An analysis on various high efficiency video codec approach for better compression of high dynamic range videos

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Abstract

Backgrounds/Objectives: The main objective of this methodology is to improve the video compression process by eliminating the perceptive details that are present in the high dynamic range videos without affecting the quality parameters in terms to various contrast and brightness properties. To do so, analysis is done on different research works that are conducted before in terms of attaining the qualified video compression and decompression.
Methods/Statistical analysis: This analysis the number of compression methods in terms of high dynamic range videos. The research is conducted to find the most considerable methodology that can retrieve the qualified videos without degradation of its quality through which high dynamic range quality video can be retrieved for the users.
Findings: The various research works has been analysed and it is evaluated by using toolkits called "DivX HEVC tool, HDR Tools, Luminance HDR" with varying quality high dynamic range videos. The performance evaluation conducted were proves that the HEVC HDR Intensity Dependent Spatial Quantization (HEVC-HDR-IDSQ) provides more qualified videos while transmitting than the other methodologies. This work also proves that the HEVC HDR Intensity Dependent Spatial Quantization method provides better result than the other methodologies in terms efficient reconstruction of videos without quality degradation.
Application/Improvements: The findings of this work proves that the HDR-IDSQ provides better result than the other approaches in terms of improved quality level and low bandwidth consumption

Keywords: High Dynamic Range Videos, Human Visual System, Video Compression Perception Details

1. Introduction

Video compression technique is the most essential process in the real world environment where sharing of videos across multiple locations are increased in number. Video compression provides the mean to transfer the videos in the less computation time. Video compression needs to be done with more concern to provide the video to the receivers without quality degradation. The main issue that might occurs in the video compression technology is the loss of detailed information while compressing videos which might leads to low quality video reception in the receiver side. Thus this video compression needs to be done by using the methodologies which can preserve the qualified details of the video.

Human Visual System (HVS) is the one of the most prominent technology in the image processing field which is used to process the videos with the physical and biological behaviours of human eye system. This technology is mostly adapted by the various compression techniques to preserve the quality of the videos with out degradation of performance. This compression technique that follows HVS behaviour would find the finer details that are present in the videos which cannot be located by the human eye systems and will remove it. Thus HVS plays key role in the video compression which could also be applicable in the video compression techniques.

The analysis done mainly focuses on the High Dynamic Range (HDR) videos which can cover every color gamuts. These HDR videos can cover every photometrics and colorimetrics pixel values of the high dynamic range videos which can preserve the finer details of the videos that are present in the system. Most of the technologies in the real world attempts to capture the high dynamic range videos which increase the influences of the video compression techniques.

The main issue that arises while using the HDR videos are technology adaptation where the most of the available display devices in many holds supports only 8 bit video content where the HDR videos consists more amount. Hence to avoid these issues an analysis is done to identify the most preferable system which may lead to the high definition support for low quality videos too. Most of the methodologies attempt to reach this goal by converting the high dynamic range videos into the low dynamic range videos before applying the compression methodologies. By doing so, well qualified videos can be retrieved as output.

The main contribution of this work is to find the most suitable and efficient mechanism to proceed the video compression technique in which better quality can be retained than the other approaches in terms of improved quality and the luminesce level. The organization of this work is given as follows:

In this section detailed introduction about the introductory part is given. In the section 2, various research methodologies that has been conducted before for achieving the better compression scenario is given and discussed in the detailed manner. In the section 3 pros and cons of the different methodologies that have been discussed in section 2 is given. In section 4 experimental results that has been obtained in these research methodologies has been given and discussed with graphical proof. Finally in section 5 overall conclusion of this work is given in terms of improved performance level.

