Style Aware Tone Expansion for HDR Displays

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Abstract

The vast majority of video content existing today is in Standard Dynamic Range (SDR) format and there is a strong interest in upscaling this content for upcoming High Dynamic Range (HDR) displays. Tone expansion or inverse tone mapping converts SDR content into HDR format using Expansion Operators (EO). In this paper, we show that current EO's do not perform as well when dealing with content of various lighting style aesthetics. In addition to this, we present a series of perceptual user studies evaluating user preference for lighting style in HDR content. This study shows that tone expansion of stylized content takes the form of gamma correction and we propose a method that adapts the gamma value to the style of the video. We validate our method through a subjective evaluation against state-of-the-art methods. Furthermore, our work has been oriented for 1000 nits HDR displays and we present a framework positioning our method in conformance with existing SDR standards and upcoming HDR TV standards.

Index Terms: I.4.0 [Image Processing and Computer Vision]: General—Image displays; I.3.3 [Computer Graphics]: Picture/Image Generation—Display algorithms H.1.2 [Models and Principles]: User/Machine Systems—Human Information Processing

1 Introduction

High Dynamic Range (HDR) displays [3] are the latest trend in television technology. This new generation of displays are characterized by high peak brightness and an increase in contrast levels between dark and bright regions. This gives the user an unprecedented closeness to reality never seen on traditional Standard Dynamic Range (SDR) displays. It is expected, as with any new technology, that the introduction of the HDR video format will be a phased approach which will co-exist with legacy SDR video transmission infrastructure. Hence, it is essential that an SDR to HDR conversion technique exists at different stages of the video transmission pipeline. Furthermore, most digital video existing today is in SDR format and it would be beneficial to convert such content for HDR displays.

Previous research refers to this conversion problem as *inverse/reverse tone mapping* or alternatively termed as tone expansion [4]. These tone *expansion operators* (EO's) attempt to process the SDR video pixels in the best possible way to be displayed on an HDR monitor. As a result, they attempt to solve a typical ill posed inverse problem where the additional dynamic range available in HDR displays is missing in SDR format. This information is lost during acquisition from the SDR camera and also the SDR post production process. Most EO's attempt to solve this problem on a set of strong a priori assumptions that lead to positive or negative results based on specific conditions.

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In a recent study, Simone et al. [7] presented a detailed subjective analysis suggesting that out of the many EO's in literature, a simple linear operator gives the best results. However, as shown later on, such an approach does not preserve artistic intent particularly for complex lighting styles (extreme variation in luminance and contrast).

In this paper, we propose a new EO based on lighting style for tone expansion by using mathematical models coming from user studies. Our main aim is to display SDR content on HDR monitor while fully exploiting the available dynamic range and fully preserved artistic intent. In addition to this, unlike other EO's, our experiments have been implemented on a professional 1000 nits HDR display instead of prototype displays. We kept in mind that initial commercial HDR displays in the market will be limited to 1000 nits and have oriented our work towards it. The main contributions of this paper are:

- User studies giving insight on human preference on viewing HDR content
- Tone expansion technique that preserves artistic intent and is also faithful to reality
- General framework for tone expansion on commercial HDR displays compliant with emerging standards for HDR video

This paper is structured as follows. Section 2 reviews the related work on tone expansion, lighting styles and also gives an overview of the HDR television systems. Section 3 provides details of our tone expansion method with detailed user studies and algorithm framework. We present our results in Section 4 and conclude the paper in Section 5.

2 Background and Related Works

In this Section we position our approach with respect to the current state-of-the-art tone expansion models. We define lighting style aesthetics and also discuss the present day industrial scenario related to HDR technology.

2.1 Expansion Operators (EO's)

The most basic EO is a global model where a single global expansion function is applied to every pixel of the SDR video. Akyuz et al. [2] presented a series of psychophysical experiments to conclude that trivial linear operation is sufficient to provide good HDR tone expansion. The paper further argues that mean luminance is preferred over contrast. This method works well in optimum conditions such as for uncompressed well-exposed images. For the special case of over-exposed content, Masia et al. [16] found that a nonlinear tone expansion in the form of an adaptive gamma correction is sufficient for HDR displays. In real world scenarios, particularly in the case of live broadcasting, these global methods are practical for real time applications. They are also the least complex and avoid temporal artifacts due to their frame based nature [7]. However, when dealing with broadcast video a simple scaling tends to amplify compression artifacts along with camera noise. Furthermore, Masia's et al. [16] adaptive gamma correction method works very well for a specific test set of images but gives an artificial appearance when tested with a different set of data.

