DUAL LAYER VIDEO STREAM IN HEVC THROUGH INFORMATION HIDING

Yiqi Tew, KokSheik Wong

Faculty of Comp. Sci. & Info. Tech.,
University of Malaya, Malaysia.
{yiqi@siswa., koksheik@}um.edu.my

Vishnu Monn Baskaran

Faculty of Engineering,
Multimedia University, Malaysia.
vishnu.monn@mmu.edu.my

ABSTRACT

A dual layer video streaming technique is proposed by utilizing information hiding technique. Based on the HEVC standard, our technique utilizes the coding unit size in each slice of a higher resolution video to embed a different video which is of lower resolution. Result shows that, with a perceptual quality degradation of $< 1\%$, a higher resolution video can be simultaneously streamed with an embedded video of lower resolution.

Index Terms— dual layer video, information hiding, HEVC, coding unit size, data embedding

INTRODUCTION

Video streaming has gradually become a necessity in daily life due to its adoptation in business, entertainment, security, etc. The growing of end-user internet speed from 10kbps (1993) to 100Mbps (2013) based on Nielsen's Law [1], it is now possible to provide online video streaming service. However, some users are still limited to streaming one video due to the limitation of internet bandwidth in certain geographical regions. To establish a more efficient video streaming service, we proposed a technique to transmit two different videos (one high resolution, another at lower resolution or quality) using a single stream, which slightly degrades the quality of the higher resolution video. This technique utilizes the information hiding technique in [2] with the underlying latest video compression standard (i.e., HEVC [3]) architecture. Figure 1 shows an overview of our proposed dual layer video streaming by utilizing information hiding technique.

PRELIMINARIES

HEVC (high efficiency video coding) has been deployed recently by ITU-U, as H.265 standard [4]. It provides better performance by saving the bitrate by at least 50% of the previous video compression standard (i.e., H.264/AVC) [5] to produce similar video quality. Similar to H.264/AVC, HEVC divides the video content into three types of slice (i.e., I, B and P-slices) and each slice consists of a number of CTUs (coding tree unit) with 64×64 pixels. In each CTU, a CU (coding unit) can be coded in (a) square blocks with sizes of $N\times N$ and $2N\times2N$, (b) SMP (symmetry motion partition) with two equal rectangular sizes of $2N\times N$ and

Fig. 1. Overview of proposed dual layer video stream

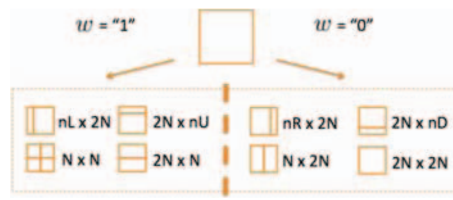

Fig. 2. Embedding technique using CU size

$N\times2N$, or (c) AMP (asymmetry motion partition) with two unequal rectangular sizes of $2N\times nU$, $2N\times nD$, $nL\times2N$ and $nR\times2N$, where $N \in 4, 8, 16, 32$ [6]. In particular, AMP provides better prediction reference and less bitstream size overhead for CU that contains slight movement at either the top, bottom, left or right part in the P/B-slice.

VIDEO EMBEDDING TECHNIQUE

In the HEVC encoder, the RDO (rate distortion optimizer) decides the CU sizes to achieve the best compression ratio based on the desired bitrate. In our approach, instead of utilizing the size determined by RDO, we force the size of CUs in every slice to embed a different video content of lower resolution or quality. It should be noted that our previous technique [2] is merely utilized as a mean to embed the second video.

The CU sizes are decided based on two categories, where one encodes "0" and the other encodes "1". In particular, category "0" includes $2N\times N$, $2N\times nU$, $nL\times2N$, and $N\times N$, while category "1" includes $N\times2N$, $2N\times nD$, $nR\times2N$, and $2N\times2N$. In other words, the CU size in each CTU only considers the sizes of $N\times2N$, $2N\times nD$, $nR\times2N$, and $2N\times2N$ when $w = 1$, and vice versa, as depicted in Fig. 2. For instance, if the CU size decided by RDO is 16×8 and $w = 1$, then the proposed technique will force the RDO to recalculate the required bitrate (i.e., cost) of 8×16, 16×16, and two AMPs (i.e., $2N\times nD$, $nR\times2N$), then choose the

978-1-4799-8745-0/15/$31.00©2015 IEEE

Table I. Total number of bits available for video embedding

Video Class	Quantization Parameter			
	12	**24**	**36**	**48**
A (2560 × 1600)	3767283	2382218	971589	191794
B (1920 × 1080)	2496968	574840	180398	176372
C (832 × 480)	950295	608255	238836	36623
D (416 × 240)	280655	193915	85829	18457
E (1280 × 720)	1869281	404823	189915	75808
F (1024 × 768)	1176599	615821	201676	25898

Table II. Total number of bits required for compressed video

Video Class	Quantization Parameter			
	36	**40**	**44**	**48**
A (2560 × 1600)	25932920	16281208	9861392	5629376
B (1920 × 1080)	6374064	3941024	2381208	1410976
C (832 × 480)	89602208	4840736	2388040	1042752
D (416 × 240)	2265560	1353352	783656	430896
E (1280 × 720)	4527648	2869344	1742136	1009016
F (1024 × 768)	8420568	4930376	2812056	1569552

CU size that results in the lowest cost. For CU with larger block sizes (e.g., 32×32), it is reasonable to encode it by utilizing some combination of smaller block sizes (e.g., two 32×16, four 16×16, etc.). Sequences of w are embedded based on the order from top-left to bottom-right (i.e., Z-scanning) as in HEVC structure [3]. This approach maintains the video quality at the expense of slight increment in bitstream size.

