m means the number of angular prediction modes selected for the RMD process, and n means the number of INTRA angular prediction modes selected for the following RDO process. On the one hand, m should be set as small as possible, so that only a little part of INTRA prediction modes need to be traversed by the INTRA prediction mode selection process, which can largely reduce the encoding time. On the other hand, m can not be too much small, otherwise the real optimal INTRA prediction mode might be excluded by the candidate set, which directly affects the prediction accuracy and encoding quality. As for the parameter n, it should be set in the same manner as the parameter m.

In order to find the best combination of the parameter m and n, a series of experiments had been completed. We tested different sequences with different m and n. Firstly, we carried out the experiments related to m. We used the experimental conditions mentioned above, and 50 frames selected randomly from each test sequence were encoded. Since different PU blocks have different texture direction errors, we used different prediction angle ranges which are associated to the value of m in different sequences and PU blocks sizes. That means, we should select the appropriate m for a certain sequence and PU size. The results are shown in TABLE 3.

Then we carried out experiments by using different pairs of m and n. One of the experimental results is shown in TABLE 4. The test sequence was RaceHorses in class D, and 30 frames selected randomly from the whole test sequence were encoded. The QP value was set to 32. When the pair of m and n was determined, the corresponding data means the percentage of the real optimal INTRA prediction mode contained in the candidate set. For example, if the PB size is 64×64, m and n are set to 7 and 3 separately, then the percentage of the real optimal INTRA prediction mode gotten by the proposed

TABLE 3. Deviation between the coarse texture direction and the actual optimal prediction direction

Test Sequences	PU Size	angle offset (in degree)	prediction angle range(in degree)
PeopleOnStreet	64×64	5.625	11.25
	32×32	11.250	22.50
	16×16	16.875	33.75
	8×8	16.875	33.75
	4×4	11.250	22.50
Kimono	64×64	0.000	0.000
	32×32	0.000	0.000
	16×16	5.625	11.25
	8×8	5.625	11.25
	4×4	5.625	11.25
RaceHorsesC	64×64	5.625	11.25
	32×32	11.250	22.50
	16×16	22.500	45.00
	8×8	16.875	33.75
	4×4	16.875	33.75
BlowingBubbles	64×64	11.250	22.50
	32×32	16.875	33.75
	16×16	28.125	56.25
	8×8	28.125	56.25
	4×4	28.125	56.25
vidyo4	64×64	5.625	11.25
	32×32	11.250	23.94
	16×16	16.875	33.75
	8×8	22.500	45.00
	4×4	16.875	33.75

DCT based fast INTRA mode selection process is 90.74%. While, if the PB size is 8×8, we need to set $m = 13$ and $n = 15$ to obtain an accuracy of about 94%. Thus, the performance of our DCT based fast INTRA mode selection algorithm is adjustable, and different m and n could be selected to balance the coding complexity and compression efficiency in various applications.

In summary, our fast INTRA mode decision methods are completed with following steps:

0. Select m and n according to TABLE 4 and the application requirements. For high speed, m and n should be as small as possible, but the percentage of the optimal INTRA prediction mode hit by our algorithm shouldn't below 70%. So we set m: 1, 5, 5, 1, 1, and n: 3, 3, 3, 3, 2 for the PB sizes of 4×4, 8×8, 16×16, 32×32, 64×64. For high quality, we could select bigger m and n to increase the percentage of the optimal mode hit by our algorithm. So we set m: 7, 9, 7, 5, 3, and n: 4, 5, 6, 7, 4 for the PB sizes of 4×4, 8×8, 16×16, 32×32, 64×64.

1. Build an INTRA mode candidate set, which included the texture direction prediction modes selected by equation (1), equation (2), equation (3) and TABLE 2. However, there could be unavoidable errors when calculating. To compensate for the errors, the neighboring $m - 1$ angular prediction modes of the selected mode were added to the

Table 4. Percentage of the optimal INTRA prediction mode hit by the proposed DCT based fast INTRA mode selection process of RaceHorses under various pairs of m and n

