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Research paper

Image contrast enhancement techniques-a survey

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Abstract

Image Enhancement plays an essential role in a wide area of vision applications. Image enhancement is a technique used to enhance the qual-ity of the image such that it can be easily viewed by both men and machine.Contrast makes a visual difference that makes an object distin-guishable from background and other objects. The major goal of image contrast enhancement is to increase the visual quality of the image. In this research study, various image contrast enhancement techniques are reviewed. This research work also focuses on the comparative study of contrast enhancement techniques for identifying an effective contrast enhancement technique.

Keywords: *Image Enhancement; Contrast Enhancement; Spatial Domain; Frequency Domain.*

1. Introduction

Image processing is an advanced technique by which a low quality image can be converted to a high quality image digitally such that important information can be retrieved from the same. Experts alter the image information through Image enhancement techniques which play a vital role in image processing applications.Image enhancement includes dominance of certain properties or suppressing the ambiguity of two different regions of the image.

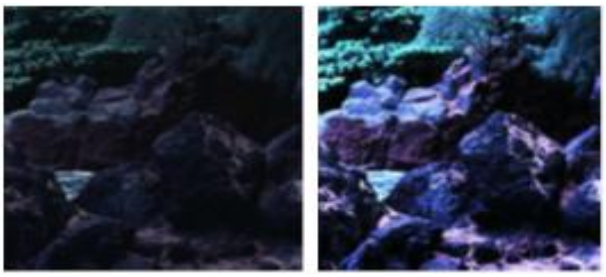

Fig. 1: Enhancement Results A) Original Image B) Enhanced Image D.

1.1. Image enhancement techniques

Image enhancement technique includes both Spatial domain methods. and Frequency domain methods.Whereas Spatial domain method directly works upon the pixel value to obtain better enhancement. Point processing methods , Gray Level Transformation, log transformation, histogram processing, Image Negatives ,morphological operators, Piecewise Linear Transformation, Global Power Law Transform, Adaptive Power Law Transform, Spatial Filtering are spatial domain enhancement methods.
Frequency domain method basically works on image transform coefficients like Fourier Transform (FT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT). In Frequency Domain method, the Fourier transform coefficient is computed first followed by inverse Fourier transform in order to obtain the perfection.

1.2. Contrast enhancement techniques

Contrast Enhancement aims at enhancing the global or local contrast of an image. Some of the enhancement techniques include histogram equalization, Genetic algorithms and fuzzy set algorithms. Many modifications are done in the standard methods to improve the contrast of the images.

Fig. 2: Enhancement Results A) Original Image B) Enhanced Image.

2. Literature survey

M. Shakeri [6] proposed a contrast enhancement algorithm based on local histogram equalization which was used to calculate the total sub-histograms automatically and their division based on their density.The algorithm worked in three stages. Initially, the estimation of the number of clusters for image brightness levels is done using histogram equalization. In the next stage, the image brightness levels are clustered and finally include the contrast enhancement for each individual cluster separately. The algorithm is compared with other methods based on quality and quantity measurement.
Lalit Maurya [7] proposed a social spider optimization algorithm which produces two quality images one with better contrast, increased entropy and the second image with increased peak signal to noise ratio.Both the images are combined to get an effective image later. Comparisons were done with HE, Linear contrast stretching,

Standard Particle Swarm Optimization. Results show that the proposed method achieves better Peak signal to noise ratio, preserves brightness, enhances the contrast of any given image resulting a quality visual.

Se EunKim [8] worked upon wavelet domain using entropy for contrast enhancement.Initially it uses a local entropy scaling in the wavelet domain to obtain the desired contrast .mathematical works were used and then a color enhancing method in the HSI color space was developed. The algorithm worked in two steps: Modification of the low frequencies in the wavelet domain and scaling HIS colour space by enhancing the intensity component such that low light images will get detailed colour information with out any post processing.

Anil Singh Parihar [9] proposes an entropy-based dynamic sub-histogram equalization algorithm for contrast enhancement with better intensity levels over the entire dynamic range.Parameters were not used.Results were compared with conventional contrast enhancement algorithms.

