Video Compression with Rate Distortion Approach: A Review

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Abstract: In this paper, a rate distortion approach is studied to solve the optimization purpose. Now a day, digital video compression technique is most popular for cost reduction. Many applications such as digitized music or internet broadcasting the movie, provided by the digital video industry cannot be forgotten. These attributes of digital video provides continue progression in compression technology & improvement on different media storage or audio / video service streaming. A RDO **(**Rate Distortion Optimization**)** technique is an optimization technique which involves diamond and exhaustive search. An exhaustive search process is involved to determine the optimal quantized transform coefficient, used in block code. The computational cost of exhaustive search quantization is more expensive than conventional quantization.

Keywords: **Rate distortion approach, High definition television, Spatial smoothness map, DCT, Quantization parameter.**

I. Introduction

A conventional system setting for researching on video compression is the pair of encoder and decoder, assuming abundant computation power for encoding, limited computation power for decoding, and no diversity for spatial and temporal resolutions. Under this circumstance, a critical question is what the best Rate Distortion (RD) trade-off is, which is the first problem to be tackled [1]. Furthermore, if we consider the spatial resolution diversity between the capturing unit and the displaying unit, there is a transcoding problem, which involves converting the spatial resolution for a compressed source. This transcoding task with spatial resolution conversion motivates the second major work in this thesis for image/video down-sampling in the Discrete Cosine Transformation (DCT) domain [4]. Lossy video compression under the conventional system setting with abundant encoding power generally adopts a hybrid structure, where several different compression methods including motion prediction, transform, quantization, and entropy coding are employed together. In general, this is referred to as hybrid video compression. This structure follows an intuitive understanding of video data about the temporal redundancy (similarity between Video compression in a practical multimedia system may be customized by different system settings such as its device diversities and the data delivery method [4] Conventional hybrid video compression assumes only the pair of encoder and decoder, overlooking the device diversities and the data delivery method. Transcoding considers the spatial resolution diversity, and/or the temporal resolution diversity, and/or channel bandwidth diversity through a network. Distributed video coding addresses the computation power diversity, technically speaking [5].

The following research paper is designed as follows. Section II describes the overall previous research work whereas Section III gives idea of problem formulation. Performance parameter defines in section IV and last but not the least Section V concludes the paper.

II. Literature Review

In this section, we will discuss basic introduction and high points of influence, explanations and issues in the research work by researchers in different field. Researchers have tried a lot in recent times to attain the max peak signal to noise ratio.

Yi Liu et.al described about Locally Adaptive Resolution, Quad tree Partitioning, Quantization Process and Proposed RDO Model. The result was found that Gradient Entropy and Bit Rate for Lossless Coding was 5.892 and 12.460 respectively [4].

Sanchuan Guo et.al described about Syntax-based context-adaptive Binary Arithmetic Coding the Gloom coding, which was widely used in HEVC. The PSNR loss, Rate computation reduction were 0.0428 and 28.4% respectively [5].

Mohammadreza Stephane et.al described about Promising Rate distortion approach and non - promising modes of Rate distortion approach. The major findings from his research were encoding time reduction, BD PSNR,BD Rate were 41.8 %, 0.058 db and 1.24% respectively [7].

Yanbo Geo et.al described about a layer-based temporal RDO technique for RA-HVC and Embedded Temporal for Random- Access Hierarchical Video Coding. The average BD-rate gain, BD-rate saving was 1.4% and 3.8% respectively. Such method has average ETR of sequence is about 104% and average ETR of each class was approximately around 103%~105% [8].

Shuichi Ohno et.al described About quantize with feedback filter & design of the Noise Shaping Filters. The result was found that MSEs of best feedback quantize, best feedback quantize is-10, -20, -30 db respectively [9].