2. Analysis of research methodologies

Yu-Cheng Fan et al [1] introduced a novel methodology for compressing the 3D videos without degrading the quality parameters in terms various 3D video depth value. This approach attempts to compress the 3d videos based on motion behaviour of videos which would be varied for each pixel of the videos in terms of various parameters. This approach mainly concentrates on the color videos and depth videos from the three dimensional videos. It attempts to find the variable length of videos and the motion vector of videos in different block sizes. This motion is used to predict the different moving behaviour of the 3D videos in terms of their scalability. The issue that has been met by this approach is the wrong motion vector identification. This is happened because of using the same procedure for motion vector detection in all the blocks. This is resolved in this work by introducing the motion depth vector movement identification by using the different motion detection approaches in terms of various blocks. After finding the motion vectors the depth map identification is done in terms of colour parameter in different block level.

The main issue that has been detected in the previous research work is it only considers the temporal features of the videos where the compression cannot be done in the efficient manner where the number of redundancy may exist more.

Anmin Liu et al [2] introduced an optimal compression plane methodology for video coding process where both spatial and temporal features of the videos are considered. Temporal features is the data's present in the x axis plane where the spatial features is the data's present in the y axis plane. This work will perform the initial pre-processing in which the frames would be initialized in which the x axis and y axis plane would be constructed. The redundant features would be identified in those frames in order to reduce the data size which can reduce the bandwidth consumption considerably. The redundancies of features are found by calculating the correlation among pixels that are present in both horizontal and vertical planes. The correlation is used indicate the higher correlation present between the different number of pixels that are present in the videos. This is done in two ways. Those are with inter-frame prediction and with out inter frame prediction. This categorization is based on finding the correlation in videos within or out of video frames. Moreover this methodology can overcome the limitation present in the previous methodology in terms of various correlation parameters.

The above mentioned research methodologies are about to compress and decompress the videos with good quality. However, these methodologies cannot support the high dynamic range videos effectively which in may lead to the performance degradation of reconstructed videos.

Zicong Mai [3] et al introduced a novel methodology for supporting high dynamic range videos in turn to provide the better qualified service to the users. The approach used in this work attempts to compress the high dynamic range videos in the efficient manner with the help of consideration of the tone mapping parameters which will compress the videos by converting the videos into low dynamic range videos. This methodology is introduced from the impression of low quality devices which cannot adapt the more than 8 bit video pixels. This approach is works as follows: First the HDR video would be converted in to the LDR by applying the tone mapping operator (TMO) on them. TMO would find the pixels that are not visible to the users by finding the various illustration techniques which could then be processed by the images. After converting it into the LDR video the encoding would be applied on that corresponding video to compress it. In the receiver side, first the decoding would be done on the encoded video which would then be progressed in to the inverse tone mapping process which will retrieve the final HDR video to the users without any violation of pixels. The results of this work prove that this approach leads to better result than the other techniques in terms of improved techniques and methodologies.

The above research methodologies cannot support the dynamic variation present between the same pixels that are retrieved from the same video content.

Christoph Posch et al [4] introduced the novel approach that is capable to predict the dynamic variation present between the various pixels present in the environment. This approach is based on the event detection system where the differentiation between the pixels at each time would be calculated in terms of various signalling parameters. This approach would iteratively communicate with the pixels values with the output values whenever the new communication is established between the grey scale parameters. By doing the database of the new pixel environment would be updated dynamically according to which the lossless image compression would be achieved. This would be done in the parallel manner which concentrates mainly on the temporal features of the images that resides in the environment. This approach would reduce the various redundancies that are present in the images in terms of temporal feature analysis (i.e.) on x axis analysis.

All of the above methodologies cannot guarantee the assured quality of the decompressed images in terms of performance quality ratio. The system need to be improved by checking the various performance parameters in order to assure the performance quality.