Jeyong Shin [10] proposed HBLPCE,an optimzization problem to preserve the localities of the histogram for performing contrast enhancement. By this method the shape of the enhanced image remains the same as the original image. HBLPCE was quite successful on all images with different statistical properties.

Huang Lidong [11] proposed an image enhancement method CLAHE-DWT which combines both CLAHE and DWT. The algorithm works in three stages. First the original image is disposed to as low frequency and high frequency components byDWT.Low frequency coefficients are enhanced using CLAHE and high frequency coefficients are unchanged.Upon Inverse DWT the image is mounted successfully.LEI, Noise estimation, PSNR, MAE are the parameters used for evaluation. Results show impressive performance and the over enhancement could be avoided.

Mayank Tiwari [12] proposed a highspeed quantile-based histogram equalisation (HSQHE) algorithm for contrast enhancement suitable for high contrast digital images.The recursive segmentation of the histogram is not done, so only a minimal time is required for segmentation.For the Assessment of contrast enhancement PSNR, Entropy metrics are used. For Assessment of brightness preservation AMBE is used. HSQHE preserves image brightness more accurately in less time interval.

Zhao Wei [13] proposed a EMHM (Entropy maximization histogram modification) method, which consists of dividing the global histogram equalization into two steps, pixel populations mergence (PPM) step which goes in hand with entropy maximisation rule followed by the grey-levels distribution (GLD). Proposed method performs better than the existing methods.

Mohsen Abdoli [14] proposed a new contrast enhancement method named GMMCE (Gaussian mixture model-based contrast enhancement) to enhance low contrast images. This method deals with the histogram of low-contrast image using Gaussian which represents dominant intensity level of the image. Upon enhancing the sub histogram separated by the mean value of the Gaussians of the GMM the global contrast enhancement of the image is achieved.Experimental results show that the shape preserving method of GMMCE enhances the contrast of the image.

Kristofor B [15] proposed CETM to improve the turbulence removal algorithm. An analysis of fog and turbulence is incorporated in this method.Turbulence Mitigation Metric (TMM) is also proposed to evaluate turbulence. The average of the motion compensated images is considered in order to remove the turbulent artifacts. Comparative Study of different Contrast Enhancement techniques.

Table 1: Comparative Study of Different Contrast Enhancement Techniques

S. No.	Authors	Title of the paper	Methodology	Features	Advantages	Disadvantages
1	Huanjing Yue, Jingyu Yang, Xiaoyan Sun, Feng Wu	Contrast Enhancement Based on Intrinsic Image Decomposition,2017	Split Bregman algorithm and CLAHE	To enhance images by estimating illumination and reflectance layers through intrinsic image decomposition	Good enhancement	Designed only for CE. Cannot be used for methods like surface re-texturing, object insertion etc
2	Cheolkon Jung, Tingting Sun	Optimized Perceptual Tone Mapping for Contrast Enhancement of Images,2017	Optimized Perceptual Tone Mapping (OPTM)	Focuses on the human visual attention by constructing a saliency histogram and performs Contrast Enhancement	Improves the performance without over enhancement	Needs more time for CE compared to HE,CLAHE
3	Daeyeong Kim, Changick Kim	Contrast Enhancement Using Combined 1-D and 2-D Histogram-Based Techniques,2017	Histogram stretching technique ,quadratic programming	To preserve the shape of the 1-D histogram the statistical information on the gray-level differences	Enhanced images and perceptual image quality	Processing time is slower
4	Anil Singh Parihar, Om Prakash Verma, Chintan Khanna	Fuzzy-Contextual Contrast Enhancement,2017	Fuzzy dissimilarity histogram (FDHE), Fuzzy Contextual Contrast Enhancement (FCCE)	Captures the intensity level differences in the neighborhood of the pixels	Global and local CE. No parameters are used. Original shape of histogram is preserved	EME measure is low
5	Shilpa Suresh, Shyam Lal, Chintala Sudhakar Reddy, Mustafa Servet Kiran	A Novel Adaptive Cuckoo Search Algorithm for Contrast Enhancement of Satellite Images,2017	Novel Adaptive cuckoo search based enhancement algorithm (ACSEA)	Contrast enhancement for satellite images	Improved convergence rate. Good efficiency and robustness	Complex in its execution
6	M.Shakeri, M.H.Dezfoulian, H.Khotanlou, A.H.Barati, Y.Masoumi	Image contrast enhancement using fuzzy clustering with adaptive cluster parameter and sub-histogram equalization,2017	Contrast enhancement algorithm based on local histogram equalization	Determination of the number of sub-histograms and density based histogram division	Natural appearance of images and enhanced the contrast	Loss of details in high brightness levels of the image. Noise in the output image.
7	Lalit Maurya, Prasant Kumar Mahapatra, Amod Kumar	A social spider optimized image fusion approach for contrast enhancement and brightness preservation,2017	A social spider optimization (SSO)algorithm	Improvement in sharpness, PSNR, brightness preservation	Better visual quality	The number of edge pixels of HE technique is high while the fitness value is less

