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Implementation Comparison of Intra Prediction Scheme

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Abstract**—**Due to increasing demand of video application such as video conference, video communication, video streaming and storage, video compression is required. Due to this requirement new international standard H.264 & H.265 HEVC are introduce for video compression. These standards improve video compression based on intra prediction. Intra prediction is a technique to enhance compression through use of neighboring pixels to predict current coding block. Intra prediction in H.264 / AVC is executed in the spatial domain, to predict with reference to neighboring samples of previously coded blocks to the left and / or above the block. There are total nine modes used to predict the current block. This work supports 4×4 block size and 16×16 block size for the prediction of the mode. The goal of this work is to reduce the computational complexity of intra prediction and to give accurate prediction result. In this work efficient intra prediction scheme is implemented and compared to literature.

Keywords*-Intra prediction, H.264, PSNR,computational complexity*

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I. Introduction

Video compression systems are used in many commercial products, from consumer electronic devices such as video conference, video communication, and video streaming systems. In order to improve the performance of the existing applications Intra prediction is main building blocks of the H.264 encoder.H.264 standard is not only depending on the intra prediction block but a combination of a number of encoding sub blocks. One of the most important factors of the improved compression efficiency of the H.264 is its intra prediction algorithm.

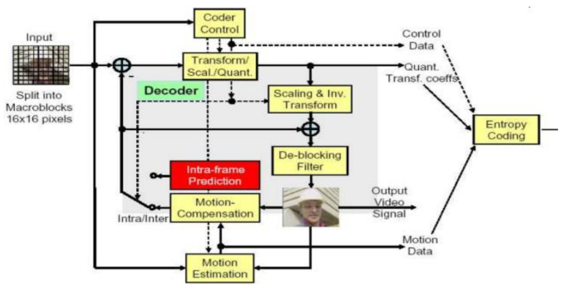

Fig:-1 blocks diagram of the H.264 encoder [6]

Intra prediction in H.264 / AVC is executed in the spatial domain, to predict with reference to neighboring samples of previously coded blocks to the left and / or above the block. This work supports 4×4 block size and 16×16 block size for the prediction of the mode. There are total nine modes used among that 8 are directional modes and 1 is non-directional mode named as DC. Fig 2 describes the 8 directional modes of4x4 intra prediction. The samples from a top of a 4×4 block are predicted by encoded samples A to M. In 16×16 intra prediction, the entire MB is predicted in the same mode. Four prediction modes are introduced in 16×16 intra prediction.

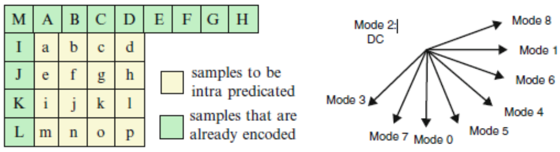

Fig: -2 Sample position in the 4× 4 macroblock [8]

If we calculate no of computation require for one full HD $(1920\times1080\ \frac{\text{Pixels}}{\text{frames}})$ frame we require 11,66,400 modes calculation so the number of computation is require more so the computation complexity will be increase. Here it require more time for the computation. Our goal is to reduced computation complexity with high efficiency. For that introduce fast intra prediction algorithm with reduce computation complexity. There are many fast intra prediction algorithms like Fast intra-mode decision algorithm[1], Pixel-Based Direction Detection (PDD) Method[2], Sub-blockBased Direction Detection (SDD) Method[2], Edge-Detection Method[5],Spatial Mode Prediction Method[5] etc. Here we compare Fast intra-mode decision algorithm [1] and Sub-blockBased Direction Detection (SDD) [2] and identified best algorithm based on the PSNR and reduction in computation.

Section 2 describes the fast Intra prediction algorithms. Section 3 describes simulation flow and simulation result. Section 4 Conclusion.

II. Fast Intra Prediction algorithm

In this sectiondifferent fast mode algorithm for the intra prediction are described. In order to reduce the computation, the direction detection algorithm and fast mode algorithm could be used to reduce the prediction modes**.**

FAST INTRA-MODE DECISION ALGORITHM [1]

Fast intra-mode decision algorithm presented in [1] is based on the dominant edge strength. Edges of the images are important features to characterize the contents. The edges are divided into five types as shown in Fig.3 there are 4 directional edges,

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which are vertical, horizontal, 45 diagonal, 135 diagonal, and 1 non-directional edge.