Qin Huang et.al described about RBF technique. Linear Kernel and Non-linear Kernel technique was used. For linear kernel technique GM, SSM and STSM was 2.39 2.49 and 2.43 respectively. For non-linear kernel techniques GM, SSM and STSM were 2.55, 2.38 and 1.88 respectively [10].

Takashi Tanaka et.al discussed about SRD Approach for Gaussian SRD problem, Linear Gaussian sensor plan tricky, SRD optimization as max-det problem and Max-det problem as SDP respectively. The result was found that it provides min. downlink bandwidth for satellite attitude determination [11].

Alexandre Mercat et.al described about Quad-tree partitioning Intra encoding and RD-cost technique. The better outcome has been found for video

arrangement of class F up to 36% BD-BR saving .
amongst inverse allocator & CDC [12]

Table1. Literature Review Table

Ref	Year	Paper Title	Research Methodology used	Major Findings	Research prospects
[1]	2010	Rate-Distortion Cost Estimation for H.264/AVC	Bit-Rate Estimation Rate-Distortion Cost Estimation Block Classification	$\Delta PSNR = -0.21$ db Δ Bit Rate : 2.8 % Δ TD_{RDCOST} (%) :71.48 %	Block arrangement has been planned to categorize residual block for optimum modal constraint weighting to advance correctness of approximations.
[2]	2011	Rate Distortion Theory for Causal Video Coding: Characterization, Computation Algorithm, and Comparison	More And Less Coding Theorem Extended Markov Lemma used	Rate Allocation R_1 : 0.0035 R_2 : 0.3546 R_3 : 0.2274	The idea of causal video coding appear in actual video codec, coming work effort could be towards scheming real causal video coding procedure
[3]	2012	On Rate Distortion Optimization Using SSIM	SSIM in RDO Picking λ for SSIM-RDO	SSIM :7.9% PSNR : 2.1% Encoding Time : 99%	In present application, we only utilize local variance of luminance module in defining adjustment.
[4]	2013	Low Complexity RDO Model for Locally Subjective Quality Enhancement in LAR Coder	Locally Adaptive Resolution 1. Quad tree Partitioning 2. Quantization Process 3. Proposed RDO Model	Gradient Entropy : 5.892 Bit Rate for Lossless Coding : 12.460	Although objective quality is not enhanced from measured result, individual excellence is improved perceptibly
[5]	2014	Linear Rate Estimation Model for HEVC RDO Using Binary Classification Based Regression	Syntax-based Binary Arithmetic Coding Golomb coding which can be used in HEVC, we develop fast method to approximation its rate cost	PSNR loss : 0.0428 Rate computation reduction : 28.4%	Organization based linear regression technique to originate fast approximation model of rate Cost.
[6]	2015	An Adaptive	Lagrange	BD-PSNR	This method

		Lagrange Multiplier Determination Method For Rate-Distortion Optimization In Hybrid Video Codec's	Multiplier Selection Record distortion information	I.A: 0.17 db I.B: 0.69 db I.C:003 db	proposals a reliable bit rate saving over numerous test arrangements with diverse spatial resolution & content.
[7]	2016	RDO Cost Modeling for Low Complexity HEVC Intra Coding	Promising Rate distortion approach Non promising modes of Rate distortion approach	Encoding time reduction : 41.8 % BD PSNR : 0.058 db BD Rate : 1.24%	RDO Cost Modeling to decrease computational difficulty of HEVC intra coding
[8]	2016	Layer-Based Temporal Dependent Rate-Distortion Optimization in Random-Access Hierarchical Video Coding	Embedded Temporal propagation Chain for Random-Access Ordered Video Coding	average BD-rate gain : 1.4% BD-rate saving : 3.8% Average ETR of each class is about 103%~105%, & average ETR all orders is about 104%.	Temporal dependent RDO can be expressed as diminishing Combined distortion of to-be-coded unit & its affected
[9]	2016	Rate-Distortion Analysis of Quantizes with Error Feedback	1.Quantize with an error feedback filter 1. Design of the Noise Shaping Filters	MSEs of optimum f/b quantize, optimum f/b quantize is -10 , -20, -30 db respectively	The adequacy reaction of the ideal blunder input channel that limits the MSE can be parameterized by one parameter and can be found numerically.
[10]	2017	Measure and Prediction of HEVC Perceptually Loss /Lossless Boundary QP Values	Linear Kernel Non-linear RBF Kernel JND-based quality assessment dataset for HEVC-coded video	Linear Kernel GM : 2.39 SSM : 2.49 STSM : 2.43 Non Linear RBF Kernel GM : 2.55 SSM : 2.38 STSM : 1.88	By describing significant relics and inferring powerful highlights, the proposed SVR based forecast framework can foresee the main JND esteem for every Goop.
[11]	2017	Semi definite programming Approach to Gaussian Sequential Rate-Distortion Trade offs	SRD Approach for 1. Gaussian SRD problem 2. Linear Gaussian sensor design problem 3. SRD optimization as max-det problem	It provides min. downlink bandwidth for satellite attitude determination	The suggestion is that Gaussian SRD issues are effectively feasible utilizing standard SDP solvers.

