A SINGLE BACKLIT IMAGE ENHANCEMENT METHOD FOR IMPROVEMENT OF VISIBILITY OF DARK PART

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ABSTRACT

The paper proposes a simple image enhancement method that improves the visibility of the dark regions in an image .

The proposed method uses Alpha blending to blend in an intensity-adjusted image and a contrast-enhanced image. These images are made by using Gamma Correction Method and Histogram Equalization respectively.

The Original Image and blended image are blended by Alpha Blending. Weight of this blend is calculated by using Otsu's Method and Guiding Filter.

Verification of the results is by calculation of NIQE and their comparison with other methods.

***Index Terms*—** Image enhancement, Alpha-Blending, Otsu's Method, Gamma Correction, Histogram Equilization

1. INTRODUCTION

In general when taking pictures of objects under a backlight environment, the object and its surroundings become exceptionally dark resulting in very low visibility .

The reason behind such low visibility is due to the dynamic range of the camera being narrower than that of the human eye.

It is practical use High Dynamic Range images to acquire images with high visibility even under backlight, but multiple Low Dynamic Range images taken at the same shooting position with different exposures to be combined are needed.

A few methods for improving the visibility of a single LDR image have been proposed so far [1], [2], [3], [4]. However Gamma Correction does not sufficiently improve the contrast of the entire image.And while Histogram Equalization (HE) [5], [6] and Contrast Limited Adaptive Histogram Equalization (CLAHE) [7] are typical contrast enhancement methods, however there is a high chance of causing artifacts in the process .

Although the method [3] is an edge-aware image enhancement, the smoothness of flat parts tends to be impaired and method [4] for backlit image enhancement has relatively high chance of causing artifacts in bright parts .

2. PROPOSED METHOD

This study proposes a simple enhancement method that improves the visibility of dark parts in backlit images while suppressing the artifacts mentioned above.

By usage of Gamma Correction and Histogram Equalization an enhanced intensity image with balanced intensity and contrast is generated.

Next, focusing on the intensity histogram of the backlit image, a binary image is generated by usage of Otsu's method.

The edge-preserving smoothed version of this image is made by using Guided Filter and is used to suppress the artifacts at the edge parts. Finally, an output image is obtained by alpha blending between the input image and the enhanced intensity image using the weight map. The effectiveness of the proposed method is verified by using NIQE score and comparing against other image enhancement methods .

Let $I_{(i,j)}^{RGB} = (I_{(i,j)}^{R}, I_{(i,j)}^{G}, I_{(i,j)}^{B})$.

We calculate the intensity values b using the following formula :

$$I_{i,j} = ((0.299){I_{i,j}}^{R} + (0.587){I_{ij}}^{G} + (0.11){I_{i,j}}^{B})/3 \quad (1)$$

We have divided the entire process into 3 parts : (a) Gamma Correction and Histogram Equalization (b) Alpha Blending (c) Weight Map Generation (d) Image composition using Guided Filter

2.1. Gamma Correction and Histogram Equalization

The gamma correction is applied to $I_{(i,j)}$ and their pixel distribution moves to the right while the pixels with values closer to zero moderately decrease.

$${I_{i,j}}^{\gamma} = 255(I_{i,j}/255)^{1/\gamma} \quad (2)$$

Next step is Histogram Equalization; as the we need the contrast to be improved which can't be done by gamma correction alone .

Here the histogram shifts to right in gamma correction and spreads out in histogram equalization .

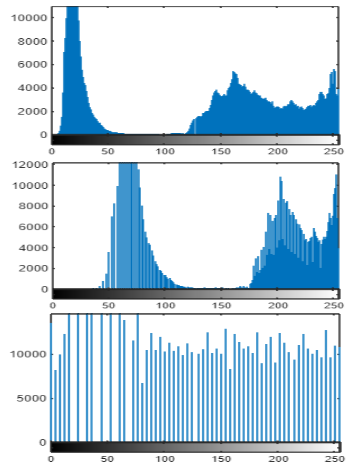

Fig. 1. Histogram of (a) Original Image (b) Gamma Correction (c) Histogram Equalization

2.2. Alpha Blending

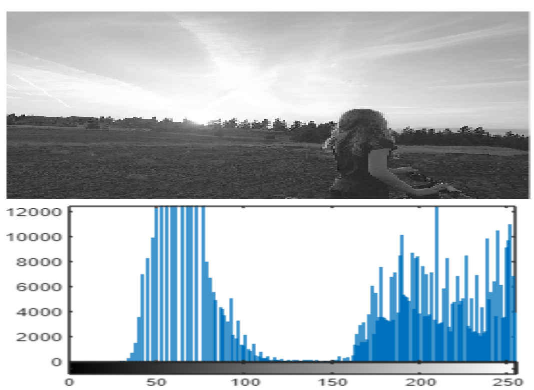

Fig. 2. Alpha blended Image and its Histogram

Following the histogram equalization and gamma correction, we blend them using Alpha Blending;

$$O_{i,j} = (1-\alpha) I_{i,j}{}^{\gamma} + (\alpha) I_{i,j}{}^{HE} \tag{3}$$

Where O is the alpha blended image with $I_{(i,j)}{}^{\gamma}$ being the gamma corrected image and $I_{(i,j)}{}^{HE}$ being contrast enhanced image from 2.1 .

