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A Review on Image Enhancement with Brightness Preserving Behavior for Fuzzy Statistics

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Abstract: The aim of image enhancement is to improve the interpretability or perception of information in images for human viewing or to provide 'better' input for other automated image processing techniques. Various Histogram Equalization techniques like CHE, GHE, BBHE, DSIHE, RMSHE and Multi-HE techniques are used for processing the image input to enhance its output.

Keywords: Image enhancement, Fuzzy Statistics, Brightness Preserving, Histogram Equalization, Contrast Adjustment.

1. Introduction:

Every single day world is evolving very fast. Rapid development of the technology has affected all the scientific areas. Medicine, automation, data analysis, finances, biology, chemistry, economics and many, many more have benefited from the technology expansion. Those big changes have also influenced fields as an image processing.

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. Enhancement of noisy image data is a very challenging issue in many research and application areas. Image enhancement techniques can be divided into three broad categories:

1) Spatial domain methods, which operate directly on pixels using gray level transformations or histogram processing (classical histogram equalization).

2) Frequency domain methods, which operate on the Fourier transform of an image.

3) Fuzzy domain methods, which involve the use of knowledge-base systems that are capable of mimicking the behavior of a human expert using fuzzy based histogram equalization.

Classical Histogram Equalization (HE) has proved to be a simple and effective image contrast enhancement technique .But this has a drawback that it does not preserve the brightness of the input image on the output one. This makes HE not suitable for image contrast enhancement on consumer electronic products, such as video surveillance, where preserving the input brightness is essential to avoid the generation of non-existing artifacts in the output image. To overcome such drawback, variations of the classic HE technique have proposed to first decompose the input image into two sub-images, and then perform HE independently in each sub-image . Although these methods preserve the input brightness on the output image with a significant contrast enhancement, they may produce images which do not look as natural as the input ones.

Fuzzy logic represents a good mathematical framework to deal with uncertainty of information. Fuzzy image processing is the collection of all approaches that understand represent and process the images, their segments and features as fuzzy sets.

In the present thesis, an algorithm is proposed for Fuzzy Histogram Equalization. This algorithm enhances image contrast as well as preserves the brightness very effectively. This also reduces its computational complexity. This Fuzzy Histogram Equalization technique uses the representation and processing of digital image in fuzzy statistics. These images in fuzzy domain handle the inexactness of grey-level values in a better way as compared to GHE and CLAHE like conventional techniques, which improves its performance. Hence, proposed Fuzzy algorithm can be used for image enhancement of poor quality images. All the implementation work has been done in MATLAB 7.5 Image Processing tool box.

Data representation in Matlab is the feature that distinguishes this environment from others. Every data is presented with matrices. The definition of matrix is a rectangular array of numbers. Most pictures are kept in two-dimensional matrices. Each element corresponds to one pixel in the image. True color pictures require a third dimension to keep the information about intensities of RGB colors. Fuzzy Logic Toolbox offers wide range of functions responsible for fuzzy calculations. It allows user to look through the results of fuzzy computations.

Experimental results show that the quality of image is improved after fuzzy histogram equalization. It is tested on different common formats of images taking different fuzzy membership function.

2. Related Work:

Digital image processing is a broad subject and often involves procedures which can be mathematically complex, but central idea behind digital image processing is quite simple. The ultimate aim of image processing is to use data contained in the image to enable the system to understand, recognize and interpret the processed information available from the image pattern. Image enhancement can be applied to different areas of science and engineering. Except for illumination conditions, quality of images is also affected by external noises and environmental disturbances such as ambient pressure and temperature fluctuations. Approaches of contrast limited image enhancement via stretching the histograms over a reasonable dynamic range and multi-scale adaptive histogram equalizations have been developed. Various authors proposed various methods such as histogram equalization, multipoint histogram equalizations and pixel dependent contrast preserving, but all these methods are not up to mark. Here, a brief review over various proposed methods in image enhancement methodology is presented.

