Image Histogram Equalization using Fuzzy Logic for Contrast Enhancement

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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. This paper proposes 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.

Keywords: GHE, BBHE, Fuzzy Logic, BPDFHE.

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.

2. Related Work:

In 2009 Tarik Arici, Salih Dikbas, and Yucel Altunbasak gave a wellknown framework primarily based on histogram equalization for image comparison enhancement is presented. In this framework, evaluation enhancement is posed as an optimization problem that minimizes a price feature. They introduced specially designed penalty terms, the level of contrast enhancement may be adjusted; noise robustness, white/black stretching and imply-brightness preservation may also easily be incorporated into the optimization. Analytic solutions for some of the important standards have been offered. Finally, a low-complexity set of rules for comparison enhancement turned into offered, and its overall performance became tested against a recently proposed method.

He provided framework employs cautiously designed penalty phrases to modify the diverse factors of comparison enhancement. Hence, the evaluation of the photo/video may be advanced with out introducing visible artifacts that lower the visible first-class of an picture and cause it to have an unnatural appearance.

To reap a real-time implementable set of rules, the proposed approach avoids bulky calculations and memory-bandwidth consuming operations. Obtained effects were visually eyecatching, artifact loose, and herbal looking. A suitable feature of the proposed algorithm became that it does not introduce flickering, which is essential for video packages. This is particularly because of the fact that the proposed approach uses the enter (conditional) histogram, which does now not exchange considerably within the equal scene, because the primary supply of information. Then, the proposed method modifies it using linear operations attributable to one of a kind cost phrases in the objective instead of making algorithmic hard decisions.

In 2009 Hyunsup Yoon, Youngjoon Han, and Hernsoo Hahn proposed that so one can enhance the assessment in the areas where the pixels have comparable intensities, they offered a brand new histogram equalization scheme. Conventional international equalization schemes over-equalize those areas so that too brilliant or dark pixels are resulted and local equalization schemes produce unexpected discontinuities at the barriers of the blocks. The proposed set of rules segments the authentic histogram into sub-histograms on the subject of brightness level and equalizes each sub-histogram with the restrained extents of equalization considering its mean and variance. The very last photo is decided as the weighted sum of the equalized photographs obtained by using the usage of the sub-histogram equalizations. By limiting the most and minimum tiers of equalization operations on individual sub-histograms, the over-equalization effect is removed.

In 2010 Debdoot Sheet, Hrushikesh Garud, Amit Suveer, Manjunatha Mahadevappa, and Jyotirmoy Chatterjee gave a unique modification of the brightness maintaining dynamic histogram equalization method to enhance its brightness preserving and contrast enhancement talents while decreasing its computational complexity. The changed approach, referred to as Brightness Preserving Dynamic Fuzzy Histogram Equalization (BPDFHE1), uses fuzzy data of digital photographs for their representation and processing. Representation and processing of pix inside the fuzzy area permits the approach to deal with the inexactness of gray level values in a higher way, resulting in advanced performance. Execution time is dependent on photo size and nature of the histogram, however experimental effects display it to be quicker in comparison to the techniques in comparison here. The overall performance evaluation of the BPDFHE along side that for BPDHE has been given for comparative assessment.

In 2011 Kuo-Liang Chung, Yu-Ren Lai, Chyou-Hwa Chen, Wei-Jen Yang, and Guei-Yin Lin proposed a unique nearby brightness maintaining dynamic histogram equalization (LBPDHE) set of rules for evaluation enhancement. Previous evaluation enhancement works have proven the advantages of histogram partitioning earlier than histogram equalization to avoid over or under enhanced pics. In addition, brightness preservation has been diagnosed as one of the maximum essential homes for comparison enhancement schemes. Brightness upkeep is essential for decreasing electricity consumption in purchaser digital products, inclusive of liquid crystal shows (LCD) and televisions. The most important concept of that work changed into the statement that brightness protection could be performed regionally and independently for each partition, in place of globally over the whole histogram as in previous studies proposals. Based on eighty take a look at photographs, experimental outcomes suggest that their proposed approach can not simplest produce suitable contrast stronger pics, but additionally obtain the first-class mean brightness protection whilst compared with the other modern-day methods. It augments the DHE approach with a simple, but critical local imply brightness maintaining approach. Based on 80 test pics, experimental consequences show that our proposed LBPDHE approach now not handiest has appropriate comparison enhancement, but also achieves the nice brightness maintenance. Their proposed approach has saved extra strength than the other comparison enhancement techniques when carried out in customer electronic products.