Chaminda T. E. R. Hewage et al [5] introduced the novel approach to prove the quality assurance of the decompressed videos at the end side. The main issue that might occur while decompressing the videos at the receiver side is it is more complex to deliver the full reference video for comparison. It is eliminated by introducing the concept called reduce reference video method which attempts to generate the reduce reference video by eliminating the unwanted features. This reference reduction is done based on the color feature value where the redundant color features are indexed and eliminated in different iteration in terms of various performance parameter values. This reduction of features would done with the help of depth map concept in which reductant temporal color features are identified in different frames of image. This depth map would eliminate the various edge redundancies and the pixel mapping present in the different pixel levels. This reduced reference concept leads to better comparison of the decompressed video quality in the receiver side by comparing it with the various measures.

All of the above mentioned methodologies cannot support the high resolution images in terms of more sequence of images to be processed. The processing methodology of the signal processing system would lead to more computational time in terms of higher resolution.

Jens-Rainer Ohm et al [6] introduced the new generation video compression methodology to attain the high resolution images as output with the consideration of efficient handling of signalling system. This is attained by introducing the new methodology called the High Efficiency Video Coding technique which in turn will output the high resolution images. This approach is introduced by ITU-T Video Coding Experts Group (VCEG) and ISO/IEC Moving Pictures Expert Group (MPEG) who migrates the old generation of the video compression methodology into the new generation. This methodology make use of knowledge of the neighbourhood pixel values which will further reduce the burden of users from producing more distorted images. This decompression is done by segmenting the images into multiple partitions which in turn will lead to improved decompression process in terms of various neighbourhood pixel values.

The above mentioned methodology cannot support the high dynamic range video in which more distortion occurred dynamically.

Zicong Mai et al [7] introduced the novel tone mapping parameter that attempts to find the variation present between the different pixels based on three parameters. The tone mapping range is used to convert the high dynamic range videos into the low dynamic range videos in terms of better performance level. This tone mapping value is identified in the proposed methodology by finding the variation between the following parameters called the base layer bit rate, enhancement rate bit rate and the mismatch rate. These methodologies would fine the different performance parameter values in terms of different accuracy valued. This variation range is used to predict the different valuation parameters in terms of different values. This approach also concern of the RGB parameter values in terms of different bit map depth. The enhancement layer of the methodology would find the variation between the different values that are occurred in the environment.

The drawback present in the previous methodology is that it cannot support the more variation present in the high dynamic range videos which would lead to the more decompression ratio. This need to be supported by the variation of different system parameters.

Yang Zhang et al [8] introduced the novel methodology to support the improved video decompression technique in the high dynamic range videos in terms of various parameter changes. This approach is introduced in terms of human visual system in which various perceptual details that cannot be identified by the human eye would be removed. This is done in terms of finding the various functional perceptual details. This is done based on the luminance masking effect in terms of various performance parameters that are present in the system. Tone mapping curve would be drawn in terms of the different pixels that are present in the HDR videos which would be optimized by exploiting the luminance masking effect on the videos. This methodology provides considerable performance in terms of providing the better analysis over the different functionalities.

The comparison analysis of various merits and demerits of previously discussed approaches has been listed in the following sub section.

3. Comparison of methodologies

This section provides an overview about the pros and cons that are occurred in the research methodologies whose functional scenarios are discussed in depth in the previous section. From the following table, it can be predicted a better approach that provides considerable improvement in the proposed scenarios.