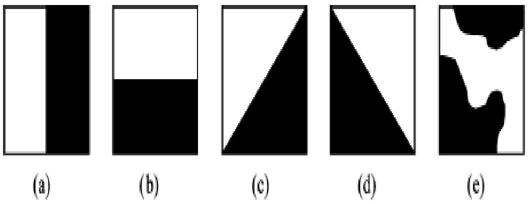

Figure: -3 Five types of directional non-directional edges. (a) Vertical edge. (b) Horizontal edge. (c) The 45 edge. (d) The 135 edge. (e) Non-directional edge. [1]

The edge detection process is based on a spatial domain filtering technique. In this first each original block is divided into 4 sub-blocks. The Each sub-block describes average magnitude of pixel. After that is obtain a 2×2 pseudoblock with a0, a1, a2, and a3 pixel values for the mode decision. For example, Fig.4 shows the computed pseudoblock of a 4×4 luma block, where the 2×2 pseudoblock with a0=(a+b+e+f)/4, a1=(c+d+g+h)/4, a2=(i+j+m+n)/4,and a3=(k+l+o+p)/4.

Fig: -4 Definition of sub-blocks for detection of the dominant edge and Computation of sub-blocks for detection of dominant edge (4×4 luma block) [1].

Let f^v ,f^h ,f^{45},f^{135} and f^{nd} denote the 2×2 filter coefficients for computing the vertical, horizontal, 45 diagonal, 135 diagonal, and non-directional edges , respectively.

The edge strength of each direction is derived from the filtering operation.

$$S^v = \sum_{n=0}^{3} a_n \times f_n^v \quad (1)$$

$$S^h = \sum_{n=0}^{3} a_n \times f_n^h \quad (2)$$

$$S^{45} = \sum_{n=0}^{3} a_n \times f_n^{45} \quad (3)$$

$$S^{135} = \sum_{n=0}^{3} a_n \times f_n^{135} \quad (4)$$

$$S^{nd} = \sum_{n=0}^{3} a_n \times f_n^{nd} \quad (5)$$

The dominant edge will be chosen as maximum value obtained from (1) to (5). Then dominant edge strength is expressed by

$$E_p = arg \max_{v,h,45,135,nd} \{S^v, S^h, S^{45}, S^{135}, S^{nd}\} \quad (6)$$

From the dominant edged strength mode operation is performed accordingly. Due to that number of searched modes is reduced from nine to four in a 4×4 luma block.If the non-directional edge is dominated then only nine modes are computed.

Sub-block Based Direction Detection (SDD) Method [2]

In this method first each original block is divided into 4 sub-blocks for direction detection. The Each sub-block computed from the equation

$$P_k = \frac{\{f(x_k, y_k) + f(x_k+1, y_k) + f(x_k, y_k+1) + f(x_k+1, y_k+1)\}}{4} \quad (7)$$

For k=0, 1, 2, and 3, where (x_k, y_k) denotes the starting position of the k[th] 2×2 sub-block.to improve the work they further added an overlapped inner 2×2 sub-block as shown in Fig.5 the pixel value, of overlapped block also obtained by computing the average of inner 2×2 pixels in the block.

Figure: - 5 4×4 block partition into five 2×2 sub-blocks [2].

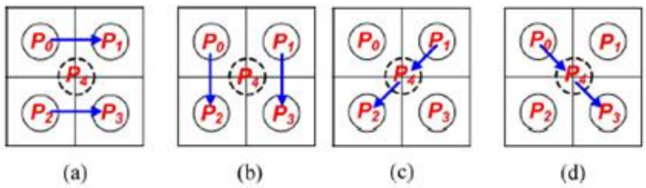

Figure: -6 Diagrams of edge assent computation suggested by the SDD algorithm for (a) horizontal, (b) vertical (c) diagonal-down left, and (d) diagonal-down right directions [2].

After computing the sub-block pixel compute block direction strength using pixel value computed byP_k. The block direction error strengths in the SDD methods are computed by

$$d^0 = P1 - P0| + P3 - P2| \quad (8)$$

$$d^{90} = P2 - P0| + P3 - P1| \quad (9)$$

$$d^{45} = P4 - P1| + P2 - P4| \quad (10)$$

$$d^{135} = P4 - P0| + P3 - P4| \quad (11)$$

By using this equation computed the block direction error strengths of averaged pixel values in the specified directions as shown in Fig.6 the small error strength means the similar

