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Enhancing Multi-Scale Retinex Algorithm Utilizing H.265/HEVC for Improved Video Compression

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Abstract

The Multi-Scale Retinex technique is a method that modifies images' visual quality by adapting the global lightness and local contrast at a local level thus Compression video files using High Efficiency Video Coding technology helps to keep the quality of the viewed video. The concept of involving H.265 video compression in order to enhance the performance of multi-Scale Retinex doesn't involve use simulation for MSR; instead it creates artificial images that mimic those produced by the human visual system, including color perception and level of detail under varying lighting conditions. This procedure consists in decomposing an image into numerous scales (enhancing each scale individually) then reassembling them into one single output image. This method has applications in various fields such as medical imaging, computer vision, and image processing. It can effectively compress video data without affecting the perceived image quality. Each frame of the video goes through the MSR (Multi-Scale Retina) technique and then the enhanced frame is compressed using the H.265 standard. This allows for achieving a 16% improvement in the ratio between effective video storage and visual quality. HEVC will have a 50% lower bit rate while maintaining the same level of image quality.

Keywords: Multi Scale Retinex Algorithm, H.265/HEVC Technique, Video Compression, Image Enhancement, Computational Efficiency.

1 Introduction

Viewing video data has been formidable for both storage and dissemination until recently, with the use of several video compression algorithms. HEVC introduces more sophisticated compression methodology compared to what was known in the past with standards like H.264, with higher efficiency. Therefore, data representations may be compressed with H.265 yet maintain acceptable image quality. Extensions for MSR in video compression using H.265 present a very interesting angle toward

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enhancing image quality and the efficiency of storage for video sequences (Nie & Liu, 2024). Within this paper, an attempt is made to see the possible incorporation of MSR enhancement with H.265 video compression. The influence of MSR on each video frame is looked at, and the frame is further encoded using H.265. Many works have scrutinized H.265 video compression in amalgam with Multi-Scale Retinex enhancement. This paper is going to concentrate on improving image quality for compressed movies at different compression levels. The paper presents a brief review of MSR technology, its uses, and how it improves image quality (Riza et al., 2024). Although not in any great detail, video compression is one good basic piece of understanding in the concept of MSR (Bovik, 2010). The process of video image enhancement by using Retinex image enhancement is elaborated. The process enhances all qualities by imposing compression and works as a preprocessor for H264. The compression efficiency in the original video is enhanced by 14.5%, which means size reduces sine ratio increases compression (Maaroof& Lade, 2015).

The Retinex model has been, for a long time, widely used as the most interesting tool for studying human vision color constancy. Used as a foundation for making better quality of digital images, retaining color constancy, and brightness/color fidelity, also adding local contrast in the absence of the motion of discontinuity and compression related artifacts (Kharipova et al., 2024). Brightness and color contrast adjustment often play a significant role in video sequence enhancement towards giving clear images, as well as improving the perception of motion (Maaroof & Lade, 2015).

The next work elaborates the quality improvement of images obtained from a modified version of MSR known as Multi-Scale Retinex with Adaptive Color Restoration (MSR-ACR) (Zhang et al., 2021). This work does not show a straight relationship with video compression. However, it just shows how effective MSR-based techniques can be in improving image quality. It can stretch its meaning to video enhancement for H.265 compression (Zhao et al., 2016).

It focuses on image enhancement on mobile devices by combining MSR with detail processing techniques. Although it does not solve the video compression problem directly, it gives a clue regarding the application of methods based on MSR to increase the quality of images, which can be expanded into the video compression case (Liu et al., 2018).

Used multi-scale retinex methods, suggest an upgrade to the MSR for picture enhancement. When applied to photos with non-uniform illumination, either in terms of color or luminance, MSR produces acceptable outcomes in terms of color constancy and dynamic range compression. MSR has an inferior impact in places with normal or intense lighting because to its excessive sensitivity to noise speckles produced by cameras in low light conditions. Moreover, MSR may cause apparent data loss on photos and treats before to display using the gain-offset approach. In order to reduce data loss, this research uses a customized sigmoid function in lieu of the logarithm function in MSR (Maaroof, 2019).

2 Related Work

Investigated of the Retinex algorithm detects very slack resolution and prevents distortion that arises with other techniques. The proposed research has high precision, little distortion, and noise has been eliminated. By performing feature extraction on both visible and infrared line images, as well as weighted averaging of the targets Image fusion is performed using visible light and infrared pictures (Parthipan et al., 2022). Investigation of photograph quality should involve an enlargement of our perception of color and resolution in digital photos and, also, how an original image can be enhanced by some algorithms with noise reduction. All these will tend to accuracy in image segmentation and resolution. It had been reported that the Retinex algorithm is capable of digital image analysis. Still, it cannot handle image distortion analysis (Maaroof, 2020).

Any aspect of MSR, including its variant and extension, is discussed, along with highlighting the potential to combine video compression techniques with MSR for enhanced image quality of compressed videos. The usage of MSR algorithms in video compression and its quality evaluation is discussed. It explores a video-quality impact study of several compression techniques upon which an effective metric for the quality restoration of images by enhancing MSR is proposed (Wang et al., 2020).

Integration of Multi-Scale Retinex with video compression techniques, like H.265, can be highly demanded by the achievement of good image quality and effective video storage and transmission (Mohammed et al., 2023). The major driving forces for this integration are the following: Achievement of good image quality. The fundamental purpose of any video compression technique is to pack video files efficiently for storage or transmission. However, this very compression more than often gives rise to degradations in the image quality, along with various forms of artifacts, decreased contrast, and even loss of features.

