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MODIFICATION OF ADAPTIVE LOGARITHMIC METHOD FOR DISPLAYING HIGH CONTRAST SCENES BY AUTOMATING THE BIAS VALUE PARAMETER

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ABSTRACT: High dynamic range imaging (HDRI or just HDR) is a set of techniques that allow a greater dynamic range of luminance between the lightest and darkest areas of an image than current standard digital imaging techniques. Most of the display devices commercially available nowadays are not able to display HDR content. Tone mapping is the operation that reduces the dynamic range of the input content to fit the dynamic range of the display technology. It provides the mapping between the luminance's of the original scene to the output device's display values. When the dynamic range of the captured scene is smaller or larger than that of the display device, tone mapping expands or compresses the luminance ratios. There are number of tone mapping operators (TMO), we have done survey on various tone mapping operators and have improved Drago's operator by introducing automatic bias value instead of user defined bias value. It is found that results are better visually and with quality metrics also.

Keywords: Tone Mapping, TMO, HDR, HDRI.

1. INTRODUCTION

In image processing, computer graphics and photography, high dynamic range imaging (HDRI or just HDR) is a set of techniques that allow a greater dynamic range of luminance between the lightest and darkest areas of an image than current standard digital imaging techniques or photographic methods. This wide dynamic range allows HDR images to more accurately represent the range of intensity levels found in real scenes, ranging from direct sunlight to faint starlight. The two main sources of HDR imagery are computer renderings and merging of multiple photographs, the latter of which in turn are individually referred to as low dynamic range (LDR). HDR images are generated by merging of multiple photographs taken at different exposure values. The basic idea of multi-exposure image capture is to generate an HDR image from differently exposed LDR images, if the dynamic range of the scene exceeds the range of the imaging device. By varying the exposure and taking multiple images of the same scene, different parts of the scene can be combined to a cohesive HDR image from differently exposed single images. The fundamental goal of image reproduction is to display images that correspond to the visual impression an observer had when watching the original scene. The ultimate aim of realistic graphics is the creation of images that provoke the same response and sensation as a viewer would have to a real scene. However, realistic rendering is not enough to ensure perceptual fidelity. Displaying an image is also an important part of the overall process, and weaknesses in this area may significantly detract from advances made in image creation. Tone mapping is a major component of image reproduction. It provides the mapping between the light emitted by the original scene and display values. Tone mapping scales the RGB values of an image, which might be too bright or too dark to be displayed. Tone mapping techniques, which reduce overall contrast to facilitate display of HDR images on devices with lower dynamic range, can be applied to produce images with preserved or exaggerated local contrast for artistic effect. Tone mapping is a technique used to map one set of colors to another, often to approximate the appearance of high dynamic range images in a medium that has a more limited dynamic range. Print outs, CRT or LCD monitors, and projectors all have a limited dynamic range which is inadequate to reproduce the full range of light intensities present in natural scenes. Tone mapping is introduced in the graphic pipeline as the last step before image display to address the problem of incompatible luminance ranges. The main goal of tone reproduction is to adjust the dynamic range of an image to the range that can be displayed on physical devices when the luminance range of the images does not fit that of the physical devices.Various tone mapping operators have been developed in the recent years. They all can be divided in two main types:

Global (or spatially uniform) operators: Spatially uniform operators apply the same transformation to every pixel regardless of their position in the image. A spatially

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uniform operator may depend upon the contents of the image as a whole, as long as the same transformation is applied to every pixel.They are non-linear functions based on the luminance and other global variables of the image.

Local (or spatially varying) operators: The parameters of the non-linear function change in each pixel, according to features extracted from the surrounding parameters. In other words, the effect of the algorithm changes in each pixel according to the local features of the image. Those algorithms are more complicated than the global ones, they can show artifacts (e.g. halo effect and ringing), the output can look un-realistic, but they can provide the best performance, since the human vision is mainly sensitive to local contrast.

The paper is organized as follows. In Section 2 we provide the review on various tone mapping operators. In Section 3, we have provided implementation of Modified Drago's operator. In Section 4, we have provided the results. In section 5, we have drawn some conclusions.

2. RELATED WORK

Tumblin and Rushmeier in 1993 [1], the method focused on preserving the viewer's overall impression of brightness, providing a theoretical basis for perceptual tone reproduction, again by using Stevens and Stevens data [2]. This model of brightness perception is not valid for complex scenes but was chosen by Tumblin and Rushmeier due to its low computational costs. They created observer models- mathematical models of the HVS that include light-dependent visual effects while converting real-world luminance values to perceived brightness images.

