An Efficient Rate Distortion Approach for Video Compression

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Abstract:* The digital video compression technology has been gaining popularity for many years. Today, when people enjoy HDTV (high definition television), movie broadcasting through Internet or the digital music such as MP3, the convenience that the digital video industry brings to us cannot be forgotten. All of these should attribute to the advances in compression technology, enhancement on mass storage media or streaming video/audio services. Most rate-distortion optimized quantization methods of video coding involve an exhaustive search process to determine the optimal quantized transform coefficients of a coding block and are computationally more expensive than the conventional quantization. In this paper, we present a novel analytical method that directly solves the rate-distortion optimization problem in a closed form by employing a rate model for entropy coding. It has the appealing property of low complexity and is easy to implement.

Keywords: Rate distortion approach, SSIM, PSNR.
Local Peak signal to noise ratio, global, Rate distortion approach, video decoding.

I. INTRODUCTION

The digital video compression technology has been gaining popularity for many years. Today, when people enjoy HDTV (high definition television), movie broadcasting through Internet or the digital music such as MP3, the convenience that the digital video industry brings to us cannot be forgotten. All of these should attribute to the advances in compression technology, enhancement on mass storage media or streaming video/audio services.

The core of the MPEG-4 standard was developed early twenty first century, however MPEG-4 is a existing standard with new parts added continuously as and when technology exists to address devolving applications. The significant advances in core video standard were achieved on the capability of coding video objects, while at the same time, improving coding efficiency at the expense of a modest increase in complexity.

The digital video compression technology has been gaining popularity for many years. Today, when people enjoy HDTV (high definition television) [3], movie broadcasting through Internet or the digital music such as MP3, the convenience that the digital video industry brings to us cannot be forgotten. All of these should attribute to the advances in compression technology, enhancement on mass storage media or streaming video/audio services. As the main contributor to all of above, video compression technology is the focus of this paper

The rest of paper is design as follows. The overall past work is describe in Section II. Section III describes the framework of the implementation used for proposedwork. Result discussiondescribe in section IV. Finally, Section V describes the conclusion of paper.

II. LITERATURE REVIEW

K. H. Chou 2016proposed Moving Picture Experts Group-4 part-10 advanced video coding /H.264 standard uses rate distortion optimization (RDO. The experimental results show that the proposed method can reduce the computation by approximately 4.39%–48.51% with −0.003561-dB display distortion and 1.08% bitrate increment.

YanboGao et al2016 describeimproving the coding efficiency of High Efficiency Video Coding (HEVC), especially for the hierarchical coding structure defined in the Random-Access. Experimental results show that the proposed method achieves, in average, about 1.4%.BD-rate savings.

Dan Grois et al., 2013described performance comparison of the two latest video coding standards H.264/MPEG-AVC and H.265/MPEG-HEVC. H.265/MPEG-HEVC provides significant average bit-rate savings of 43.3% and 39.3% relative to VP9 and H.264/MPEG-AVC, respectively.

Deepak Dembla et al., 2011, proposeddifferent choices during the design of a CODEC and different strategies for coding control can lead to significant variations in compression and computational performance between CODEC implementations.

Shiqi Wang et al., 2011, has been found structural similarity (SSIM) index to be a good indicator of perceived image quality. Experimental results demonstrate that, compared with conventional rate distortion optimization coding schemes, the proposed scheme can achieve better rate-SSIM performance and provide better visual quality.

TomásBrandão et al., 2011, described a set of no-reference quality assessment algorithms for H.264/AVC encoded video sequences. The performances of the algorithms are evaluated using cross-validation procedures.

H. S.Prasantha et al., 2010, describe H.264/AVC (Advanced Video Coding) is the newest video coding standard of the moving video coding experts group. The paper also proposes to analyze and compare Video Quality Metrics for different encoded video sequences.

Muhammad Shafique et al., 2010, describedH.264/AVC video coding standard features diverse computational hot spots that need to be accelerated to cope with the significantly increased complexity compared to previous standards. For a MIPS processor we achieve an average speed up of approximately 60× for Motion Compensated Interpolation.