Table 1. Comparison of Research Methodologies

S.NO	TITLE OF PAPER	AUTHOR NAME	METHOD USED	MERITS	DEMERITS
1	Three-Dimensional Depth Map Motion Estimation and Compensation for 3D Video Compression	Yu-Cheng Fan, Shu-Fen Wu, and Bing-Lian Lin	3D Depth Motion Estimation (3DMME)	Better compression improvement Attaining better quality improvement while decompression	Spatial features are not considered
2	Optimal Compression Plane for Efficient Video Coding	Anmin Liu, Weisi Lin, Manoranjan Paul, Fan Zhang, and Chenwei Deng	Optimal Compression Plane	Improved video compression based on redundant pixels present in the videos Reduced computation time	These cannot support the high dynamic range videos effectively More distortion can occurred while decompression
3	Optimizing a Tone Curve for Backward-Compatible High Dynamic Range Image and Video Compression	Zicong Mai, Hassan Mansour, Rafal Mantiuk, Panos Nasiopoulos, Rabab Ward,and Wolfgang Heidrich	Tone-Mapping With High Compression	Improved video compression ratio in HDR videos Improved performance level	It cannot find the changes occurred in the images in terms of new pixel differences that are happened
4	A QVGA 143 dB Dynamic Range Frame-Free PWM Image Sensor With Lossless Pixel-Level Video Compression and Time-Domain CDS	Christoph Posch, Daniel Matolin, and Rainer Wohlgenannt	Lossless Pixel-Level Video Compression	Improved data compression without loss Efficient reconstruction of videos with improved signalling parameter values.	Cannot assure the quality of delivered video contents More computational cost
5	Edge-Based Reduced-Reference Quality Metric for 3-D Video Compression and Transmission	Chaminda T. E. R. Hewage, and Maria G. Martini,	Reduced-Reference (RR) quality metric	Assured quality of decompressed video Improved system performance through feedback system	High resolution cannot be supported Required target cannot be attained through sequence processing
6	High Efficiency Video Coding: The Next Frontier in Video Compression	Jens-Rainer Ohm and Gary J. Sullivan	High Efficiency Video Coding	High resolution output can be reached Improved distortion rate Better decompression	More computational overhead

7	Visually Favourable Tone-Mapping With High Compression Performance in Bit-Depth Scalable Video Coding	Zicong Mai, Hassan Mansour, Panos Nasiopoulos, and Rabab Kreidieh Ward	HDR Intensity Dependent Quantization	Improved compression rate Improved system performance	Need to reduce the distortion rate to support the high definition devices Cannot decompress well in terms of more high dynamic range videos
8	High Dynamic Range Video Compression Exploiting Luminance Masking	Yang Zhang, Matteo Naccari, Dimitris Agrafiotis, Marta Mrak, and David R. Bull	HEVC - HDR Intensity Dependent Spatial Quantization	Improved compression rate More accuracy of resilience while decompressing images	Higher sensitivity in the videos cannot be supported well

From the above table it can be concluded that the "HDR Intensity Dependent Spatial Quantization (HDR-IDSQ)" methodology leads to the efficient video decompression with improved quality. The numerical proof of these of methodologies has been given and discussed in the detailed manner in the following sections.

4. Numerical results

The evaluation tests has been conducted using the Waterfall.mp4 HDR video file to find the better simulation approach that can lead to efficient reconstruction of high dynamic videos in the system. This performance evaluation is conducted in terms of parameters called compression ratio, and Peak Signal to Noise Ratio. The graphical illustration of these parameters in terms of various research methodologies is given and discussed detailed in the following sub sections. The various research methodologies that are analysed in this work are listed as follows:

- High Efficiency Video Coding (HEVC)
- Tone-Mapping With High Compression (TMHC)
- HDR Intensity Dependent Quantization (HDR-IDQ)
- HEVC - HDR Intensity Dependent Spatial Quantization (HEVC-HDR-IDSQ)

The tools that are used to compress the HDR videos by using the above methodologies are listed as follows:

- DivX HEVC tool
- HDR Tools
- Luminance HDR

Here the first tool Divx HEVC is used to perform the High Efficiency video encoding process. An HDR tool is used to perform the video compression process in the HDR videos in terms of both tone mapping and the intensity depth quantization approach. And the HDR-IDSQ is evaluated by using the tool called the Luminance HDR which is used to variate the luminance effect on the HDR videos.

To evaluate the performance of this methodology by using these tools for different approaches is done by using the Waterfall.mp4 HDR video of total size 2.08MB which would be segmented into multiple frames for the efficient processing. The Waterfall.mp4 video which was considered for analysis in this work consists of 126 frames when it is segmented into multiple frames. The performance evaluation is discussed detailed in the following sub sections.

