RESEARCH ARTICLE OPEN ACCESS

A Survey on Low light Image Enhancement based on Deep Learning Algorithms

R.Senthilkumar [1], Dr. R. Sankarasubramanian [2]

[1] Research Scholar, Department of Computer Science, Sree Amman Arts and Science College, Erode, Tamilnadu,
[2] Associate Professor and Principal, Department of Computer Science, Erode Arts and Science College, Erode, Tamilnadu - India

ABSTRACT

The problems of low light and unsuitable views of the images often exhibit a variety of degradations like as low contrast, color distortion as well as noise. The deprivations distress not only visual properties then similarly computer vision responsibilities. The traditional methods including their principles as well as improvements are familiarized from three diverse categories like as gray level transoformation, historgram equalization as well as Retinex methods. Contemporary improvements in this area are conquered by deep learning founded solutions numerous learning strategies, network arrangements, loss functions, training data etc., must been employed. In this paper deliberate almost the mixture of traditional algorithms besides deep learning algorithms in the field of image improvement. To shield numerous aspects ranging from deep learning algorithm to find the image enhancement basic open issues. The image enhancement method based on the deep learning are introduced the same time on the network structure as well as that is suitable for the method of combining the experiment database as well as enhance image evaluation criteria. The paper points out the advantages and limitations of the current deep learning technology based on Image enhancement algorithms helps to find and predict its development trend.

Keywords: Low Light Enhancement, Hybrid Deep learning, Color Distortion.

I. INTRODUCTION

From the deep learning methods the Image enhancement is unique of the significant responsibilities of image processing intentions to create images that contest the visual reply appearances as well as selectively highlight the types of importance in images by adding convinced information or converting facts to unique images by convinced approaches. The features are not interested and improve the image quality and enrich the amount of information to enhance the strengthen the image interpretation as well as image enhancement to meet the requirements of some special analysis.

Contrast Enhancement helps to covers two techniques such as contrast Enhancement as well as Deblurring. Sometimes the image might very poor contrast to enhance the contrast of the image for better visual. The images might be blurred this blurring might occur due to various reason such as might be CCTV camera setting is not proper or the lens is not focus properly that leads to one kind of blurring. The other kind of blurring can be take a picture from a moving train or moving a car might have observed the image to get a blurred image or not cleared image. Remote sensing of image which are used in the aerial image. The various aerial images are taken from satellite images. The low light image restoration methods have advantages over the disadvantages depending on their structural characteristics and apply the same structure of RGB channels. In Fig 1.1 describes the types of image enhancement such as noise removal and contrast enhancement. The low light image restoration methods have advantages over the disadvantages depending on their structural characteristics and apply the same structure of RGB channels.

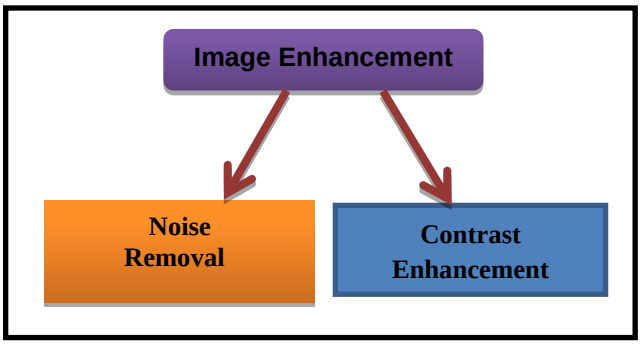

Fig 1.1 Types of Image Enhancement

The correlation between the R,G,B channels is very low so diverse color spaces would be more desirable to obtain more satisfactory results.

II. RELATED WORKS

[YAN20] suggest a CNN-based model to denoise low-light imageries with a bright frequency proceeding to approximating the communication restriction. Inspired by MSR and CNN. Ruminate that MSR is equivalent to a feed

forward convolutional neural network with diverse Gaussian convolution kernels as well as suggest an MSR-net that straight learns an end-to-end mapping among dark as well as bright images. [GUJ22] attention their investigation on real-time concert as well as introduce a novel neural network architecture enthused by mutual grid processing in addition to resident affine color converts. The algorithm practices high-resolution images on a smartphone.