While the image is enhanced, we still find artifacts in bright parts of the image .

2.3. Weight Map Generation

For the removal of artifacts in the brighter parts of the image, we generate a weight map and use to suppress the artifacts by using a guided filter .

A binary image is generated using Otsu's Method [9] where we find the number of pixels in black class (c1) and white class (c2) with a mean of m1 and m2 respectively . By maximizing the class variance :

$$class1 * class2 * (m1 - m2)^2 \tag{4}$$

we find the threshold **t** .

Finding weight map using :

$$W_{i,j} = 1, I_{i,j} < t \tag{5}$$

$$W_{i,j} = 0, otherwise \tag{6}$$

We use a guided filter[10] on $W_{i,j}$ using $I_{i,j}$ as the guide image . Since its edge preserving method, the image becomes closer to original image .

2.4. Image Composition

From 2.3 we get the weight map to suppress artifacts and now we calculate the final intensity image :

$$\tilde{O}_{i,j} = (\tilde{W}_{i,j}) O_{i,j} + (1 - \tilde{W}_{i,j}) I_{i,j} \tag{7}$$

$\tilde{W}_{i,j}$ is the final weight map after using guided filter and $\tilde{O}_{i,j}$ is the final intensity image .

3. EXPERIMENTAL CONDITIONS

The entire experiment has been divided into 4 parts : Image enhancement using gamma correction and histogram equalization where we take the value of γ = 2 .

And window of the box filter (guided filter) is taken to be r = 20 where the box is $(2 * r + 1)$ x $(2 * r + 1)$.

α is taken as 0.2 for the alpha blending .

4. RESULTS

The results according to 3 has been presented below :

Table 4.1 shows the NIQE score of various other methods as compared to our method . As we observe from table 4.1 , our scores are close to the score of akai's method .

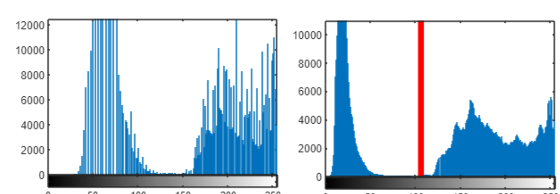

Fig. 3. Alpha Blended Histogram and Otsu's Threshold

Table 4.1 NIQE Score

Single Backlit Images	Image 1	Image 2	Image 3
Original	2.67	3.93	2.65
HE	3.18	4.53	3.28
CLAHE	2.66	3.98	2.78
Paris	2.93	5.22	2.98
Wang	2.47	4.32	2.92
Ours	2.47	3.8	2.57

We have used the naturalness image quality evaluator score and lightness order error to compare various methods . A lower score of NIQE represents a better perceptual quality .

Lightness order error [14] is : for each pixel;

$$L_{x,y} = max({I_{x,y}}^R, {I_{x,y}}^G, {I_{x,y}}^B) \tag{8}$$

and their relative order;

$$RD_{x,y} = \sum_{i=1}^{m} \sum_{j=1}^{n} (U(L_{x,y}, L_{i,j}) \oplus U(Le_{x,y}, Le_{i,j} \tag{9}$$

where Le is the lightness of the enhanced image while L is the lightness of the original image and m and n are the dimensions of the image, being the height and width respectively .

The lightness order error is given by :

$$LOE = \frac{1}{m*n} \sum_{i=1}^{m} \sum_{j=1}^{n} RD_{i,j} \tag{10}$$

Table 4.2 LOE

Single Backlit Images	Image 1	Image 2	Image 3
HE	310	475	157
CLAHE	1045	1763	1222
Paris	602	1144	844
Wang	619	749	526
Ours	76	378	104

We have the Original image, Enhanced Image and Final histogram of each image in that order .

We have compared each of the method mathematically and now we are comparing them visually .

We have

5. CONCLUSION

A simple and fast method of image enhancement of single backlit images has been proposed for improving the visibility of the dark parts . The images are enhanced by using alpha blending on intensity corrected images and contrast enhanced images. A weight map is is then used to suppress the artifacts to provide the final result .

We verify the result using NIQE Score (Nauralness Image Quality Evaluation Score) and LOE (LLightness Order Error) .

Fig. 4. Image 1 result comparison

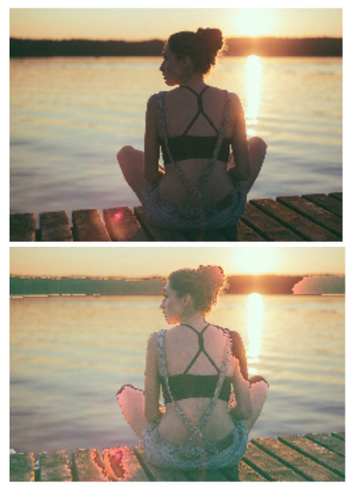

Fig. 5. Image 2 result comparison

Fig. 6. Image 3 result comparison

From the value of NIQE and LOE we see a trend; the quality of our images are much higher in some types of images in NIQE score but has a significantly lower amount of lightness order error .

Future plans should be directed towards enhancing the bright part of images .

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