More advanced tone expansion models are based on image segmentation. This family of EO's segments the SDR image into different regions (such as diffuse and specular highlights) and expands the segments accordingly. Meylan's et al. [17] work detects the specular highlight and the diffuse part of the image and applies a separate linear tone curve to both regions. Didyk et al. [8] and Wang et al. [27] also use EO's based on segmentation but require manual assistance. In a practical system, an automated approach would be more appropriate. The expand map model is another approach that has been investigated in various works [23] [5] [6]. In these techniques, the expansion process is guided by an expand map which gives the magnitude of expansion per pixel.

These tone expansion techniques provide credible insight into requirements for subjective visual quality and computational performance. The evaluation by Simone et al. [7] clearly identifies the linear EO by Akyuz et al. [2] as the one giving best subjective results and also the least complex. Thus, we base our approach on a global model especially as local methods do not offer substantial gains in terms of video quality or reduced complexity. A general global model is based on the Equation below:

$$Y_{HDR} = L_{Max} \times Y_{SDR}^{\gamma} \tag{1}$$

where Y_{HDR} is the HDR luminance, L_{Max} is the maximum luminance that can be supported by the display, Y_{SDR} is SDR luminance and γ is an adaptive parameter that varies per frame. The work by Akyuz et al. [2] proposes a similar global expansion model with $\gamma = 1$ while Masia's et al. [16] EO varies the γ using the key [22] of the image based on a user study of over-exposed content. We align our work on a similar user study that models the choice of gamma [21] considering not only on well-exposed or over-exposed images but a variety of lighting style aesthetics.

2.2 Lighting Style Aesthetics

Lighting styles are used in cinematography for artistic purposes in order to portray a particular mood of a scene [28]. The terms *low key* and *high key* are used commonly in photography, to describe dark luminance with high contrast and bright tones with low contrast respectively. A low key image usually captures a dark and dramatic mood while high key images are usually associated with a upbeat feelings. In our experiments, the source content has been classified by lighting styles in five categories based on luminance and contrast:

1. Dark Key (DK): Lighting with low contrast and low luminance. Typically found in horror or murder mystery movies used to build fear or suspense.

2. Low Key (LK): Lighting with high contrast and low luminance. As previously mentioned, this lighting style is used to convey intense and tension filled atmosphere. A good example of low key cinematography is the film Sin City [18].

3. Medium Key (MK): Lighting with average contrast and moderate luminance. Most video content comes under this category - news broadcast, television drama series, etc.

4. Bright Key (BK): Lighting with high contrast and high luminance. This style is commonly found in an exterior environment when shooting nature on a bright sunny day.

5. High Key (HK): Lighting with low contrast and high luminance. From the previous definition we know that a high key style normally expresses a light mood. This lighting style is often used in fashion and advertisement videos.

Figure 1 summarizes the five lighting styles considered in this paper and gives examples of each style.

2.3 HDR Ecosystem

Recently, many new consumer and professional HDR displays have been showcased at various technology shows (NAB, CES, IBC etc.) and there is a strong effort amongst standardization bodies (SPMTE, MPEG, ARIB, ITU etc.) to define a telecommunication system for distribution of HDR content. As HDR technology is being standardized, it is clear that video transmission chain will be similar to that of the SDR transmission chain. The SDR video transmission is governed by an OETF-EOTF (Opto-Electronic Transfer Function - Electro-Optical Transfer Function) combination defined in BT.709 [10] and BT.1886 [12]. The current SDR TV systems were not designed to handle HDR content and hence an alternative OETF-EOTF is needed to capture the dynamic range of the HDR video. In current industrial scenario, Society of Motion Picture & Television Engineers (SMPTE) has standardized the ST 2084 [24] while the Association of Radio Industries and Businesses (ARIB) has standardized the STD-B67 [20]. Both offer higher dynamic range than the SDR BT.709/BT.1886.

For the experiments in this paper, we have worked with the professional Sony BVM-X300 OLED display [25] equipped with an Slog3 [26] and the ST 2084 transfer functions. We chose to work with the ST 2084 since it is a defined standard and has been part of the Sony monitor since the v1.1 firmware update. The Sony display is different from the Sim2 HDR47 or the BrightSide DR-37P monitors used in previous HDR studies as it can be interfaced with industry standards and is compliant with BT.709 and BT.2020 [9] colorimetry. Furthermore, it has peak brightness of 1000 nits with a contrast ratio of a million-to-one which is closer to the expected consumer HDR TV's specifications. In addition to this, the BVM-X300 is a professional display so we expect no internal processing in comparison to consumer displays and hence an ideal system to test our algorithms.

3 Style Aware Tone Expansion

This Section presents our tone expansion operator. We start by defining a method to classify different lighting styles and discuss the source content used. We then explore user gamma preference on viewing different stylized contents in HDR. Finally, we define a style adaptive gamma correction method and present a framework to implement our tone expansion for modern displays.