RESULT AND DISCUSSION

We modified the HM10.0 reference model to generate the dual layer video stream. First, we examine the number of bits available for embedding the second video (hereinafter referred to as *payload*) for six classes of standard test video sequence (i.e., A (PeopleOnStreet), B(Tennis), C(PartyScene), D(BasketballPass), E(FourPeople) and F(ChinaSpeed)), which are summarized in Table I. Here, the payload is considered for different QPs (quantization parameter), which controls the quality of the compressed video under the HEVC standard. Table II records the file size of the HEVC compressed videos using various QP's, which will be embedded into the higher resolution videos. Since not all videos can be embedded, only those with the file size $<$ 470kBytes (the largest possible payload achievable in Table I - Class A with QP=12) are recorded. Here, any video in Table II with smaller file size than the payload recorded in Table I can be embedded into the respective video. Based on the results, a relatively high quality HEVC compressed video (e.g., Akiyo in QCIF, compressed to $\sim$ 407kBytes with QP=24) can be embedded into video of Class A with QP=12.

Figure 3 shows the graph of SSIM versus bitrate for the dual layer video stream, under the RA (random access) configuration. For Class A video, the perceptual quality in SSIM index drops from ~ 0.98 to ~ 0.97 in the case of 3kbps. On the other hand, a drop in quality of merely ~ 0.01 is observed for videos of other classes for all ranges of bitrate $>$ 1kbps. In other words, for dual layer video streaming, Class A requires at most 1kbps extra to maintain the perceptual quality of 0.98 which hosting a different video

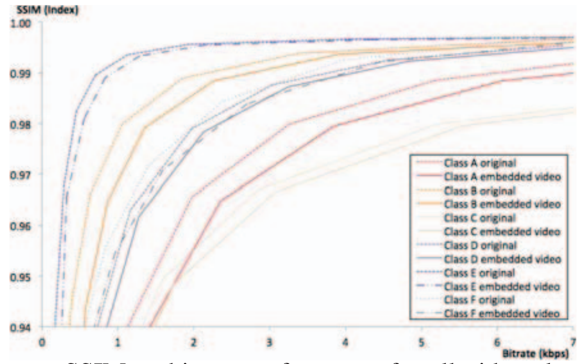

Fig. 3. SSIM vs bitrate performance for all video classes

within its bitstream. In terms of file size, the total size of both video for Class A (QP=12, $\sim$ 91.2MBytes) and Class D (QP=36, $\sim$ 2MBytes) is $\sim$ 93MBytes. By using the proposed streaming technique, $\sim 2\%$ file size is reduced.

Based on the structure of HEVC, CU size information is one of the earliest entities to be decoded for reconstructing the CTU. Hence, the extracted payload (i.e., video) can be fed into another decoder while the higher resolution video is still being decoded from the dual-layer video stream.

CONCLUSION

A dual layer video streaming is proposed by utilizing information hiding technique. Preliminary result shows that by decreasing the perceptual quality of the higher resolution video by $< 1\%$, the proposed video streaming technique can simultaneously transmit another video stream of lower resolution or quality. For future work, we would like to explore different applications using information hiding under the HEVC video standard.

REFERENCES

[1] Jakob Nielsen, "Nielsen's law of internet bandwidth," Apr. 1998, [Online; accessed 9-Feb-2015].

[2] Y. Tew and K. Wong, "Information hiding in HEVC standard using adaptive coding block size decision," in *21th IEEE Int. Conference on Image Process. (ICIP)*, Oct. 2014, pp. 5502–5506.

[3] G. J. Sullivan, J-R. Ohm, W-J. Han, and T. Wiegand, "Overview of the High Efficiency Video Coding (HEVC) standard," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 12, pp. 1649–1668, Dec. 2012.

[4] ISO, "Information technology – High efficiency coding and media delivery in heterogeneous environments – part 2: High efficiency video coding," ISO/IEC 23008-2:2013, Int. Organization for Standardization, Geneva, Switzerland, 2013.

[5] J-R. Ohm, G. J. Sullivan, H. Schwarz, T. K. Tan, and T. Wiegand, "Comparison of the coding efficiency of video coding standards - including High Efficiency Video Coding (HEVC)," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 22, no. 12, pp. 1669–1684, Dec. 2012.

[6] J. Vanne, M. Vitanen, and T. D. Hmlinen, "Efficient mode decision schemes for HEVC inter prediction," *IEEE Trans. Circuits Syst. Video Technol.*, vol. 24, no. 9, pp. 1579–1593, Sep. 2014.