PU	m	n														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Percentage of The Optimal INTRA Prediction Mode														
64	1	57.41	96.30	100.00												
	3	53.70	94.44	96.30	100.00	100.00										
	5	53.70	88.89	96.30	96.30	98.15	100.00	100.00								
	7	51.85	87.04	90.74	96.30	98.15	98.15	100.00	100.00	100.00						
	9	50.00	81.48	88.89	94.44	98.15	98.15	98.15	100.00	100.00	100.00	100.00				
	11	48.15	81.48	85.19	90.74	96.30	98.15	98.15	98.15	100.00	100.00	100.00	100.00	100.00		
	13	48.15	77.78	85.19	88.89	92.59	96.30	98.15	98.15	98.15	100.00	100.00	100.00	100.00	100.00	100.00
32	1	41.03	63.37	72.16												
	3	40.29	59.34	65.20	69.96	74.36										
	5	40.66	60.81	64.10	69.60	73.26	76.19	79.12								
	7	39.56	59.34	63.00	67.40	72.53	75.09	76.92	78.75	81.32						
	9	39.19	59.34	62.27	66.67	71.06	74.73	77.66	79.49	80.22	81.32	83.52				
	11	38.83	57.51	61.90	64.84	69.96	73.99	76.92	79.85	80.95	82.05	83.15	84.62	85.35		
	13	39.19	56.04	60.81	64.84	68.50	73.63	76.19	79.12	81.32	82.05	83.52	85.35	86.45	87.18	87.18
16	1	43.54	57.22	61.99												
	3	48.80	62.93	68.09	71.40	73.53										
	5	49.89	64.75	70.32	73.70	75.99	77.90	79.15								
	7	50.16	65.12	70.91	74.76	77.46	79.41	80.83	81.94	82.79						
	9	50.19	65.20	71.16	75.26	78.32	80.58	82.22	83.45	84.34	85.02	85.59				
	11	50.23	65.14	71.20	75.47	78.70	81.29	83.12	84.46	85.58	86.38	87.01	87.45	87.78		
	13	50.13	65.03	71.20	75.58	78.90	81.56	83.63	85.17	86.38	87.33	88.09	88.64	89.06	89.34	89.54
8	1	54.87	67.63	71.89												
	3	58.32	72.19	77.09	79.61	81.04										
	5	59.22	74.03	79.46	81.99	83.65	85.03	85.95								
	7	59.53	74.59	80.44	83.28	85.25	86.62	87.60	88.45	89.01						
	9	59.65	74.89	80.92	84.01	86.15	87.71	88.86	89.69	90.36	90.88	91.25				
	11	59.69	75.08	81.20	84.41	86.67	88.41	89.65	90.62	91.38	91.98	92.40	92.71	92.94		
	13	59.73	75.17	81.45	84.70	87.06	88.83	90.21	91.27	92.11	92.80	93.32	93.70	94.36	94.55	94.69
4	1	68.06	80.07	84.19												
	3	68.98	80.60	84.82	87.23	88.66										
	5	69.36	81.29	85.67	87.64	89.07	90.54	91.46								
	7	69.52	81.63	86.14	88.18	89.71	90.90	91.85	92.78	93.38						
	9	69.61	81.79	86.40	88.49	90.07	91.32	92.32	93.13	93.77	94.35	94.75				
	11	69.64	81.91	86.54	88.67	90.29	91.58	92.61	93.45	94.15	94.70	95.13	95.48	95.74		
	13	69.66	82.00	86.71	88.83	90.48	91.78	92.86	93.71	94.42	95.02	95.50	95.88	96.55	96.76	96.93

candidate set. Besides, DC and Planar prediction modes were probably selected as the optimal mode, so these two modes were also added to the candidate set.

2. The standard RMD of HM 12.0 was used to refine the candidate set. The SAD values of all the modes in the candidate set were calculated.

3. Select the first n INTRA modes with lower SAD values to build a candidate set for the following RDO process. To ensure the continuity and consistency of neighboring PBs, Most Probable Modes (MPMs) derived from the neighboring PBs were also added to the RDO candidate set.

4. At last, the RDO process was applied to achieve the most optimized INTRA mode.

FIGURE 3 shows the flow chart of our fast INTRA mode decision algorithm process.

