International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 – 5161
Available at http://inpressco.com/category/ijcet

Research Article

A Novel Hybrid Approach For Night Time Image Visibility Enhancement using Robust Retinex Model and Fusion Based Enhancement Method

Akshay D. Shirbhate and Dr. Sudeep D. Thepade

Department of Computer Engineering Pimpri Chinchwad College of Engineering, Pune, Maharashtra, India

Received 10 Nov 2020, Accepted 10 Dec 2020, Available online 01 Feb 2021, **Special Issue-8 (Feb 2021)**

Abstract

Images taken under low light conditions or at night time has significantly less details compared to images taken under proper lighting. For computer vision applications, this kind of image is not acceptable as loss of visibility might result in undesirable output. It is also not very convenient for observation and for accurate analysis. To overcome this issue, different techniques have been used for low light images. In this paper, we presented a hybrid approach to enhance the visibility of the low light image by fusion of Robust Retinex Model (RRM) and Fusion based enhancement methods. The performances of existing and proposed system are compared based on the average entropy of input images. Different split ratio of multiplying factors have been tried to achieve the best results.

Keywords: *Visibility enhancement , computer vision, Retinex method, fusion based methods.*

Introduction

Night time images have poor illumination. Lot of details gets hidden due to poor illumination. For computer vision applications, such as filmmaking, video surveillance, night vision, this kind of images are often unacceptable. To help proper functioning of these applications, enhancement weakly illuminated image is necessary. For applications like object detection and object tracking, the performance of the application highly depends on the visibility of the object and its surrounding (target scene). Weakly illuminated image not only suffers from the low illumination and low contrast but also high level noises. By simply amplifying the illumination, the image can be enhanced, but it can arise other issues like over saturation of already bright parts of the image. So, different enhancement methods have to be used to properly balance the attributes of the image. Contrast enhancement helps in revealing the information present in low illuminated night time images. For increasing the dynamic range of the observed image, basic techniques like histogram equalization are used. However it does not help in adjusting the illumination. Different filters can also be used in the preprocessing of image to reduce the noise present in the image. This ensures a better quality of input to the application. Thus helps in getting an improved output for the application.

The paper presents recent methods of night time image visibility enhancement. The main contribution of this paper is the hybridization of robust retinex model and fusion based image enhancement methods. The fusion of the techniques is achieved by adjusting the split between the effect of each technique on the processed image. The remaining paper is organized as follows, section 2 presents literature review of existing methods. The proposed methodology is presented in section 3. Section 4 puts forth the experimentation environment setup for the work. The obtained results with analyzed observation are presented in section 5. The concluding remarks are given in section 6.

Review Of Literature

Many image enhancement techniques have been used to improve the visual quality of poorly illuminated images. The most commonly used approaches are often based on techniques like histogram-based methods, retinex-based methods and filteringbased methods. In this section we have briefly reviewed some techniques as well as potential drawbacks and advantages are addressed. Mading Li et. al. [1] is based on the classic Retinex model. The classic Retinex model is based on the illumination and reflectance parameters of the input image, but does not consider noise effect. To address this issue, the paper [1] proposed a method by considering a noise map. The noise map is considered for the input images which contains intensive noise. An optimization function which includes regularized terms for reflectance and illumination is presented. To achieve optimization, an augmented multiplier of language is used which basically based on the alternating direction minimization algorithm.

The highlight of this paper [1] is that it can be used for problems like underwater visibility enhancement, remote sensing haze or dust removal applications. One of the limitations of this paper is that it is somewhat computationally costly, so it cannot be used in real time applications. Thus, it's not suitable for real time video enhancement.

In Xueyang fu et. al. [2], author has proposed a fusion based method which makes use of difference mature image processing techniques. In this article, the initial illumination is estimated and based on it the observed image is decomposed into reflectance image and elimination image. Then using sigmoid function and histogram equalization two inputs are derived from the illumination image. Based on the derived weights the adjusted illumination is produced. By compensating the adjusted illumination with initially derived reflectance the final image is obtained.

