# DESIGN AND IMPLEMENTATION OF NEW TMOS FOR HDR IMAGES

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***Abstract---*** With the developments in Image acquisition techniques there is a growing interest towards High Dynamic Range (HDR) images in which the number of intensity levels ranges between 2 to 10,000. With those many intensity levels, the correct illustration of luminance variations is absolutely possible. But, because the standard display devices are devised to display Low Dynamic Range (LDR) images, there may be a desire to transform HDR image to LDR image without losing important image structures in HDR images. In the literature some of the techniques are proposed to get tone mapped images from HDR images. Out of them, Gamma corrections TMO, Reinhard with and without color correction are most popular. But to evaluate these techniques there exist no single effective quality assessment parameter. We are used to design and implement new tone mapping operators and to apply on various numbers of HDR images.
Keywords --- HDR, LDR, Tone Mapping, Gamma Correction, Reinhard.

## I INTRODUCTION

With latest advances in imaging and computer graphics technologies, HDR images are becoming more extensively available. A common problem that is regularly encountered in practice is how to visualize HDR images on standard display devices like trendy show gadgets that are designed to display low dynamic range (LDR) images. To conquer this problem, more and more tone mapping operators (TMOs) that convert HDR to LDR images have been developed. Because of the reduction in dynamic range, tone mapping processes inevitably cause information loss. With multiple TMOs available, one would ask which TMO faithfully preserves the structural statistical information in the original HDR images, and which TMO provides natural-looking realistic LDR images.

The important purpose of image reproduction is to display images that correspond to the visual effect an observer had at the same time as searching the original scene. Tone mapping is a prime and main component of image reproduction. It provides the mapping among the light emitted by the original scene and display values. For good and better image reproduction, it is important to bear in mind the manner the human visual system (HVS) processes light information.

The SSIM approach provides a useful design philosophy in addition to a realistic and practical approach for measuring structural fidelity between images. The original SSIM algorithm is applied locally and contains three comparison components − luminance, contrast and structure.Let x and y be two local image patches extracted from the HDR and the tone-mapped LDR images, respectively.

$$S_{local}(x,y)=\frac{2\sigma'_x\sigma'_y+C_1}{\sigma'^2_x+\sigma'^2_y+C_1}\cdot\frac{\sigma_{xy}+C_2}{\sigma_x\sigma_y+C_2}$$

Statistical naturalness provides useful information regarding the correlations between image naturalness and different image attributes such as brightness, contrast, color reproduction, visibility and reproduction of details.

$$N=\frac{1}{K}P_mP_d$$

## II LITERATURE REVIEW

In 2006, M.Cadwık, M. Wimmer et al. developed Image Attributes and Quality for Evaluation of Tone Mapping Operators. In this, they have contributed a top level view of photograph quality attributes of various tone mapping methods.Furthermore, they have proposed a scheme of

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relationships between these attributes, leading to the definition of an overall image quality measure. They have presented results on subjective psychophysical tests that they have performed to prove the proposed relationship scheme.

In 2010 Hojatollah Yeganeh and Zhou Wang proposed a new objective assessment algorithm that creates multi-scale similarity maps between HDR and LDR images. Their experiments showed that the proposed method correlates well with subjective rankings of existing tone mapping operators. Furthermore, they have demonstrated how their proposed algorithm can be employed in an existing tone mapping algorithm for optimal parameter tuning. Their experiments proved that the proposed measure agrees well with subjective rankings of overall image quality.

In 2012 Francesco Banterle, Alessandro Artusi and Elena Sikudova proposed a Dynamic Range Compression through Differential Zone Mapping primarily based totally on psychophysical experiments. They have supplied a brand new method for the show of HDR photographs on LDR displays. The defined procedure has 3 stages. First, the entered photo is segmented into luminance zones. Second, the TMO that plays higher in every sector is routinely selected. Finally, the ensuing tone mapping (TM) outputs for every sector are merged, producing the very last LDR output photo. Their method has been verified on severa HDR photographs via an in depth psychophysical experiment, the usage of an HDR dis-play because the reference. They additionally showed the statistical importance of the overall performance of the hybrid in comparison to the 2 satisfactory unmarried TMOs.

