

CHROMA FORMAT SCALABLE VIDEO CODING

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ABSTRACT

A scalable video coding (SVC) extension to the H.264/AVC standard has been developed by the Joint Video Team (JVT). SVC provides spatial, temporal and quality scalability with high coding efficiency and low complexity. SVC is now developing the extension of the first version including color format scalability. The paper proposes to remove some luminance related header and luminance coefficients when an enhancement layer adds only additional color information to its lower layer. Experimental results shows 0.6 dB PSNR gain on average in coding efficiency compared with an approach using the existing SVC standard.

Keywords: Scalable video coding, chroma format scalability

1. INTRODUCTION

A recently standardized scalable video coding (SVC) has been developed as the scalable extension of the H.264/AVC by the Joint Video Team (JVT) of the ITU-T Video Coding Experts Group (VCEG) and the ISO/IEC Moving Picture Experts Group (MPEG) [1]. The SVC provides coded stream scalability in temporal, spatial and/or fidelity domain, which allows the scalably coded stream to be efficiently delivered over heterogeneous network for diverse clients with different system resources and application requirements. Currently, the SVC is being developed in the phase II of SVC project, where the bit-depth scalability and the chroma format scalability have been identified as one of the study issues. The newly designed feature enables scalable bit-stream to support professional applications such as digital visual content management in digital workflows while keep a backward compatibility.

From an investigation on the current SVC regarding the chroma format scalability, it is found that the current SVC design works for most of cases when the chroma format scalability is combined with the spatial and/or fidelity scalability where both luma and chroma components in the enhancement layer are encoded. However, there is one case where the cur-

rent standard design does not work in terms of coding efficiency performance. This is when only chroma format scalability is applied to an enhancement layer, the current design encodes both luma and chroma signal for the enhancement layer even there is no need to re-encode the luma component as it has already been coded in the lower layer. This paper discusses this issue and proposes a solution to it.

This paper goes as follows. Section 2 presents a brief review of the SVC design and explains how it supports the chroma format scalability. Section 3 analyzes the distribution of bit usage for single-layer coded streams, then discusses the proposed solution in detail. Section 4 gives the performance analysis, followed by conclusions drawn in Section 5.

2. SVC AND CHROMA FORMAT SCALABILITY

The SVC extension provides a significantly enhanced coding efficiency performance in comparison with the scalable profiles of previous video coding standards, for instance, the MPEG-2, H.263+, and MPEG-4 part II. This enhanced performance of SVC comes from the intensively developed inter-layer prediction mechanism and the time domain hierarchical prediction structure[2]. This section presents a brief review of the SVC coarse gain scalability (CGS) and how it supports the chroma format scalability.

2.1. Inter-layer prediction for SVC CGS

The SVC provides fidelity scalability in the form of CGS and medium gain scalability (MGS). The MGS employs motion compensated prediction from previously decoded pictures regardless of the quality layer, while the CGS applies motion compensated prediction only within the current scalable layer.

Fig. 1 illustrates a blockdiagram of the SVC CGS coding design where two layers are scalably coded being targeted for different reconstruction fidelity, respectively. The base layer is coded in an AVC compatible mode, where both spatial intra picture prediction and motion compensated inter picture prediction are employed. The enhancement layer employs both intra-layer prediction and inter-layer prediction. The intra-layer prediction predicts macroblock (MB) from previously

