IJCAES
ISSN: 2231-4946
Volume III, Special Issue, August 2013

International Journal of Computer Applications in Engineering Sciences
Special Issue on National Conference on Information and Communication (NCIC'13)
www.caesjournals.org

Performance Analysis of Quantization Parameter for Base and Enhancement Layer in H.264 Scalable Video Coding

Balaji L[1] and Thyagharajan KK[2]

[1]Research Scholar, Faculty of I&C, Anna University, Chennai, India
[2]Professor & Dean, Dept of CSE, RMD Engineering College, Chennai, India

[1]mailbala81@yahoo.co.in

Abstract*— Scalable Video Coding is an extension of H.264/AVC, which has better coding efficiency and scalability in terms of temporal, spatial and quality levels and the Scalability is done based on the value of Quantization Parameter (QP). This paper aims to compare the quantization parameter value for Base Layer and Enhancement Layer. The bit rates and the PSNR generated under each layer of a YUV sequence for the assigned QP value in Base Layer and Enhancement Layer is compared using JSVM 9.19.5 SVC Reference Software Model, and the experimental results shows that the Base Layer assigned with small QP value than the Enhancement Layer generates better PSNR and reduced bit rate.

***Keywords*— Quantization Parameter, Base Layer, Enhancement Layer, h.264 Scalable Video Coding**

I. INTRODUCTION

ISO/IEC MPEG and ITU-T VCEG are jointly making a scalable video coding (SVC) standard that is based on the hierarchical B frame structure and the scalable extension of H.264/AVC [1]. The latest version JSVM 9.19.15 has been released, which describes the specific decoding process and bitstream syntax of the proposed SVC [2]. As an extension of H.264 Advance Video Coding (AVC) standard, it supports three kinds of scalabilities, i.e. temporal, spatial and quality scalability [3]. In coding performance comparison with video simulcast [4], spatial scalability of H.264/SVC can provide higher coding efficiency with the concept of inter-layer prediction, which consists of three kinds of inter-layer prediction mechanisms, i.e. Inter-Layer Motion Prediction, Inter-Layer Residual Prediction and Inter-Layer Intra Prediction. In Spatial scalability of H.264/SVC is implemented based on the multilayer coding structure. Each spatial layer is attached to a specified spatial resolution and indexed by a so-called dependency identifier *D*. In each layer, inter-coding and intra-coding are performed as the usual way in single layer coding. However, this kind of multilayer coding structure would decrease the overall coding performance. Accordingly, the inter-layer prediction mechanisms are employed and the decoding of a spatial layer is dependent on its reference layers data. Obviously, spatial layers with smaller *D* are more important than other layers and the number of bits of reference layers need to be counted into the bit-rate of a specified layer. We have to take these features into consideration during the development of rate control scheme for spatial scalability of H.264/SVC.

The Rate Control mainly depends upon the total number of target bits to be generated. These bits are generate based on the value of the quantization parameter, so the region of more important is assigned with more number of bits and the region of the less important is assigned with more number of bits. The bits generated depending on the region of interest depends upon the QP value set for each layers. In this work, we compare the bit rates, encoding speed and PSNR for different values of quantization parameter of Base Layer and Enhancement Layer using the JSVM encoder.

The rest of this paper is organized as follows. In section 2, an Underlying Problem formulation on dependent quantization decision is discussed section 3, a comparative analysis between the values of quantization parameter for BL & EL of spatial scalability in H.264/SVC. In section 4, the experimental results are presented to verify the performance evaluation. At last, a conclusion is carried out.

II. UNDERLYING PROBLEM FORMULATION

The reference software Joint Scalable Video Model (JSVM) [5] adopts a JVT-G012-like rate control scheme for its base layer, some initial research has been carried out for rate control of spatial scalability. Y. Liu [6] proposed a rate control scheme for spatial scalability and a switched model to predict the mean absolute difference (MAD) with the multilayer structure. Recently, the famous ρ-domain model has been incorporated into the rate control scheme for spatial scalability [7]. In H.264/SVC, [8] the spatial scalability is achieved by a multilayer coding approach. That is, a video signal with a high spatial resolution is encoded in such a way that the output bit stream provides multiple layers of various spatial resolutions. When a target bit budget constraint is imposed, it is essential for an encoder to efficiently distribute the target bit budget to each spatial layer for the optimal coding efficiency. The rate and the distortion of a coded video stream are determined by the choice of quantization step-size Q. In the following, the problem is formulated as the spatial layer Q-decision problem.

