IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

A Review Paper on LIME: Low-Light Image Enhancement

Dinesh tete
Chandra Sekhar panda

Abstract-Low lighting is difficult for seeing well in the images which are taken. This poor quality may significantly decrease the performance of many computer vision and multimedia algorithms, which are primarily built for high-quality inputs, in addition to degrading the visual aesthetics of images. In this research, we provide a low-light image enhancement (LIME) method that is both simple and efficient. To overcome the low visibility of the image, some operations are to be performed. Moreover, because of the increasing demand for computer vision technology, the concept of digital image processing has been quickly adopted in a broad range of real-world information-gathering applications, such as medical images, video monitoring, machine/robot vision, industrial productions, intellectual translations, etc.

Keywords- survey, low-light image enhancement, Retinex method, image enhancement, Pre-Enhancement & Post-Enhancement, illumination

INTRODUCTION-

Digital image processing systems have become widely used in a variety of fields due to the quick advancements in digital vision technology, including industrial production, video monitoring, intelligent transportation, and remote sensing monitoring. As a result, they play significant roles in industrial production, daily life, military applications, etc. However, various uncontrolled elements are common during the image capture process, leading to a number of image deficiencies. Particularly in low-light environments like indoors, at night, or on cloudy days, the light reflected from the object's surface may be feeble. As a result, noise and colour distortions may significantly impair image quality. After converting, storing, transmitting, and other processes with images.to remember the visibility of dark areas, direct enhancement of the low-light image is perhaps the most natural and straightforward method. However, this technique creates a new issue, such as the potential for relatively bright spots to get saturated and lose the corresponding details. Histogram may solve the multiple input by constraining the output image to fall within the acceptable range. Furthermore, applying various denoising terms to the histogram variational methods seek to enhance the HE performance. For instance, contextual and variational contrast enhancement (CVC) seeks to express big gray-level differences in a layered manner for 2D histograms, whereas the work improves by focusing on large gray-level differences (LDR). However, they run the danger of being over- and under-enhanced in nature since they emphasize contrast improvement rather than utilising true illumination sources. Gamma correction, a nonlinear correction to images, is another method. The

primary premise of Retinex theory is that reflectance and lighting may be used to separate the (colour) picture into its component parts.The reflectance is treated as the ultimate increase resulting overly enhanced. By combining several derivations of the initially calculated illumination map, Fu et al. suggested a technique for adjusting the lighting (MF). The majority of MF's performance is good. However, because of the lighting structure's blindness, MF may lose the realism of areas with dense textures. A weighted variational model for a concurrent estimate of reflectance and illumination was suggested in the most recent study (SRIE). The target picture can be improved by manipulating the lighting using the estimated reflectance and illumination. Inverted low-light image approach hazy images, as seen in. The authors of alternatives decided to dehaze the inverted low-light photos based on this discovery. Dehazing is followed by a second inversion of the obtained unrealistic images to provide the final enhanced results [1].

The major goals of low-light image enhancement are to enhance the image's global and local contrast, visual impact, and suitability for human or computer processing, all while preventing noise amplification and attaining good real-time performance. In order to produce clear images or videos, it is essential to enhance the validity and accessibility of data recorded in low-light conditions. Such improvements can make images more consistent with people's subjective visual experience, increase the dependability and robustness of outdoor visual systems, and make it easier for computers to interpret and process those images.

vision technology, which is crucial for advancing the growth of picture information mining. Related study findings may be utilised as a reference for studies on subjects like underwater image analysis and hazy picture clarity and can be widely applied in sectors like urban traffic monitoring, outdoor video capture, satellite remote sensing, and military aviation inquiry. Low-light image enhancement, a crucial area of study in the field of image processing, also has interdisciplinary appeal, is novel, has a wide range of potential applications, and has recently drawn the attention of multidisciplinary researchers. For a long time, both domestic and international scholars have been focusing more and more on this area [2].

Different Methodology

Gray level transformation-spatial domain methods are procedures that operate directly on the pixels. The spatula domain process will br denoted by the expression

$$g(x,y)=T[f(x,y)]$$

Where, g(x,y)is processed image f(x,y) is input image and T is an operator on f.

Pixels are directly transformed at the gray scale. The gray scale image picture has 256 different shades, and the horizontal axis of a histogram ranges from 0 to 255.

