Advances in Basic and Applied Sciences 3 (2024) 67-71

Advances in Basic and Applied Sciences

journal homepage: https://abas.journals.ekb.eg/

Increase contrast of low light image using modified histogram equalization

A. M. M. Madbouly

Mathematics Department, Faculty of Science, Helwan University, Cairo, Egypt.

ARTICLE INFO

Article history:
Received 12 October 2024
Received in revised form 2 November 2024
Accepted 22 November 2024
Available online 22 November 2024

10.21608/ABAS.2024.327925.1052

Keywords: Histogram, Image Process, Contrast, Low Light Image.

ABSTRACT

Low-light images often suffer from poor visibility and reduced contrast, leading to degradation in image quality. This paper proposes a novel algorithm to improve contrast in low-light images through modified histogram equalization. The approach divides the image into different layers and applies a histogram to these layers. By balancing local brightness while preserving details, the method produces visually enhanced images with improved clarity and contrast. Our experimental results demonstrate significant performance gains compared to existing methods when evaluated using various image quality metrics, including NIQE and CPCQI.

1. Introduction

There is no doubt the enhancement of Low-light images plays an important role in many applications. Low light image reduces the detail of images that came from dark region in image. This low contrast affects human perception. There are several methods that work on increasing contrast of image to reduce this dark region. Agaian et al. proposed algorithm to improve contrast of images using contrast entropy but the calculation of contrast entropy may require defining parameters such as window size or contrast thresholds. Poor choices of these parameters can lead to suboptimal results [1]. Arici et al. present a histogram modification framework [2] that can be used to increase contrast of image, but the computational complexity makes it not suitable for real time problems. By Feng et al. developed improvement in contrast while minimizing noise using techniques like dark channel enhancement [3]. Celik developed a novel procedure, that improves the contrast of an input image using spatial information of pixels.it rely on spatial information of pixels often require more intensive computation than simpler, global methods (like histogram equalization). Which makes it not effective for real time problems [4].

Farid offered a method for blindly guessing the amount of gamma correction in the lack of any

* **Corresponding author E-mail:** *ammadbouly@yahoo.com*

calibration information or knowledge of the imaging device [5] that can be used to increase contrast in mages. Park et al. present algorithm improves the usability of images taken in environments with extremely poor lighting, making them clearer and more suitable for both human interpretation and further automated analysis, such as in medical imaging, security, or nighttime photography [6]. This algorithm is effective in very dark images. Yang et al. aimed optimization challenges based on the median of pixel quantities in an image [7]. However, since the median is a nonlinear function, determining the optimal parameter requires an iterative approach, which results in computational inefficiency, making it less suitable for practical applications [8]. In the transform domain, Dabov et al. presented a denoising technique based on an improved sparse representation. In order to improve sparsity, related 2D image fragments (like blocks) are grouped into 3D data arrays that we refer to as "groups." A unique process called Collaborative Altering was created to address these 3D groups [9]. But the main drawback of this method is complex computation and implementation. Tan et al. presented an improved histogram equalization -depending on contrast improvement technique for non-uniform illuminated images specifically Exposure Region-Based Multi-Histogram Equalization (ERMHE) [10]. The main idea of this algorithm is to state the varying exposure degrees across different regions of the image by splitting it into multiple segments based on exposure, then histogram equalization applied. As noticed, the drawback of it is complex computation and it is suitable only for images that have non uniform illumination. Banik et al. proposed method that can improve illumination in low dark image that combines histogram equalization and illumination adjustment [12] which is slow as mentioned in [11]. The approach improves image visibility and contrast, making it suitable for images captured in challenging lighting environments while maintaining a natural look.

2. Proposed method

The major solution of the proposed way is that there is no necessity to use complex methods to increase contrast in low dark images. According to previous research there are a lot of complex methods used to improve luminance in low dark images and compare it with Histogram equalization due to it is the simplest method to do that. The algorithm consists of three steps. The first one is separate channels of images (red, green and blue), secondly applying histogram equalization into each layer. Thirdly merge these layers into one layer to compose color image again. This is clear in the following figure.