Xiaoyin Cheng et al., 2009 studied the video CODEC system and H.264 standard, as well as the rate-distortion theory. In consideration of compromising average quality and ringing artifact reduction, the distortion multiplier k between 8 and 16 is preferred.

Performance improvement could not been seen when high Ks were applied.

Gary J.Sullivan et al., 2005, describedtechniques for video compression. The paper starts with an explanation of the basic concepts of video codec design and then explains how these various features have been integrated into international standards, up to and including the most recent such standard, known as H.264/AVC.

III. Framework of the Implementation

In the proposed work, there israte distortion approach is applied.

With the rapid development and continuous expansion of mobile communications, mobile internet services are becoming more and more popular. As a result, mobile video applications, such as mobile video broadcasting, mobile video conference, and mobile video surveillance, have become an active research area in recent years. However, due to the fact that mobile devices typically have limited communication bandwidth, constrained power capacity, and various display capabilities, there are several fundamental difficulties in deploying high-quality video service for mobile devices over wireless networks. Among them, one crucial problem for mobile video application is how to browse high-resolution (HR) videos on mobile devices with small screens. Like the other video coding standards, H.264/AVC incorporates different profiles and levels. Profiles define sets of bit stream features a H.264 stream can use. Levels define restrictions on the video resolution, frame rate and some stuff called VBV (Video Buffer Verifier). There are up to 16 profiles and 16 levels in the current version. Three most commonly used profiles are baseline profile (BP), main profile (MP), and extended profile (EP), Two of the most commonly used profiles i.e. baseline profile (BP), main profile (MP), will be studied and SSIM (Structural Similarity) and PSNR Matrices will be Analyzed for various input videos samples. Figure below shows the flowchart of the RDO based H.264

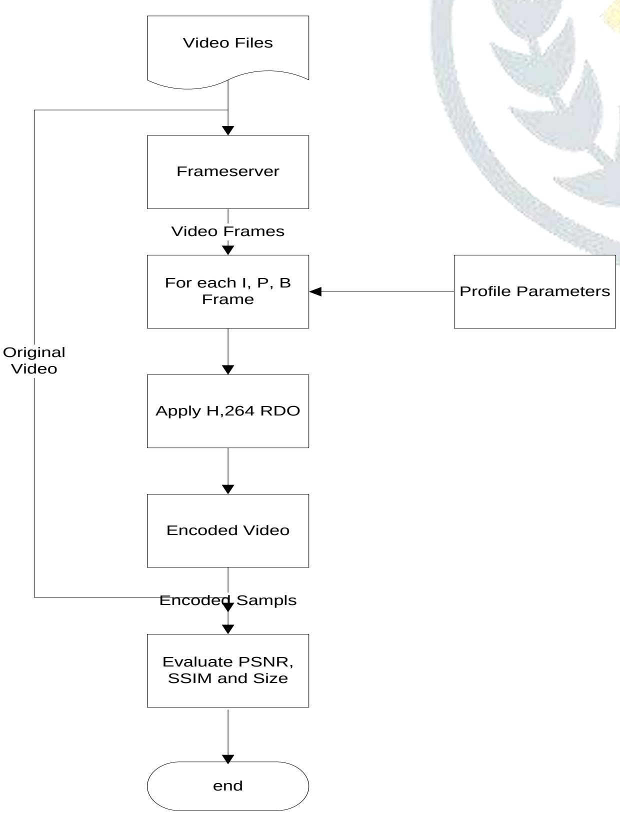


Fig 1. Proposed Flow chart of RDO enabled H.264 supporting I, P and B frames

A video file normally consists of a container format containing video data in a video coding format alongside audio data in an audio coding format. The container format can also contain synchronization information, subtitles, and metadata such as title etc. A standardized video file type such as baseline is a profile specified by a restriction on which container format and which video and audio compression formats are allowed. The AVIsynth alongside the FFMPEG allows us to use following formats as FFMPEG can import files with the following file name extensions into Windows Movie Maker to use in the script: asf, .avi, .dvr-ms, .m1v, .mp2, .mp2v, .mpe, .mpeg, .mpg, .mpv2, .wm, and .wmv