In 2012 Mrs. Ashwini Sachin Zadbuke proposed histogram equalization (HE) became one of the not unusual strategies used for enhancing contrast in virtual snap shots. However, this technique turned into not very well ideal to be implemented in purchaser electronics, together with tv due to the fact the approach has a tendency to introduce pointless visible deterioration along with the saturation effect. They discussed that one of the solutions to overcome this weak point is by means of retaining the mean brightness of the enter photo in the output picture. They furnished the changed dualistic sub photograph HE method which preserves the brightness of the picture. They discussed results of first 5 techniques that are to be had for assessment enhancement and brightness preservation which includes traditional global HE, local HE, ADPHE, BBHE, DSIHE. The last approach as MDSIHE gives higher effects than all other.

3. Methodology:

Principal objective of image enhancement is to modify attributes of an image to make it more suitable for a given task and a specific observer. During this process, one or more attributes of the image are modified. The choice of attributes and the way they are modified are specific to a given task. There exist many techniques that can enhance a digital image without spoiling it. The enhancement methods can broadly be divided into the following three categories:

- Spatial Domain Methods
- Frequency Domain Methods
- Fuzzy Domain Methods

Fuzzy image processing is a collection of different fuzzy approaches to image processing that can understand, represent and process the image. It has three main stages, namely, image fuzzification, modification of membership function values, and de-fuzzification. Fuzzy image enhancement is based on gray level mapping into membership function. The aim is to generate an image of higher contrast than the original image by giving a larger weight to the gray levels that are closer to the mean gray level of the image that are farther from the mean.

In the field of digital image processing contrast enhancement is very important. The image looks definitely better than the original image effects contrast is enhanced. This can be done by changing pixel intensities. Many technologies are available for image contrast enhancement. Histogram equalization is very popular technology. Global histogram equalization is the simplest technology that uses HE technology. It also gives good performance over a variety of images. But the GHE has a drawback that it cannot preserve the mean brightness as it introduces major changes in the image gray-level when histogram spreading is not significant. Preserving mean

brightness is very critical in conserving electronics applications.
To overcome drawback other brightness preserving approaches proposed are:
1. Bi histogram equalization (BBHE)
2. MMBEBHE
3. Multi-histogram equalization (DHE)
4. BPDHE
5. BPHEME
Dynamic HE (DHE) partitions the image histogram into multiple segments and then independently equalizes them. The limitation of this method is remapping of the peaks which changes the mean brightness of the image. To overcome the problem of remapping brightness preserving dynamic histogram equalization (BPDHE) technique smoothes an image histogram by using Gaussian Kernel and then segments its valley regions for their dynamic equalization.
These techniques do not take into account the inexactness of gray – values, as well as smoothing of histogram is needed to segment for equalization. So a modification is this technique is done by using fuzzy histogram. The imprecision in gray-levels is nicely handled by using fuzzy histogram. Then imprecision in gray – levels is nicely handed by using fuzzy histogram. Fuzzy histogram does not have random fluctuations or missing intensity levels is essentially smooth when computed with appropriate fuzzy membership function. The smoothness helps in obtaining its meaningful partitioning required for brightness preserving equalization. Use of fuzzy statistics also improves the performance of the algorithm. Hence
this modified technology is known as BPDFHE (Brightness preserving dynamic fuzzy histogram equalization technique).
This is having application in most electronic equipments that acquire and display color images. Most of the traditional techniques apply equalization of red, green and blue planes, in RGB images. BPDFHE technique has an inherent problem of changing the hue of the output image. Thus we perform the Y CbCr color space where we only equalized the intensity band of the image while chromaticity of the images is preserved, which in turn produces better results.
BPDFHE -this technique manipulates the image histogram in such a way that only redistribution of gray-level values in valley portion between two consecutive peaks takes place and no remapping of the histogram takes place. The BPDFHE technique involves the following processing stages;

