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"A review on gamma correction base image contrast enhancement techniques"

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Abstract: ***Image enhancement is the way toward changing digital images with the goal that the outcomes are progressively reasonable for show or further image analysis. For instance, we can remove noise, sharpen, or brightness of an image, making it simpler to distinguish key highlights. The aim of image enhancement is to improve the interpretability or perception of information in images for human viewers or to give 'better' contribution for other automated image processing techniques. In past few decades different types of image enhancement methods have been developed by various groups of researchers. One such class of image enhancement methods is 'adaptive gamma correction' (AGC) based methods. In these types of methods each intensity value of given digital images is enhanced by modifying it using a power of gamma. The value of variable gamma is calculated by considering various properties of given digital image. In this paper we are going to provide a systematic review on various AGC methods.***

Keywords: Adaptive gamma correction (AGC), cumulative distributed function (CDF), Contrast Enhancement (CE).

1. INTRODUCTION

Gamma correction function is a function that maps luminance levels to compensate the non-linear luminance effect of display devices (or sync it to human perceptive bias on brightness). Gamma can be any value between 0 and infinity. If gamma is 1 (the default), the mapping is linear. If gamma is less than 1, the mapping is weighted toward higher (brighter) output values. If gamma is greater than 1, the mapping is weighted toward lower (darker) output values.

The transformation function of the AGC is based on the traditional gamma correction given by:

$$Y = c.X^{\gamma}, \quad (1)$$

Where X in and Y out are the input and output image intensities, respectively, c and γ are two parameters that control the shape of the transformation curve. In contrast to traditional gamma correction, AGC sets the values of γ and c automatically using image information, making it an adaptive method. In the following subsections, we describe the procedure of setting these two parameters for different classes of images.

In this paper we are going to provide an overview of widely used AGC methods.

2. Methods of Adaptive Gamma Corrections

2.1 S.C. Hung et. al. (2013) proposed an efficient method [1] to modify histograms and enhance contrast in digital images using adaptive gamma correction with weighting distribution. They presented a novel enhancement method for both images and video sequences. The proposed method is completed in three major steps. First, the histogram analysis provides the spatial information of a single image based on probability and statistical inference. In the second step, the weighting distribution is used to smooth the fluctuant phenomenon and thus avoid generation unfavorable artifacts. In the third and final step, gamma correction can automatically enhance the image contrast through use of a smoothing curve. Experimental image enhancement results demonstrate that proposed method performed well compared with other state-of –the-art methods. By the analysis of time consumption, the proposed method can be implemented in a real-time video system with limited resources.

2.2 L. Huang et. al. (2016) proposed [2] an efficient contrast enhancement method with truncated adaptive gamma correction. They described an improved adaptive gamma correction algorithm instead of directly applying cumulative distributed function (CDF) curves as the gamma parameter; they truncate them by thresholding with a reasonable limit. They find that the prior CDF – based adaptive gamma correction method typically incurs over-enhancement and details losing in bright image regions. In order to attenuate such deficiency, they novelly propose to truncate the CDF curves via thresholding. Both qualitative and quantitative experimental results validate the effectiveness and efficiency of proposed method.

2.3 Himanshu et. al. (2017) Proposed [3] fuzzified histogram equalization based gamma corrected cosine transformed energy redistribution method for image enhancement. In this method fuzzy based technique used for digital image enhancement in histogram domain following cosine transformed domain. Fuzzified histogram redistribution is sigmodial membership function so its cumulative distribution can be used for gamma value set evaluation. The main objective is to enhance the visual appearance both from the machine vision as well as human vision perspective.

2.4 Himanshu et. al. (2018) presented [4] piecewise gamma corrected optimally framed grumwald-letnikov fractional differential masking for satellite image enhancement algorithm. It is used for qualify enhancement of dark images. In this parallel band processing generally required for multiband images, but for enhancement of color images Hue saturation-Intensity (HSI) model used. The color image enhancement can be done by processing only the luminance intensity channel. Nature inspired and mathematically hybridized well-framed levy-flight firefly algorithm (LFA) is used for optimal solution.

2.5 Rangu et. al. (2018) present [5] homomorphically rectified Tile –wise equalized adaptive gamma correction method for histo-pathological color image enhancement with primary aim for quality improvement of histopathology slides images along with proper luminance restoration and color correction. The non- iterative and adaptive behavior of the proposed approach fascinates a lot and similar kind of strategy can be further explored for another image domain and also for avoiding the display artifacts.

2.6 P.S. Reddy et. al. (2018) presents an advanced [6] retional fundus image enhancement method by employing an efficiently modified and biologically inspired levyflight firetly optimizer in association with a novel optimally weighted piecewise gamma corrected energy redistributed dominant orientation based texture histogram equalization framework for imparting overall quality improvement of retinal fundus images. In this method, the piecewise gamma correction is optimally associated with energy redistributed texture orientation dominance framework for transmitting intensity as well as for the texture based quality enhancement approach and is employed for optimal enhancement of dark images. The dominant texture –orientation based equalization when associated with the recently proposed piecewise gamma corrected weighted summation framework, yields highly appreciable results when intuitively governed by highly efficient exploration.

2.7 R. Silpasai et. al. (2019) proposed [7] an optimal quality enhancement approach for haematoxlin and cosin stained histopathology images. They introduced an optimally weighted framework for achieved objective. They also introduced Gaussian filter to impart the associated unsharp masking. The fitness function is used more information by minimizing more and more information by minimizing the count of over-ranged pixels. Various performance metrics like brightness, global contrast, average local contrast, spatial frequency and mean gradient are evaluated and they underline the superiority of the proposed image enhancement approach when compared with respect to various already existing methods.

