

# A New Mode for Coding Residual in Scalable HEVC (SHVC)

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**Abstract**— Recently, an effort on standardizing the scalable extension of High Efficiency Video Coding (HEVC), known as SHVC, has been initiated. To improve the compression performance of SHVC, a new mode is proposed for coding residual information, which reduces the bit-rate of the enhancement layer by up to 3.13%.

## I. INTRODUCTION

Using video applications on a variety of devices has become an integral part of our everyday lives. This is mainly due to the availability of a wide range of video-enabled gadgets and mobile devices with network connectivity. To transmit video content to heterogeneous devices, the content needs to be encoded in a way that is compatible with the playback capabilities of each specific device. Simulcast coding is a well-known approach for providing support for wide variety of display devices [1]. This approach is computationally expensive and requires large amounts of bandwidth. Another solution is to use Scalable Video Coding (SVC), which enables multicast service and video transmission to heterogeneous clients with different capabilities [1]. An SVC stream consists of a base layer (BL) and one or more enhancement layers (ELs). On the decoder side, based on the type of the application and supported complexity level, the appropriate part of an SVC bit stream will be decoded.

Recently, the High Efficiency Video Coding (HEVC) has been standardized by the ISO/IEC MPEG and the ITU-T VCEG organizations [2]. HEVC achieves high compression performance using several advanced coding features. Each of these features leads to a slight improvement in compression performance. However, all of them used together yield bit-rates saving up to 50% compared to H.264/AVC [2]. Currently, the Joint Video Team (JVT) of the ISO/IEC MPEG and the ITU-T VCEG are working towards developing the scalable extension of the (HEVC) standard [2-4], known as SHVC [4]. The idea of SVC was proposed to use less bandwidth and transmit video content more efficiently. Therefore, the compression performance of SHVC is of paramount importance in enabling new market opportunities in digital media applications. To this end, this work focuses on reducing the bit-rate of SHVC coded scalable streams by introducing a new residual prediction mode for the emerging standard.

## II. PROPOSED METHOD

The focus of this work is to design a new prediction mode that decreases the bit-rates of SHVC, while minimally hampering the video quality. This mode is based on the fact that in video coding, sometimes the same patterns are repeated in the residual signals. To take advantage of these redundancies, the current SHVC encoder and decoder are modified by implementing a new prediction mode for coding residual information. This mode is called the *residual* mode, hereafter. Fig. 1 shows the flowchart of the proposed mode. In this implementation, the encoder checks merge mode and each inter/intra prediction mode presently supported by SHVC. During the mode prediction process for the merge mode and each inter prediction mode, the predicted signal, the residual signal, and the RD-cost of utilizing that mode are computed. After checking the merge mode and each original SHVC's inter prediction modes, the modified SHVC encoder checks the proposed *residual* mode. Similar to other SHVC modes, the *residual* mode needs two signals; namely the predicted signal and the residual signal. Here, the predicted signal of the original SHVC mode is stored as the predicted signal of the *residual* mode. In this study, the main goal is to reduce the bit-rates by compressing the residual signal more efficiently. To save bit-rates in SHVC, it is suggested to store the low-resolution version of the residual signal instead of the original residual. Therefore, in the *residual* mode the modified encoder checks if the residual signal has a pattern that let the encoder store the down-sampled version of the residual signal instead of the original residual signal without losing important characteristics of the residual signal. In order to do this, the residual signal of the SHVC mode is down-sampled by 2 using the two-dimensional bi-linear down-sampling operator. Then, the number of bits which are required to represent this new residual signal is computed. Note, for the *residual* mode, this new residual signal is encoded and transmitted to the decoder side. The next step is to decide whether the *residual* mode yields lower rate distortion cost (RD-cost) compared to the ordinary SHVC mode. In order to do this, it is required to compute the reconstructed signal. Here, the size of the residual signal should be the same as the size of the predicted signal and for this reason the residual signal is up-sampled. Then, the resulting signal is added to the predicted signal to find the reconstructed signal. In the next step, the resulting reconstructed signal is used to find the overall distortion. Afterwards, the distortion and the bit-cost that was computed in the previous step are used to find the RD-cost of the