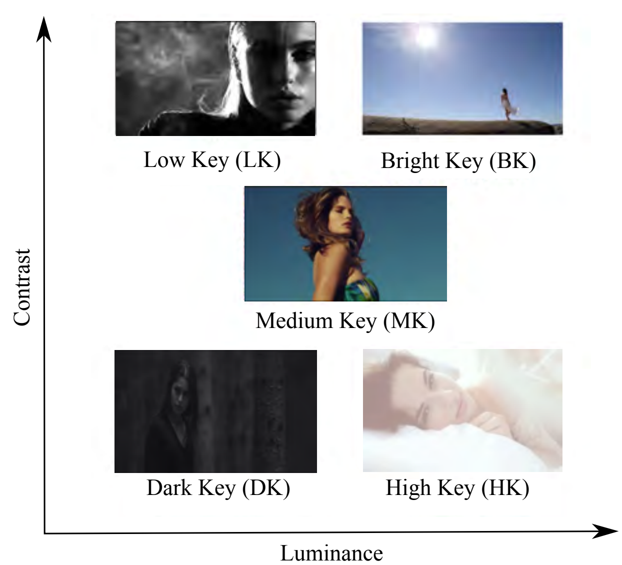

Figure 1: Different lighting styles can be distinguished by their luminance and contrast.

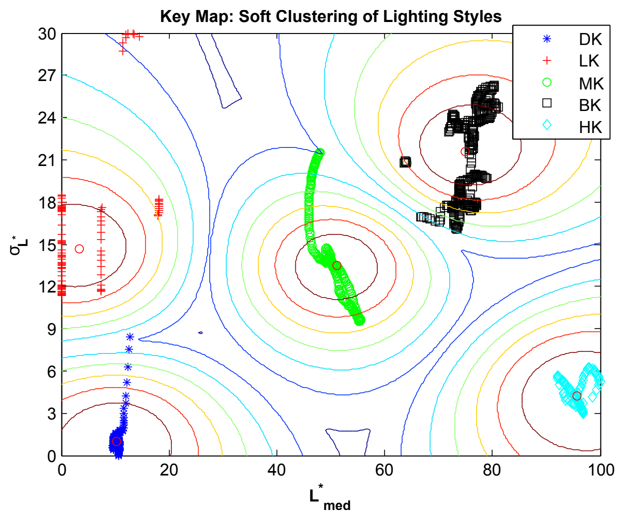

Figure 2: A fuzzy c-means clustering of lighting styles of videos. Clusters with overlapping boundaries account for the change in lighting style of video over time, thus an image can be part of more than one style.

3.1 Lighting Style Classification and Source Content

We can broadly visualize each video style mentioned in Section 2.2 in the Figure 2. This technique can be easily applied on images as well. For each video sequence style, every frame was analyzed in the CIE-Lab domain. Each point on the map represents the statistic of one frame. We define the luminance of a style as the median of the lightness channel L^*_{median} of the frame and the contrast as the standard deviation σ_{L^*} of the lightness channel of the frame. We have selected the L^*_{median} over the L^*_{mean} as it does not vary significantly over time when there are slight changes in lighting of a scene and hence gives better representation of the mood.

It should be noted that the data in Figure 2 has been extracted from video scenes of 4-5 seconds which were considered to be a good representation of a each style. However, a normal video sequence may undergo a number of lighting style changes over a period of time. To visualize smooth transitions over different style clusters, we allow the clusters boundaries to overlap in the form of a fuzzy c-means algorithm. This soft classification can be visualized by the contour map which represents the position of points of equal membership.

For this paper, our source content could be classified using one or more lighting styles. The video sequences were in 1280×720p or 1920×1080p, 8 bits and of BT.709 colorimetry. The sequences consisted of various frame rates: 24, 25, 30, 50 and 60 fps. A lot of our stylized content are available on the Internet and have been compressed using VP9 and AVC codecs.

3.2 User Study on Stylized Video

This Section investigates the human preference for gamma at different video lighting styles. The choice of gamma is essential to the tone expansion process in Equation 1. In this study, an HDR video of a particular style will be shown to the user using different gammas (1.0-2.2) and we attempt to answer the following questions:

1. At what gamma is the HDR video aesthetically pleasing?
2. At what gamma does the HDR video best represent the SDR video?

The first question is non-reference user study, where the user is required to choose the best gamma without a reference SDR video. Hence, the user is required to choose the most aesthetically pleasing gamma without knowing the style of the source content. The second question is a reference user study, where the user matches the fidelity of the lighting style of the HDR content using the SDR video as reference. We aim to use both tests not only to give us a better understanding of choice of gamma but also human preference on viewing different lighting styles in HDR.