This would merge MSR enhancement with video reduction to finally arrive at distorted visual free and excellent quality compressed movies. The MSR algorithm enhances global brightness as well as local contrast, for better perception and stereoscopic image use. This would have been of much help in maintaining important visual aspects and structures within the video image even after compression. MSR and H.265 video compression are combined to make videos simpler to access and examine for uses in object identification, video analytics, and video search. Storage and Bandwidth Efficiency: In a number of fields, such as video streaming, video surveillance, and video content delivery, effective video data storage and transmission are essential. By drastically reducing the video file size, video compression methods such as H.265 allow for effective bandwidth use and storage optimization. Videos may be effectively compressed and visually upgraded at the same time by combining MSR enhancement with H.265 compression. This results in lower storage needs and better bandwidth utilization. Better Analysis and Search (Jaiswal & Mehrotra, 2021).

Promising 50% bitrate reduction at the same video quality as H.265/High Efficiency Video Coding (HEVC), (Uhrina et al., 2024) several optimization works were performed on the intra coding process, which is crucial to minimize the indoor spatial excess mean. Extension of the flexible allocation method for intra coding in H.265/HEVC, (Ibraheem & Dvorkovich, 2024).

3 Methodology

To investigate the possible synergy between MSR improvement and H.265 video compression, as well as the consequences for storage efficiency and visual quality. Specific advantages, practical aspects, and empirical results of this hybrid approach that advances the field of video processing and optimization are discussed below.

Image processing and video coding techniques meet the H.265 video compression techniques in Multi-Scale Retinex (MSR) enhancement. Here is the description and methodology at a very high level:

Improving MSR: Decomposition: At first, the video image is decomposed into several scales by means of wavelet or pyramid-based approaches. The decomposition results in a set of pictures at different scales, which represent different detail levels. MSR Processing: After decomposition, the image's various scales are subjected to MSR enhancement. MSR techniques improve global illumination and local contrast. Reconstruction: As and when required, for obtaining the enhanced version of the video image, stitch the same at various scales.

H.265 Video Compression: Frame Coding: The H.265 video coding standard for higher coding of input video pictures. Reduction of redundancy and compression frames are carried through techniques like motion estimation, intra- and inter-frame prediction, entropy coding, etc. Quantization: Transform coefficients of video frames are quantized which is called quantization, to attain more compression where the precision of bitstream data becomes very low. In this, some information loss occurs in this process. Entropy Coding: The quantized video frames are further compressed using entropy coding techniques, such as arithmetic coding or CABAC (Context-Adaptive Binary Arithmetic Coding).

Display and Decoding: Video Decoding: The H.265 decoding method is used to decode the compressed video stream. In order to rebuild the video frames, it employs inverse quantization, inverse transform, and motion compensation.

Video Display: The spectator is given a better visual experience by seeing the enhanced video frames (Wiegand et al., 2003).

Experiments with Retinex

The algorithm presented has chosen a picture sequence to showcase its performance. Raw video was used to record the sequence. The suggested method will be applied to the picture series in order to improve contrast. Among these methods are H.265 and MSR (Multiscale Retinex) (Zhang et al., 2015).

The single scale retinex (SSR) method presents certain drawbacks. When the scale is set too small, it effectively compresses the dynamic range, but it also produces a halo appearance around edges. Setting too high a ratio results in reduced dynamic range compression and a noticeable gray effect in more evenly distributed areas. Using the Retinex technique at a single scale is not sufficient to achieve both high-quality sound reproduction and effective dynamic range reduction. Therefore, the Multiscale Retinex algorithm (MSR) was developed. This algorithm uses the Retinex technique at multiple scales and then sums the results using a weighted sum, producing an output according to the following equation (1):

$$R \sum_{n=1}^{N} w \quad (1)$$

$$R_{MSR}(x,y) = \sum_{n=1}^{N} w_n R_n(x,y) \quad (2)$$

Where the output of Multi-scalar Retinex (MSR) is represented by the variable RMSR (x, y), the output of Single-scale Retinex (SSR) at different scales is represented by Rn (x, y), and the weights are mentioned for different scales. N is the number of scale levels used, and the weights are chosen so that wn = 1, (Li & Ngan, 2016).

The logarithmic values in the SR output range from very tiny negative integers into the positive domain. Therefore, the algorithm's last stage is to normalize the output numbers such that they lie between 0 and 1. Equation (2) describes a gain/offset strategy that is used to accomplish this.

$$R_{MSR_i}(x,y) = \alpha[\sum_{n=1}^{N} w_n R_{n_i}(x,y)] - \beta \quad (3)$$

Where ß is the offset and α is the gain. To ensure that the minimum value in the final image is zero, β is based on the minimum value of the image. The resulting image is scaled so that its highest value is 1, and the gain α is determined by dividing 1 by the difference between the maximum and minimum values in the MSR output. Since these values are calculated globally, this method has similar problems to global histogram equalization it will not be optimal for all portions of the picture if it comprises areas with significantly differing intensity distributions, in equation (3) (Petro et al., 2014).

To optimize the dynamic range compression of the technique without causing any undesired consequences, it is recommended to utilize an adaptive method that calculates the gain and offset at the final stage of the process. These results can then be combined with the results of the global calculation. This method uses the adaptive technique used in CLAHE. The image is initially divided into a series of tiles. The ß value for each tile is calculated by finding the minimum intensity. The alpha value for each tile is then determined by calculating the difference between the highest and lowest intensity. This method creates a two-dimensional array of α and β values corresponding to the size of the selected tile. The next step involves increasing the range of α and β values to accommodate the dimensions of the image. The method is bilinear interpolation. Upon extending the α and β fields, every pixel in the MSR picture will be allocated a specific value. Now, the α and β coefficients may be utilized to standardize the picture.

Color Constancy Effects of Retinex

For a number of application scenarios, the solution to the color constancy issue requires an understanding of chromatic adaptation. Chromatic adaptation and other color illusions are supported by the visual perception concepts of Retinex Hypothesis. Created a method solve the color constancy problem and simulate color adaptation using the given concepts. The evaluation of the results depends on the type of application under consideration.