In 2013 Zijian zhu proposed High Quality High Dynamic Range Imaging where he had taken Multiple input images which produce a new ghosting artifact due to moving objects. A ACTUAL time de ghosting TECHNIQUE is first proposed by him using bi-directional comparison and IRF based moving object detection and patching. It is lightweight in PHRASES of EACH time complexity and physical memory consumption, which makes it APPROPRIATE for CELLULAR devices. He further extended it by merging the IRF with a histogram intensity mapping and adopting a new threshold VERSION PRIMARILY BASED TOTALLY on statistical study.

In 2014, Toshiyuki Dobashi, Tatsuya Murofushi, Masahiro Iwahashi and Hitoshi Kiya developed a Fixed-Point Tone Mapping Operation for HDR Images in the RGBE Format their proposed method reduces a computational cost. The experimental results show the comparison between PSNR of LDR images in the proposed method and those of the conventional methods. Their proposed method can perform a TMO with only fixed-point arithmetic. This method calculates the equation which is difficult to calculate without floating-point arithmetic by branching and approximation. As a result, the technique reduces a computational cost, and it may be executed under limited resources, together with processors without FPU. The experimental results confirmed that the proposed method has a high accuracy even though it is with only fixed-point arithmetic.

In 2017, Choi et al. provides the tone mapping approach composed of the tone mapping operator to beautify the contrast as well as to compress the dynamic range and chromatic adaptation transform to deal with mismatch among real-life style scene and displayed image primarily based on the modified CMCCAT2000 using CIE XYZ tristimulus value. In the proposed TMO, the key value of scene and visual gamma ,both are used to enhance the contrast in the entire resulting image in addition to scale the dynamic range using input luminance value, simultaneously. Here, input luminance value is obtained with the aid of using the geometric mean of the given image based on the logarithmic function to symbolize the distinctive information in the given HDR image.

## III EXISTING METHOD

Already we have so many existing TMOs like Gamma correction TMO, Linear Mode,Reinhard with and without color correction TMO.

### A.Gamma Correction And Linear Mode

Gamma correction is an integrated printer feature that allows users to modify the lightness/darkness level of their prints. The quantity of correction is detailed by a single value ranging from 0.0 to 10.0. Gamma correction may be specified on each printer default and user-specific basis across the network and on a printer default basis via the printer’s front panel. Gamma correction lets users

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match the perfect intensity of their prints to what they see on their computer screen (CRT). For instance, an image that appears just fine on the CRT would possibly print out darker at the printer. This is due to the fact the printer "gamma" (the characteristic traversal from darkness to light) isn't the same as that of the monitor.

To fix this problem, the user can choose a "gamma curve" to be applied to the image earlier than printing with a purpose to lighten or darken the overall tone of the image without affecting the dynamic range. The shape of the gamma curve is determined by a number ranging from 0.0 to 10.0 known as the "gamma value". Fig. 1 shows several gamma curves demonstrating the effect that the gamma value has on the shape of the gamma curve.

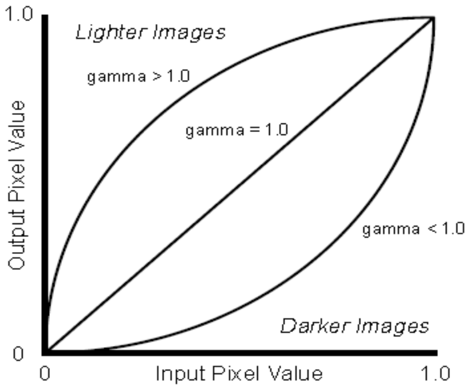


Fig.1.Gamma curve

In Fig. 1, the pixel values range from 0.0 representing pure black, to 1.0, which represents pure white. As the figure shows, gamma values of less than 1.0 darken an image. Gamma values greater than 1.0 lighten an image and a gamma equal to 1.0 produces no effect on an image. The actual gamma function used within the printer is given as follows:

$$newval(x) = x^{\left(\frac{1}{gammaval}\right)}$$

where x is the original pixel value and gammaval is the gamma value ranging from 0.0 to 10.0. This curve is valuable in keeping the pure black parts of the image black and the white parts white, while adjusting the values in-between in a smooth manner. Thus, the overall tone of an image can be lightened or darkened depending on the gamma value used, while maintaining the dynamic range of the image.