Gray transformation method is a spatial-domain image enhancement algorithm which is working by transforming the gray values of single pixels into other gray values. The simplest formula for image enhancement technique is:

$$s=T(r)$$

Where r and s denote the gray levels of f(x,y) and g(x,y) at any point(x,y)

Further the gray level transformation is divided in to 3 categories-linear(negative and identity trasformations), logarithmic(log and inverse-log transformations), power-law(*n*th power and *n*th root transformations)[3].

Image negative-

The negative of an image with the gray levels in the range [0,L-1] is obtained by using the negative transformation. The expression of the negative transformation

$$S = L - 1 - r$$

Reversing the intensity levels of an image in this manner produces the equivalent of a photographic negative. This type of processing is particularly suited for enhancing white or gray details embedded in dark regions of an image especially when the black area are dominant in size.

Logarithmic transformations- However, it comes in two types: inverse logarithmic transformation and logarithmic transformation. The log function has the important characteristics that it compresses the dynamic range of images with large variations in pixel values. This formula could be used to define the log transformations:[4]

$$s = c \log(1 + r)$$

Where c is a constant and its assumed that r>=0.

Power-law transformation-

The power-law transformation's basic shape is:

$$g(x,y)=c\{f(x,y)\}\gamma$$

where c and are two constants to the equation and g(x,y) and f(x,y) are the output and input images, respectively. The enhancement of the images varies depending on the value. Because each display device or monitor has a unique gamma correction, the image is seen at varying intensities. Images are improved using this kind of processing for various display devices.

Histogram Equalization:

Contrast enhancement uses histogram equalisation. For example, if an image's pixel values are equally distributed throughout all possible grey levels, the outcome of this combination will be a high-contrast image with a wide dynamic range.[5] As a result, the HE algorithm uses the cumulative distribution function (CDF) to alter the output grey values with the aid of a probability density function that causes the grey levels to have a uniform distribution. resurface, and as a result, an improved performance might be expected.[6] [7].

The BPBHE (Brightness Preserving Bi- Histogram Equalization), DSIHE (Dualistic Sub-Image Histogram Equalisation), MMBEBHE (Minimum Mean Brightness Error Bi-Histogram Equalisation), CLAHE, etc. algorithms were developed incrementally to deal with the challenges of the HE approach.[8]

Frequency Domain Method:

Since technology evolves drastically, image enhancing techniques likewise shift from the spatial to the frequency domain. A digital image is transformed from the spatial domain to the frequency domain in the frequency domain [9]. This technique uses image filtering for a particular application to improve the image. Frequency domain uses a Fast Fourier

transformation as a technique to convert spatial domain to frequency domain. High pass filter is used to sharpen an image, whereas low pass filter is used to smooth it out. The ideal filter, the Butterworth filter, and the Gaussian filter are examined after the implementation of both filters. The two primary categories of frequency-domain techniques are wavelet transform (WT) and homomorphic filtering (HF).[10]

Homomorphic Filtering(HF)-

The illumination-reflection model's fundamental idea is applied using HF-based image enhancement to modify the illumination and reflection components as a sum in the logarithmic domain. The high-frequency reflection component is then enhanced once more through the use of a high-pass filter, which by nature passes high frequencies while suppressing low ones. In this case, the suppression of the illumination component in the Fourier transform domain results in a properly enhanced output [11]

Wavelet Filtering(WF)-

The Wavelet Transform (WT) is a collection of mathematical transform functions that are used for probabilistic assessment or representation of signals, much to the Fourier Transform (FT). The WT is used to conduct a multi-scale analysis of functions or signals using operations like scaling and translating, which also results in global enhancement, in addition to characterising local characteristics, or altering local enhancement factors, of signals in the time and frequency domains. The input image is split into low-frequency and high-frequency image components in this enhancement process.[12]These image components with varying frequencies levels are then handled individually to produce an enhanced image that may emphasise the details the features of the image both local and globally.