C. V. Jawahar, et.al (1997) proposed about thresholding. In this work, the problem of pixel classification is attempted using fuzzy clustering algorithms. The segmented regions are fuzzy subsets, with soft partitions characterizing the region boundaries. The validity of the assumptions and thresholding schemes are investigated in the presence of distinct region proportions. The hard **k** means and fuzzy **c** means algorithms was found useful when object and background regions are well balanced. Fuzzy thresholding is also formulated as extraction of normal densities to provide optimal partitions.
The problem of pixel classification is well suited to be formulated as a clustering problem. The problem of thresholding in the presence of region imbalances is analyzed by transforming the geometrical structure of gray distribution by modeling the distance and density function. Analytical discussions and experimental details validate the importance of fuzzy thresholding schemes based on fuzzy clustering.

In 2004 Chaohong Wu, Zhixin Shi and VenuGovindaraju worked on the performance of fingerprint recognizer, which highly depends on the fingerprint image quality. Different types of noises in the fingerprint images pose greater difficulty for recognizers. They focused on an effective methodology of cleaning the valleys between the ridge contours are lacking. It was found that noisy valley pixels and the pixels in the interrupted ridge flow gap are \impulse noises". They described a new approach to fingerprint image enhancement, which is based on integration of Anisotropic Filter and directional median filter (DMF). In this paper Gaussian-distributed noises are reduced effectively by Anisotropic Filter, \impulse noises" are reduced efficiently by DMF. The enhancement algorithm has been implemented and tested on fingerprint images from FVC2002. Images of varying quality have been used to evaluate the performance of their approach. They compared the proposed work with other methods in terms of matched minutiae, missed minutiae, spurious minutiae, and flipped minutiae (between end points and bifurcation points). Results shown for their model can effectively reduce gaussian-distributed noises (by anisotropic filter) and impulse noises along the direction of ridge flow (by DMF). This algorithm may fail when image regions are contaminated with heavy noises and orientation field in these regions can hardly be estimated.

In 2004 Soong-Der Chen, Abd.Rahman Ramli discussed about the issue on Histogram equalization (HE).They analyzed that HE has been a simple yet effective image enhancement technique. However, it tends to change the brightness of an image significantly, causing annoying artifacts and unnatural contrast enhancement. They proposed a novel extension of BBHE referred to as minimum mean brightness error bi-histogram equalization (MMBEBHE). MMBEBHE has the feature of minimizing the difference between input and output image's mean. Simulation results showed that MMBEBHE can preserve brightness better than BBHE and DSIHE. Furthermore, this paper also formulated an efficient, integer-based implementation of MMBEBHE. Nevertheless, MMBEBHE also has its limitation. They also proposed a generalization of BBHE referred to as recursive mean-separate histogram equalization (RMSHE). RMSHE is featured with scalable brightness preservation. Simulation results showed that RMSHE is the best equalization technique compared to HE, BBHE, DSIHE, and MMBEBHE. It can be observed in there work that in context of bi-histogram equalization, MMBEBHE is better than BBHE and DSIHE in preserving an image's original brightness.

In 2004 H.D. Cheng and X.J. Shi found that image enhancement is one of the most important issues in low-level image processing. In their algorithm basically enhancement methods were classified into two classes: global and local methods. In their work the multi-peak generalized histogram equalization (multi-peak GHE) is proposed. In this method, the global histogram equalization is improved by using multi-peak histogram equalization combined with local information. They described that the enhancement methods are based either on local information or on global information. Their approach used both local and global information to enhance image. This method adopts the traits of existing methods. It also makes the degree of the enhancement completely controllable. Experimental results show that it is very effective in enhancing images with low contrast, regardless of their brightness. Multi-peak GHE technique is very effective to enhance various kinds of images when the proper features (local information) can be extracted.