[YEN20] It has a high degree of parallel structure and parallel implementation ability, can give full play to the high-speed computing ability of the computer, and can quickly and the optimal solution. Based on the transform domain image enhancement method, the image information is transformed into the frequency domain space, and the image is enhanced by changing the components of the image with different frequencies. This kind of algorithm mainly uses low-pass filter, high pass filter and homomorphic filter to enhance the image. Tian et al. [TIE21] adjusted multi-scale wavelet coefficients by using the contrast of visual statistical characteristics to correct the global and local contrast of the image. The color of the image enhanced by this algorithm is more in line with human visual characteristics. [GUI22] used the brightness masking characteristics and contrast masking gradient characteristics of HSV model to enhance the image contrast and adjust the image brightness in the fixed wave transforms dominion and the double tree compound wave transform domain by utilizing the nonlinear contrast charting quantity. The typical frequency domain enhancement algorithm is also the Retinax based enhancement algorithm proposed by land Peng et al. [PEN20].

II. METHODOLOGY

3.1 Histogram Equalization Based Methods

HE algorithm has been generally calculated besides functional in image enhancement, as well as there are numerous algorithms advanced on HE algorithms. Most HE-based algorithms division the histogram as well as image into sub-components and performs the histogram equalization operation aimed at the sub-components, separately. The method frequently growths the worldwide contrast of numerous images, particularly after the image is signified by a slender variety of strength values. The intensities dismiss be enhanced dispersed on the histogram utilizing the occupied variety of strengths consistently. For extents of lower local difference to gain a higher contrast. Histogram equalization achieves effectively dispersal available the extremely occupied strength standards which are utilized to damage copy difference. The basic technique is valuable in images with circumstances besides centres that are both optimistic or both dark. It can lead to better interpretations of clean construction in x-ray images, besides to enhanced feature in photographs that are both over then below exposed. A key improvement of the process is that it is an impartially forthright technique adaptive to the input image as well as an invertible operator. The histogram equalization function is known, as the original histogram can be improved. The calculation is not computationally exhaustive. It might growth the dissimilarity of contextual noise, although declining the practical signal. This method frequently growths the inclusive contrast of numerous images, particularly when the image is signified by a contracted variety of passion values.. The above method accepts the areas of lower level contrast and the histogram equalization accomplishes the effectively spreading out the highly popular intensity used to degrade image contrast. The backgrounds and foregrounds are utilized in images as bright color as well as grey scale image. The retinex method gives the better process in various photographs are under exposed. The method is that it is a fairly straightforward technique adaptive to the input image and an invertible operator is most important advantages of this method. So in theory, if the histogram equalization function is known, then the original histogram can be recovered in this histogram equalization function theory and the calculation is not computationally exhaustive.

The object of gamma transform is to restrain histogram spikes from avoiding over-enhancement and noise artifacts effects. Histogram splitting is for preservative despicable brightness, as well as histogram addition is utilized to mechanism histogram pits. [GUO21] propose a new adaptive plateau limit and a new edge-enhancing transformation function, and a further improved HE algorithm. [GUO20] propose a novel adaptive image enhancement technique based on genetic algorithm (GAAHE) [ZHA21] to enhance magnetic resonance images. Similar work includes, both of which combine Particle Swarm Optimization (PSO) and HE, and apply them to magnetic resonance images.

3.2 Retinex Methods

Retinex proposed by Land, [WEI18], is a commonly used image enhancement method based on scientific experiments and analysis. The word “Retinex” is a combination moulded as of “retina” and “cortex”. The Retinex exemplary is founded on three expectations: The actual world is colorless, besides the color is the consequence of the communication among light as well as objects. The water in people's eyes is colorless, then the water-soap film is colorful, subsequent after light interfering scheduled the external of the film. Every color region is collected of red, green, as well as blue primary colors of a given wavelength. The three primary

colors regulate the color of every component province. The theory of Retinex is founded happening the impression that the color of an object is resolute by its capability to reproduce long-wave (red), medium-wave (green), as well as short-wave (blue) brightness slightly than the complete worth of the replicated light. Divergent as of the traditional linear as well as nonlinear approaches that container individual increase a influenced characteristic of images, Retinex container slow down a balance in dynamic range compression, edge development, as well as color invariance, consequently it container improve numerous types of images. After years of research and development, the Retinex algorithm has been improved from single-scale Retinex algorithm (SSR) to multi-scale Retinex algorithm (MSR), and then to multi-scale Retinex algorithm with color restoration (MSRCR).