- A Fuzzy histogram computation
- B Partition of the histogram
- C Dynamic histogram equalization of the partitions
- D Normalization of the image brightness

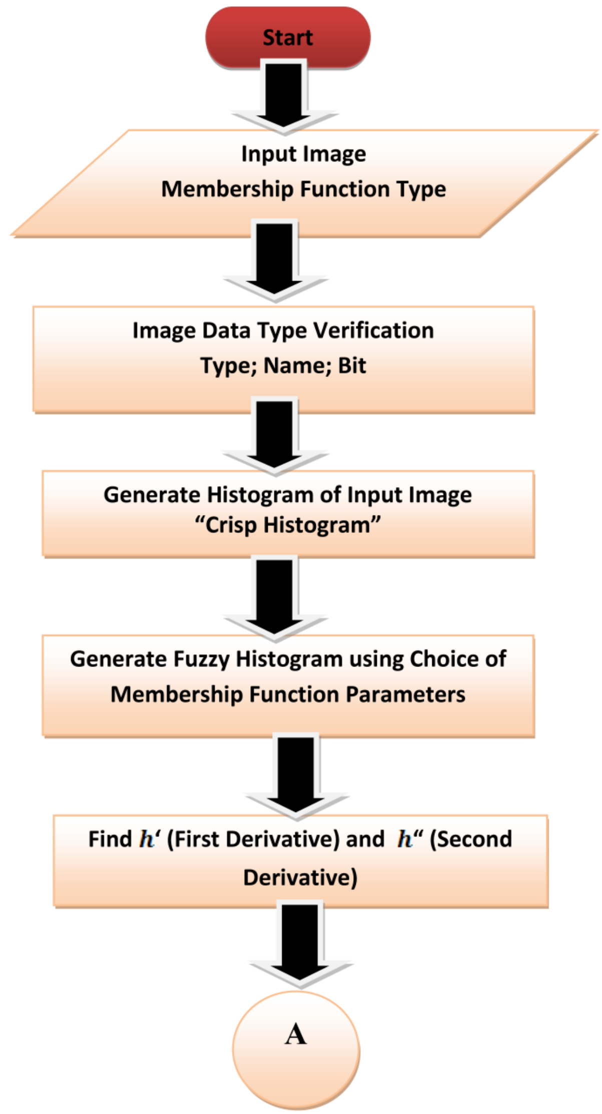

Fig. 1. Flow Chart

4. Result and Discussion:
Testing of our image enhancement method is performed on 5 different images. The results are shown in the form of images alongwith there histogram in comparison with the original mage and its histogram. The quantative analysis is performed by calculating the mean brightness of images before and after enhancement, difference in mean brightness and the PSNR of enhanced and original images.
We have used 3 different histogram equalization techniques to demonstrate the performance of our brightness preserving enhancement algorithm. The methods we have used are written below:
Generalized histogram equalization (GHE)
Uniform histogram equalization (UHE)
Adaptive histogram equalization (CLAHE)