8	Se EunKim,JongJu Jeon,IlKyuEom	Image contrast enhancement using entropy scaling in wavelet domain,2016	An entropy based contrast enhancement method in the wavelet domain	Used in HSI color space and performs image contrast enhancement	Color information of low light images are good without any post processing.	Over-enhanced regions exist
9	Anil Singh Parihar , Om Prakash Verma	Contrast enhancement using entropy-based dynamic sub-histogram equalization,2016	Entropy-based dynamic sub-histogram equalization algorithm (EDSHE)	Performs a recursive division of the histogram based on the entropy of the sub histograms	Natural-looking, good contrast images	Entropy measure is less for few images.
10	Jeyong Shin, Rae-Hong Park	Histogram-Based Locality-Preserving Contrast Enhancement,2015	Histogram-based locality-preserving CE (HBLPCE)	To preserve the localities of the histogram for performing contrast enhancement	Adapts well on images with various statistical properties.	Longer Execution time of global CE for small images.
11	Huang Lidong, Zhao Wei , Wang Jun, Sun Zebin	Combination of contrast limited adaptive histogram equalisation and discrete wavelet transform for image enhancement,2015	Combines both CLAHE and DWT	To enhance the local details of an image	Performs well in detail preservation and noise suppression.	High-frequency component which contains most of the noise in original image is unchanged
12	Mayank Tiwari, Bhupendra Gupta, Manish Shrivastava	High-speed quantile-based histogram equalisation for brightness preservation and contrast enhancement,2015	Highspeed quantile-based histogram equalisation (HSQHE)	Contrast enhancement suitable for high contrast digital images	Image brightness more accurately in less time interval	High PSNR value only for certain images
13	Zhao Wei, Huang Lidong, Wang Jun, Sun Zebin	Entropy maximisation histogram modification scheme for image enhancement,2015	Entropy maximization histogram modification (EMHM)	Divides the global histogram equalization into two steps, pixel populations mergence (PPM) step and the grey-levels distribution (GLD) step	Good enhancement, avoids amplified noise and image artefacts.	Contrast Overstretching problem
14	Mohsen Abdoli, Hossein Sarikhani, Mohammad Ghanbari, Patrice Brault	Gaussian mixture model-based contrast Enhancement,2015	Gaussian mixture model-based contrast enhancement)(GMMCE)	Uses Gaussian mixture modeling of histograms to model the content of the images	Lowest approximation error highest similarity to the original histogram low-complexity method	Subjective Quality measures not used
15	Kristofor B. Gibson and Truong Q. Nguyen	An Analysis and Method for Contrast Enhancement Turbulence Mitigation,2014	Contrast enhancement and turbulence mitigation (CETM)	Provides an analysis of fog turbulence	Increased contrast Less time consumption	PSNR is very low

3. Conclusion

In this research work, several contrast enhancement techniques were analysed and reviewed. The Comparative study of these techniques is also presented. The investigation of these methods show that some of the methods suffered low processing time, low PSNR, and Entropy values. Few algorithms experienced enhancement only in some regions while the other few had over enhancement, loss of the details in a darker regions etc. In order to overcome these limitations a new approach can be formulated.

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