3.3 Multi-scale Retinex algorithm With Color Restoration (MSRCR)

When enhancing the RGB images by SSR and MSR, the three channels of the image are processed independently, which might lead to the color distortion of the enhanced images. The SSR and MSR algorithm propose a color renewal MultiScale Retinex algorithm (MSRCR). The expression of [ZHA19] MSRCR is as shown in Equation.

$$r_i(x,y) = \sum_{k}^{K} C_i(x,y) w_k \{\log S(x,y) - \log[F(x,y) * S(x,y)]\}.$$

Compared to MSR, the most important improvement of MSRCR is the addition of the color restoration function and i represent the ith channel. Dissimilar color restoration functions for dispensation on the experimental scene, counting linear besides nonlinear functions. The following function can provide the best overall color restoration.

3.4 Fusion-based Learning Methods

Image fusion is the method of merging multiple images into unique that conserves the features of significance of every image. The methods based on image fusion usually take images under different exposure conditions as input or obtain multistate features by different feature extraction methods. Multiple exposure fusion-based image enhancements normally combine multiple derived images to recover details and resolve colour biases,

Most deep learning-based image enhancement algorithms require paired datasets. Conversely, collecting paired images of the same scene in both low and normal light conditions is sometimes difficult, and training a deep learning model based on paired dataset might result in overfitting and limited generalization capability. In contrast to paired learning, some researchers try to adopt unsupervised learning methods to complete image enhancement tasks without paired datasets. Based on information entropy theory and the Retinex model, Zhang et al. propose a self-supervised low-light image enhancement method that can be trained with low-light images only. Enlighten GAN is an unsupervised learning method based on GAN, which can be trained without low/normal-light image pairs. EnlightenGAN adopts an attention-guided U-net as the generator and uses the dual-discriminator to direct the global and local information. Experiments on various datasets demonstrate that Enlighten GAN is easily adaptable to enhancing real-world images from various domains.

3.5 Contrast Limited Adaptive Histogram Equalization (CLAHE)

AHE tends to over amplify the contrast in near-constant regions of the image because of the high concentration of histograms in these areas. As a result, noise might be amplified in near-constant regions. [JIA14] discuss the Contrast Limited Adaptive Histogram Equalization (CLAHE) is a kind of adaptive histogram equalization in which the contrast amplification can be limited to reduce the problem of noise amplification. CLAHE boundaries the magnification of noise by clipping the histogram which can limit the slope of the CDF.

$$I_0(p)=\max c \in \{R,G,B\} Sc(p)$$

The worth at which the histogram is clipped be determined by on the standardization of the histogram as well as, the neighbourhood region's size. The clipping worth of the histogram requirements to be evenly distributed gray range. The entire area of the histogram is reliable with that previously clipping. The images handled by the three kinds of HE algorithms.

IV. RESULTS AND DISCUSSIONS

The remaining low-light image enhancement data set presents a tendency from small to large, since single to miscellaneous. A low illumination enhancement method based on attention mechanism, residual dense blocks and generation of counter measure. In table 1.1 describes the primary image enhancement data sets are largely minor in scale as well as simply comprise low-light images, such as DICM, LIME, MEF, NPE and VV. Now current years, with the expansion of deep learning, a consignment of large-scale paired datasets obligate appeared, in the middle of which the characteristic

LoL datasets are balancing datasets attained from real scenes by altering disclosure time.