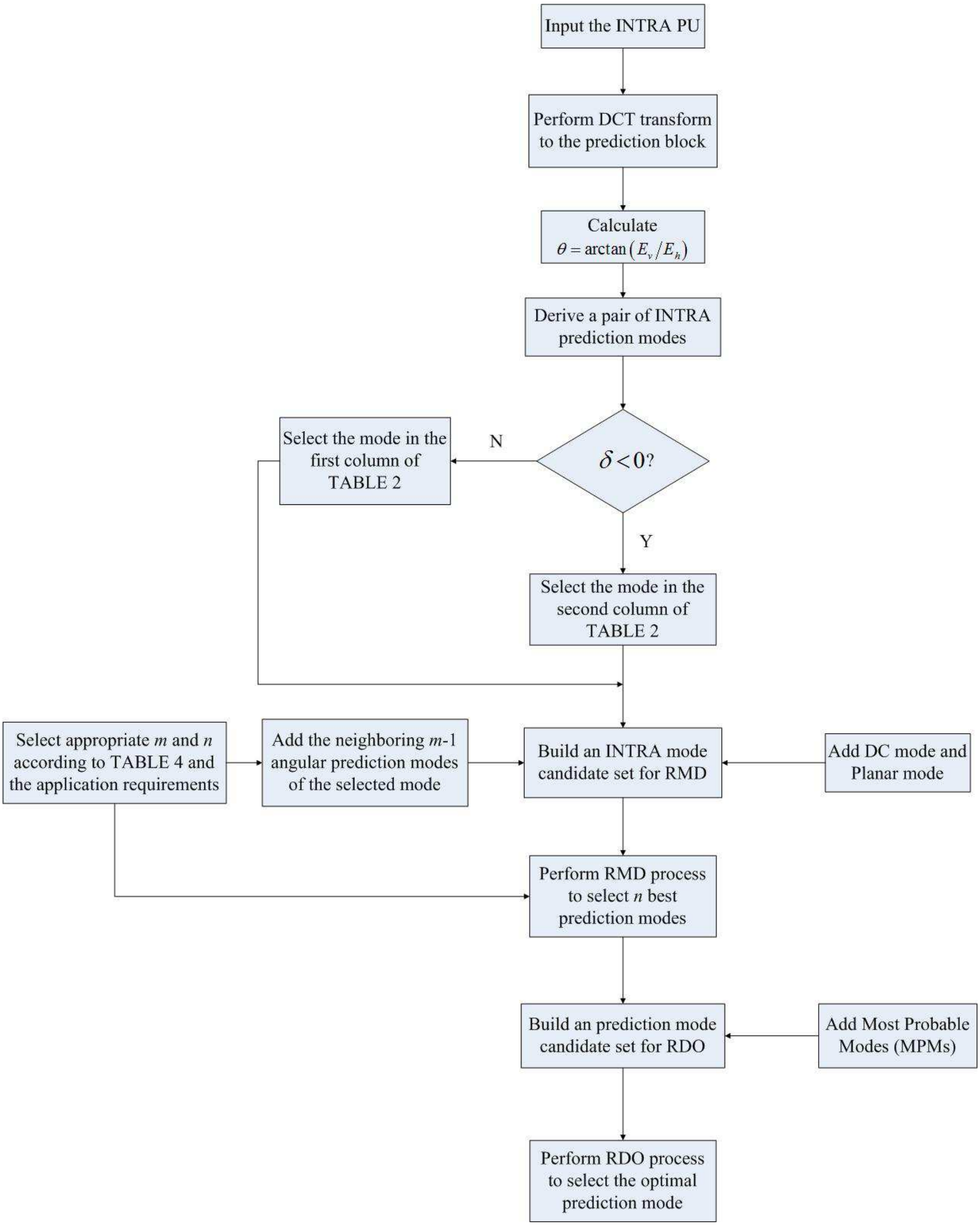

FIGURE 3. The flow chart of our fast INTRA mode decision steps.

3. **Experimental Results and Discussions.** The proposed algorithm was implemented on the HEVC reference software HM 12.0 [10]. The test platform was Intel Xeon CPU E31230-3.20GHz with four cores, 8.0G RAM. Test video sequences were coded in all INTRA frame with high efficiency (HE) test conditions [11], and the QP = 22, 27, 32 and 37. The performance of the proposed fast INTRA mode selection was evaluated by the Bjontegaard method [12].

To achieve better tradeoff between the coding efficiency and the computation complexity, we got two sets of the values of m and n. The first set: m is set to 1, 5, 5, 1, 1 for

4×4, 8×8, 16×16, 32×32, 64×64 and n is set to 3, 3, 3, 3, 2 for the PB sizes of 4×4, 8×8, 16×16, 32×32, 64×64. TABLE 5 shows the experimental results of the proposed algorithm compared with the HM 12.0 reference algorithm. As depicted in TABLE 5, the proposed method obtains about 42.68% of the time saving, while the bit rate increases by about 2.89% and PSNR-Y decreases by about 0.166dB, which is a condition of high speed and low quality. The second set: m is set to 7, 9, 7, 5, 3 for 4×4, 8×8, 16×16, 32×32, 64×64 and n is set to 4, 5, 6, 7, 4 for 4×4, 8×8, 16×16, 32×32, 64×64 PB sizes. TABLE 6 shows the experimental results. We can see that the proposed method obtains about 24.69% of the time saving, while the bit rate increases less obvious by only about 0.92% and PSNR-Y decreases by about 0.0515dB, which is a condition of high quality and low speed. The encoding speed becomes much faster.