To be able to produce good quality outputs for multiple conditions like non-uniform illumination and backlighting is the major advantage of this paper. Good trade-off of naturalness preservation, contrast enhancement and improved luminance is achieved. But the system proves to be complex thus, comparatively computationally costly.

Xuesong Jiang et. al. [3], is based on the observation that the negation of a weakly illuminated image majorly resembles the hazy are misty image. So, using this assumption, the intensity inverted night image is given to the Haze removal algorithm as an input which processes it to produce an enhanced low light image. In this paper, an improved Dark Channel Prior (DCP) technique is used. In this technique, the global atmospheric light is estimated to know the thickness of haze. After using soft matting pre-processing technique, medium transmission is calculated which is then used to obtain the scene radiance. Negation of the obtained result is calculated to get the final enhanced image.

This method is computationally cost-effective thus, can be used for real time application. Another highlight of this paper is that it avoids excessive enhancement while preserving the local details. As the method is based on dark channel prior method, it fails when the scene object is similar to the air light.

Proposed Methodology

A. Architecture

The architecture of the proposed system is as shown in the following figure (Fig 1) :-

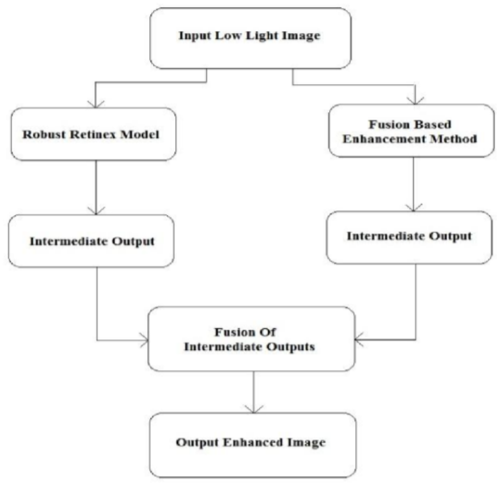

Fig 1. Architecture of proposed system

The aim of the proposed system is to accept a low light input image and produce an enhanced image with better visibility as the output image. For this purpose, we have compared multiple image visibility enhancement techniques like:-

1) Robust Retinex Model based method.
2) Dark channel Prior based method.
3) Fusion Based Enhancement method.

Comparison among the above three methods is done on the basis of entropy of the image. On comparison, we found that the Robust Retinex Model based method and fusion based enhancement techniques produce better results. The comparison of these techniques was done on individual results of each technique.
Based on the performance of each method, we selected the two best methods.

• Robust Retinex model (RRM) : -
The average entropy by this method was calculated as 7.2303.
• Fusion based image enhancement: -
The average entropy by this method was calculated as 6.9964.
Dark Channel Prior :- The average entropy by this method was calculated as 6.0716.
Based on these results, RRM and fusion based enhancement techniques were chosen.

In our proposed system, we have tried to fuse the two best techniques compared in above discussion. For fusion, we have applied method 1 and method 2 (i.e. RRM and fusion based enhancement technique) in splits. We have tried and tested nine splits factors (i.e. 0.1 & 0.9 , 0.2 & 0.8 , 0.3 & 0.7 , 0.4 & 0.6 , 0.5 & 0.5 , 0.6 & 0.4 , 0.7 & 0.3 , 0.8 & 0.2 , 0.9 & 0.1). Then that split factor is selected which produces the result with maximum entropy value.

Experimentations

A. Dataset used

The input dataset used in our paper is collection of images used in the following articles Mading Li et. al. [1], Xueyang fu et. al. [2], Xuesong Jiang et. al. [3].