Table1.1 Summary of Low Light image Dataset

Abbreviations	Format	Real/ Synthetic	Number	Dataset Value
DICM	RGB	Real	64	Unpaired
LIME	RGB	Real	10	Unpaired
MEF	RGB	Real	17	Unpaired
LOL	RGB	Real& Synthetic	500	Paired
MIT Adobe5K	RAW	Real& Synthetic	5000	Paired

Conversely, due to the complicated experimental Settings, such as the camera needs to be fixed and objects cannot be moved, there are only 500 pairs. It largely attained by shifting contact time or expert modification. Low-light image enhancement data sets fit to unpaired data sets. Table 1.1 shows the examples of images in some low-light image datasets with format.

Natural Image Quality Evaluator (NIQE)

The stimulus for NIQE is founded on building a series of features used to quantity image quality as well as expending these types to fit a multivariate Gaussian model. In the assessment procedure, the distance between the image feature model parameters is used to determine the image quality. A lower NIQE score designates improved preservation of sincerity.

Table 1.2 discuss the diverse types of deep learning methods and diverse types of traditional algorithms and its values are evaluated using Natural Image Quality Evaluator (NIQE) dataset. Aiming at medical image fusion, many methods were proposed by many researchers, but the effects are not significant.

The latest image enhancement techniques can be divided into two groups, heuristic and classic image enhancement techniques. IE replicates the quantity of evidence approved by an image. The larger IE value is, the richer the image information is, the clearer the image is and the higher the quality is. NIQE completes the evaluation of enhanced images by extracting features from natural landscapes and using a multivariate Gaussian model to describe the features. The smaller the NIQE value is, the smaller the gap between the enhanced image and the normal natural image, and the smaller the image enhancement effect. Trendy directive to have an active colour improvement framework for statistical as well as logarithmic image processing improvement algorithms. For Smart City applications it is crucial to have a good pre-processing technique for infrared image enhancement. Existing gray scale mapping-based algorithms always suffer from over-enhancement of the background, noise amplification and brightness distortion. Subsequently classic image enhancement techniques, the original heuristic devices resolve be labeled. Low-light is a challenging environment for image processing.

Table 1.2 Comparison Table of NIQE dataset with Deep Learning Methods

Method	DICM	LIME	MEF	LOL	MIT Adobe 5K
Histogram Equalization	5.3397	5.4956	5.4168	5.5805	1.1121
Retinex Methods	1.0812	1.0372	1.0228	0.9557	1.0094
MSRCR	0.7459	0.8148	0.7877	0.7814	0.8392
CLAHE	0.7818	0.8820	0.9461	0.8576	0.8396
Fusion Based Learning Methods	0.9999	0.9139	1.1097	1.0451	1.4572

In terms of learning mechanism, the fully supervised method requires a large number of paired training samples, but currently paired data resources are not abundant, so the training method is transitioning from fully supervised to semi-supervised and unsupervised. In application scenarios, enhancement objects are now being transformed from simple scenes to complex real scenes.

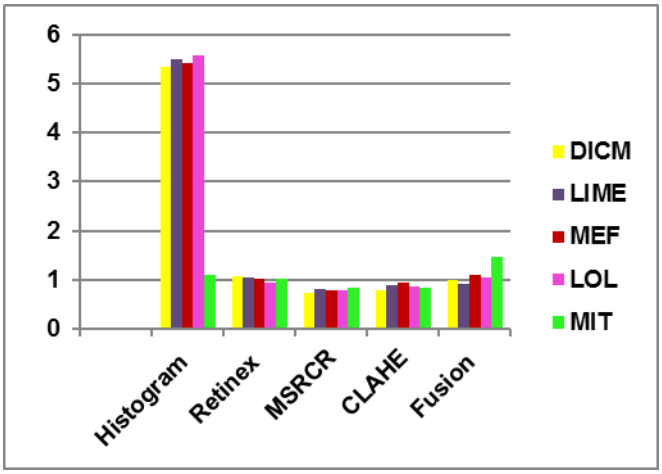

Fig 1.1 Comparison Chart of NIQE dataset with Deep Learning Methods

In Figure 1.1 numerous techniques have been put advancing for low light image enhancement it is quiet hurts from the over under improved imageries payable to reduced image perceptibility. The brightness structure by minimizing the color effects as well as these methods hurts since loss of textual particulars resulting in smoothed out surfaces of objects.