IV. Result & discussion

The quality the codec can achieve is heavily based on the compression format the codec uses. A codec is not a format, and there may be multiple codecs that implement the same compression There are collection various video samples of different formats with different profiles including codec, Resolution and Bitrate. The Comparison of the baseline and High (advances) profile are made using PSNR and SSIM. Although both follow the same general framework, there are several fundamental changes are in the profiles for ARM computers. As Described in previous chapter the comparison will be based upon PSNR and SSIM. PSNR for a video sample can be described using equation 1:

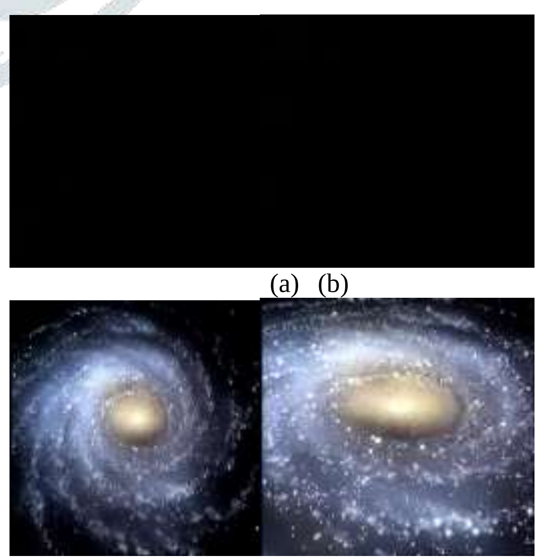
$$PSNR_{est[DB]} = 10.Log_{10}\frac{255^2}{MSE_{est}} \text{ ....(1)}$$

But as video files contain multiple frames and are much more complex than still image samples, that's why we will use $PSNR_{AVG}$ and $PSNR_{Global}$for comparison of video samples. Similarly for SSIM, for two input samples x and y, can be described using eq 2

$$\mathrm{SSIM}(x,y) = \frac{(2\mu_x\mu_y + C_1)(2\sigma_{xy} + C_2)}{(\mu_x^2 + \mu_y^2 + C_1)(\sigma_x^2 + \sigma_y^2 + C_2)} \text{ ....(2)}$$

- $\mu_x$isthe average of x.
- $\mu_x$the average of y;
- $\sigma_x$the variance of x;
- $\sigma_y$the variance of y;
- $\sigma_{xy}$the covariance of x and y;

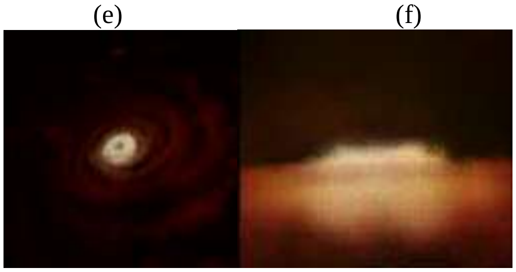
The Mean SSIM for whole video sample is collected, i.e. $SSIM_{MEAN}$.



(a) (b)

(c) (d)

(e) (f)



(g) (h)

(i) (j)

Figure 2 Frames of Database video

Some of the samples we collected are described in Table 1. The compression may employ lossy data compression, so that quality-measurement issues become important.

Table 1. Input Video Samples for x264 with profiles.

Video Sample	Format	Resolution	Bitrate (Kbps)
grb_1	AVI	640x480	776.15
m84_1	AVI	320x240	365.1
wg_gdo_1	AVI	1280x720	2185.66
wg_gdo_2	AVI	1280x720	2502.45
wg_gdo_3	MP4	560x320	33.91

Table 2 represents the comparative analysis of the size reduction of video using baseline approach & rate distortion approach.

Table 2 Final File size Video Samples for both Baseline and rate distortion approach

Video Sample	Original Size	baseline Profile	RDO
grb_1	3409.92	285	225
m84_1	1587.20	319	278
wg_gdo_1	2027.52	178	152
wg_gdo_2	3041.28	306	239
wg_gdo_3	374.00	28.4	28.7

When comparing compression codecs, PSNR is an approximation to human perception of reconstruction quality. Although a higher PSNR generally indicates that the reconstruction is of higher quality, in some cases it may not.