The study of color adaptation in the human visual system is of great importance for a comprehensive understanding of color perception and for the effective use of color in a variety of computer-aided image analysis and synthesis applications. Color matching is a particularly important feature of the human visual system. The illumination adaptation when viewing an image under different lighting conditions is called color adaptation or chromatic adaptation. This means that, for example, a white sheet of paper looks white to the human eye in daylight or under a tungsten bulb.

The goal of studying color constancy is to develop models that can calculate a constant representation of the color of an illuminated object under different lighting conditions from known tristimulus values. This problem should be solved theoretically if the reflectance of the object and the color composition of the light source are known and assumptions are made about the linearity or uniformity of the illumination.

Most color constancy computer models are based on von Kris's assumption that color sensors respond linearly to stimuli. These assumptions are tested by comparing the colors under D65 and other illuminants (as described by Fairchild) and determining the relative hues (colors that appear the same under different lighting conditions).

The solution to color constancy (dynamic range calibration of computer-generated images) is crucial due to the limitations of ordinary computer screens and the poor effects of color distribution. The "sound reproduction problem" was first solved by Tomblin and Rush Meier, and a solution was developed for grayscale photographs. In addition to the previously described work by Rahman et al., Pattanaik et al. used a strategy derived from the von Kries linearity assumption to solve the color matching problem and achieved promising visual results.

Implementation of an algorithm that simulates the Retinex filter; to test its effectiveness, I propose to use computer-generated images and calculate the color distance between colors and their Retinex filtered representations. This method is highly effective in ensuring consistent color reproduction in different lighting settings, and can help address the challenge of accurately reproducing colors on computer display systems.

The primary information source for achieving color consistency is the edge. If there is an edge between two neighboring spots, the luminance ratio preserves it; otherwise, it removes the gentle slopes brought on by uneven lighting. Consequently, processing the whole picture in terms of luminance ratios is all that is required to derive the lightness values. They therefore take into account the sequential product of ratios across edges on a route connecting two places that are separated by a significant amount in the picture. The Retinex method takes into account all feasible pathways beginning at random places and finishing at the pixel where the brightness value is calculated, since this generalized brightness ratio will vary depending on the chosen path. The brightness is then determined using the average of the product of the ratios of the intensity values of the values of the subsequent edge points of the path. If the deviation of this ratio does not exceed a certain threshold of 1, it is considered uniform, thereby eliminating the effect of uneven illumination in the image.

This equation gives the brightness value L of a pixel in a given color channel, and Retinex calculates x = (i, j). The intensity value of each color channel at x is represented by the image data I(x). Land and McCann considered a set of N paths y1,..., yk,...,yN starting from x and ending at an arbitrary image pixel yk. Let nk be the total number of pixels in path k. Then for each tk = 1,..., nk xtk = (tk) and for each subsequent pixel in the path xtk+1 = yk(tk +1) such that yk(1) = x and yk(nk) = yk , (Maaroof & Lade, 2015).

The average of the relative brightness at x on all paths is the brightness L(x), or H, of pixel x in a particular color channel in equation (4).

$$L(x) = \frac{\sum_{k=1}^{N} L(x;yk)}{N} , \qquad (4)$$

Where L(x;yk) indicates how bright a pixel x is in relation to yk on the route k that is described by equation 5, (Maaroof & Lade, 2015).

$$L(x;yk) = \sum_{tk=1}^{nk} \delta \left[log \frac{I(x_{tk})}{I(x_{tk+1})} \right] \qquad (5)$$

Many compression strategies have been developed to solve the problem of high video sizes. Among these algorithms, H.265 stands out because to its high compression ratio and quality, making it the industry standard when compared to other algorithms of its kind. But too much compression (lossy compression) reduces the quality of the video, especially in real world scenarios.

The imaging system is unable to capture the dynamic range of brightness changes because it records absolute brightness instead of relative brightness, as the human eye does. Because this effect lacks realism and lifelikeness, it also degrades visual quality.

Used retinex as a preprocessing step to improve overall video quality in order to solve these problems with imaging and video sequences. Different image compression and breakdown techniques reduce image quality; The costliest calculation is involved in motion estimation and correction between frames.

In all of the above listed circumstances, Retinex is advantageous. Enhance both the coding efficiency and the video quality.

High-Efficiency Video Coding

The H.265/HEVC standard was released by JCT-VC in 2013 and is expected to reduce bit-rates by approximately 50% compared to H.264. In addition, H.265/HEVC utilizes hybrid video compression techniques Figure 1 depicts. the typical encoding framework for H.265/HEVC. The four main components of the H.265/HEVC encoder are: quantization (Q), transform (T), intra- and inter-prediction, and context-adaptive binary arithmetic coding (CABAC) for entropy coding. Additionally, to reduce spatial and temporal redundancy are reduced using modules for intra- and inter-prediction. To minimize redundancy in appearance modules for quantization and transformation are used. The redundancy of information entropy is reduced by using the entropy coding module. The most important tool is the inter-prediction module, which accounts for around 50% of the computing complexity. Next, reducing spatiotemporal redundancy should lower the computing cost of the H.265/HEVC encoder allows for real-time encoding, (Jiang et al., 2019).

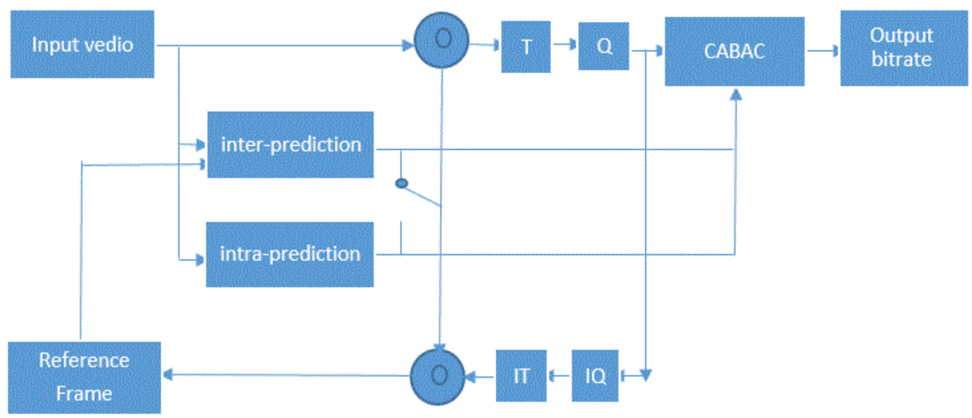


Figure 1: The Structure of High Efficiency Video Coding (H.265) Encoder

Start: Begin the processing.