In 2005 Chao Wang and Zhongfu Ye worked for preserving the original brightness to avoid annoying artifacts. This provided an extension of histogram

equalization, actually histogram specification, to overcome drawback of HE. To maximize the entropy is the essential idea of HE to make the histogram as flat as possible. Following that, the essence of the proposed algorithm, named Brightness Preserving Histogram Equalization with Maximum Entropy (BPHEME).They compared BPHEME to the existing methods including HE, Brightness preserving Bi-Histogram Equalization (BBHE), equal area Dualistic Sub-Image Histogram Equalization (DSIHE), and Minimum Mean Brightness Error Bi-Histogram Equalization (MMBEBHE), experimental results show that BPHEME can not only enhance the image effectively, but also preserve the original brightness quite well, so that it is possible to be utilized in consumer electronic products.
BPHEME used to find the optimal histogram, which has the maximum differential entropy under the mean brightness constraint, and then implements the histogram specification under the instruction of that desired histogram. Experimental results show that BPHEME can enhance the image quite well when preserving the mean brightness, which is very suitable for consumer electronics such as TV. It had potential applications considering the tolerant threshold for the human visual systems.

In 2006 Yu-fai Fung, Homan Lee, and M. Fikret Ercan worked on application of toll rate charged for the usage of facilities such as a tunnel or a bridge is usually proportional to the number of axles possessed by a vehicle. They designed an automatic system that can identify the number of axles is sought. Instead of detecting the axle, wheels of a vehicle were tested and a method based on the Hough transform for detecting circles was proposed. As the system must be able to detect the correct number of wheels in real-time, sub-sampling based on the Haar Wavelet transform was applied. The approach was able to identify the wheel correctly to process the input images in real-time.
They conclude that the Hough transform is suitable for such an application. It can process up to 24 images within 1.5 s and it satisfied the timing constraint imposed upon the system. The system setup was simple and by using commodity components, its setup cost was also low.

In 2006 ZhiYu Chen, Besma R. Abidi, David L. Page, Mongi A. Abidi gave a contrast enhancement has an important role in image processing applications. They described that conventional contrast enhancement techniques either often fail to produce satisfactory results for a broad variety of low-contrast images, or cannot be automatically applied to different images, because their parameters must be specified manually to produce a satisfactory result for a given image. They described a new automatic method for contrast enhancement. First of all they grouped the histogram components of a low-contrast image into a proper number of bins according to a selected criterion, then redistributed these bins uniformly over the grayscale, and finally ungroup the previously grouped gray-levels. Accordingly, this new technique is named gray-level grouping (GLG). GLG not only produces results superior to conventional contrast enhancement techniques, but is also fully automatic in most circumstances, and is applicable to a broad variety of images. An extension of GLG is selective GLG (SGLG). SGLG selectively groups and ungroups histogram components to achieve specific application purposes, such as eliminating background noise, enhancing a specific segment of the histogram, and so on.
They developed a new automatic contrast enhancement technique. GLG was a general and powerful technique, which can be conveniently applied to a broad variety of low-contrast images and generates satisfactory results. HE method could be conducted with full automation at fast speeds.

In 2007 David Menotti, Laurent Najman, Jacques Facon, and Arnaldo de A. Araújo proposed that Histogram equalization (HE) has proved to be a simple and effective image contrast enhancement technique. They worked on a novel technique called Multi-HE, which consists of decomposing the input image into several sub-images, and then applying the classical HE process to each one. This methodology performs a less intensive image contrast enhancement, in a way that the output image presents a more natural look. They proposed two discrepancy functions for image decomposing, conceiving two new Multi-HE methods. A cost function was also used for automatically deciding in how many sub-images the input image will be decomposed on. The work was tested a new framework called MHE for image contrast enhancement and brightness preserving which generated natural looking images. The results showed that there methods was better on preserving the brightness of the processed image (in relation to the original one) and yields images with natural appearance, at the cost of contrast enhancement.

In 2009 Tarik Arici, Salih Dikbas, and Yucel Altunbasak gave a general framework based on histogram equalization for image contrast enhancement is presented. In this framework, contrast enhancement is posed as an optimization problem that minimizes a cost function. They introduced specifically designed penalty terms, the level of contrast enhancement can be adjusted; noise robustness, white/black stretching and mean-brightness preservation may easily be incorporated into the optimization. Analytic solutions for some of the important criteria were presented. Finally, a low-complexity algorithm for contrast enhancement was presented, and its performance was demonstrated against a recently proposed method.
The presented framework employs carefully designed penalty terms to adjust the various aspects of contrast enhancement. Hence, the contrast of the image/video can be

improved without introducing visual artifacts that decrease the visual quality of an image and cause it to have an unnatural look.
To obtain a real-time implementable algorithm, the proposed method avoids cumbersome calculations and memory-bandwidth consuming operations. Obtained results were visually pleasing, artifact free, and natural looking. A desirable feature of the proposed algorithm was that it does not introduce flickering, which is crucial for video applications. This is mainly due to the fact that the proposed method uses the input (conditional) histogram, which does not change significantly within the same scene, as the primary source of information. Then, the proposed method modifies it using linear operations resulting from different cost terms in the objective rather than making algorithmic hard decisions.