K.K. Biswas and Sumanta Pattanaik [3] in 2005, they presented a simple and effective tone mapping operator that preserves visibility and contrast impression of high dynamic range images. The method is conceptually simple, and easy to use. They use a s-function type operator which takes into account both the global average of the image, as well as local luminance in the immediate neighbourhood of each pixel. The local luminance is computed using a median filter. It is seen that the resulting low dynamic range image preserves fine details, and avoids common artifacts such as halos, gradient reversals or loss of local contrast.

Michael Ashikhmin [4] in 2002, this operator takes as an input a high dynamic range image and maps it into a limited range of luminance values reproducible by a display device. This approach follows functionality of human visual system (HVS) without attempting to construct its sophisticated model. The operation is performed in three steps. First, estimation of local adaptation luminance at each point in the image is done. Then, a simple function is applied to these values to compress them into the required display range. Since important image details can be lost during this process, then details are re-introduced in the final pass over the image.

Reinhard in 2002 [5] presented two different variations of the photographic tone reproduction operator. A simple global operator and a more resource hungry local operator simulating the dodging-and-burning operator used in photographic print development. The operator uses a key value for mapping the overall image brightness information. Log average luminance is used as a key value and by default it is mapped to 18% of the display range. The value a where key value is mapped to is user controllable. Another user controllable value is Lwhite, which denotes for the smallest luminance that will be mapped to white. Reinhard has also presented simple calculations for automatic parameter estimation [8].

Logarithmic mapping algorithm by Drago et al. in 2003 [6] uses the simplified assumption that the HVS has a logarithmic response to light intensities. The algorithm uses a logarithmic base between 2 to 10 for each pixel thus preserving contrast and detail. The method is based on logarithmic compression of luminance values, imitating the human response to light. A bias power function is introduced to adaptively vary logarithmic bases, resulting in good preservation of details and contrast.

Ferschin's [7] exponential compression operator is a simple operator based on defining the average luminance of a scene and mapping an exponential curve anchored to the average luminance. The operator implemented in [10] also includes a user controllable option to anchor the computation to the maximum scene luminance instead of the average luminance.

3. IMPLEMENTATION OF DRAGO'S OPERATOR AND PROPOSED BIAS VALUE EQUATION

"Adaptive logarithmic method for displaying high contrast scenes", this method was proposed by F. Drago, K. Myszkowski, T. Annen and N. Chiba [6] in 2003. After analysing the paper written by F. Drago [6] it was found that future work was desirable to automate the bias value parameter. We have implemented this method and automate bias value parameter. Previously one default bias value '0.85' was set. It provides good results for most of the images. But we have proposed an equation to calculate the bias value based on the dynamic range of the image and scene content, this bias value provides better results than default bias value.

3.1. Algorithm:

1. Read the HDR image
2. Read R,G,B values and calculate the luminance for the pixels

   $Lw = 0.299*r + 0.587*g + 0.114*b$

3. Calculate the average logarithmic luminance value

4. Calculate the bias value

   $b = 0.18*2\text{\^{}}(^{\log_2 YA-\log_2 Lmin-\log_{10} Lmax})/(^{\log_{10} Lmax-\log Lmin})$

   Where YA are the average luminance of the image, Lmax is maximum luminance value in the scene and Lmin is the minimum luminance value in the scene.

5. Calculate Exposure factor = Average Luminance/Log Avg Luminance

6. Maximum luminance value is scaled by dividing it with logarithmic average and multiplying it with exposure factor

   Lwmax = (Lmax/La)*Exposure Factor*p

   Where p is the new parameter introduced which we named it as exposure adjustment parameter whose values gives good results within the range 0.001 to 0.02

7. Calculate the display value for all the pixels

   $Ld=Ldmax*0.01/\log_{10}(Lwmax+1)*\log(Lw+1)/\log(2+((Lw/Lwmax)^{\log(b)/\log(0.5))}*8)$

   Where Ldmax is maximum display luminance capability which is 300 cd/m^2 for LCD display.