The resultant files size compression of the different technique is given in fig 3

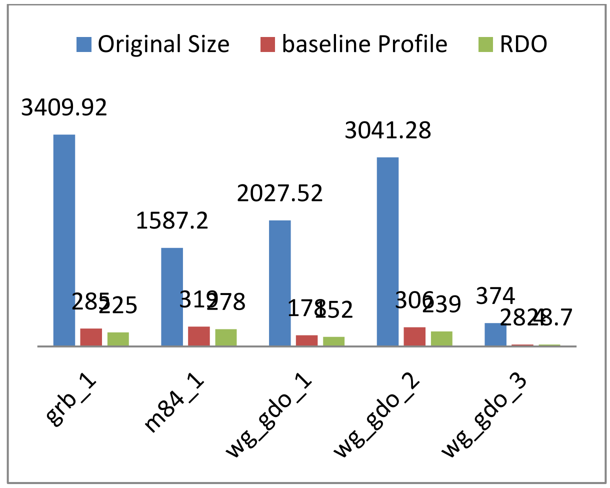


Figure 3Resultant File Size Comparison H.264 baseline and rate distortion profile.

One has to be extremely careful with the range of validity of this metric; it is only conclusively valid when it is used to compare results from the same codec (or codec type) and same content. Table 3 shows the Global PSNR Rate for Video Samples in H.264 baseline and advanced profile.

Table 3 Global PSNR Rate for Video Samples H.264 baseline and advanced profile.

Video Sample	baseline Profile	RDO
grb_1	36.0171	40.176
m84_1	38.187	42.734
wg_gdo_1	39.9087	44.857
wg_gdo_2	36.7407	41.293
wg_gdo_3	46.8072	52.665

Table 3 gives the Global peak signal to noise ratio for the different video signal. Max PSNR is achieved up to 52.665

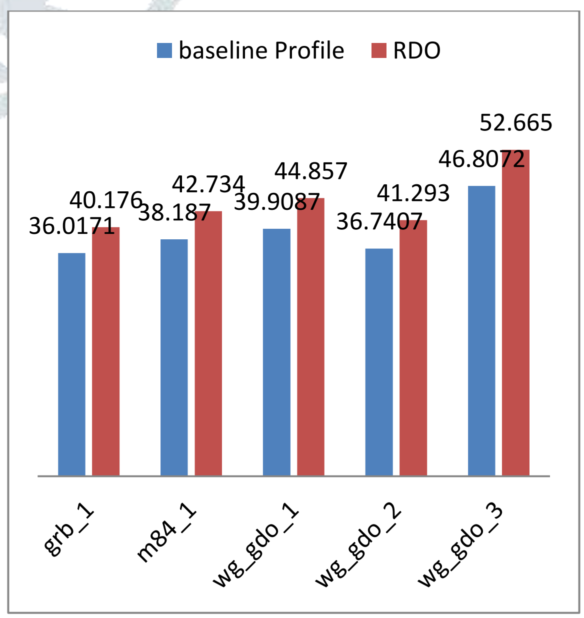


Figure 4 Global PSNR Rate for Video Samples

Fig 4 represents the graphical representation of the global PSNR.

V. Conclusion

The main goal of work is the presentation of a comparative evaluation of the quality RDO codec, using objective measures of assessment (PSNR and SSIM) with respect to MPEG-2 codec. The comparison was done using settings provided by the developers of each codec. The H.264 codec produces excellent video output achieving less than 1/3 of original file size without reducing video quality in any sense over both baseline and RDO profiles.H.264 provides gains in compression efficiency of up to 50% over a wide range of bit rates and video resolutions compared to previous standards.

The future scope of research work is understandingthe correlations between RDO and B-Frames in H.264. Profiling H.264 over other video codec matrices such as Precise-PSNR, A-PSNR, ST-SSIM, MSSIM and VQM.

References:

[1] K.-H. Chou and C.-P. Chung, "Using the Predictive Method of Adaptive 4x4/8x8 Transformations to Reduce the Computation in Motion Estimation," International Journal of Signal Processing Systems, Vol. 3, No. 2, pp. 112-117, December 2015.

[2] Gao, Yanbo, et al. "Layer-based temporal dependent rate-distortion optimization in Random-Access hierarchical video coding." IEEE 18th International Workshop on Multimedia Signal Processing (MMSP), 2016. IEEE, Dec 2016.