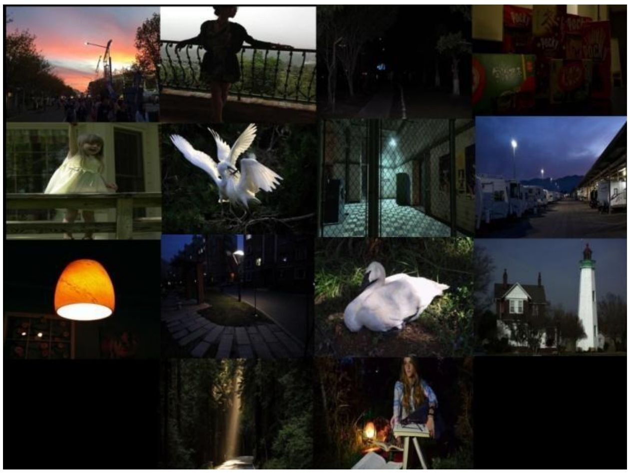

Fig 2. Input image dataset

B. Performance Measure

Performance measure is the process of collecting, analyzing and reporting information regarding performance of the given algorithm/technique/method. In this paper, we have used entropy of an image to find the performance of the algorithm.

Entropy: -Discrete entropy is used to measure the content of an image, where a higher value indicates an image with richer details. The entropy (E) referred to here is Shannon's entropy. In the field of information theory, entropy, also called entropy of information and Shannon's entropy, measures the uncertainty of a source of information.[6] The entropy of an image is given by: -

$$E(I) = -\sum_{k=0}^{L-1} p(k)\, log_2\,(p(k)),$$

................(4.1)

where, I is the original image, p(k) is the probability of occurrence of the value k in the image I, L represents different gray levels.

The entropy value is calculated with the inbuilt function 'entropy (I)' in MATLAB, where I is the image whose entropy is to be calculated.

E = entropy(I) ……………..(4.2

The equation returns e, a scalar value representing the entropy of image I.

Result And Discussion

In this paper, we have initially compared the visibility enhancement by three different methods from following articles Mading Li et. al. [1], Xueyang fu et. al. [2], Xuesong Jiang [3], using entropy of the input and output of image. At first we calculated the entropy of each input image for each colour channel (Red, Green, Blue). Then we take average of entropy of all the three channels. After obtaining this value for each image, we take average of entropy of all images to analyze the visibility of overall dataset.

Following table shows the average entropy values of 14 input images from fig 2 : -

Table 1. Average entropy of weakly illuminated input images.

Image no.	Average Entropy(R-G-B)
1	7.1714
2	6.6535
3	5.9453
4	6.7489
5	7.0528
6	4.0876
7	5.6712
8	6.6224
9	6.6512
10	5.9194
11	5.9765
12	6.5888
13	4.4528
14	5.4313
Avg	6.0695

Then RRM technique is applied to the input dataset. Entropy of resultant images is then calculated and average entropy of each image obtained by RRM method is given in Table 2. The average entropy of images by Robust Retinex Model Mading Li et. al. [1] is as follows:-

Table 2. Average entropy of each image obtained by RRM method

Image no.	Average Entropy(R-G-B)
1	7.5824
2	7.3905
3	7.4084
4	7.5372
5	7.2722
6	5.3770
7	7.3947
8	7.5192
9	7.1794
10	7.4133
11	7.2817
12	7.4525
13	6.6722
14	6.5185
Avg	7.2303

Then Fusion based Enhancement technique is applied to the input dataset. Entropy of resultant images is then calculated and average entropy of each image obtained by this method is given in Table 3.

Table 3. Average entropy of each image obtained by fusion based enhancement technique

Image no.	Average Entropy (R-G-B)
1	7.4121
2	7.2036
3	7.0368
4	7.4712
5	7.1639
6	5.8538
7	6.8724
8	7.2930
9	7.1272
10	6.9480
11	7.2136
12	7.0778
13	6.2957
14	6.9798
Avg	6.9964

Then Dark Channel Prior method is applied to the input dataset. Entropy of resultant images is then calculated and average entropy of each image obtained by this method is given in Table 4.