In 2009 Hyunsup Yoon, Youngjoon Han, and Hernsoo Hahn proposed that in order to enhance the contrast in the regions where the pixels have similar intensities, they presented a new histogram equalization scheme. Conventional global equalization schemes over-equalize these regions so that too bright or dark pixels are resulted and local equalization schemes produce unexpected discontinuities at the boundaries of the blocks. The proposed algorithm segments the original histogram into sub-histograms with reference to brightness level and equalizes each sub-histogram with the limited extents of equalization considering its mean and variance. The final image is determined as the weighted sum of the equalized images obtained by using the sub-histogram equalizations. By limiting the maximum and minimum ranges of equalization operations on individual sub-histograms, the over-equalization effect is eliminated.

In 2010 Debdoot Sheet, Hrushikesh Garud, Amit Suveer, Manjunatha Mahadevappa, and Jyotirmoy Chatterjee gave a novel modification of the brightness preserving dynamic histogram equalization technique to improve its brightness preserving and contrast enhancement abilities while reducing its computational complexity. The modified technique, called Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE1), uses fuzzy statistics of digital images for their representation and processing. Representation and processing of images in the fuzzy domain enables the technique to handle the inexactness of gray level values in a better way, resulting in improved performance. Execution time is dependent on image size and nature of the histogram, however experimental results show it to be faster as compared to the techniques compared here. The performance analysis of the BPDFHE along with that for BPDHE has been given for comparative evaluation.

In 2011 Kuo-Liang Chung, Yu-Ren Lai, Chyou-Hwa Chen, Wei-Jen Yang, and Guei-Yin Lin proposed a novel local brightness preserving dynamic histogram equalization (LBPDHE) algorithm for contrast enhancement. Previous contrast enhancement works have shown the benefits of histogram partitioning before histogram equalization to avoid over or under enhanced images. In addition, brightness preservation has been recognized as one of the most important properties for contrast enhancement schemes. Brightness preservation is important for reducing energy consumption in consumer electronic products, such as liquid crystal displays (LCD) and televisions. The main idea of that work was the observation that brightness preservation could be performed locally and independently for each partition, instead of globally over the whole histogram as in previous research proposals. Based on eighty test images, experimental results indicate that their proposed method can not only produce good contrast enhanced images, but also achieve the best mean brightness preservation when compared with the other state-of-the-art methods. It augments the DHE method with a simple, yet important local mean brightness preserving technique. Based on eighty test images, experimental results show that our proposed LBPDHE method not only has good contrast enhancement, but also achieves the best brightness preservation. Their proposed method has saved more power than the other contrast enhancement methods when implemented in consumer electronic products.

In 2012 Mrs. Ashwini Sachin Zadbuke proposed histogram equalization (HE) was one of the common methods used for improving contrast in digital images. However, this technique was not very well suited to be implemented in consumer electronics, such as television because the method tends to introduce unnecessary visual deterioration such as the saturation effect. They discussed that one of the solutions to overcome this weakness is by preserving the mean brightness of the input image inside the output image. They provided the modified dualistic sub image HE method which preserves the brightness of the image. They discussed results of first five methods that are available for contrast enhancement and brightness preservation such as conventional global HE, local HE, ADPHE, BBHE, DSIHE. The last method as MDSIHE gives better results than all other.

3. Conclusion:
Image contrast enhancement is a very important challenging objective in the area of image processing. In this thesis we considered contrast enhancement technique that can produce resultant image that looks better subjectively by changing the pixel gray level intensities. This algorithm find useful application in consumer electronics products, medical image analysis and radar/sonar image base operations.

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