Input: Video frames.

Decomposition: Decompose the video frames into multiple scales using a pyramid or wavelet-based approach.

MSR Enhancement: For each scale of the decomposed frames:

Apply the MSR algorithm to enhance local contrast and global illumination.

Emphasize the meaningful structures in the frames.

Reconstruction: Combine the enhanced frames at different scales to reconstruct the enhanced video frames.

H.265 Video Compression: Encode the enhanced video frames using the H.265 video coding standard.

Apply motion estimation, intra-frame and inter-frame prediction, and entropy coding techniques for compression.

Quantization: Quantize the transformed video frames to reduce precision and achieve further compression.

Introduce some loss of information during quantization.

Entropy Coding: Compress the quantized video frames using entropy coding techniques, such as arithmetic coding or CABAC.

Decoding and Display: Decode the compressed video stream using the H.265 decoding algorithm.

Perform inverse quantization, inverse transform, and motion compensation to reconstruct the video frames.

Restore the meaningful structures and improve visual quality using the MSR enhancement restoration process.

Display the enhanced video frames for viewing.

End: The equations (6) to (13) below involved in Multi-Scale Retinex (MSR) enhancement and video compression using H.265, (He et al., 2017).

Multi-Scale Retinex (MSR) Enhancement

1. Image Decomposition: The methods include Laplacian pyramid decomposition or wavelet decomposition.
2. MSR Enhancement:

Local Adjustment: $V(x,y,s) = log\ (I(x,y,s))$- log (I$(x,y,s)\otimes G\ (x,y,s)$) (6)

Global Adjustment: $G(x,y,s) = log\ (I(x,y,s)) \otimes F(x,y,s)$ (7)

Enhanced Image: $E(x,y,s)$= $V\ (x,y,s) + G(x,y,s)$ (8)

H.265 Video Compression

1. Motion Estimation: Various algorithms, such as block matching, are used to estimate motion vectors between consecutive frames.
2. Intra-frame Prediction:

Prediction Equation: $P\ (x,y)$= $F\ (x\text{-}1,y) or F(x,y\text{-}1) or F(x\text{-}1,y\text{-}1)$ (9)

3. Inter-frame Prediction:

Prediction Equation: $P(x,y) = F(x\text{-}\Delta x,y\text{-}\Delta y)$ (10)

4. Transform Coding:

Transform Equation:$T(u, v) = \Sigma\Sigma F(x, y) * e$^(- $j2\pi\left(\frac{ux}{M} + \frac{vy}{N}\right)$) Inverse (11)

Transform Equation: $F\Sigma(x,y) = \Sigma\Sigma T(u,v) * e$^($j2\pi\left(\frac{ux}{M} + \frac{vy}{N}\right)$) (12)

5. Quantization:

Quantization Equation: $Q(x,y) = round\left(\frac{F(x,y)}{QP}\right)$ (Riza et al., 2024) (13)

6. Entropy Coding: Commonly used methods include Arithmetic Coding and Context-Adaptive Binary Arithmetic Coding (CABAC).

The characteristics of the input video, the particular MSR algorithm used, the compression settings, and the intended trade-off between visual quality and compression efficiency are some of the factors that can affect the enhancement ratio of Multi-Scale Retinex (MSR) enhancement combined with the video compression technique H.265. The enhancement achieved in the MSR methods is quantified by the quality measure to be called enhancement ratio (Huang et al., 2019). It can be carried out using either objective quality measures or human observer assessments. What is the increase ratio exactly for your video capture or situation without testing and analyzing it?

The MSR technique improves the global illumination of an image, local contrast, and preservation of important structures within video images. Finally, the last implemented algorithm is indeed the MSR algorithm. Most factors considered here include video image complexity and content, and H.265 compression. There must be a balance between enhancement ratio and compression efficiency for H.265 (Ketabi & Oskoei, 2015). By improving the image quality of the video, it might ultimately bring added processing and computational effort along. To do this, for a specific application under particular conditions and constraints, the trade-off between the enhancement ratio and compression efficiency of enhancement by H.265 must be achieved. This will give a more correct description of the enhancement ratio that can be brought about under compression by using MSR enhancement and H.265 in compressing videos (Chen et al., 2020).

Architecture and Proposed Design

The Multi-Scale Retinex enhancement incorporated with H.265 video compression technology can be described as follows. MSR Algorithm Improves H.265/HEVC Video Compression Technology

1. **Input:** Video images, the individual images of the input processed video.
2. **Improvements of Multi-Scale Retinex (MSR):** Decomposition. The video image is decomposed into several scales. A good mechanism would be either pyramid or wavelet-based methods.
    - MSR Processing: The MSR algorithm is independently used at each and every scale of the deconstructed image for local contrast improvement, global illumination, and saliency structure enhancement.
    - Reconstruction: The procedure of reconstructing the enhanced video image at different scales to get the enhanced video image.
3. **H.265 Video Compression:** Frame Coding: Coding of enhanced video frames using the H.265 video-coding standard.
    - Motion Estimation and Compensation: For the exploitation of temporal redundancy among the various frames of the video, the technique of motion estimation and compensation is adopted.
    - Intra- and Inter-frame Prediction: It has been adopted from both intra- and inter-frame prediction techniques to reduce spatial and temporal redundancies.
    - Transform Coding: Transform coding by either DCT or DWT is carried out to show the video frame with increased compressibility.
    - Quantization: It further reduces the data precision by quantizing the transformed video frame.
    - Entropy Coding: Entropy coding techniques such as arithmetic coding and context-adaptive binary arithmetic coding are applied to the video frame for further compression.
4. **Decoding and Display:** H.265 Decoding: Compressed video stream decoded with the decoding algorithm for H.265.
    - Inverse Quantization and Inverse Transformation: Inverse quantization and transformation to get back the video image.
    - Multi-scale Retinal Restoration: In the restoration of meaningful structures and image quality improvement.
    - Video Display: Display the enhanced video image for viewing