The Lagrangian multiplier method converts the constrained optimization problem in to an equivalent unconstrained optimization problem by introducing the Lagrangian cost function.

$$Q^* = arg \min_{Q_k \to Q} J(Q, \lambda)$$

$$J(Q,\lambda) = \sum_{k=1}^{N} \omega_k . D_k(.) + \lambda . (\sum_{k=1}^{N} R_k(.) - R_{total})$$

where λ is the Lagrangian Multiplier.

Without loss of generality, we consider bit allocation in a simple two-layer scenario first. The solution can be easily generalized to a multi-layer scenario. The Lagrangian cost function can be expressed as,

$$J(Q,\lambda) = \omega_1 D_1(Q_1) + \omega_2 D_2(Q_1,Q_2) + \lambda(R_1(Q_1) + R_2(Q_1,Q_2) - R_{total})$$

We assume equal importance to these two layers; namely, BL & EL. To solve the dependent quantization decision problem in one solution is to conduct a full search over all possible combinations of admissible quantization choices. However, since the search space grows exponentially as the number of layers increases, the complexity of full search is prohibitively large. We address the complexity issue by modeling the R-D characteristics of dependent layers in the next section. From [8], based on the observation, that the difference in assigning Quantization Parameter for BL & EL should be less than or equal to 6.

III. PERFORMANCE ANALYSIS OF QP VALUE FOR BASE & ENHANCEMENT LAYER

R-D characteristics of a dependent layer are represented by a function consisting of quantization step sizes for the reference layer and the dependent layer. The impact of an individual quantization parameter on the R-D characteristics of the dependent layer has to be known to solve the bit allocation problem. For dependent R-D modeling, we convert the multi-variable function into a number of single variable functions which simplifies the solution framework to the bit allocation problem greatly.

In [8], GOP based Rate & Distortion modeling is proposed for two layer scenario. Since the inter layer dependency is two low the two models were proposed as shown below, the rate model as

$$R_2(Q_1,Q_2) = \begin{cases} r.R_1(Q_1) + (s-r)R_1(Q_2), & QP_1 \geq QP_2 \\ s.R_1(Q_2) & QP_1 < QP_2 \end{cases}$$

where s and r are slope when Q1 = Q2 and the distortion model as

$$D_2\,(Q_1, Q_2) = \begin{cases} pi.C(Q_1) + (m - pi).C(Q_2/2) + n, & QP_1 \le QP_2 - 6, \\ m.C(Q_2/2) + n, & QP_1 > QP_2 - 6, \end{cases}$$

where p is slope, function of Q2 and m & n are slope and intercept of line Q1 = 0.5Q2.

Basically, a QP with less value produces more number of bits and QP with more value produces less number of bits. At the same time PSNR of the sequence will be improved while allocating more bits and the tradeoff continues.

A state where a minimum bit rate to be achieved, such that it should guarantee that the Distortion level should not exceed average distortion. So, a region of more important information has to be encoded with more bits and the region of less important information has to be encoded with less bits by the Quantizaton Parameter. A performance analysis on different sets of values of quantization parameter for both the Base Layer and Enhancement Layer is studied under the results shown using JSVM 9.19.5 Encoder and the bitstreams generated shows the PSNR for the chrominance and the two luminance signals with the encoding speed at each values of quantization parameter.

IV. EXPERIMENTAL RESULTS

To evaluate the performance under different values of Quantization Parameter for Base Layer and Enhancement Layer, we use JSVM 9.19.5 SVC Reference Software Model. We took Foreman sequence of QCIF & CIF formats with 15 and 30 fps, GOP size of 16, maximum delay of 1.2s under Fast search mode. The Base Layer assigned with QP values of 26, 28, 30, 32, 34, 36 and Enhancement Layer with 32, 34, 36 38, 40, 42 respectively for each sets and the corresponding reconstructed sequence is as shown in figure 1 and 2 for both the formats of CIF & QCIF. JSVM 9.19.5 Encoder is used to encode the sequence and their corresponding bits generated for each layer with PSNR is shown in figure 3. The snapshot shows for each set of values for Base Layer and Enhancement layer. Table 1 shows the bit rates for each scalable layer for different values of Quantization Parameter.