3.2.1 Testing Environment and Methodology

Both tests were conducted using ITU-R recommendations BT.500-13 [13], in a room within ambient luminance of approximately 25 lux which is the accepted luminance levels for a dark environment. The HDR display used is the Sony BVM-X300 while the SDR display is the Panasonic BT-LH310P. Both displays are 32 inch professional monitors which have minimal internal processing. It should be noted that the Sony is an OLED while the Panasonic is a LCD display and the Sony gives better picture quality in SDR mode than the Panasonic. For the experiments, both displays were placed side by side 0.5 m apart from each other. The distance between the participants and the display was around 1.5 m.

We have used a high performance video player that can display UHD (3840×2160) content at high frame rates. Both the Sony and the Panasonic displays can take in UHD video with 4 3G-SDI cables. This allowed us to concatenate 4 HD videos in UHD format and feed each display with a single SDI cable to view content in HD. This was very useful in side by side subjective testing.

Since both these studies are conducted to determine the choice of gamma in Equation 1, it was preferred to carry out this pilot study with a few video experts. We considered three videos each of different lighting styles: LK, DK, MK, BK and HK. Hence a total of 15 videos varying 8-15 seconds. Videos of the same style were not displayed one after the other. Each video was displayed with different gammas (1.0-2.2) in an incremental order and the participant was asked to choose the preferred gamma. The user was given the option to view the sequence multiple times before they made their final choice. The objective of the experiment was given to the experts prior to the start of the test. This was followed by a short training on a Medium Key sequence which was not used in our results. Each user study lasted between 45 minutes to 1 hour. Hence, both tests were conducted with prolonged breaks between tests and sometimes different days depending on the availability of the video expert.

3.2.2 User Study 1: Aesthetics

The result of the non-reference test is shown in Figure 3. It can be seen that DK and LK sequences have a preference for gamma ranging from 1.9 to 2.1. While MK and HK sequences have a variety of gamma preferences and BK sequences are closer to $\gamma = 1$. This result suggests that changing gamma or contrast does play an important aesthetic role for videos with different lighting styles. Experiments conducted by Akyuz et al. [2] and Simone et al. [7] were done for correctly exposed or medium key images so a $\gamma = 1$ could be a reasonable outcome. However, for LK and DK contents, $\gamma = 1$ results in expanding compression artifacts and banding. Our user study shows a higher gamma value avoids such artifacts. This is mostly due to the nonlinear signal expansion in which the gamma expands the mid-tones and highlights more than dark regions. For this non-reference study, we also observe that for HK content there is a huge variation in gamma. This is primarily because the participants was trying to increase the contrast to find missing regions in the over saturated regions (saturated for artistic reasons). A more reliable gamma could be chosen by performing a test using the SDR video as reference.

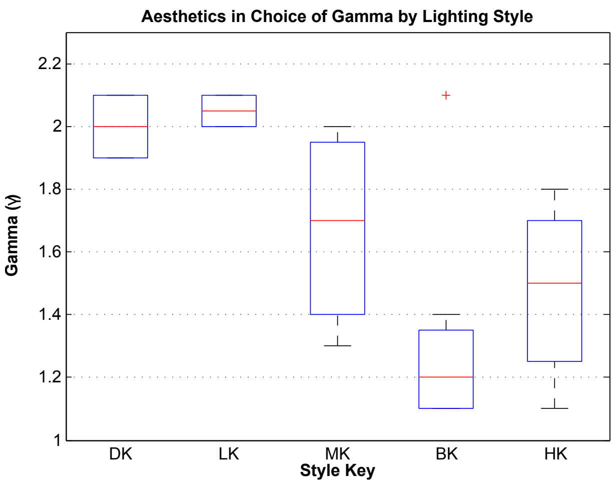

Figure 3: Aesthetics in Choice of Gamma by Lighting Style.

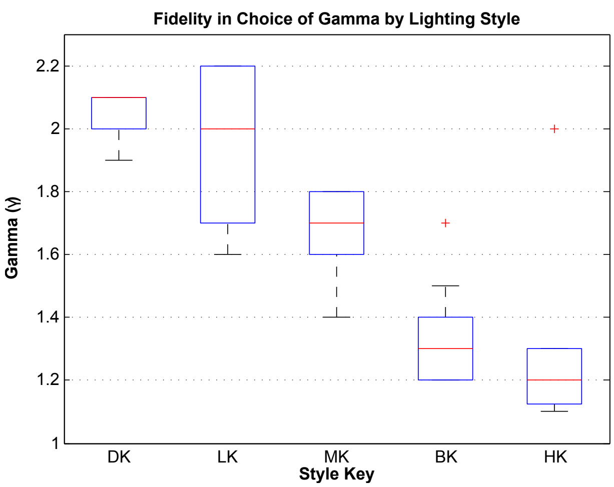

Figure 4: Fidelity in Choice of Gamma by Lighting Style.