8. If Ld <= 0.0018

   Ld_new=4.5*Ld

   Else

   Ld_new =(1.099*(Ld).^0.45))-0.099

   End

9. Calculate the new r,g,b values of an image with new display luminance

3.2. Objectives Achieved: Following Objectives are Achieved After Implementing this Algorithm:

1. Automation of Bias value parameter which was specified as a future work in the research paper [6] by F. Drago.
2. An Equation is proposed to calculate the Exposure factor and values are provided to adjust the brightness in image with exposure adjustment parameter. For this parameter no values were proposed in [6].
3. Our Modified Drago's operator requires only one user parameter setting where as original Drago's operator requires two user parameter settings.
4. In this paper quality of images is assessed with the help of quality metrics.

4. RESULTS

4.1. Comparison Based on Visual

Figure 1: Name Image with Drago's Operator

Figure 2: Nave Image with Modified Operator

Figure 3: Office Image with Drago's Operator

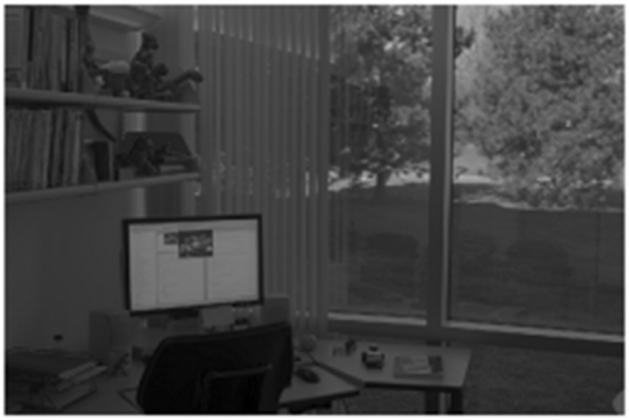

Figure 4: Office Image with Modified Operator

4.2. Subjective Comparative Analysis

If a human observer is asked to determine the quality of image, then it is found that images tone mapped with Modified Drago's operator appears to be of higher quality than images tone mapped with Drago's operator in which default bias value set by the scientists [6]. In case of Nave image (Fig. 1 & Fig. 2) images details are properly produced in bright areas like which are overexposed. Visually the images produced by Modified Drago's operator appears good as all image quality attributes like contrast, details, colours and brightness are properly maintained. Images with medium dynamic range like office (Fig. 4) image contrast and natural look to the image is maintained. On the other hand if we see the office image (Fig. 3) carefully then we can make out that colours are preserved but it provides artificial look to the image. It is found that modified Drago's operator works better in case of images with very high dynamic range which includes very dark and over exposed areas.

4.3. Comparative Analysis Based on Quality Metrics

We have implemented three quality metrics to assess the quality of images:

SSIM: It is Structural SIMilarity index metrics [9]. It compares the structures of two images reference image and the tone mapped image. Higher the value of SSIM is better the quality of produced image.

PSNR: It is Peak Signal to Noise Ratio. Higher the value betters the quality of produced image.

CPU Time (in secs): It is the time the particular algorithm takes to execute.

Table 1
SSIM Value Comparison

Images	SSIM_Drago's	SSIM_Modified
Office	0.5790	0.9293
Nave	0.2011	0.2012

Table 2
PSNR Value Comparison

Images	PSNR_Drago's	PSNR_Modified
Office	55.0015	65.2852
Nave	19.9379	19.9308

Table3
CPU Time (in secs) comparison

Images	CPU Time Drago's	CPU Time Modified
Office	28.60	28.65
Nave	13.17	14.13

4.4. Objective Analysis

From the above tables results for Drago's operator and Modified Drago's operator it is found that SSIM quality metrics values in case of Modified Drago's operator are greater than SSIM values in case of Drago's operator. If we compare in terms of PSNR parameter then results are better in case of Modified Drago's operator. CPU time is almost equal and comparable in case of Drago's operator and Modified Drago's operator.

5. CONCLUSION

In the end of the paper we would like to conclude that Modified Drago's operator i.e. operator modified by automating the user parameter bias value produce better results in terms of visual quality and quality metrics and CPU time is not affected much it is slightly increases for some images but also for few images it is even lesser than the Drago's operator. This little increase in time hardly matters at the expense of quality and automation of parameter. Now "Adaptive logarithmic method for high contrast scenes" by F. Drago is left with only one user parameter but the range of values on which all the images works well are also provided and one equation is also derived to calculate that parameter. Hence, automation of bias value helps to make the algorithm user friendly and increases quality.

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