Algorithm - Inputs: HDR image – img, Gamma Value – g

Output: LDR image – im.

Ig → 1/g

I → (img)ig

Im → Clamp(I)

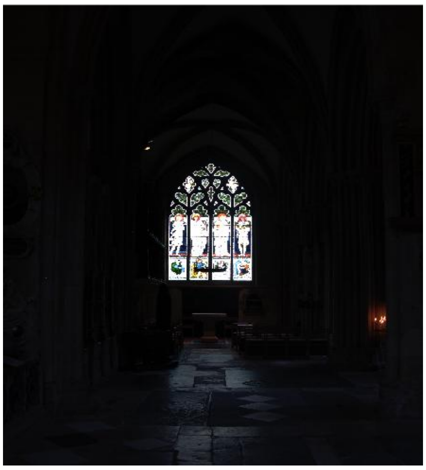

Fig.2. Linear Mode of Oxford Church Fig.3.Gamma Mode of Oxford Church

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**B.Reinhard TMO**

The tone reproduction problem was first encountered by photographers. Often their purpose is to produce realistic “renderings” of captured scenes, and that they should produce such renderings even as dealing with the limitations occurred by slides or prints on photographic papers. Many usual practices had been developed over the 150 years of photographic practice. At the same time there had been a bunch of quantitative measurements of media response characteristics by developers. However, there has been normally a disconnect among the artistic and technical aspects of photographic practice, so it became very hard to produce satisfactory images without a great deal of experience. Ansel Adams tried to bridge this gap with an approach he knew as the Zone System which first advanced in development in the 1940s and later popularized through Minor White. It is a system of “practical sensitometry”, where the photographer makes use of measured information in the field to enhance the possibilities of producing a good final print. The Zone System remains widely used more than fifty years after its inception. Therefore, we believe it is useful as a basis for addressing the tone reproduction problem.

Algorithm - Input: HDR image – I
Output: LDR image – im.
L → Luminance of I
Calculate pAlpha, pWhite, pPhi
Lwa → Logarithmic mean of L
Lscaled → (pAlpha*L)/Lwa
Ld → Lscaled*(1+Lscaled/pWhite2)/(1+Lscaled)
Im → ChangeLuminance (I, L, Ld)

Fig.4.Reinhard TMO visualization of Oxford Church

**C. Reinhard With Color Correction**

While many tone mapping algorithms provide sophisticated techniques for mapping a real-world luminance range to the luminance range of the output medium, they frequently cause modifications in color appearance. The most common technique used for tone manipulation is luminance compression, which generally causes darker tones to seem brighter and distorts compare and contrast relationships.

Algorithm - Input: LDR image – img
Output: Color corrected LDR image – imgOut.
Step 1: L → Luminance of img
Step 2: imgOut → L * (img)½

Fig.5.Reinhard with Color Correction of Oxford Church


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## IV PROPOSED METHOD

We are used to proposing two TMOs other than existing ones. And compare the existing TMOs with the proposed ones using Quality Assessment Parameters like Structural Fidelity and Statistical Naturalness.

### A.Logarithmic TMO

In this work, for an interactive display of high contrast scenes, we presented a perception-motivated tone mapping algorithm. In the proposed algorithm the scene luminance values are compressed using logarithmic functions, which might be computed using different.