Although applying DCT to the PB data can cause some extra computation cost, the proposed algorithm can still reduce the computation cost of the INTRA mode decision process significantly. Thats because our algorithm much reduce the number of modes that need to deal with the RMD process and RDO process. Specifically, the proposed algorithm only need to apply once DCT to the PB data, then we can reduce the number of modes which need to deal with the Hadamard Transform (the computation costs of Hadamard Transform and the DCT are very close) and RDO process from 35 to less than 10 modes generally. For example, as for a 4×4 PU, according to the proposed algorithm, you just need to select 7 direction prediction modes from all the 33 direction prediction modes to enter the RMD process together with the DC and Planar modes, then select 4 modes of them to enter the next RDO process. The probability of the final selected mode is the real optimal INTRA prediction mode can reach 88.2%. So our algorithm can no doubt reduce the computation cost significantly.

Table 5. Comparison between our algorithm and the HM 12.0 reference algorithm with the first set of m and n

Sequences		BDR(in dB)	BDP(in dB)	TS(in %)
Class A (2560×1600)	Traffic	2.01	-0.1080	43.9415
	PeopleOnStreet	2.14	-0.1211	45.9622
Class B (1920×1080)	Kimono	0.51	-0.0182	41.3802
	ParkScene	1.18	-0.0528	44.2831
	Cactus	2.53	-0.0938	42.0882
	BQTerrace	2.43	-0.1396	42.0783
	BasketballDrive	2.75	-0.0732	38.4488
Class C (832×480)	RaceHorses	1.75	-0.1136	49.4929
	BQMall	3.07	-0.1798	42.3895
	PartyScene	3.42	-0.2611	36.9131
	BasketballDrill	4.74	-0.2247	38.5175
Class D (416×240)	RaceHorses	3.36	-0.2192	43.3723
	BQSquare	5.21	-0.4508	37.2303
	BlowingBubbles	3.38	-0.2013	49.6154
	BasketballPass	4.28	-0.257	40.0199
Class E (1280×720)	Vidyo1	3.39	-0.1702	40.8597
	Vidyo3	3.57	-0.1984	44.7481
	Vidyo4	2.3	-0.1051	46.9608
	Average	2.89	-0.166	42.6834

Table 6. Comparison between our algorithm and the HM 12.0 reference algorithm with the second set of m and n

Sequences		BDR(in dB)	BDP(in dB)	TS(in %)
Class A (2560×1600)	Traffic	0.76	-0.0412	27.8031
	PeopleOnStreet	0.52	-0.0297	24.5556
Class B (1920×1080)	Kimono	0.09	-0.0038	28.6425
	ParkScene	0.44	-0.0201	23.7105
	Cactus	0.81	-0.0238	28.5205
	BQTerrace	0.77	-0.0451	21.4774
	BasketballDrive	0.98	-0.0260	19.6892
Class C (832×480)	RaceHorses	0.57	-0.0366	25.6763
	BQMall	0.97	-0.0575	19.8709
	PartyScene	1.24	-0.0956	20.4580
	BasketballDrill	1.64	-0.0785	18.1086
Class D (416×240)	RaceHorses	1.02	-0.0662	20.0131
	BQSquare	1.76	-0.1543	25.0394
	BlowingBubbles	1.19	-0.0735	26.1531
	BasketballPass	1.32	-0.0980	20.5484
Class E (1280×720)	Vidyo1	0.92	-0.0467	31.3125
	Vidyo3	0.94	-0.0522	29.0654
	Vidyo4	0.58	-0.0267	33.8480
	Average	0.92	-0.0515	24.6940

4. **Conclusions.** This paper presented a fast INTRA mode decision algorithm for HEVC. By using the texture information of the PBs extracted from DCT coefficients, the number of INTRA prediction modes that will take part in INTRA prediction mode decision process are reduced significantly, which results in obvious time saving and computation complexity reduction. In the high speed condition, the average time saving is about 42.68%, the average bit rate increase is about 2.89% and the average PSNR drop is 0.166dB. In the high quality condition, the average time saving is about 24.69%, the average bit rate increase is about 0.92% and the average PSNR drop is 0.0515dB. The experimental results prove that the proposed DCT based algorithm is efficient.

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