[3] P. Yin, H. Y. Cheong, A. M. Tourapis, and J. Boyce, "Fast mode decision and motion estimation for JVT/H.264,"inProc. IEEE ICIP, pp. 853-856 ,Sep. 2003,

[4] Y. Cheng, S. Xie, J. Guo, Z. Wang, and M. Xiao, "A fast inter mode selection algorithm for H.264,"inProc.1st Int. Symp.on Pervasive Computing and Applications, pp. 821-824 , Aug. 2006.

[5] Y. W. Huang, et al., "Analysis and reduction of reference frames for motion estimation in MPEG-4 AVC/JVT/H.264," Proc. IEEE Int. Conf. on Multimedia and Expo (ICME '03), pp. 809-812.Jul. 2003.

[6] Y. M. Lee, Y. F. Wang, J. R. Wang, and Y. Lin, "An adaptive and efficient selective multiple reference frames motion estimation for H.264 video coding,"Advances in Image and Video Technology, Springer vol. 5414, pp. 509-518, 2009.

[7] B. Zhan, B. Hou, and R. Sotudeh,"An efficient fast mode decision algorithm for H.264/AVC intra/inter predictions," Proc. IEEE Int. Conf. on Acoustics, Speech and Signal Processing (ICASSP '08), pp. 1057-1060 , Mar 2008

[8] K.-H. Chou and C.-P. Chung, "Using the Predictive Method of Adaptive 4x4/8x8 Transformations to Reduce the Computation in Motion Estimation," International Journal of Signal Processing Systems, Vol. 3, No. 2, pp. 112-117, December 2015.

[9] Ismail, M., Hyunho Jo, and DonggyuSim. "Fast intra mode decision for HEVC intra coding." 18th IEEE International Symposium on Consumer Electronics (ISCE 2014), 2014.

[10] Li, Chenglin, Dapeng Wu, and HongkaiXiong. " DelayPower-rate-distortion model for wireless video communication under delay and energy constraints." IEEE Transactions on Circuits and Systems for Video Technology Vol7 ,pp 1170-1183 , 2014.

[11] He, Jing, and Fuzheng Yang. "High-speed implementation of rate-distortion optimized quantization for H. 264/AVC." Signal, Image and Video Processing ,Vol 9 , 543-551 , 2015.

[12] Pastuszak, Grzegorz."Architecture design of the H. 264/AVC encoder based on rate-distortion optimization." IEEE Transactions on Circuits and Systems for Video Technology Vol 11 , 1844-1856 , 2015

[13] Ma, Siwei, et al. "Low complexity rate distortion optimization for HEVC." IEEE Data Compression Conference (DCC), pp 525-531 , 2013.

[14] Tanaka, Takashi, et al. "Semidefinite programming approach to Gaussian sequential rate-distortion trade-offs." IEEE Transactions on Automatic Control ,pp 431-436 , 2015.

[15] Gao, Yanbo, et al. "Layer-based temporal dependent rate-distortion optimization in Random-Access hierarchical video coding." IEEE 18th International Workshop on Multimedia Signal Processing (MMSP) ,

[16] Valizadeh, Sima, PanosNasiopoulos, and Rabab Ward. "Perceptually-friendly rate distortion optimization in high efficiency video coding."Signal Processing Conference (EUSIPCO), 2015 23rd European.IEEE, 2015.

[17] Ohno, Shuichi, et al. "Rate-Distortion Analysis of Quantizers with Error Feedback." arXiv preprint arXiv:1609.01383 (2016).

[18] Schuster, Guido M., and AggelosKatsaggelos. Rate-Distortion based video compression: optimal video frame compression and object boundary encoding. Springer Science & Business Media, 2013.

[19] A. M. Tourapis, O. C. Au, and M. L. Liou, "Predictive motion vector field adaptive search technique (PMVFAST) - Enhancing block based motion estimation," in Proc. Visual Communications and Image Processing 2001 (VCIP-2001), San Jose, CA, Jan. 2001.

[20] K. Cheung and L. M. Po, "A hierarchical block motion estimation algorithm using partial distortion measure," in Proc. International Conference on Image Processing, Apr. 1997, pp. 606-609.