			4. Max-det problem as SDP		
[12]	2017	Constrain the Docile CTUs: an In-Frame Complexity Allocator for HEVC Intra Encoders	Quad-tree partitioning Intra encoding RD-cost	The best outcomes are acquired for the video groupings of class F with up to 36% BD-BR reserve funds among CDC and the backwards allocator.	1. RD-cost is connected to the apportioning profundities of CTUs. 2. CTUs with low RD-cost have less increment of bit rates as well as contortion than CTUs with high RD-cost when compelled

III. Problem Formulation

The quantization is not implemented on residues for lossless model in HEVC and to avoid distortion. As due to this a new method i.e. lambda model is implemented in Rate-Distortion Optimization (RDO), where lambda is an factor that is based on quantization, which is independent to the

Loss less coding. This paper firstly shows the role of lambda that it played in RDO of HEVC. It also shows the simulation results that are based on the annealing algorithm. This technique is proposed to get the most appropriate lambda result for every large coding unit. If we consider the complexity of computer than these methods are not so efficient for this we proposed some prediction to improve RDO process.

The main objective of the paper is to study and analyze various rate distortions

Optimization in HVEC and H.264/AVC. To recover the video encoding efficiency propose and design HEVC with variable size of coding unit using Rate-Distortion Optimization (RDO).

IV. Performance Parameter

The performance of image and video compressions measure with compression ratio, global PSNR, average PSNR, SSSIM and gradient entropy.

1. Compression Ratio

Compression ratio basically an ration between the sizes of files that are before compression process and after compression process respectively. This ration gives an theoretical value that by how much times the files is compressed from original file. For an algorithm the compression ratio must be larger.

$$\text{Compression Ratio} = \frac{\text{Size after Compression}}{\text{Size before Compression}}$$

2. Compression Factor

Inverse of CR is called compression factor or it is an ratio of file before compression and after compression respectively [3].

$$\text{Compression Factor} = \frac{\text{Size before Compression}}{\text{Size after Compression}}$$

3. Compression Time

For calculation the time take by compression and to decompress the file has to be taken in separate account. Because in some application the decompression time is significant factor whiles in other application the combination of both compression and decompression time plays an important role. For an acceptable result time taken by compression must be smaller than algorithm [3]. The time taken for decompression is totally depended on computing devices.

4. Global PSNR Rate

MPEG-4Signal-to-noise ratio (often abbreviated SNR or S/N) is an measure that are being used in technology field now a day's which gives an comparison between the required signal with the background noise. So in mathematical terms this can be distinct as ration between signal and noise power. This term is defined in decibels. If the ration is greater than 1:1 (greater than 0 dB) then this shows that signal is more than the noise. As a SNR is only applicable for the electrical signal but this technique can be employed for any kind of signal and gives satisfactory results. (such as isotope levels in an ice core or biochemical signaling between cells).