Table 4. Average entropy of each image obtained by Dark Channel Prior method

Image no.	Average Entropy (R-G-B)
1	7.1825
2	6.8124
3	5.9918
4	6.9388
5	7.1612
6	6.1512
7	5.6916
8	6.6824
9	6.8512
10	6.0213
11	6.1269
12	6.6097
13	4.8262
14	5.7389
Avg	6.3418

Then, proposed method is applied to the input dataset. Entropy of resultant images is then calculated and average entropy of each image obtained by the proposed method is given in Table 5

Table 5 . Average entropy of each image obtained by proposed method

Image no.	Average Entropy (R-G-B)
1	7.5975
2	7.4227
3	7.5152
4	7.5431
5	7.2891
6	5.7918
7	7.4374
8	7.5397
9	7.1876
10	7.4748
11	7.3935
12	7.4716
13	6.8457
14	6.8588
Avg	7.2406

The resultant images obtained by the proposed method are shown in fig 3.

Fig 3. Output images obtained by the proposed method

The comparison of average entropy of each image by each technique is given in table 6.

Table 6 . Average entropy of each image obtained by each method

	Input dark image	RRM [1]	Fusion based [2]	DCP[3]	Proposed method
Avg. Entropy (R-G-B)	6.0695	7.2303	6.9964	6.3418	7.2406

Conclusion

In this paper, we presented a hybrid approach for low light image visibility enhancement. Initially, three techniques Robust Retinex Method, Fusion based and Dark Channel Prior methods were considered analyzed. We proposed a system by fusing the two best methods. The output of the proposed system was found to be better in terms of visibility. The performance was analyzed with the help of entropy. It is also observed that the output of different techniques can vary with different input. The computation time required for the processing is reasonably little more as the proposed system based on the fusion of the remaining two techniques. In future, the system may be extended to apply for videos. We can also potentially decrease the processing time of the application.

References

[1]. Mading Li, Jiaying Liu, Senior Member, IEEE, Wenhan Yang, Xiaoyan Sun, Senior Member, IEEE, and Zongming Guo, Member, IEEE, "Structure-Revealing Low-Light Image Enhancement via Robust Retinex Model" 978-1-4799-2341-0/13/$31.00 ©2018 IEEE

[2]. Xueyang fu,Delu zeng,Yue huang Yinghai Liao,Xinghao Ding John Paisly, "A fusion based enhancing method for weakly illuminated images" @2016 Elsevier B.V.

[3]. Xuesong Jiang1,2, Hongxun Yao1, Shengping Zhang1, Xiusheng Lu1 and Wei Zeng3 "NIGHT VIDEOE Nhancement Using Improved Dark Channel Prior", 978-1-4799-2341-0/13/$31.00 ©2013 IEEE

[4]. L. Li, R. Wang, W. Wang, and W. Gao, "A low-light image enhancement method for both denoising and contrast enlarging," in Proc. IEEE Int'l Conf. Image Processing, Sept 2015, pp. 3730–3734.

[5]. X. Zhang, P. Shen, L. Luo, L. Zhang, and J. Song, "Enhancement and noise reduction of very low light level images," in Proc. IEEE Int'l Conf. Pattern Recognition, Nov 2012, pp. 2034–2037.

[6]. K. G. Lore, A. Akintayo, and S. Sarkar, "LLNet: A deep autoencoder approach to natural low-light image enhancement,"PatternRecognition,vol.61,pp.650–662, 2017.

[7]. E. H. Land et al., "The retinex theory of color vision," Scientific America, 1977.

[8]. D. J. Jobson, Z. Rahman, and G. A. Woodell, "Properties and performance of a center/surround retinex," IEEE Transactions on Image Processing, vol. 6, no. 3, pp. 451–462, Mar 1997.

[9]. S. Wang, J. Zheng, H.-M. Hu, and B. Li, "Naturalness preserved enhancement algorithm for non-uniform illumination images," IEEE Transactions on Image Processing, vol. 22, no. 9, pp. 3538–3548, 2013.