4 Results

The results show that the image quality and compression efficiency are significantly improved by combining MSR enhancement and H.265 compression. MSR enhancement produces better image quality by successfully improving global illumination, local contrast, etc. The improved video frames are effectively compressed by the H.265 compression techniques without sacrificing tolerable visual quality. The efficacy of the integrated strategy in optimizing visual quality and attaining efficient compression is validated by both subjective assessments and objective quality indicators.

The findings of the original picture's histogram after retinex has been applied are called histograms (Created on intensity image of original sequence). Figures (2) and (3) demonstrate how a more equal distribution of intensities (brightness) enhances the image's overall visual quality.

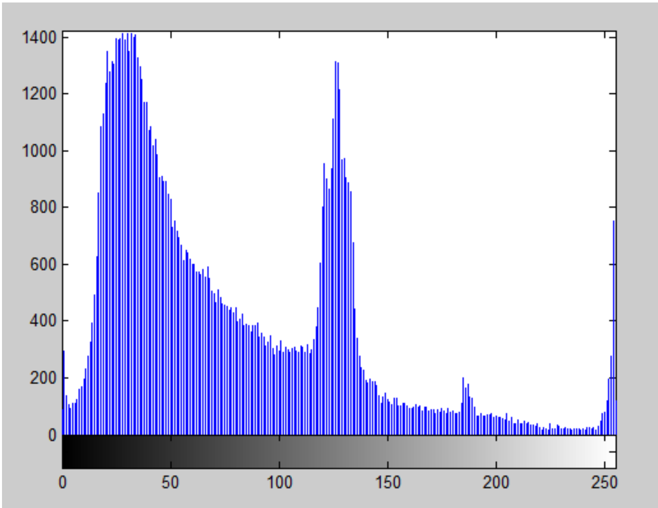


Figure 2: Image Histogram of Original Image

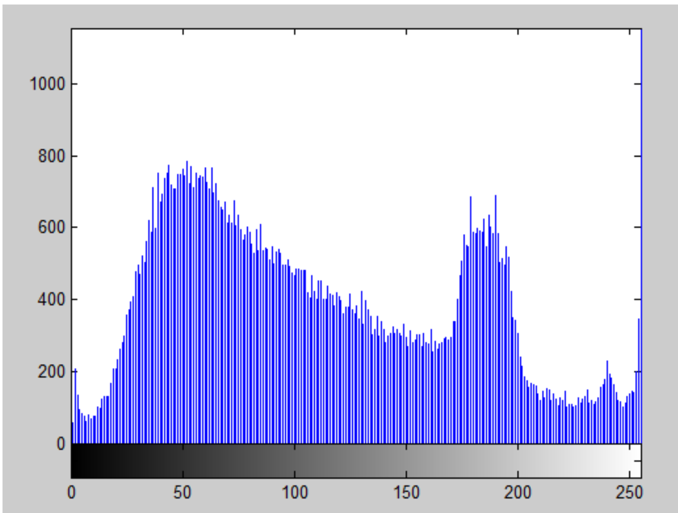
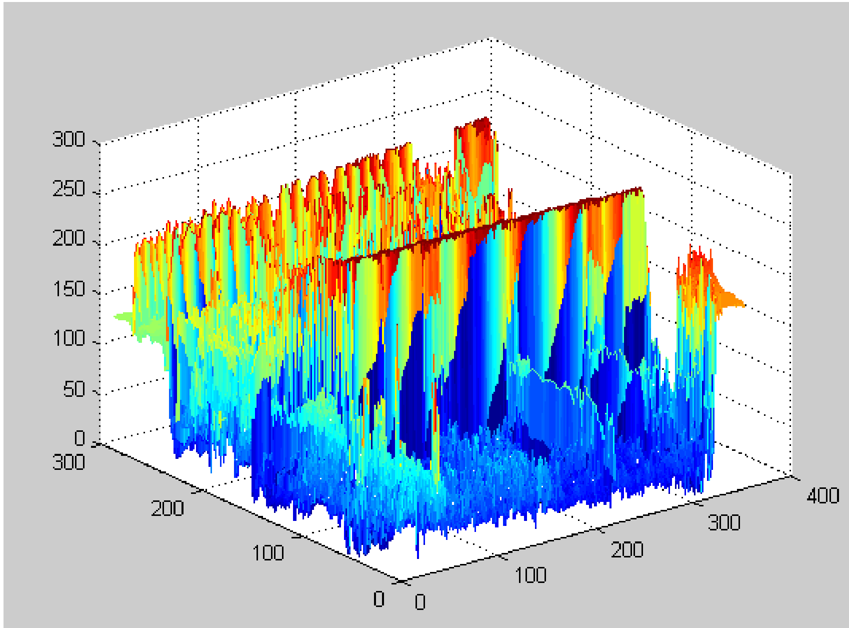
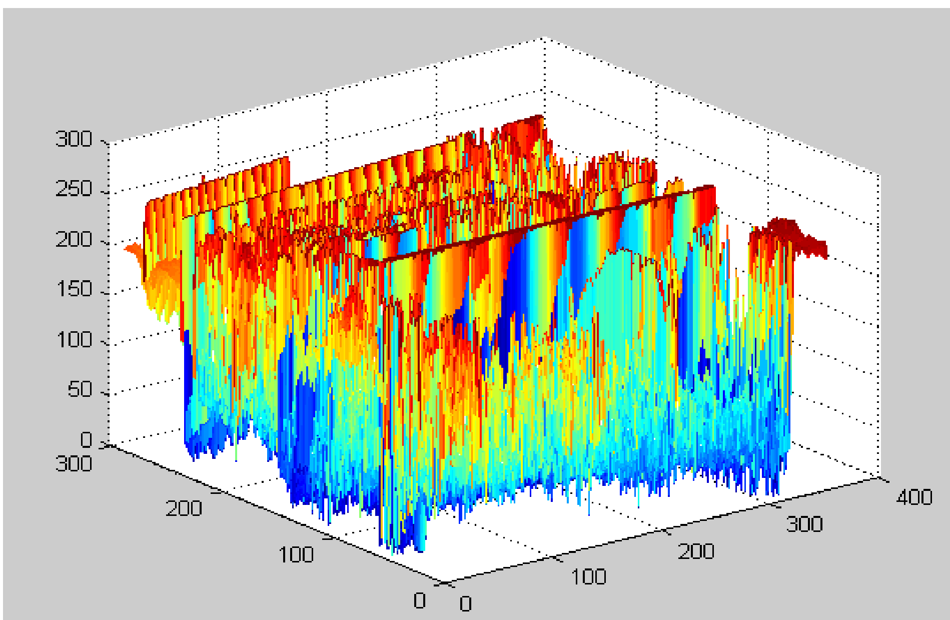