5. Average PSNR Rate Video Samples ($PSNR_{global}$)

The difference between "PSNR" and "APSNR" is in the way of average PSNR calculation for a sequence. The requisite way to compute average PSNR for an sequence is to first find the mean square error for all the frames and after this we can calculate the PSNR value by the conventional simple equations of PSNR.

6. SSIM Rate Video Samples (SSIM)

SSI basically is based on the results of three factors after finding the results of these three factors all the results are combined to give a final result i.e. (luminance similarity, contrast similarity and structural similarity). There are mainly two implanted SSIM present which are fast and precise. The difference between these two implementations is that in Fast SSIM it uses box filter and in precise SSIM it uses gauss blur.

V. Conclusion

In this review paper different video and audio compression techniques with its simulation parameters global PSNR, average PSNR and SSIM are studied. The different techniques are used to improve the performance parameter. These video are used for personal and commercial used. A rate distortion is more efficient than other video compression technique like quad tree partition technique, syntax based arithmetic coding. In context to complete survey it is clear that RDO technique have less time complexity in comparison to RBF kernel technique.

References

[1] Ke-Ying Liao, Jar-Ferr Yang, "Rate-Distortion Cost Estimation for H.264/AVC " IEEE Transactions On Circuits And Systems For Video Technology, Vol. 20, issue 1, pp 38-49 , January 2010.

[2] En-Hui Yang "Rate Distortion Theory for Causal Video Coding: Characterization,

Computation Algorithm, and Comparison" IEEE Transactions on Information Theory, VOL. 57, NO. 8, pp 5258-5270 AUGUST 2011.

[3] Chen-Chou Huang, Hsu-Feng Hsiao "Perceptual Rate Distortion Optimization for Block Mode Selection in Hybrid Video Coding" IEEE Transactions on Information Theory, VOL. 57, NO. 8, pp 489-493, Mar 2012.

[4] Yi Liu "Low Complexity RDO Model for Locally Subjective Quality Enhancement in LAR Coder" *IEEE International Conference on Signal and Image Processing Applications*, pp 176 -181, 2013.

[5] Sanchuan Guo "Linear Rate Estimation Model for HEVC RDO Using Binary Classification Based Regression" *IEEE Data Compression Conference*, pp 406 -410, 2014.

[6] *Fan Zhang and David R. Bull "*An Adaptive Lagrange Multiplier Determination Method For Rate-Distortion Optimizations In Hybrid Video Codec's*" International Progress Conference on Image Processing,* pp. 671-680 , *July 2015.*

[7] Mohammadrezaet.al "RDO Cost Modeling for Low Complexity HEVC Intra Coding" *IEEE Canadian Conference on Electrical and Computer Engineering , pp 1-5 , 2016.*

[8] Yanbo Gao et.al "Layer-Based Temporal Dependent Rate-Distortion Optimization in Random-Access Hierarchical Video Coding" *IEEE 18th International Workshop on Multimedia Signal Processing*, pp 1-6, 2016.

[9] Shuichi Ohno "Rate-Distortion Analysis of Quantizes with Error Feedback" *IEEE journal of multimedia communication, Vol 74, issue 4*, pp 406-416, Sept 2016.

[10] Qin Huang et.al "Measure and Prediction of HEVC Perceptually Lossy/Lossless Boundary QP Values" *IEEE Data Compression Conference (DCC)*, pp 42-51, 2017.

[11] Takashi Tanaka et.al "Semi definite programming Approach to Gaussian Sequential Rate-Distortion Tradeoffs" *IEEE Transactions on Automatic Control* , pp1896-1910 , 2017

[12] Alexandre Mercat et.al "Constrain the Docile CTUs: an In-Frame Complexity Allocator for HEVC Intra Encoders" IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp 1163 – 1167, 2017.