Base Layer	Enhancement Layer	Layer Number	Resolution	Frame Rate	Bit rate	Min Bit rate	DTQ
26	32	3	176x144	15.00	212.70	212.70	(0,3,0)
28	34	3	176x144	15.00	172.90	172.90	(0,3,0)
30	36	3	176x144	15.00	141.40	141.40	(0,3,0)
32	38	3	176x144	15.00	117.50	117.50	(0,3,0)
34	40	3	176x144	15.00	95.10	95.10	(0,3,0)
36	42	3	176x144	15.00	78.20	78.20	(0,3,0)
26	32	8	352x288	30.00	595.40	595.40	(1,4,0)
28	34	8	352x288	30.00	473.40	473.40	(1,4,0)
30	36	8	352x288	30.00	373.60	373.60	(1,4,0)
32	38	8	352x288	30.00	297.10	297.10	(1,4,0)
34	40	8	352x288	30.00	237.80	237.80	(1,4,0)
36	42	8	352x288	30.00	185.50	185.50	(1,4,0)

Table 1 Bit Rates for different values of QP in BL and EL

```
profile & level info:
=====================
DQ=  0:   Main @ Level 1.1
DQ= 16:   Scalable High @ Level 2.2


AU      0: I    T0 L0 Q0    QP 22    Y 41.5662   U 44.2757   V 46.1550      37760 bit
        0: I    T0 L1 Q0    QP 26    Y 39.1256   U 41.9504   V 45.2818      63760 bit
AU     16: I    T0 L0 Q0    QP 22    Y 41.3910   U 43.9552   V 46.4875      40928 bit
       16: I    T0 L1 Q0    QP 26    Y 38.6897   U 41.8155   V 45.0490      70936 bit
AU      8: B    T1 L0 Q0    QP 25    Y 39.6095   U 43.1159   V 44.5608      14880 bit
        8: B    T1 L1 Q0    QP 30    Y 37.2660   U 41.4311   V 44.0884      12936 bit
AU      4: B    T2 L0 Q0    QP 27    Y 38.7239   U 42.7261   V 44.4516       7760 bit
        4: B    T2 L1 Q0    QP 31    Y 36.7588   U 41.4123   V 44.1334       7736 bit
AU      2: B    T3 L0 Q0    QP 28    Y 38.9070   U 43.4536   V 44.9023       4120 bit
        2: B    T3 L1 Q0    QP 32    Y 36.7079   U 41.6610   V 44.5503       3944 bit
AU      1: B    T4 L1 Q0    QP 34    Y 36.9891   U 41.7640   V 44.8609       2936 bit
AU      3: B    T4 L1 Q0    QP 34    Y 36.1889   U 41.4759   V 44.1396       3152 bit
AU      6: B    T3 L0 Q0    QP 28    Y 38.2583   U 42.7568   V 44.0656       3768 bit
        6: B    T3 L1 Q0    QP 32    Y 36.2353   U 41.3819   V 43.9523       3688 bit
AU      5: B    T4 L1 Q0    QP 34    Y 36.1454   U 41.3758   V 44.0329       3056 bit
AU      7: B    T4 L1 Q0    QP 34    Y 36.2521   U 41.3121   V 43.8208       3224 bit
AU     12: B    T2 L0 Q0    QP 27    Y 38.4427   U 42.7305   V 44.2297       8624 bit
       12: B    T2 L1 Q0    QP 31    Y 36.4765   U 41.3249   V 43.9246       8472 bit
AU     10: B    T3 L0 Q0    QP 28    Y 37.9640   U 42.5527   V 44.1377       4264 bit
       10: B    T3 L1 Q0    QP 32    Y 36.1353   U 41.2063   V 43.7883       5200 bit
AU      9: B    T4 L1 Q0    QP 34    Y 36.1472   U 41.2078   V 43.7417       3416 bit
AU     11: B    T4 L1 Q0    QP 34    Y 35.8635   U 41.1467   V 43.7375       3632 bit
AU     14: B    T3 L0 Q0    QP 28    Y 38.3364   U 42.9014   V 44.5880       5328 bit
       14: B    T3 L1 Q0    QP 32    Y 36.2814   U 41.3091   V 44.1887       5080 bit
AU     13: B    T4 L1 Q0    QP 34    Y 35.7897   U 41.1788   V 44.0079       4936 bit
AU     15: B    T4 L1 Q0    QP 34    Y 36.5927   U 41.5370   V 44.6026       3504 bit


SUMMARY:
                             bitrate     Min-bitr    Y-PSNR   U-PSNR   V-PSNR
                            ---------   ---------   -------  -------  -------
    176x144 @  1.8750        73.9275     73.9275   41.4786  44.1155  46.3213
    176x144 @  3.7500       117.1700    117.1700   40.8556  43.7823  45.7345
    176x144 @  7.5000       165.1800    165.1800   39.9467  43.3607  45.1769
    176x144 @ 15.0000       212.6667    212.6667   39.2443  43.1631  44.8420
    352x288 @  1.8750       200.3925    200.3925   38.9076  41.8830  45.1654
    352x288 @  3.7500       301.9600    301.9600   38.3604  41.7323  44.8064
    352x288 @  7.5000       411.2400    411.2400   37.6633  41.5869  44.4954
    352x288 @ 15.0000       515.9200    515.9200   37.0751  41.4992  44.3285
    352x288 @ 30.0000       595.4259    595.4259   36.6850  41.4406  44.2294

Encoding speed: 503.941 ms/frame, Time:8567.000 ms, Frames: 17
```