Low-light is a challenging environment for human vision as the absence of discernibility distresses a person's aptitude to achieve tasks. The computer vision algorithms that can afford support in such circumstances are highly valuable.

Table 1.3 Pros and cons of Deep Learning Algorithms

Algorithms	Advantages	Disadvantages
Histogram Equalization	**Simple and Enhance and Contrast of an image**	**If they are grey values that are physically far apart from each other in the image**
Retinex Methods	**Display good Contrast**	**Have Problems with Histogram which covers all grey values**
MSRCR	**Preserve More Details**	**Unnatural Color Appearance**
CLAHE	**Satisfactory in Clinical Representation**	**No improvements in adding CLACHE**
Fusion Based Learning Methods	**Traffic sensing based on frugal audio and image sensor feeds motivated by their complementary strengths**	**overall processing time for 10s audio and image snapshot,**

In table 1.3 describes the advantages and disadvantages of various deep learning methods. It helps to highlight the importance of color appearance, image snapshot, contrast of the images are discussed.

V. CONCLUSION

This paper discusses the idea, purpose, implementation steps, advantages and shortages of image enhancement from the views of traditional methods and deep learning-based algorithms in detail. Aiming at analysing the image enhancement algorithms based on deep learning from the digital image theory, innovatively classify them according to the model strategy and the traditional methods combined with the algorithm. In order to compare diverse algorithms, we reproduce some algorithms and quantitatively evaluate their performance in image quality evaluation methods and its merits and demerits.

REFERENCES

[CHE18] Chen Wei, Wenjing Wang, Wenhan Yang, and Jiaying Liu. Deep retinex decomposition for low-light enhancement. arXiv preprint arXiv:1808.04560, 2018.

[FEN20] X. Feng, J. Li and Z. HuaC, "Low-light image enhancement algorithm based on an atmospheric physical model," Multimedia Tools and Applications, 2020, pp:1–25.

[GUJ22] J. Gujoseph and G. W. Shaofeng, ``Quality evaluation data set for real underwater image enhancement," Chin. J. Image Graph., vol. 27, no. 5, pp. 1467_1480, 2022.

[GUO20] C. Guo, C. Li, J. Guo, C. C. Loy, J. Hou, S. Kwong et al. "ZeroReference Deep Curve Estimation for Low-Light Image Enhancement" Conference on Computer Vision and Pattern Recognition (CVPR), 2020, pp: 1777-1786.

[GUO21] C. Li, C. Guo, and C. C. Loy, "Learning to enhance low-light image via zero-reference deep curve estimation," IEEE Transactions on Pattern Analysis and Machine Intelligence, 2021.

[JIA14] Q. Xu, H. Jiang, R. Scopigno and M. Sbert, "A novel approach for enhancing very dark image sequences," Signal Processing, 2014, pp.309-330.

[JIA19] Y. Jiang, X. Gong, D. Liu, Y. Chen, C. Fang, X. Shen, et al. "EnlightenGAN: Deep Light Enhancement without Paired Supervision" ,2019, arXiv: 1906. 06972.

[LIN14] H. Lin and Z Shi, "Multi-scale retinex improvement for nighttime image enhancement" Optik-International Journal for Light and Electron Optics, 2014, pp: 7143–7148.

[LIM18] F. Lv, F. Lu, J. Wu and C. Lim, "MBLLEN: Low-light Image/Video Enhancement Using CNNs," British Machine Vision Conference (BMVC), 2018. pp: 220-228.

[LOR17] K. G. Lore, A Akintayo and S. Sarkar, "LLNet: A Deep Autoencoder Approach to Natural Low-light Image Enhancement" Pattern Recognition, 2017, pp: 650-662.

[PEN20] J. Peng and L. Bo, ``Improved Retinex underwater image enhancement algorithm based on HSI," Lab. Res. Explor., vol. 39, no. 12, pp: 1_4 and 14, 2020.