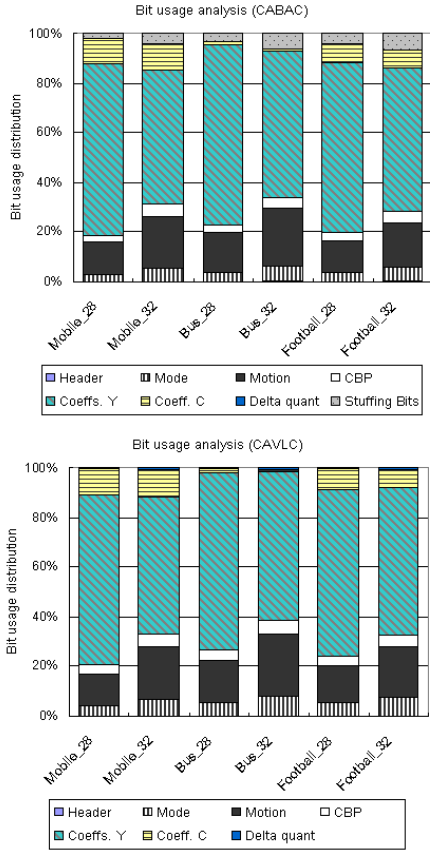


Fig. 2. Bit usage analysis for AVC single-layer coding.

can be further derived from the lower layer, coding efficiency performance for the chroma format scalable video coding can be further improved. Therefore, it is considered not to encode the luma component as well as the motion data for the enhancement layer when only chroma format scalability is applied.

3.2. The proposed scheme

Following the above analysis, when only chroma format scalability is employed, it is proposed to predict MB prediction mode, motion data as well as luma data for the enhancement layer from the corresponding base layer. The proposed scheme implements this idea via an MB level syntax modification. Fig. 3 illustrates the basic architecture of the proposed chroma format scalable coding design. For the description of the syntax and semantics modification, readers are referred to [4].

In Fig. 3, a two-layer chroma format scalable coding is portrayed, where the base layer and enhancement layer are coded in YUV4:0:0 and YUV4:2:0 format, respectively. From the figure, it can be seen that there is only one motion estimation process employed in the proposed scheme,

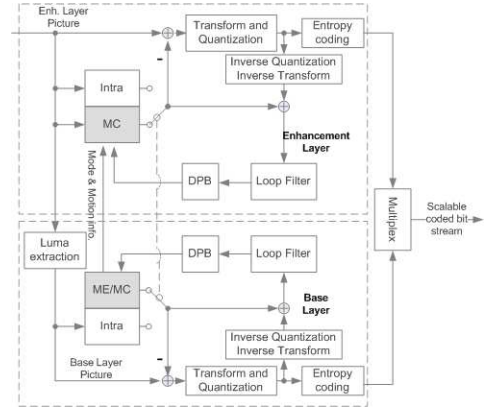


Fig. 3. Basic architecture of the proposed chroma format scalable coding design.

which is performed in the base layer. For the enhancement layer, only motion compensation is performed. Moreover, the inter-layer residual prediction is removed from the inter-layer prediction for the enhancement layer coding. This is because when only chroma format scalability is applied, there is no difference regarding the luma signal between the base and the enhancement layer. Therefore, the luma coefficients are not coded for the enhancement layer. Neither the inter-layer residual prediction is needed. Regarding the chroma component, there is the case that chroma component might not be coded in the base layer, for instance, the YUV4:0:0 format for the base layer. Therefore, for simplicity, the inter-layer residual prediction is neither performed for the chroma component in the enhancement layer coding. MBs which just include the chroma components in the enhancement layer are encoded with the exact same prediction mode and motion data as those that has been used for the collocated base layer MBs. Finally, it can be seen that, besides the header and coded block pattern information, all we need to code for the chroma format enhancement layer is just the chroma coefficients. This brings the significantly enhanced coding efficiency performance in comparison with the case where both luma and chroma components are coded in the enhancement layer.

4. PERFORMANCE ANALYSIS

To evaluate the performance of the proposed scheme, simulations based on the JSVM_8_12 [5] were performed with different test sequences. Two scalable layers are encoded in the simulations. The enhancement layer are encoded at YUV4:2:0 format, while the base layer are encoded at YUV4:0:0 format, which are extracted from the corresponding YUV4:2:0 sequences.

In the following simulations, the CABAC is employed as the entropy coding method, and the QCIF format is utilized

for all the test sequences. Rate points are obtained by setting QP value as 12, 17, 22, 27 and 32. Furthermore, the hierarchical B frames are enabled with the QP scaling process defined in the JSVM_8_12.