Figure 3 Snapshot of JSVM 9.19.5 Encoded YUV Sequence for BL=26 EL=32

Figure 1 Snapshot of Reconstructed YUV Sequence (CIF) for sets of different QP a) BL=26 EL=32 b)BL=30 EL=36 c)BL=36 EL=42

Figure 2 Snapshot of Reconstructed YUV Sequence (QCIF) for sets of different QP a)BL=26 EL=32 b)BL=30 EL=36 c)BL=36 EL=42

V. CONCLUSION AND FUTURE WORK

The Quantization Parameter decides the PSNR level and the target bits to be generated for the spatial layer in H.264 Scalable Video Coding. A performance analysis on different sets of values of quantization parameter for both the Base Layer and Enhancement Layer is studied under the results shown using JSVM 9.19.5 Encoder and the bitstreams generated shows the PSNR for the chrominance and the two luminance signals with the encoding speed at each values of quantization parameter. It is experimented that the QP with less value is assigned to more important parts of SVC and less important parts are assigned with large QP value. Generally, QP with small value produces more number of bits and QP with large value produces less number of bits, which means a perfect rate control mechanism can be able to minimize the bit budget as well maintaining the PSNR level for h.264/SVC can be designed as a future work.

REFERENCES

[1] ISO/IEC JTC 1/SC 29/WG 11, *Working Draft 4 of ISO/IEC 14496-10:2005/AMD3 Scalable Video Coding*, N7555, Nice, Oct. 2005.

[2] ISO/IEC JTC 1/SC 29/WG 11, *Joint Scalable Video Model (JSVM) 4.0 Reference Encoding Algorithm Description*, N7556, Nice, Oct. 2005.

[3] H. Schwarz, D. Marpe, T. Wiegand, Overview of the scalable video coding extension of the H.264/AVC standard, *IEEE Trans. Circuits Syst. Video Technol.*, vol. 17, no. 9, pp. 1103-1120, 2007.9.

[4] M. Wien, H. Schwarz, T. Oelbaum, Performance Analysis of SVC, *IEEE Trans. Circuits Syst. Video Technol.*, vol. 17, no. 9, pp. 1194-1203, 2007.9.

[5] Julien Reichel, Heiko Schwarz, Mathias Wien, Joint Scalable Video Model JSVM-12 text, *ISO/IEC JTC1/SC29/WG11 and ITU-T SG16/Q6*, Doc. JVT-Y202, In the 25th Meeting, Shenzhen, 2007.10.

[6] Y. Liu, Z. G. Li, Y. C. Soh, Rate control of H.264/AVC scalable extension, *IEEE Trans. Circuits Syst. Video Technol.*, vol. 18, no. 1, pp. 116-121, 2008.

[7] Y. Pitrey, M. Babel, O. Déforges, J. Viéron, ρ-domain based rate control scheme for spatial, temporal, and quality scalable video coding, *In Visual Comm. and Image Proces. 2009, SPIE Electronic Imaging*, vol. 7257, 2009.1.

[8] J. Liu, Y. Cho, Z. Guo, and J. Kuo, “Bit allocation for spatial scalability coding of H.264/SVC with dependent rate-distortion analysis,” Circuits and Systems for Video Technology, IEEE Transactions on, vol. 20, no. 7, pp. 967–981, 2010.