3.2.3 User Study 2: Fidelity

The result for the reference test can be seen in Figure 4. We once again observe higher gamma values for DK and LK similar to the aesthetic test. MK has a gamma value in the mid range while BK and HK have low gamma values. It can be noticed that the LK box-plot has a larger deviation from the mean. This is because a high gamma value exhibits nonlinearity and this results in a change in hue. Some participants attempted to lower the gamma to achieve matching hues while compromising lighting style fidelity. Nevertheless, the range of each boxplot is limited as compared to the non reference test which makes this a more precise model to select the gamma. The most important findings of both these user studies suggest that adjusting contrast in the form of gamma correction is essential for a global tone expansion model as it improves both aesthetics and fidelity of the HDR video. Furthermore, the fidelity study shows a decrease in the gamma value as the lighting of the style increases. This is fundamentally different from what is proposed by Masia et al. [16] which suggests that the gamma value increases as the key of the image increases.

3.3 Style Adaptive Gamma Correction

The user studies conducted in this paper gives us an indication on how gamma preference varies with the lighting style. However, in a practical scenario, it is not possible to manually tweak γ values according to the style. In this Section we propose a frame by frame style adaptive γ correction process.

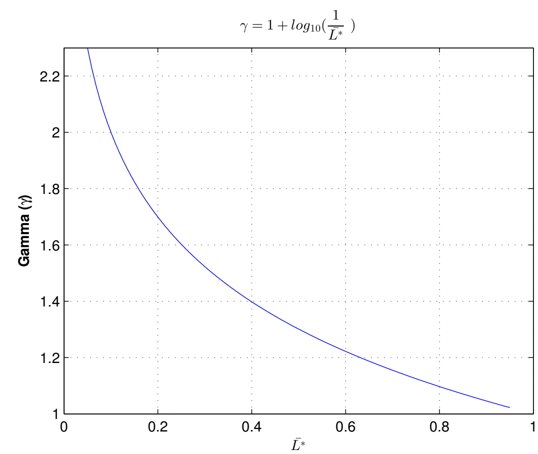

Figure 5: Adaptive Gamma Curve.

As previously mentioned, the results of the fidelity test show a steady decline in gamma as the luminance of the style increases (Figure 4). Considering our video style classification in Figure 2, we can characterize a video's style by the L^*_{median} statistic of each frame. Thus, the referenced subjective tests have shown that the ideal γ for tone expansion can be modeled by the $\bar{L^*}$ of the SDR image by Figure 5 and is fitted to the following Equation:

$$\gamma = 1 + log_{10}\left(\frac{1}{\bar{L^*}}\right) \tag{2}$$

where:

$\bar{L^*} = L^*_{median}/100$ and has been clipped in the interval [0.05(:)0.95]

Hence, our tone expansion model takes the form below:

$$Y_{HDR} = L_{Max} \times Y_{SDR}^{\gamma} \tag{3}$$

where:

Y_{HDR} is the Y component of XYZ colorspace in HDR domain

Y_{SDR} is the Y component of XYZ colorspace in SDR domain

L_{Max} is the maximum display luminance (1000 nits)

γ is a style adaptive parameter defined by $\gamma = 1 + log_{10}\left(\frac{1}{\bar{L^*}}\right)$

3.4 Tone Expansion Framework

Now all pieces are in place to position our tone expansion operator in an industrial framework. To apply our EO to a video, in SDR format to be displayed on an HDR television, requires certain format conversions and signal pre-processing. We define the SDR to HDR up-conversion process chain in Figure 6. We have taken as input an SDR source content (R'G'B') which is a display referred nonlinear signal encoded by an OETF (gamma for BT.709/BT.1886). The content is 8 bit and hence has [0:255] code values. The SDR video input is normalized and then linearized using the BT.709 OETF^{-1} decoding. The result is a linear RGB signal that passes though an Expansion Operator. This signal is encoded using an HDR OETF (ST 2084 in our case) and converted again into R'G'B' but in HDR format. We then change the colorspace to Y'CbCr used in digital