Algorithm- Input: HDR image – I
Output: LDR image – im.
L → Luminance of I
Lmax → maximum luminance value
Ld → log(2)/log(1+LMax)
Im → ChangeLuminance (I, L, Ld)

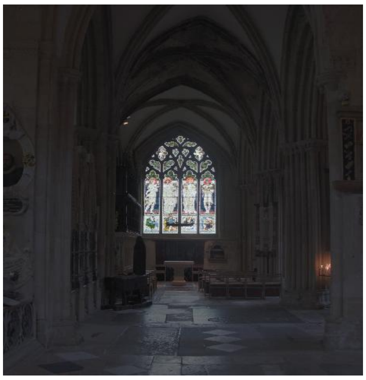

Fig.6.Logarithmic TMO Mode of Oxford Church

### B.Exponential TMO

In terms of color reproduction, a few operators produce outputs constantly too bright (Retina model TMO, Visual adaptation TMO, Time-adaptation TMO, Camera TMO), or too dark (Virtual exposures TMO, Color appearance TMO, Temporal coherence TMO). That, however, changed into now no longer was not as the excessive color saturation in Cone model TMO and Local adaptation TMO.

Algorithm - Input: HDR image – I
Output: LDR image – im.
L → Luminance of I
Lwa → logarithmic mean value
Ld → 1 –eL/Lwa
Im → ChangeLuminance (I, L, Ld)
ChangeLuminance Function:
Input: HDR image – I,
Old Luminance – Lold,
New Luminance – Lnew
Output: LDR image – im.
Remove the old Luminance
Im → (I*Lnew)/Lold


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Fig.7.Exponential TMO Mode of Oxford Church

**C.Quality Assessment Metrics**

Structural Fidelity -The structural fidelity is defined and calculated as follows:

$$S_{local}(x,y) = \frac{2\sigma'_x\sigma'_y + C_1}{\sigma'^2_x + \sigma'^2_y + C_1} \cdot \frac{\sigma_{xy} + C_2}{\sigma_x\sigma_y + C_2}$$

where σx, σy and σxy are the local standard deviations and cross correlation between the two corresponding patches in HDR and LDR images, respectively, and C1 and C2 are positive stabilizing constants.

$$S_l = \frac{1}{N_l}\sum_{i=1}^{N_l} S_{local}(x_i, y_i)$$

$$S = \prod_{l=1}^{L} S_l^{\beta_l}$$

where L is the total number of scales and βl is the weight assigned to the l-th scale.

Statistical Naturalness - the histograms of Statistical naturalness measure is defined as

$$N = \frac{1}{K} P_m P_d$$

where K is a normalization factor given by K = max{Pm Pd }, where

$$P_m(m) = \frac{1}{\sqrt{2\pi}\sigma_m}\exp\left[-\frac{m-\mu_m}{2\sigma_m^2}\right]$$

$$P_d(d) = \frac{(1-d)^{\beta_d - 1} d^{\alpha_d - 1}}{B(\alpha_d, \beta_d)}$$

where B(·, ·) is the Beta function.

**V SIMULATION AND RESULT**

A performance study on the tone mapping operators is presented.We are considering six HDR images as input and applied to six TMOs and analyze the quality assessment metrics that are Structural Fidelity and Statistical Naturalness.

The assessment parameter values are given in a tabular column for six HDR images.

The tone mapped images of ‘glass’ HDR image obtained using the TMOs presented is shown below:


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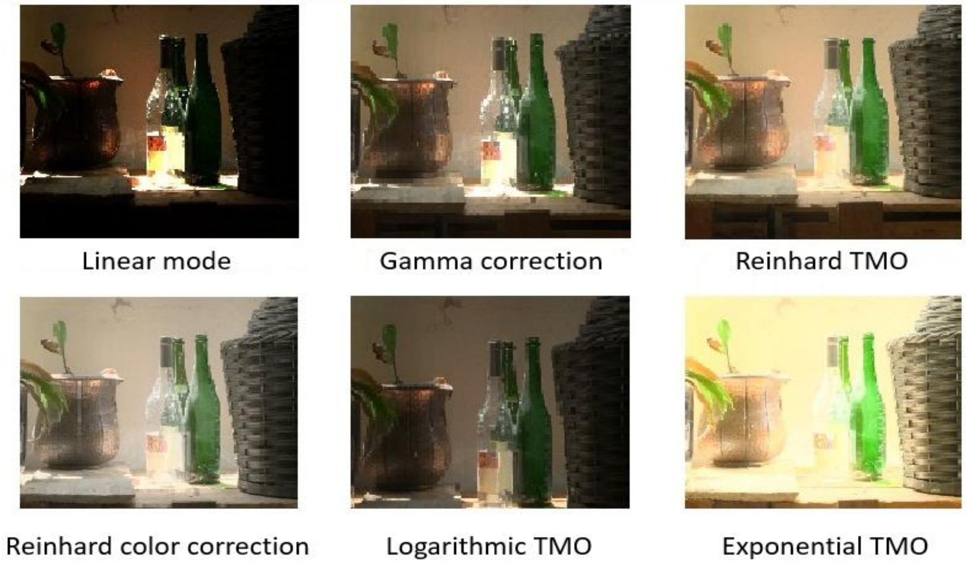


Fig.8.Different TMO modes of glass bottle HDR image

The simulation results as shown in a tabular column below:

Table.1.Structural Fidelity of six different HDR images in various modes of TMOs

| TMO | Im1 | Im2 | Im3 | Im4 | Im5 | Im6 |
|---|---|---|---|---|---|---|
| **Linear Mode** | 0.0136 | 0.0264 | 0.014 | 0.0424 | 0.038 | 0.04 |
| **Gamma Correction** | 0.0133 | 0.0257 | 0.013 | 0.0423 | 0.038 | 0.04 |
| **Reinhard TMO** | 0.0136 | 0.0258 | 0.013 | 0.0424 | 0.038 | 0.039 |
| **Reinhard Color Correction** | 0.0133 | 0.0258 | 0.013 | 0.0424 | 0.038 | 0.039 |
| **Logarithmic TMO** | 0.0131 | 0.0257 | 0.013 | 0.042 | 0.038 | 0.04 |
| **Exponential TMO** | 0.0126 | 0.023 | 0.014 | 0.0403 | 0.036 | 0.037 |

The simulation result of Structural Naturalness of six Different HDR images given in a tabular column:

Table.2.Statistical Naturalness of six different HDR images in various modes of TMOs Colour

| TMO | Im1 | Im2 | Im3 | Im4 | Im5 | Im6 |
|---|---|---|---|---|---|---|
| **Linear Mode** | 1E-12 | 2E-12 | 3E-13 | 1.3E-12 | 1.5E-13 | 4E-12 |
| **Gamma Correction** | 2E-12 | 2E-12 | 8.9E-13 | 3.9E-13 | 6.7E-13 | 5E-12 |
| **Reinhard TMO** | 1.8E-12 | 2E-12 | 7.4E-13 | 1.5E-11 | 2.7E-12 | 7E-12 |
| **Reinhard Colour Correction** | 1.8E-12 | 2E-12 | 7.4E-13 | 1.5E-11 | 2.7E-12 | 7E-12 |
| **Logarithmic TMO** | 8.1E-14 | 1E-12 | 4E-14 | 5.5E-13 | 6.5E-14 | 1E-12 |
| **Exponential TMO** | 7.1E-12 | 3E-12 | 1.4E-11 | 3.2E-11 | 1E-11 | 9E-12 |

## VI CONCLUSION

In this project an attempt has been made to recognize and examine different Tone Mapping Operators. A conventional photographic task is the mapping of the potentially high dynamic range of real world luminance to the low dynamic range of the photographic print. This tone reproduction problem is also faced by computer graphics practitioners who map virtual images to a low dynamic range print or screen. The work presented in this paper was practice to develop a new tone reproduction operator. Tone Mapping necessarily results in an image distortion which impacts each tone and color reproduction.

The most common tone manipulation is luminance compression, which generally causes darker tones to appear brighter and distorts contrast relationships. along with tmos, in this project color correction techniques are presented. two new tmos are proposed which mapped the tone of hdr images as comparable with the existing tmos.


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