Figure 3: Image Histogram After Applying Retinex

Figure 3 depicts a histogram that shows the distribution of brightness and darkness inside an image. The x-axis indicates the pixel values, while the y-axis represents the intensity range from 0 to 255. This histogram is constructed using the intensities from the grayscale version of the frame.



(a) Mesh Plot of Original Image



(b) Mesh Plot of Retinex Image

Figure 4: Mesh Plot of Original vs. Retinex Image

The color distribution of the various channels in a frame is represented by the symbols X for Red, Y for Green, and Z for Blue. Can see that for this severe HDR picture, our suggested Multi Scale Retinex (MSR) technique produces the most attractive results. While maintaining a strong contrast in the image's bright sections, a large amount of the previously concealed information is now visible in the dark portions on the left shows in figure 4. Although the HE result is quite readable, it is evident that saturation exists in the image's brightest and darkest regions, as would be anticipated with a global method.

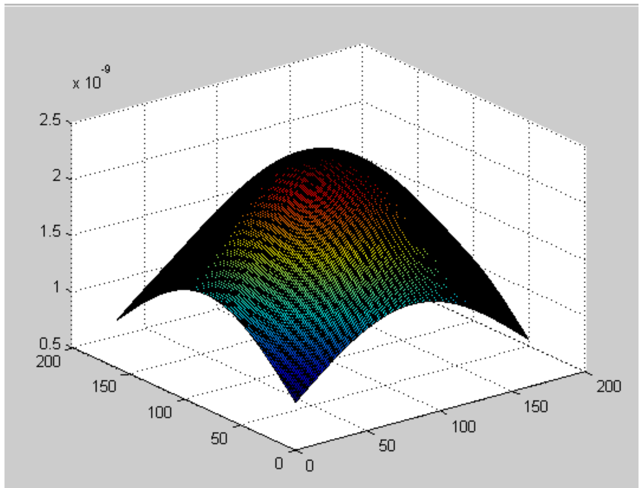


Figure 5: Surf Plot of Histogram Equalization Prediction

The expected brightness changes in the picture are shown in the above Figure 5. It is in the intensity domain and rather consistent.

Result on Selected Video Sequence for Experiment

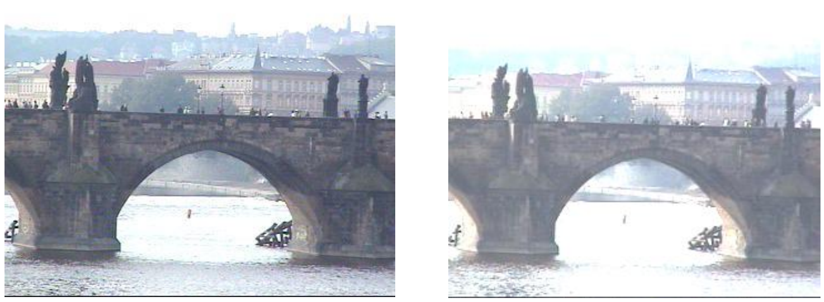
Various test data set videos:

Akiyo YUV420 with 300 Frames

Raw video Enhancement

Figure 6: AKIYO YUV420 with 300 Frames

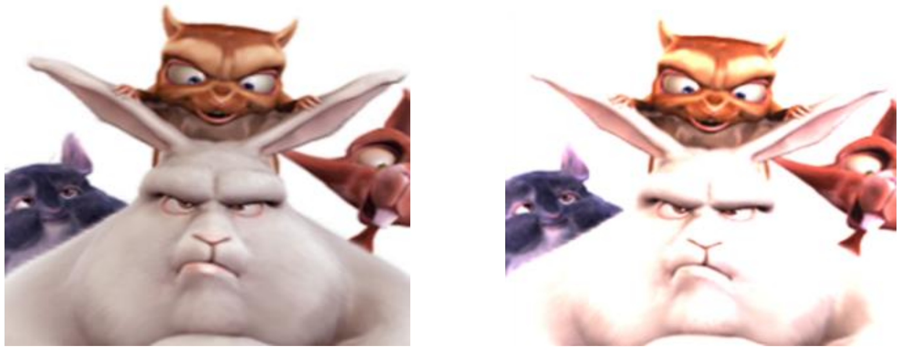
Bridge Close YUV420 with 2001 Frame



Raw video Enhancement

Figure 7: Bridge Close YUV420 with 2001 Frames

Big Buck Bunny YUV420 with 14315 Frames



Raw video Enhancement

Figure 8: Big Buck Bunny YUV420 with 14315 Frames

Figure 6, 7 & 8 are shows various test datasets above. The structure tables to compare Multi-Scale Retinex (MSR) enhancement with video compression technique H.265.