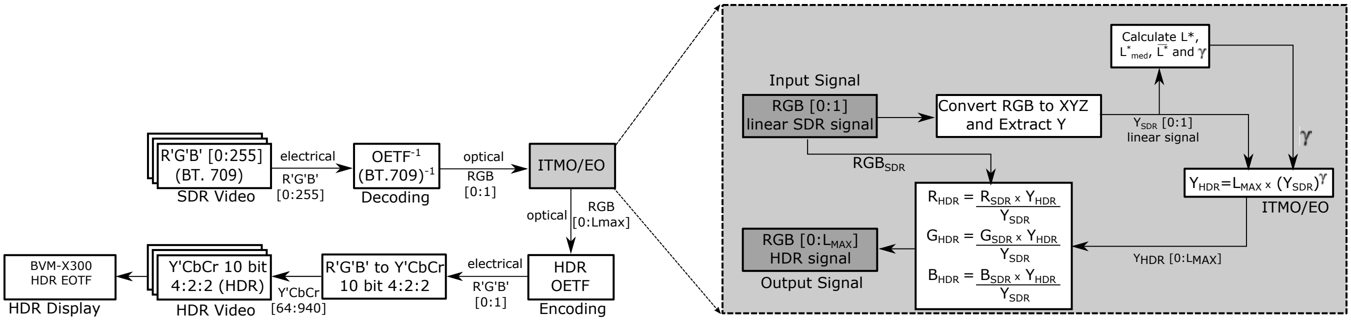

Figure 6: Format conversion for Tone Expansion: We start with an input 8 bit SDR video encoded with BT.709 gamma. This signal is normalized and decoded with BT.709 OETF^{-1} and it passed through an EO explained in Section 3.3. The resultant HDR signal is encoded by an HDR OETF. The encoded RGB signal is converted to a 10 bit Y'CbCr 4:2:2 signal to be viewed on an HDR display.

television and quantize it 10 bit as per BT.1361 [11] with video levels of [64(:)940]. The Chroma is sub-sampled from 4:4:4 to 4:2:2 UYVY (v210 format). We use a 10 bit signal as the ST 2084 curve exhibits perceptual uniformity at 10 bits [19]. The 10 bit Y'CbCr 4:2:2 HDR signal is the final format displayed on to the HDR TV. We maintain BT.709 colorimetry in the HDR format.

Our tone expansion method is applied in the ITMO/EO block in Figure 6. This process is further detailed on the right hand side of the figure. The SDR RGB video is converted to XYZ in linear domain. We extract the Y_{SDR} component and calculate γ as defined in Equation 2. We then apply the tone expansion model using Equation 3. Once the Y_{HDR} is calculated, we can determine the RGB values in HDR domain by subsequently changing the luminance as shown below:

$$\begin{bmatrix} R_{HDR} \\ G_{HDR} \\ B_{HDR} \end{bmatrix} = \frac{Y_{HDR}}{Y_{SDR}} \begin{bmatrix} R_{SDR} \\ G_{SDR} \\ B_{SDR} \end{bmatrix} \tag{4}$$

We purposely choose to work using the luminance channel of XYZ to avoid color artifacts during the expansion process. BT. 709 is the output colorspace after tone expansion resulting in BT. 709 primaries and D65 white point. It should be noted that this exact framework was used for the pilot study in Section 3.2. This pipeline was also used in Section 4 to evaluate our method with existing state-of-the-art technologies.

4 Results

To evaluate our method, we compare our EO with existing global operators by Akyuz et al. [2] and Masia et al. [16]. The evaluation will be a subjective study that will take into account the fidelity of the HDR content and the aesthetic pleasingness of the results. The environmental setup and test methodology was similar to the pilot study conducted with experts.

We asked 23 users to evaluate 3 videos of each style. We start with a test without SDR reference to evaluate the aesthetic value of the three methods and a test with SDR reference to assess the fidelity. The participants were 23 to 55 years old with 20 males and 3 females. 10 had previously seen HDR videos. 11 of them wear glasses and all have normal color vision. First, the user was asked to do the non-reference test and give a score to each method on a Five-point scale (5-excellent, 4-good, 3-acceptable, 2-poor, 1-bad). Second, the user had to evaluate the fidelity of the HDR rendering of the different EO's to the SDR content using the same scoring method.

Figures 7 and 8 show the Box-and-Whiskers plots for each method. Both plots identify that our method gives significant gains in terms of aesthetics and fidelity over existing methods. We see that our method has a highest mean for both types of scores while the method by Masia et al. [16] has the lowest mean. Our method also has less deviation than Akyuz et al. [2] in both type of scores. Figure 10 shows the mean score of each method according to the lighting style. We can observe that the method of Akyuz et al. [2] is superior to the method of Masia et al. [16] for DK, LK and HK sequences. Both give similar results in terms of aesthetics and fidelity

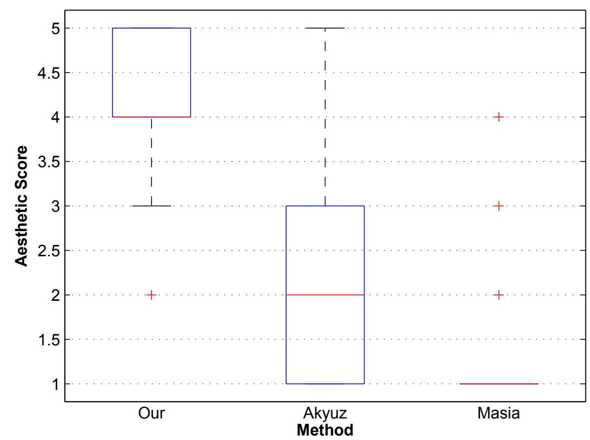

Figure 7: MOS Score Evaluation of Aesthetics of Algorithms.