RETINEX MODEL-

This theory by Land and McCann is concerned with how colours are seen by the human eye and how those colour invariances are re-modeled [13]. By removing the effects of the illuminating light from the original picture, this approach aims to determine the reflectance of an image. The idea states that under illumination, the human eye collect data in a certain way, i.e., when light strikes an item and reflects, the eye may detect or perceive that thing. As the aforementioned statement describes in detail the various lighting environments, lighting is the primary aspect on which a human eye may depend.[14]This theory by Land and McCann is concerned with the re-modelling of those colour invariances and how colours are perceived by the human eye [15]. This methodology's goal is to identify a picture's reflectance by removing the influence of the illuminating light from the original image. Theoretically, when light strikes an item and reflects, the human eye may detect or perceive that thing.[16] This information is acquired in a certain way depending on the lighting conditions. The key component on which a human eye may depend is illumination, as the aforementioned remark about the various lighting environments clearly describes.[17]

$$I(x, y) = R(x, y)L(x, y)$$

Where R(x, y) is the reflection component of the image, L(x, y) is the illumination component of the image, and I (x, y) is the output image.

LITERATURE REVIEW-

Since a few years ago, technologies based on fusion and ratinex have been popular for enhancing colour images. There are a number of techniques for improving colour images, such as the one developed by Ziaur Rahman et al. using the CRM and De-hazing concept. This technique effectively improves low-light images while maintaining the naturalness of the image, but it mainly depends on various exposure map estimation strategies.

Vallabhun i Vijay et. al. In the low light image enhancement process using an effective illumination mapping approach, it enhances the contrast of the image but in the case of a dark image, it darkens more than the dark area.

Chunle Guo et. al. The zero reference deep curve estimation for low light image enhancement to introduce sematic information to solve the hard cases and consider the effect of noise

Youghua Zhang et.al. in the Kindling the darkness :a practical Low light image enhancer used the Deep neural network network(kinD) method , but due to the un-sufficient of data set availability it is not suitable for all category image.

P. Janani et. al. Image enhancement techniques a case study models specially studied n two methods spatial domain and frequency domain but the development of adaptive algorithms can improve the output of the digital image.

Weicheng wang et. al. An experiment based on Low-light image enhancement methods fusion-based Low-light image enhancement algorithms are used .it could improve the robustness and adaptive capabilities of Low-light image enhancement algorithms.

Xiaojie Guo et. al Low-light image enhancement via Illumination map estimation used a fusion-based method but it over enhance the bright part of the image.

Bhavya Vasudeva et. al apply the retinex model and the gamma correction method but in case of the JPEG image it does not support

Summery table of Low Light Image Enhancement Method.

sl. no	Author	Topic	Method	Research gap
1	Vallabhuni Vijay et. al.	A Simple and Enhanced Low-Light Image Enhancement Process Using Effective Illumination Mapping Approach	Power-law transformation	By this enhance the contrast level of the image but but other side it darken more then the dark area of the image.
2	Chunle Guo et. al.	Zero-Reference Deep Curve Estimation for Low- Light Image Enhance- ment	Zero-Reference Deep Curve Estimation	introduce semantic information to solve hard cases and consider the effects of noise
3	Youghua Zhang et.al.	Kindling the darkness :a practical Low light image enhancer	Deep neural network network(kinD)	No sufficient data-set available to train the model for LIME, NPE, MEF
4	P. Janani et. al.	Image Enhancement Techniques: A Study	1-Spatial domain method 2-Frequency domain methods	development of adaptive algorithms for Image processing development and implementation

5	Weicheng wang et. al.	An Experiment-Based of Low-Light Image Enhancement Methods	Fusion based low-light image enhancement algorithm	We can Improve the robustness and adaptive capabilities of low-light image enhancement algorithms.
6	Xiaojie Guo et. al	Low-light Image Enhancement via Illumination Map Estimation	fusion based method	Enhance the result but in the bright part of the image algorithms over enhance the image
7	Bhavya Vasudeva et. al	Low light image enhancement	Retinex model Gamma correction	This method does not support the JPEG image .For JPEG image a method may develope.

CONCLUSION-

After reading through several articles and methods, it is evident that low light picture enhancing approaches fall into two primary categories: pre-enhancement and post-enhancement. Pre-enhancement refers to the procedures we employ to impose our enhancement approach before taking any photographs, and post-enhancement refers to the set of techniques utilised after the photograph has been taken. There are several approaches. belongs to these two major groups with the intention of enhancing low light picture. Each strategy is known to have advantages and drawbacks of its own. That example, some ways are overly improved, other methods are more sophisticated, and some approaches also provide results that are spectacular, but these methods are also expensive both in terms of the cost of computing and the cost of gathering any images for data. Therefore, we may say that Instead of using a single technique with all of its benefits and drawbacks, if we can combine two or more techniques and develop a fusion-based approach, one technique will be the answer to another's weakness and be able to produce a suitable enhanced output that will be helpful in low-light image enhancement. This will also help to sustain the main goal of low-light image enhancement by retrieving all hidden details from the image that are hidden by low light.