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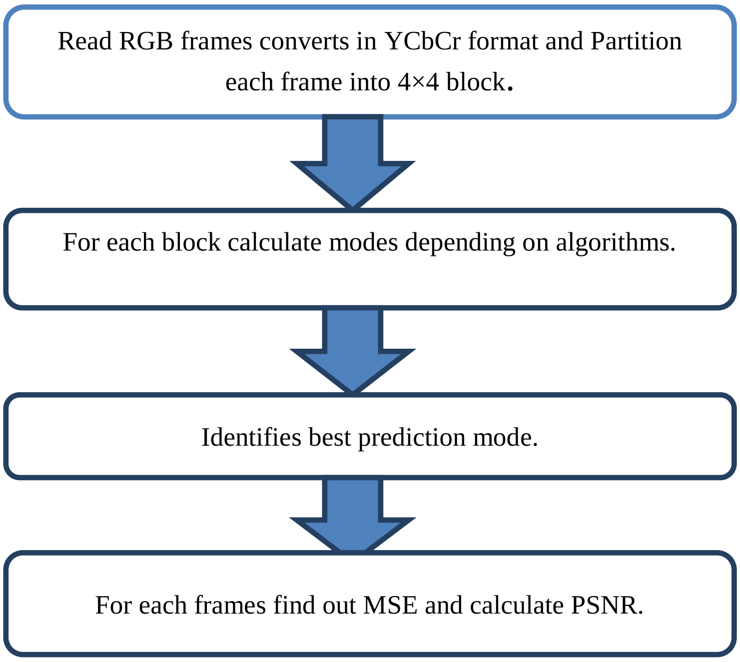
averaged pixel values in a direction. When the strongest edge is chosen, the neighboring edges will also be selected as prediction modes. Based on the above computation of direction we will choose four predictions modes.

III SIMULATION RESULT

The algorithm is implemented on matlab 2014a.In our experiments test platform All the frames are encoded. The performance parameters are the Peak signal to noise ratio (PSNR) is computed for various video sequences with 300 CIF frames were processed at once in which it runs frames by frameand compared to conventional method and algorithms in literature. PSNR measured between predicted image and original image. Here first we have taken a YUV or RGB images frame by frame. After fetching the frame first converted in to YCbCr format and partitions each frame into 4×4 block. After that we performing mode calculation based on algorithms. By calculating mode performance we identified best prediction mode based on SAD (sum of absolute difference) value and find out MSE and calculate PSNR between predicted image and original image.