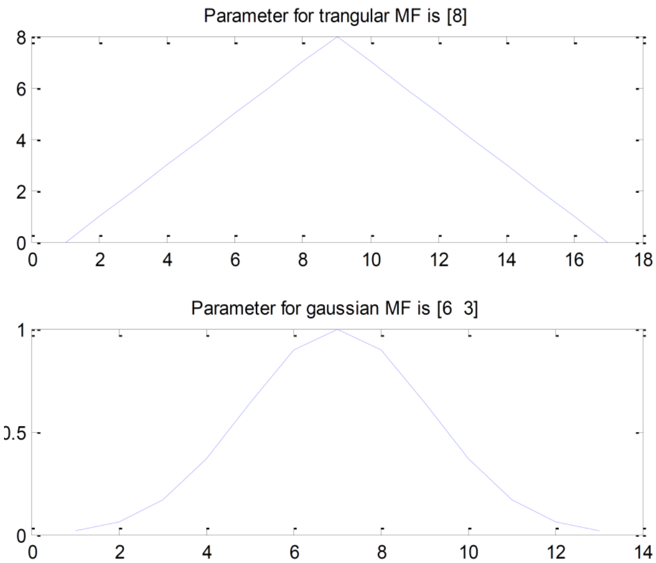

Fig 2. Shape of Triangular and Gaussian membership functions

The parameter for TMF is 8 due to this its peak is 8 and base width from the peak center is also 8+1 i.e. 9. Hence, if we take TMF parameter as n then its height will be n and base spread is of 2n+1. For Gaussian MF if parameter is [6 3] then base spread is of 1 to 13 i.e. 2*6+1 but over the spread of width 3 i.e. 6 to 9 (center part) the peak remains high then it decreases exponentially fast.

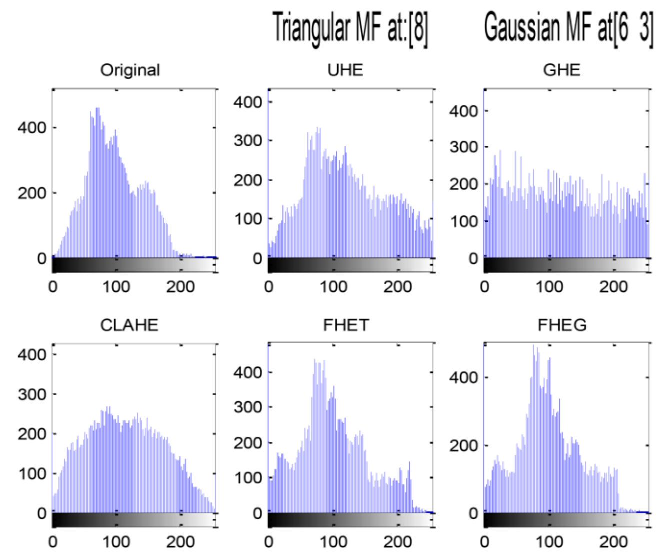

Fig 3 Image enhancement for image "flower6.jpg"

Fig 3 shows result for image named as flower6.jpg. Top left image is original image and remaining 5 images are obtained by applying different histogram based enhancement technique. We can observe that in GHE and UHE after applying enhancement the bright portions of flower petals have become almost white in UHE the background part that was somewhat dull has become black. Content wise GHE looks improved and clearer than original image but it has become over bright hence most of the information has eliminated due to white color impression especially in center part of flower. CLACHE has improved the contrast but it has lost the beauty of the image perceptually as compared to original image. The background has become very dull and most of the colour variation has diluted. Some of the image parts are also become almost white specially the portion at border part of flower petals.FHE in both case TMF and GMF enhanced the image contrast but there is image brightness is maintained due to this there is no over brightness or white patches in the in the image. Background is also looking perceptually better than other methods. However, performance of both GMF and TMF looks similar. The lower images show the figures of respective histogram of original and enhanced images. In FHE (TMF/ GMF) the shape of histogram remains almost same. But in case of GHE resemblance of processed image to the original one is totally lost as histogram is distributed uniformly for all gray levels. UHE histograms are preserving their resemblance to the original one, but as it has spread to higher gray scales (spreading towards right side), the maximum brightness is abnormally increased. In CLACHE the histogram is in showing a close resemblance to original one however it can be seen from the fig that it has distributed along the envelope of original histogram. It is touching the right sided bright gray shades but here its value is not so large to increase the brightness abnormally, this is a good indication for equalization.

5. Conclusion:

The algorithm was applied on image of flower. It has been observed that in generalized HE and CLACHE method after applying enhancement the bright portions of images have become almost white. In uniform HE the background part that was somewhat dull has become black. Content wise GHE looks improved and clearer than original image but it has become over bright hence most of the information has eliminated due to white color impression and it shows non uniform white and dark patches. CLACHE has improved the contrast but it lost the original color content of the image perceptually as compared to original image. The background becomes very whitish and most of the color variation has diluted. Some of the images parts are also become almost white FHE in both case of GMF enhanced the image contrast but there is image brightness and color both are maintained. In both there is no over brightness or white patches in the in the image. Background is also looking perceptually better than other methods

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