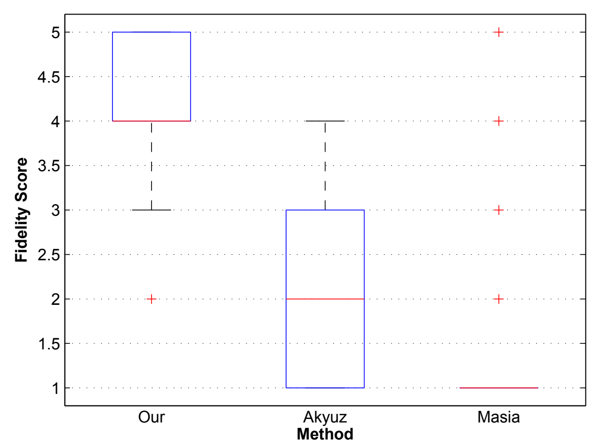

Figure 8: MOS Score Evaluation of Fidelity of Algorithms.

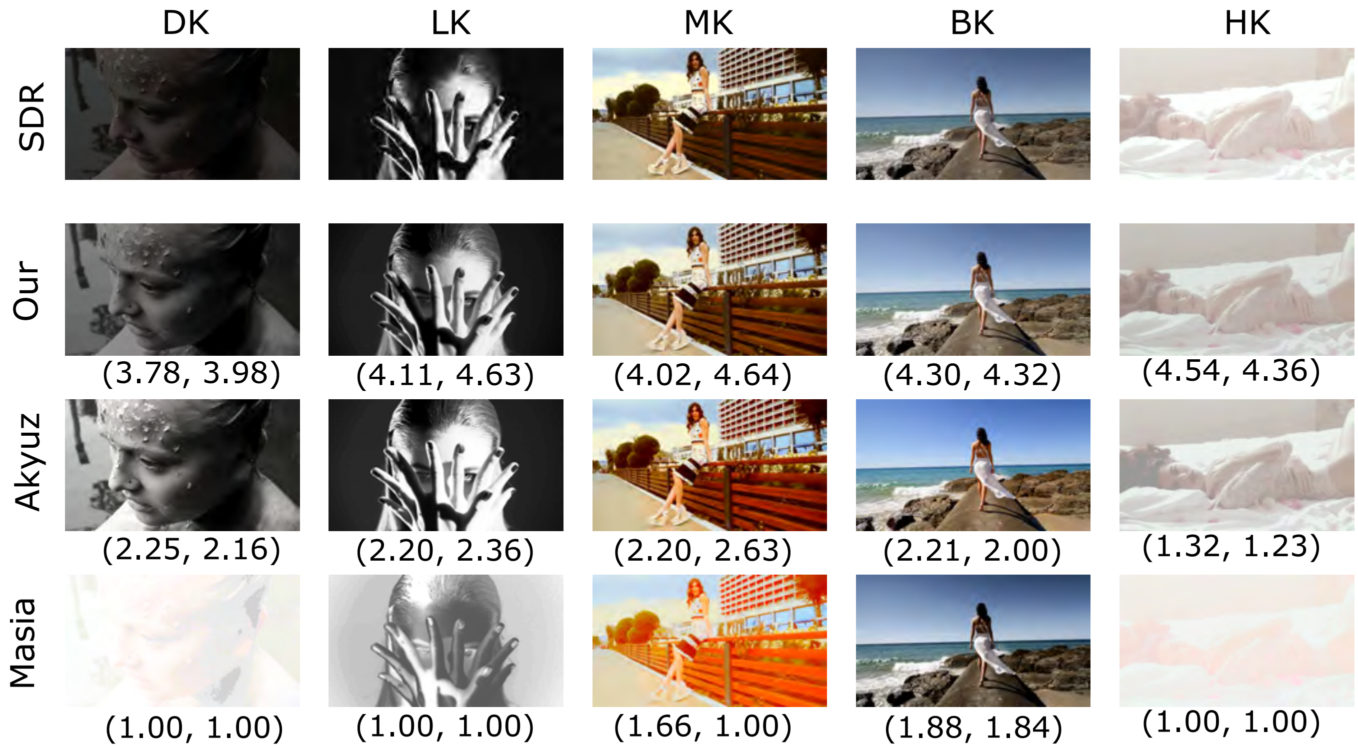

Figure 9: Comparing the results of various EO's: The aesthetic and fidelity scores for each algorithm are presented below each result in the form: (Fidelity, Aesthetics). The tone mapped HDR content seen in this paper is done using display adaptive tone mapping by Mantiuk et al. [14]. These results are far more visually convincing when seen through an HDR display. However, certain discrepancies of other algorithms can be easily spotted.

for MK and BK sequences. Nevertheless, figure 10 shows that our method has the highest mean score in the subjective evaluation for all lighting styles.