Simulation flow:-



SIMULATION RESULT

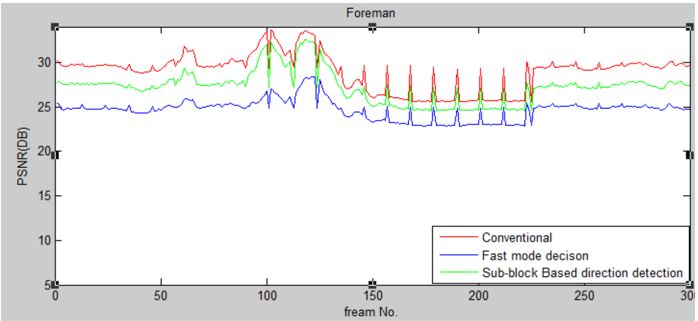


Figure 7 PSNR of foreman sequence

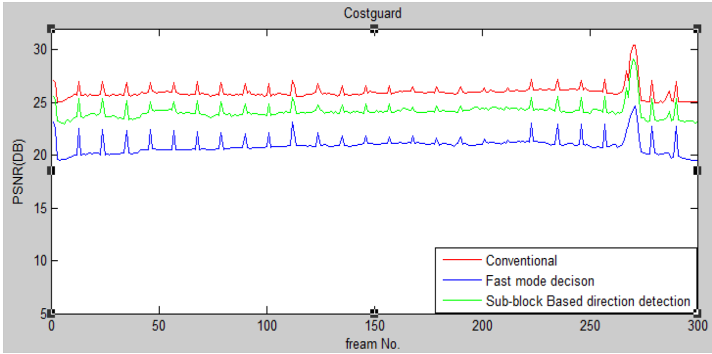


Figure:- 8 PSNR of Costguard sequence

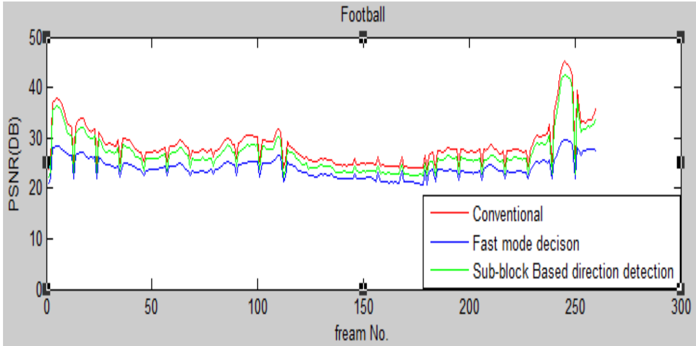


Figure:- 9 PSNR of Football sequence

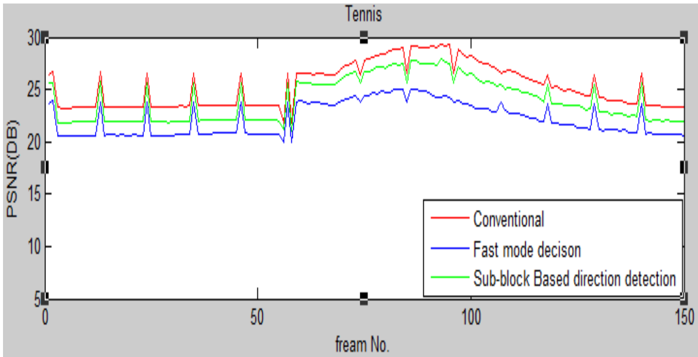


Figure: - 10 PSNR of Tennis sequence

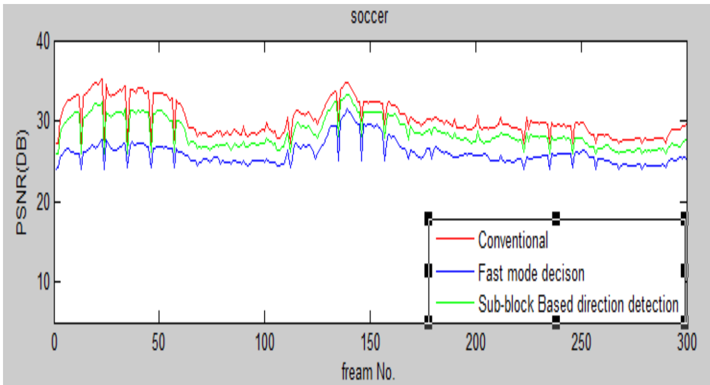


Figure:-11 PSNR of Soccer sequence

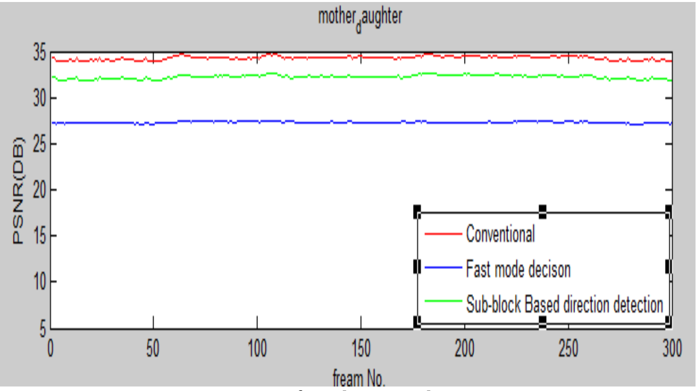


Figure:-12 PSNR of Mother_Daughter sequence

The above figs 7 to 12 are describe result of fast mode algorithms where red line describe conventional method, blue line describe fast intra mode decision algorithm and green line describe sub-block based direction detection method. Each result tested at different video sequences with 300 CIF frames.

Based on the Algorithm calculate the PSNR value using different method (i.e. conventional method, fast mode decision algorithm, SDD.) for different video sequences. By analyzing below table 1 conventional method gives best PSNR value among all algorithms. If we talk about Fast mode decision the SDD (sub-block based direction detection method) gives best PSNR value. By using this method the mode calculation is reduced by 55.55%.so the computational complexity is automatically reduced by 55.55%.

	Conventional method		**fast mode decision algorithm**			**Sub-block Based direction detection method**		
Sequences	**PSNR [db]**	**No of computation**	**PSNR [db]**	**No of computation**	**Mode computation reduce in%**	**PSNR [db]**	**No of computation**	**Mode computation reduce in%**
Foreman(300)	**28.9666**	17107200	**24.6729**	10797550	**36.88**	**27.2363**	7603200	**55.55**
Costguard (300)	**25.9736**	17107200	**20.9092**	10609595	**37.98**	**24.1538**	7603200	**55.55**
Football (260)	**28.5153**	14826240	**24.0203**	9064625	**38.86**	**26.9416**	6589440	**55.55**
Tennis(150)	**25.3233**	8553600	**22.1851**	5516210	**35.51**	**24.0069**	3801600	**55.55**
Soccer (300)	**30.2030**	17107200	**25.9937**	10655985	**37.71**	**28.5008**	7603200	**55.55**
mother_daughter (300)	**34.2870**	17107200	**27.3030**	11116835	**35.01**	**32.2198**	7603200	**55.55**

Table:-1 PSNR and Mode Performance analysis for different method

IV Conclusion

The paper has presented a different algorithm for H.264 intra-prediction. The algorithms not only increase the encoding speed but also retain the coding performance in intra-prediction. The sub-block based algorithms greatly reduce the computational complexity of H.264 intra-prediction while maintaining the appreciable objective and subjective quality.

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