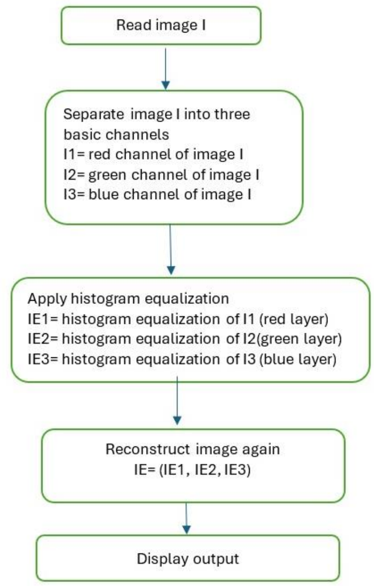

Figure 1: proposed algorithm

3 Experimental results

In this section, we will introduce the results of the proposed method, we will examine our proposed method against the method introduced in [11] which we will refer to as new histogram equalization (NHE). We will display the results of comparison between histogram equalization, NHE, proposed method. We used the same data set used in paper [11] to compare results with it. There are many image quality assessments that can be used in this experiment like: Natural Image Quality Evaluator (NIQE) [13], this is a no-reference (blind) image quality assessment model that estimates image quality based on statistical properties of natural scenes. The higher NIQE score indicates lower image quality, while a lower NIQE score indicates higher image quality.

Peak Signal-to-Noise Ratio (PSNR) [14] is usually applied metric for image and video quality measurement that quantifies the difference between a compressed or altered image and its original version. A higher PSNR rate indicates higher image quality, but a lower PSNR rate indicates lower image quality.

Content-Perceptual Color Quality Index (CPCQI) [14] is designed to assess color image quality based on perceptual color fidelity and how the human visual system perceives color distortions. The higher the score, the more accurately the image represents its original content and colors.

Mean Square Error (MSE) [14] measures the meaning of the squares of the differences between the pixel rates of the original and distorted images. A lower MSE rate signifies less distortion and better image quality, while a higher MSE indicates more errors and poorer image quality. We will use NIQE and CPCQI because they are more significant.

Figure 2(a).

Figure 2(b).

Figure 2(c).

Figure 2: list high dark images before and after improvement.

Fig. 2 shows comparison between various techniques that are used to increase the contrast of images where Fig. 2(a) shows original picture, Fig. 2(b) new histogram equalization, Fig. 2(c) result of proposed picture. Table 1 shows that the proposed method is the best way to improve the contrast of high dark image according to quality assessment scores.

Figure 3(a).

Figure 3(b).

Figure 3(c).

Figure 3: list mid dark image after applying various techniques to improve contrast.

Fig. 3 shows comparison between various techniques that used to increase the contrast of images where Fig. 3(a) original picture, Fig. 3(b) new histogram equalization, Fig. 3(c) result of proposed image.

Table 1: Quality Values of NIQE and CPCQI for high dark images.

	NIQE	CPCQI
Proposed method	118.16	22.08
NHE [11]	153.35	13.85

Table 2: Quality Values of NIQE and CPCQI for mid dark images.

	NIQE	CPCQI
Proposed method	146.16	29.23
NHE [11]	136.44	21.10

Table 2 shows that proposed method is best way to improve contrast of mid dark image according to value of CPCQI (highest value) score, While NIQE scores show that new histogram equalization is best to improve contrast of images.

Fig. 4 shows comparison between various techniques that are used to increase the contrast of images where Fig. 4(a) original picture, Fig. 4(b) new histogram equalization, Fig. 4(c) result of proposed image. Table 3 shows that the proposed method is best to improve contrast of mid dark image according to value of CPCQI (highest value) score and NIQE (lowest value).