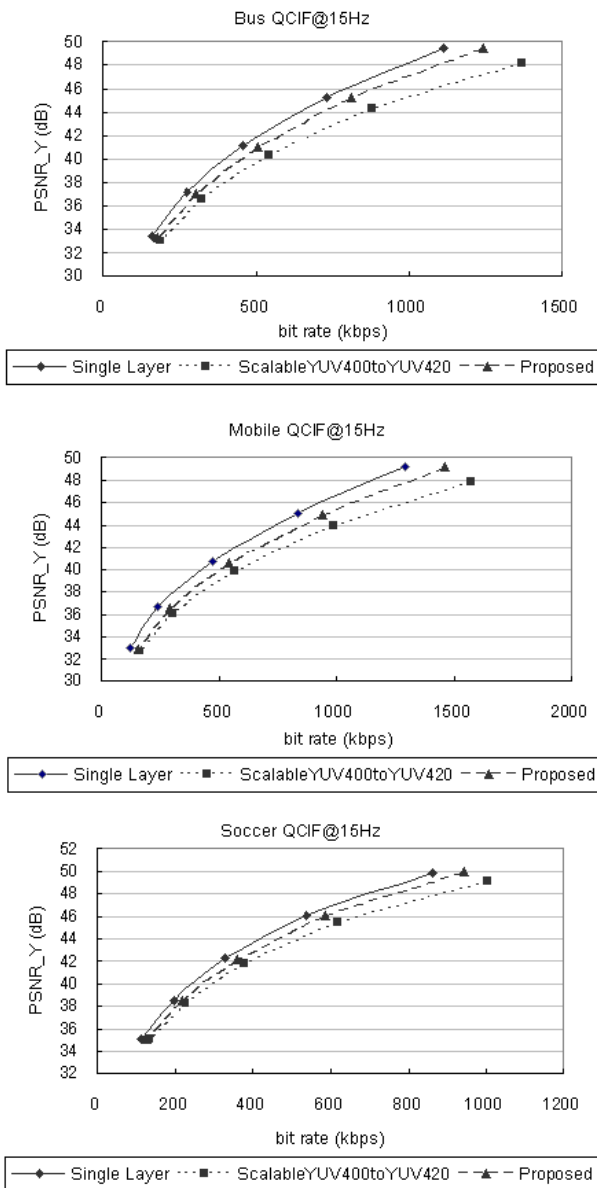


Fig. 4. Rate distortion performance of the proposed chroma format scalability design for different test sequences.

Fig. 4 presents the rate distortion performance of the proposed scheme against the original SVC performance using the CGS design which is denoted as ScalableYUV400toYUV420, where both the luma and chroma components are coded for the enhancement layer. Additionally, The single-layer performance is also presented for reference. Basically, the simulation results report that a performance improvement of 0.6

dB on average can be obtained with the proposed method in comparison with the chroma format scalable coding which is supported by the current SVC design. Also, it can be observed that the proposed scheme provides consistent performance enhancement over the current SVC design when only chroma format scalability is applied. Moreover, the larger the bit rate, the more gain can be achieved by the proposed method. This is because when the total number of bits increases, bits used for representing the corresponding luma coefficients are also getting larger. Therefore, with the proposed method, when there is no luma data need to be coded for the enhancement layer, the scalable coding efficiency performance is enhanced. For more detail simulation results, readers are referred to [6].

5. CONCLUSIONS

This paper presents an efficient chroma format scalable coding scheme for applications where only chroma format is enhanced from base layer to enhancement layer. The proposed method achieves performance improvement in terms of coding efficiency from deriving MB prediction mode, motion data, and luma coefficients from the base layer instead of coding them in the enhancement layer. Simulation results show that the proposed scheme outperforms the scheme which employs the SVC CGS coding structure by an average 0.6 dB performance enhancement.

Acknowledgments

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