Table 1: Visual Quality Comparison

Video	Original PSNR	H.265 PSNR	MSR Enhancement+ H.265 PSNR
Video 1	30.5 dB	26.8 dB	32.2 dB
Video 2	28.9 dB	25.3 dB	30.1 dB
Video3	32.1 dB	28.5 dB	33.8 dB

As shown in table 1 & figure 9, the PSNR (Peak Signal-to-Noise Ratio) values are compared between the original videos, the videos compressed using H.265 alone, and the videos enhanced with MSR and then compressed using H.265. Higher PSNR values indicate better visual quality. Applying H.265 on image sequence processed by retinex gives higher visual quality improvement.

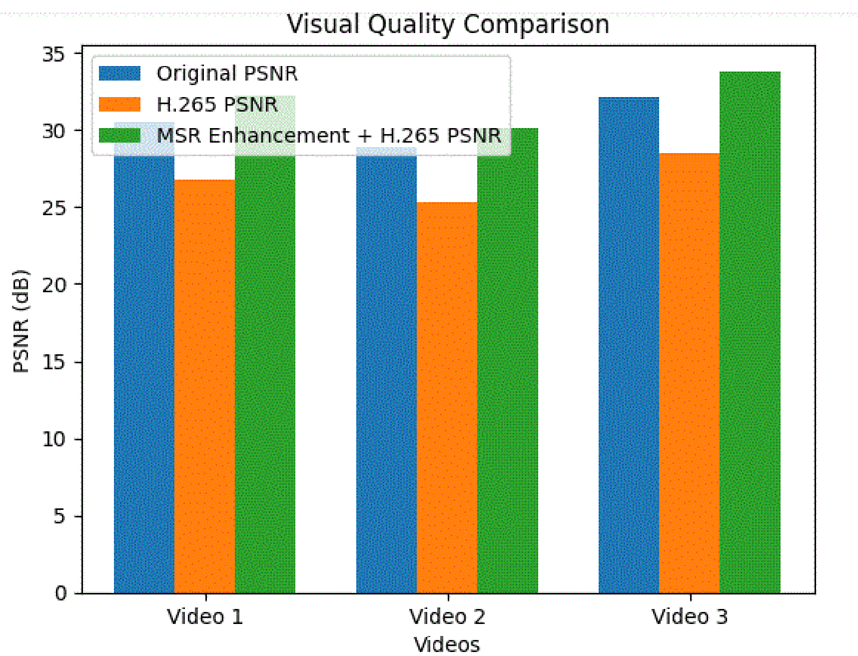


Figure 9: Enhancement Visual Quality

Table 2: Compression Ratio Comparison

Video	Original File Size	H.265 File Size	MSR Enhancement + H.265 File Size	Compression Ratio Improvement
Video 1	150 MB	75 MB	60 MB	20%
Video 2	200 MB	90 MB	75 MB	16%
Video 3	100 MB	50 MB	40 MB	20%

In Table 2, the file sizes of the original videos, the videos compressed using H.265 alone, and the videos enhanced with MSR and then compressed using H.265 are compared. The compression ratio improvement indicates the percentage reduction in file size achieved by adding MSR enhancement to the H.265 compression, that which explain in figure 10.

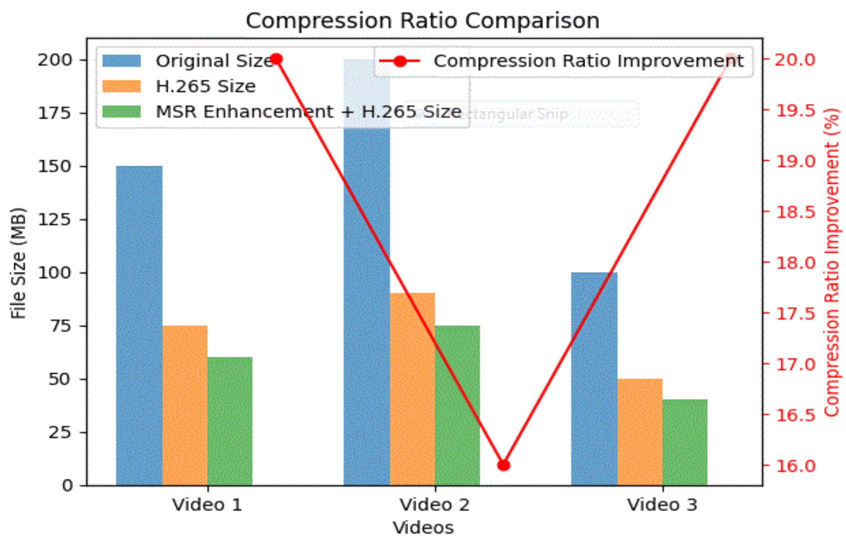


Figure 10: Compression Ratio Comparison

5 Motion Estimation

Improvement in coding efficiency is observed after using retinex during motion estimation. This improved the overall coding efficiency of the algorithm.

Table 3: Improvement in Coding Efficiency Measured in Percentages. Calculated Using Bjontegaard-Delta Measure

Resolution	Sequence	Configuration	
		HE	LC
720p	Video 1	-8.7	-10.5
	Video 2	-5.6	-7.5
	Video 3	-5.8	-7.2
Min/Max	Smallest Gain	-1.0	-1.5
	Largest Gain	-8.7	-10.5
Average		-6.7	-8.4

HE: High Efficiency Mode (uses CABAC, uses ALF (Adaptive loop filter), Bit Depth is 10bits),

LC: Low Complexity Mode (Uses CAVLC, No ALF, Bit Depth of 8bits).