Table 3: Quality Values NIQE and CPCQI for low dark images.

	NIQE	CPCQI
Proposed method	147.35	23.12
NHE [11]	165.49	17.56

NIQE score shows that new histogram equalization succeeds in improving contrast of image in mid-level dark image, while proposed method more efficient when improve low and high dark images.

Future work: improve algorithm to succeeds in three layers based on NIQE and CPCQI.

Conclusion

This paper presented a simple method which does not need complex computation to improve the quality of dark image that makes it suitable for real time problems. We try to categorize dark images into three levels to make results clearer. There are several quality evaluators used to assess the quality of output image. Due to CPCQI proposed method is the best among against mentioned algorithms in three levels (low – mid – high dark images).

Figure 4(a).

Figure 4(b).

Figure 4(c).

Figure 4: list low dark image after apply various techniques to improve contrast

Conflict of interest

The author confirms that there are no conflict of interests.

Funding

The research received no fund.

References

[1] S. S. Agaian, B. Silver, and K. A. Panetta, Transform

coefficient histogram-based image enhancement algorithms using contrast entropy, *IEEE transactions on image processing*, **16**(3), 741-758 (2007).

[2] T. Arici, S. Dikbas, and Y. Altunbasak, A histogram modification framework and its application for image contrast enhancement, *IEEE Transactions on image processing*, **18**(9), 1921-1935 (2009).

[3] B. Feng, Y. Tang, L. Zhou, Y. Chen, and J. Zhu, Image enhancement under low luminance with strong light weakening, 8^{th} International Conference on Wireless Communications and Signal Processing (WCSP), IEEE., 1-5 (2016).

[4] T. Celik, Spatial entropy-based global and local image contrast enhancement, *IEEE Transactions on Image Processing*, **23**(12), 5298-5308 (2014).

[5] H. Farid, Blind inverse gamma correction, *IEEE Transactions on Image Processing*, **10**(10), 1428-1433 (2001).

[6] D. Park, M. Kim, B. Ku, S. Yoon, and D. K. Han, Image enhancement for extremely low light conditions, 11^{th} IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS), 307-312 (2014).

[7] K. F. Yang, H. Li, H. Kuang, C. Y. Li, and Y. J. An adaptive method for image dynamic range adjustment, *IEEE Transactions on Circuits and Systems for Video Technology*, **29**(3), 640-652 (2018).

[8] I. Jeong, and C. Lee,. An optimization-based approach to gamma correction parameter estimation for low-light image enhancement, *Multimedia Tools and Applications*, **80**, 18027-18042 (2021).

[9] K. Dabov, A. Foi, V. Katkovnik, and K. Egiazarian, Image denoising by sparse 3-D transform-domain collaborative filtering. *IEEE Transactions on Image Processing*, **16**(8), 2080-2095. (2007).

[10] S. F. Tan, and N.A. M. Isa, Exposure based multi-histogram equalization contrast enhancement for non-uniform illumination images, *IEEE Access*, **7**, 70842-70861 (2019).

[11] P. P. Banik, R. Saha, and K. D. Kim, Contrast enhancement of low-light image using histogram equalization and illumination adjustment, International Conference on Electronics, Information, and Communication (ICEIC), IEEE., 1-4 (2018).

[12] H. Yue, J. Yang, X. Sun, F. Wu, and C. Hou, Contrast enhancement based on intrinsic image decomposition, *IEEE Transactions on Image Processing*, **26**(8), 3981-3994 (2017).

[13] A. Mittal, R. Soundararajan, and A. C. Bovik, Making a "completely blind" image quality analyzer, *IEEE Signal Processing Letters*, **20**(3), 209-212 (2013).

[14] Z. Wang, L. Lu, and A. C. Bovik, Image quality assessment: From error visibility to structural similarity, *IEEE Transactions on Image Processing*, **13**(4), 600-612 (2004).