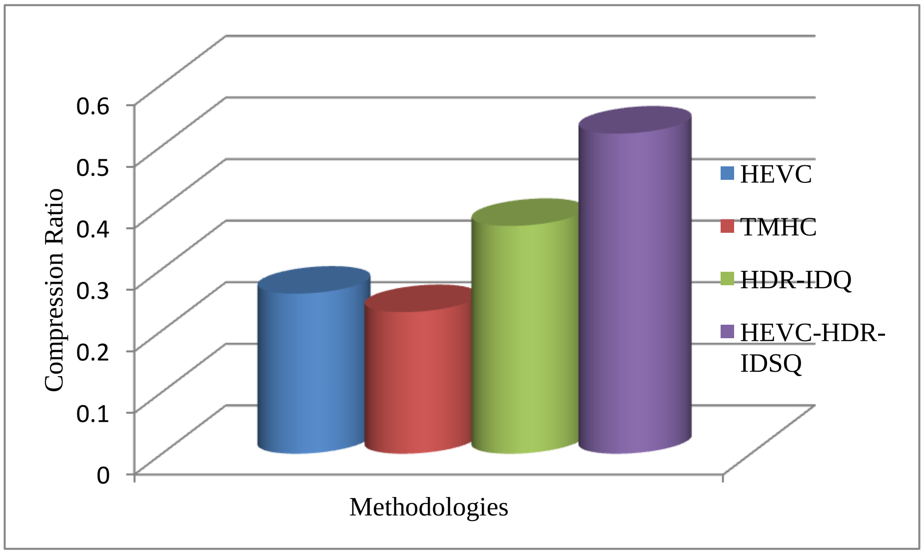
A. Compression ratio

Compression is defined as the methodology to reduce the redundant features and the unwanted pixels that are present in the image to reduce the need of bandwidth. The better image compression leads to the improved compression ration which is calculated as follows:

$$\text{Compression Ratio} = \frac{\text{Compressed Size}}{\text{Uncompressed Size}}$$

The graphical illustration of the compression ratio of these research methodologies is depicted in the following figure 1.

Figure 1. Compression Ratio



In the figure 1, compression ratio comparison is given. In the X axis different methodologies are taken where in the y axis compression ratio is taken. From this graph it can be proved that the HEVC-HDR Intensity Dependent Spatial Quantization (HEVC-HDR-IDSQ) provides better compression rate than the existing methodologies.

B. Peak signal to noise ratio

Peak signal-to-noise ratio (PSNR) is used to represent the index of media quality analysis and substitutes the average MSE of frames in the PSNR computing equation to obtain the PSNR value of the media segment, expressed as,

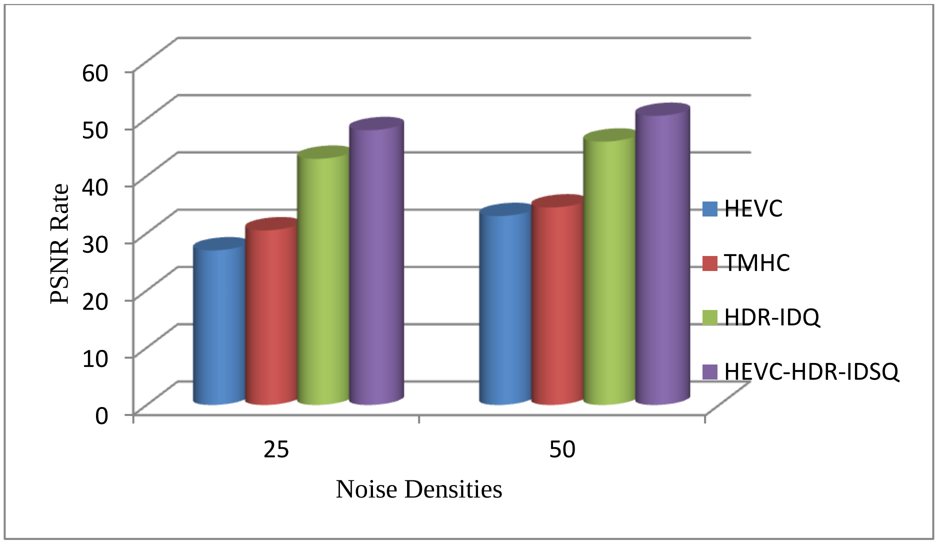
$$\text{PSNR} = 20 \times \log_{10}\left(\frac{255}{\sqrt{\text{MSE}}}\right)$$