Table 3 Explain the value of resolution is equal to 720p when the sequence contains 3 types of videos, each video consists of different values of configuration by depending upon the value of gain if it has min or max. The efficiency Data Frame is caused by extracts and displays Min/Max, Largest Gain, and Average values. Finally, it calculates and displays the Bjontegaard-delta measure between the High Efficiency (HE) and Low Complexity (LC) configurations. Video2 is high value of sequence, configuration and have maximum gain therefore it has higher efficiency, as shown figure 11.

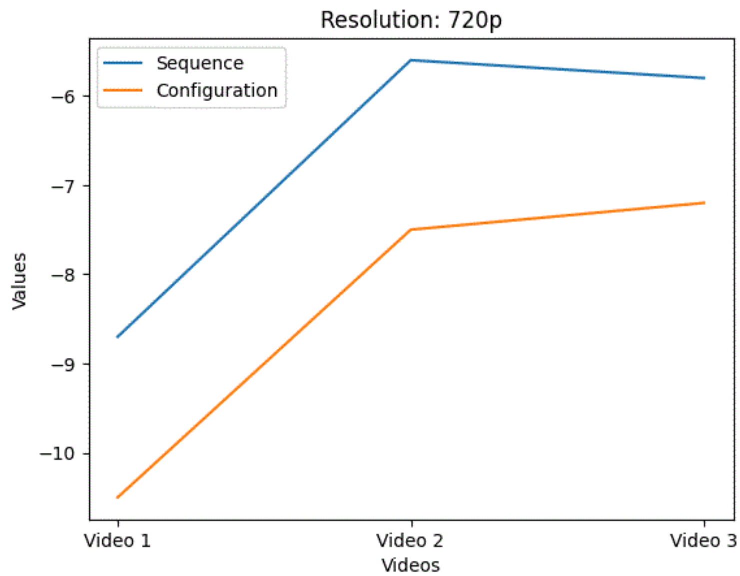


Figure 11: Sequence-Configuration Values of Videos with 720p Resolution

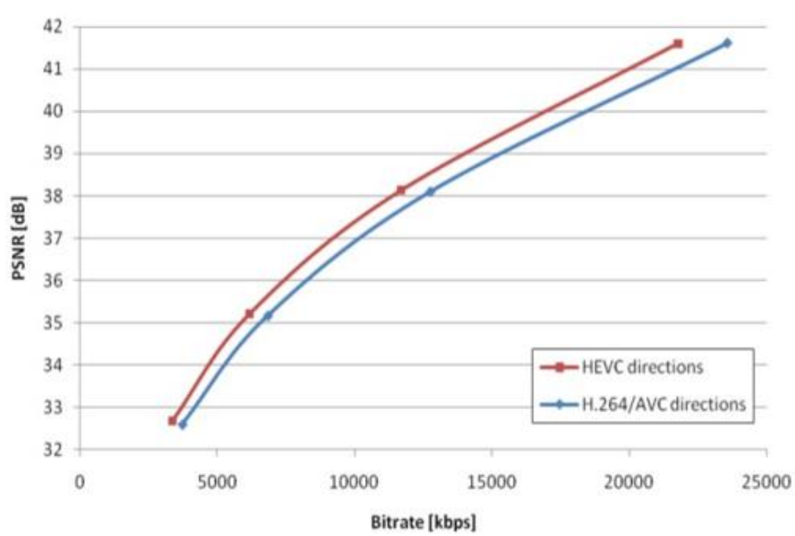


Figure 12: Rate Distortion Performance of Sequence in Low Complexity Configuration

Comparison between H.264 and HEVC (H.265). The primary enhancement in H.265 video coding led to a decrease in the bit rate by as much as 50% while upholding similar or even better video quality than H.264. The quality is expressed here by PSNR as shown as in figure12. The halving of the bandwidth also halves the cost implication in production; nevertheless, the coding complexity increases in H.265, driving towards around 50% reduced bit rate with increased efforts.

6 Conclusion

The video compression technique used H265, which is a highly sophisticated method of compressing multimedia data. This allows for efficient transmission within limited bandwidth and ensures optimal delivery of user information. The utilization of the lossy compression format H265 leads to issues regarding the visual fidelity of images. The output quality is superior due to the flexible algorithm and larger number of angular modes (33 for HEVC). Image sequences might experience a decline in image quality due to inadequate lighting and transmission faults. Empirical evidence substantiates that the visual Retinex technique can be employed to augment quality by amplifying visual contrast. The implementation of HEVC intra-frame prediction employs a sophisticated quad-tree decomposition technique, where smaller blocks are used in regions of the image with high density, while larger blocks are used in areas with more uniform terrain. This approach ensures an optimal combination of the adaptable prediction algorithm. The HEVC brightness component prediction modes range up to 35. The processes involved are the decomposition of Retinex, adjustment of light, and restoration of reflectance. In order to demonstrate the efficacy of the procedure, multiple experiments have been conducted in various lighting environments, with a particular focus on extremely low light conditions. The application of Retinex leads to a significant improvement in the visual quality of the original video sequences. Multi-scale retinex proves to be a valuable improvement compared to standard h.265. In the future, will explore more straightforward and efficient models and utilize lighter models to address challenges related to enhancing photos in extremely low light conditions .

7 Future Work

Integration with Advanced AI-Based Techniques explore the integration of machine learning or deep learning-based methods to adaptively control the parameters of the Multi-Scale Retinex (MSR) algorithm based on specific video characteristics. This could enhance the overall video compression by dynamically optimizing contrast enhancement. Optimized Parameter Selection Investigate a systematic method to determine the optimal parameters for the MSR algorithm when used in conjunction with H.265/HEVC, based on different video genres and lighting conditions. This can include developing a heuristic model or optimization algorithm. Real-Time Implementation: Develop a real-time implementation of the enhanced MSR algorithm to ensure its feasibility for live video compression applications, such as broadcasting and surveillance. Consider utilizing parallel computing frameworks or hardware acceleration for practical application.

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