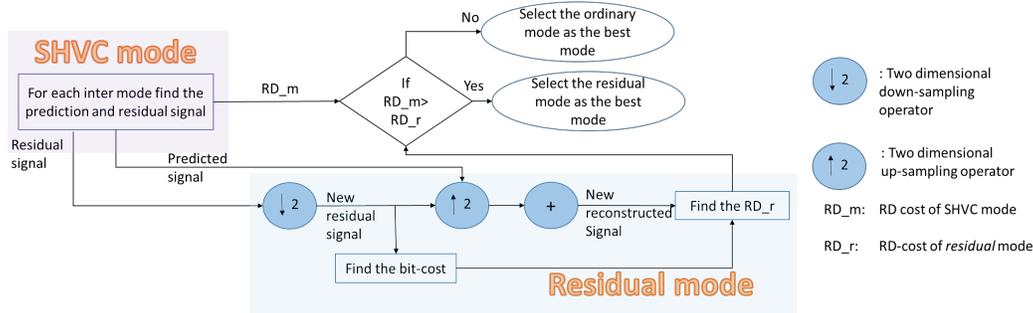


Fig.1. Block diagram of the proposed residual mode.

*residual* mode. Then, the RD-cost of the *residual* mode is compared with the RD-cost of the original SHVC mode. If the RD-cost of the *residual* mode is smaller than that of ordinary SHVC mode, the modified encoder selects the *residual* mode as the mode candidate. Otherwise, it selects the ordinary SHVC mode. To let the encoder know that if the *residual* mode is used or not, a new flag bit is added for each coding unit that shows whether the *residual* mode is the mode with the lowest RD-cost or not. If the flag bit is equal to zero, the decoder acts like the original SHVC. Otherwise, if the flag bit is set to one, the decoder first decodes the residual signal, then it applies the two-dimensional bi-linear up sampling operator on the residual signal. This resulting signal is added to the predicted signal to make the reconstructed signal.

It is important to note that in the implementation, the *residual mode* was only integrated to the merge mode and the inter prediction modes.

The future plan is to integrate a *residual mode* to the intra prediction modes in the very near future, a step that is expected to further improve the compression efficiency of SHVC.

### III. RESULTS

In the experiment, two test video sequences known as “BasketballDrill” and “Race Horse” are used [6]. The proposed method was implemented on the SHVC software (SHM 5.0 [4]). To guarantee the highest compression performance, the Random Access High Efficiency (RA-HE) configuration is used (hierarchical B pictures, GOP length 8, Sample adaptive offset (SAO), and Rate distortion optimized quantization (RDOQ) are enabled). The quantization parameters (QPs) used for the base layer and enhancement layer (QP<sub>B</sub>, QP<sub>E</sub>) are as follows: (26, 22), (32, 28), (36, 32)

TABLE I  
IMPACT OF THE PROPOSED METHOD ON BITRATE AND PSNR.

Test Video Sequences	Resolution, Frame Rate (fps)	Average PSNR Degrade	Average Bitrate Decrease
BasketballDrill	832x480, 50	BL: 0.034dB	BL: 0.83%
		EL: 0.142dB	EL: 2.34%
Race Horse	832x480, 30	BL: 0.051dB	BL: 1.43%
		EL: 0.113dB	EL: 3.13%

and (40, 36).

Table I summarizes the results of the experiment. In this table, the compression performance [7] of modified encoder is compared with the original SHVC for the BL and the EL. It is observed that the modified SHVC outperforms the original SHVC by a range of 0.83% to 1.43% in terms of bit rate for the BL. At the same time, the modified encoder outperforms the original SHVC by a range of 2.34% to 3.13% in terms of bit rate for the EL. This improvement is achieved by adding a *residual* mode to the case where merge or inter prediction modes are used in SHVC. As mentioned above, the future plans include integrating a similar mode to the intra prediction modes, which will result in further bit-rate savings.

### IV. CONCLUSION

In this paper, the addition of a new prediction mode known as *residual* mode to SHVC was proposed. The proposed mode uses a down-sampled version of the residual signal for each inter prediction mode in the scalable extension of HEVC (SHVC) to compress the residual signal more efficiently. Performance evaluations show that although in its present form the proposed approach is utilized only for merge and inter prediction modes, the proposed method still decreases the bit-rate of the scalable stream by up to 3.13% for the enhancement layer with minimal effects on the quality.

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