[SHE17] L. Shen, Z. Yue, F. Feng, Q. Chen, S. Liu and J. Ma, "MSRnet: Low-light Image Enhancement Using Deep Convolutional Network," 2017.

[TAJ14] F. Tajeripour, S. Fekri-Ershad, "Developing a novel approach for stone porosity computing using modified local binary patterns and single scale retinex" Arabian Journal for Science and Engineering, 2014, pp: 875-889.

[WEI18] C. Wei, W. Wang, W. Yang and L. Jiaying, "Deep retinex decomposition for low-light enhancement," British Machine Vision Conference (BMVC), 2018, pp:1–12.

[YAN20] W. Yang, S. Wang, Y. Fang, Y. Wang and J. Liu, "From Fidelity to Perceptual Quality: A Semi-Supervised Approach for Low-Light Image Enhancement," Computer Vision and Pattern Recognition (CVPR). IEEE, 2020.

[YEN20] L. Yeyunying, ``Mine image enhancement algorithm basd on rough set theory," J. Liaoning Teachers' College, vol. 22, no. 4, pp: 78_81 and 108, 2020.

[LIU20] R. Liu, L. Ma, J. Zhang, X. Fan and Z. Luo, "Retinex-inspired Unrolling with Cooperative Prior Architecture Search for Lowlight Image Enhancement," Computer Vision and Pattern Recognition (CVPR). IEEE, 2020.

[SON21] W. Z. Song, M. Suganuma, X. Liu, N. Shimobayashi, D. Maruta, T. Okatani et al, "Matching in the Dark: A Dataset for Matching Image Pairs of Low-light Scenes," arXiv e-prints, 2021

[ZHA19] Y. Zhang, J. Zhang, and X. Guo, "Kindling the darkness: A practical low-light image enhancer," in ACMMM, 2019, pp: 1632–1640.

[ZHA21] Y. Zhang, X. Guo, J. Ma, W. Liu, and J. Zhang, "Beyond Brightening Low-light Images," International Journal of Computer Vision, 2021.

Authors

Mr. R.Senthilkumar was Graduated in 2004 with UG Degree in BSc Computer Science from Bharathiar University, Coimbatore. He also obtained his Master Degree in MSc Computer Science and M.Phil Computer Science from the Bharathiar University. He is currently perusing Ph.D degree in Computer Science – (in the area Digital Image Processing) from the Bharathiar University. He has 16 years of teaching experience starting from Lecturer to Head of the Department. At present he is working as Head, Department of Computer Science in Sree Amman Arts and Science College, Erode, Tamilnadu. He is Member in Question Paper Setting Board and Valuation of various Autonomous Colleges and Universities. He also acted as Coordinator for Intercollegiate IT functions at Sree Amman Arts and Science College, Erode. He have successfully organized more than 5 National Level Conference and seminars at Sree Amman Arts & Science College, Erode. He acted as chief guest in Intercollegiate functions at various colleges in Erode. He has produced more than 15 M.Phil Research Scholars in various fields. He Published around 5 Research Papers in National journals and 1 Research Papers in International journals. He Presented around 5 Research Papers in National conferences and 1 Research Papers in International Conference. His current Research areas of interest are Digital Image Processing , Computer Networks and Data Mining .

Dr. R. Sankarasubramanian graduated in 1987 with a Degree in Science. He obtained his Master's in Science and M.Phil in Computer Science from Bharathiar University. He is a Double Doctorate holder in the fields of Computer Science. He has 31 Years of experience in the field of teaching under his belt. At present he is holding the Office of the Principal at Erode Arts and Science College, Erode, Tamilnadu, India. He has Guided a total of 62 M.Phil and 2 Ph.D scholars in various areas of Computer Science respectively. He is a member of UGC Autonomous Review Committee. Academic Council, Inspection Committee, and Board of Studies of various Universities and Autonomous Colleges. He has published a book titled *JAVA THE COMPLETE REFERENCE". He has published around 50 research papers in National and International journals and Conferences. His research area includes Network Security, Software Testing. Data Mining and Image Processing.