We can also visualize this in figure 9. The tone-mapped images seen in this figure also show that lighting style is not well preserved by Akyuz et al. [2] especially in LK and DK sequences, where they amplify quantization and compression artifacts and camera noise. Furthermore, experiments by Masia et al. [16] were conducted for a very specific set of over-exposed images and thus give an unnatural result when dealing with DK, LK, HK and sometimes even with MK videos. For the sequences where Masia's et al. [16] does seem to give a natural appearance (mostly BK) we observe constant flickering. This is because their method adapts the gamma with respect to the mean and not the median and thus results in temporal incoherency.

Overall, our method adapts very well to the lighting style of the source content. It does not amplify any coding artifacts or exhibit any flickering. However, there were some color discrepancies while comparing SDR-HDR fidelity for DK and LK videos. The users claimed the videos were of cooler color temperature. Furthermore, the mood of the scene is miscalculated in case of sequences with Digital Video Effects (DVE). For example, if a MK video splits half of its screen with a drop-down black colored advertisement, our method will be misled to calculate a high gamma value adapted to an LK or DK sequence and the intended mood of the MK video will be lost. Another limitation of our work is that the gamma correction is spatially global, so in a video that has lighting variation only in the background, the foreground exhibits luminance artifacts that are unrepresentative of the input SDR content.

The results of this subjective evaluation were produced using the Sony BVM-X300. To verify that our results were not "display specific" we visualized the videos on the Sim2 HDR47 monitor and

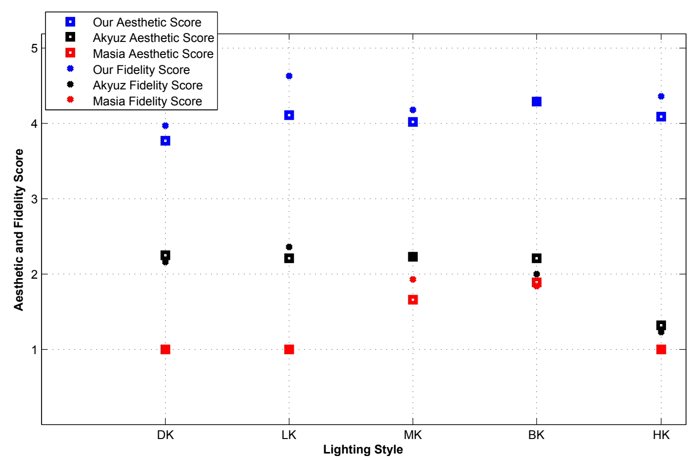

Figure 10: Mean Score of each Algorithm in terms of Lighting Style.

the Samsung JS9500 1000 nits commercial display. Through a candid crosscheck, we once again observed our method performs better than the others.

5 Conclusion and Future Work

Previous works on global tone expansion models have mostly dealt with well-exposed and over-exposed images. These methods provide substantial knowledge and lay the foundations for EO's. However, legacy SDR content not only varies in exposure but also offers a variety of lighting style aesthetics which are the result of artistic choices. Existing EO's such as the one by Akyuz et al. [2] tend to boost compression artifacts while for methods by Masia et al. [16] gamma correction only works with over exposed images. Both strategies work within their respective use-cases but no study has yet been considered using lighting style.

We performed two pilot studies, one being a non-reference test evaluating the effect of gamma correction on the HDR aesthetics while the other evaluates the same in terms of HDR fidelity to source content. This study shows that lighting style of content is strongly related to the gamma value used in tone expansion. We present a simple global tone expansion model where the gamma adapts to the style of the content. We demonstrated that this EO outperforms existing methods through a subjective evaluation.

In addition, our work has been oriented for 1000 nits HDR displays that have slowly started infiltrating the consumer market. We presented a framework that places our EO in conformance with existing SDR standards and up coming HDR TV standards.

For future work, we would like to improve certain shortcomings of our EO's, especially, to have better fidelity in terms of colorimetry and choosing poorly choosing the right gamma in special cases. One of the weaknesses of our method is that no color specific processing is take into account. Applying a luminance map in the RGB domain used in Equation 4 may result in chromatic shifts. A possible mitigation strategy could be to adjust color saturation similar to the method by Mantiuk et al.[15]. There has also been a recent study advocating further research on EO color fidelity and HDR Color Appearance Models by Adebe et al.[1]. These limitations make a strong case for an investigation into color correction methods for tone expansion. In addition to color incoherency, there are special cases where a global gamma correction fails such as a changes in lighting style in background and foreground as well as the case for DVE. More effort is needed alleviate these discrepancies. We plan to extend our method to the STD-B67 standard and common post-production transfer functions such as Slog3, V-log etc. We also hope to test this method on a variety of consumer electronic displays.

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