Authors Profile -

Mr Dinesh Tete pursued Bachelor of Science from Sambalpur University, India in 2019 and a Master of Science from Utkal University Bhubaneswar in the year 2021. He is currently pursuing MPhil in Sambalpur University, India since 2021.

Dr Chandra Sekhar Panda is currently working as an Associate Professor and Head of the Department in the Department of Computer Science, at Sambalpur University, India.

Reference-

[1] R.C. Gonzalez, R.E. Woods, "Digital Image Processing second edition", Pearson Education.ISBN: 81-7808-629-8 [3]

[2]R.C. Gonzalez, R.E. Woods, S.L. Eddins, "Digital Image Processing Using MATLAB", Pearson-Prentice-Hall, Upper Saddle River, NJ, USA, 2004.

[3]E. Land, "Contrast enhancement based on layered difference representation, vol. 237, no. 6, pp. 108–128, 1977.

[4]S. Hao, Z. Feng, and Y. Guo, ''Low-light image enhancement with a refined illumination map, ''Multimedia Tools Appl., vol. 77, no. 22, pp. 29639–29650, Nov. 2018.

[5]W. Wang, F. Chang, T. Ji, and X. Wu, ''A fast single-image dehazing method based on a physical model and gray projection, ''IEEE Access, vol. 6, pp. 5641–5653, 2018.

[6] X. Fu, D. Zeng, Y. Huang, Y. Liao, X. Ding, and J. Paisley, "A fusion- based enhancing method for weakly illuminated images," Signal Processing, vol. 129, pp. 82–96, 2016.

[7] L. Li, R. Wang, W. Wang, and W. Gao, "A low-light image enhancement method for both denoising and contrast enlarging," in ICIP, pp. 3730–s3734, 2015.

[8]F.Zhang,X.Wei,andS.Qiang,''Aperception-inspired contrast enhancement method for low-light images in gradient domain, ''(in Chinese), J. Comput.-Aided Des. Comput. Graph., vol. 26, no. 11, pp. 1981–1988, 2014.

[9] S.-Y. Yu and H. Zhu, ''Low-illumination image enhancement algorithm based on a physical lighting model, ''IEEE Trans. Circuits Syst. Video Technol., vol. 29, no. 1, pp. 28–37, Jan. 2019.

[10]L. Li, S. Sun, and C. Xia, ``Survey of histogram equalization technology," Comput Syst. Appl., vol. 23, no. 3, pp. 1_8, 2014.

[11]C.-C.Leung,K.-S.Chan,H.-M.Chan,andW.-K.Tsui,''A new approach for image enhancement applied to low-contrast-low-illumination IC and document images, ''Pattern Recognit. Lett., vol. 26, no. 6, pp. 769–778, May 2005.

[12]S. Wang, J. Zheng, H. Hu, and B. Li, "Naturalness preserved enhancement algorithm for non-uniform illumination images," TIP, vol. 22, no. 9, pp.3538–3578, 2013.

[13]C. Lee and C. Kim, "Contrast enhancement based on layered difference representation," TIP, vol. 22, no. 12, pp. 5372–5384, 2013.

[14] D. Jobson, Z. Rahman, and G. Woodell, "Properties and performance of a center/surround retinex," TIP, vol. 6, no. 3, pp. 451–462, 1996.

[15]D. Jobson, Z. Rahman, and G. Woodell, "A multi-scale retinex for bridging the gap between color images and the human observation of scenes," TIP, vol. 6, no. 7, pp. 965–976

[16]S. Sun, Y. Dong, and C. Tang, ''An enhanced algorithm for single nighttime low illuminated vehicle-mounted video image, ''(in Chinese), Comput. Technol. Develop., vol. 28, no. 4, pp. 50–54, 2018.

[17]S. Wang, J. Zheng, H. Hu, and B. Li, "Naturalness preserved enhancement algorithm for non-uniform illumination images," TIP, vol. 22, no. 9, pp. 3538–3578, 2013.