Where

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(\overline{Y}_i - Y_i)^2$$

$\overline{Y}_i$ = vector of n predictions
Y = Vector of observed values

Figure 2. PSNR comparison



In the figure 2, PSNR comparison is given. In the X axis different methodologies are taken where in the y axis PSNR rate is taken. From this graph it can be proved that the HEVC-HDR Intensity Dependent Spatial Quantization (HEVC-HDR-IDSQ) provides better PSNR rate than the existing methodologies.

5. Conclusion

High dynamic range video compression is the important functionality resides in the image processing techniques which in turn used to compress the videos with the consideration of the different system parameters. In this analysis work, survey of different methodologies were conducted in terms of various performance parameters which in turn used to find the better video compression methodology that is used to find the efficient algorithm. The simulation were conducted by using simulation toolkits like DivX HEVC tool, HDR Tool, Luminance HDR from which it is proved that the proposed methodology HEVC - HDR Intensity Dependent Spatial Quantization (HEVC-HDR-IDSQ) leads to better construction of videos than the existing methodologies. In future, these works can be further improved by considering the more sensitivity images to predict the different compression ratios.

6. Reference

1. Yu-Cheng Fan, Shu-Fen Wu, Bing-Lian Lin. Three-Dimensional depth map motion estimation and compensation. *IEEE Transactions on Magnetics*. 2011; 47(3), 691-695.
2. Anmin Liu, Weisi Lin, Manoranjan Paul, Fan Zhang, Chenwei Deng. Optimal compression plane for efficient video coding. *IEEE Transactions On Image Processing*. 2011; 20(10), 2788-2799.
3. Zicong Mai, Hassan Mansour, Rafal Mantiuk, Panos Nasiopoulos, Rabab Ward, Wolfgang Heidrich. Optimizing a tone curve for Backward-compatible high dynamic range image and video compression. *IEEE Transactions on Image Processing*. 2011; 20(6), 1558-1571.
4. Christoph Posch, Daniel Matolin, and Rainer Wohlgenannt.A QVGA 143 dB Dynamic Range Frame-Free PWM Image Sensor With Lossless Pixel-Level Video Compression and Time-Domain CDS. *IEEE Journal Of Solid-State Circuits*. 2011; 46(1), 259-275.
5. T. E. R. Chaminda Hewage, G. Maria Martini. Edge-Based Reduced-reference quality metric for 3-D video compression and Transmission. *IEEE Journal of Selected Topics in Signal Processing*. 2012; 6(5), 471-82.
6. Jens-Rainer Ohm, Gary J. Sullivan. High efficiency video coding: The next frontier in video compression. *IEEE Signal Processing Magazine*. 2013; 30(1), 152-158.
7. Zicong Mai, Hassan Mansour, Panos Nasiopoulos, Rabab Kreidieh Ward.Visually favorable Tone-mapping with high compression performance in Bit-depth scalable video coding. *IEEE Transactions on Multimedia*. 2013; 15(7), 1503-1518.
8. Yang Zhang, Matteo Naccari, Dimitris Agrafiotis, Marta Mrak, David R. Bull. High dynamic range video compression exploiting luminance masking. *IEEE Circuits and Systems Society.* 2015; 99, 1.