2.8 P.S. Reddy et. al. (2019) proposed [8] an optional approach for the enhancement of textural images. They also introduced an optimally weighted framework for achieve the objective. The objective of their work is to make Gamma corrected fusion framework of dominant orientation and edge based texture histogram equalization for image enhancement. They suggest evolutionary algorithm based optimally weighed framework for this collective contribution and desired adaptive textural improvement framed for the excellence it is compared with already existing methods in terms of metrics like brightness global contrast average local contrast spatial frequency and mean gradient. Both of the quantitative as well as qualitative results underline the outperformance of the proposed approach.

2.9 Anurag et. al. (2019) presented [9] fusion-based image enhancement framework by harvesting the swarm intelligence of Levy Firefly optimizer. The objective is Piecewise gamma corrected weighted framework for fuzzified dynamic intensity equalization for optimal image enhancement. They presented comparative experimentation with quantitative analysis based on various quality assessment metrics such as brightness (mean-intensity), contrast (variance), discrete entropy (information content), sharpness (mean gradient) and colorfulness of the image. The fuzzified histogram and corresponding equalization, leads to the re-allocation of pixel-intensities in an efficient manner. The inclusion of piece-wise gamma correction leads to overall quality improvement. The over ranges intensity levels are reduced by the penalty term inclusion in the entropy dependent fitness function. Thus, the constructive amalgamation of gamma-compressed, gamma-expanded and fuzzy-equalized channel is attained through an evolutionary approach. This final leads to the desired image quality enhancement.

2.10 G. Cao et. al. (2017) proposed [10] Contrast enhancement of brightness-distorted images by improved Adaptive gamma correction (AGC). AGC deals well with most dimmed images, but fails for globally bright images and the dimmed images with local bright regions. However, such two categories of brightness – distorted images are universal in real scenarios, such as those incurred by improper exposure and white objects, such deficiencies eliminated by this method. The novel strategy of negative images is used to realize CE of the bright images, and the gamma correction modulated by truncated cumulative distribution function (CDF) is employed to enhance the dimmed ones. As such, local over enhancement and structure distortion can be alleviated effectively.

They focus on the CE of brightness – distorted images which own a relatively high or low global intensity. The existing AGC techniques are revisited and improved formally. They find that such methods are incapable to be directly used to enhance globally bright images, and the image structure in local bright regions may be lost in enhancing dimmed images. In order to attenuate such deficiencies, they propose an improved AGC method by integrating the strategies of negative images and CDF truncation. Substantial test results verify the effectiveness and efficiency of their proposed method in enhancing both dimmed and bright types of contrast – distorted images.
They proposed CE schemes focus on the CE of two types of brightness – distorted images, i.e., the dimmed and the bright ones. The input images is judged as dimmed if t< -Ƭt, and bright if t>Ƭt, where Ƭt is the threshold used for distinguishing brightness- distorted images from normal ones. In terms of the identified image types of bright and dimmed, the AGC based on negative image and CDF truncation are applied respectively for achieving contrast improvement and brightness restoration.

Both bright and dimmed contrast – distorted images are collected as input test images which could be simulated on direct camera- outputs .Without loss of generality, the bright and dimed input images are simulated by respectively applying the gamma correction. Performance comparison tests are also conducted. Currently, the performance assessment of CE algorithms is still a challenge task. In order to keep consistency with prior works and apply the latest research achievements, the metrics Expected Measurement of Enhancement by Gradient (EMEG), Gradient Magnitude Similarity Deviation (GMSD) and Patch- based Contrast Quality Index (PCQI) are simultaneously used as objective assessment of CE algorithms. A good CE method should achieve a balance between contrast improvement and image distortion. Less distortion should be incurred while more contrast improvement is gained. In terms of such view point, their proposed method should achieve the comparative results.
Low computational complexity is also required by a good CE algorithm. They also evaluate the algorithm complexity of their proposed method. A new effective and efficient image contrast enhancement method is proposed based on an improved adaptive gamma correction. The methodology of negative images is used to enhance the contrast of bright images. CDF truncation is proposed to reconstruct the intensity sensitive adaptive gamma for improving the enhancement effects on dimmed images. Extensive qualitative and quantitative experiments show that their proposed scheme achieves better or comparative enhancement effects than previous techniques. The contrast of both bright and dimmed input images is enhanced effectively and efficiently without incurring annoying artifacts.

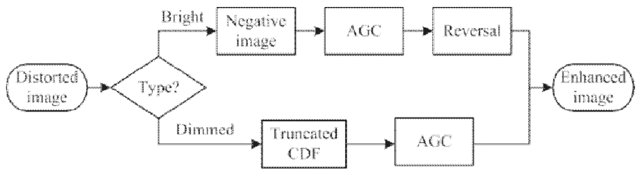

Fig 1: Flow chart [10] of Contrast enhancement of brightness-distorted images by improved adaptive gamma correction technique.

3. Tabular Summary

In this section we have performed a tabular comparison of all the methods discussed so far. This comparison is mainly performed to summarize the pros and cons of the various AGC based method.

Tabular 1 Summary of Work

S.No	Method Name	Author-Year	Pros	Cons
1	Efficient Contrast Enhancement Using Adaptive Gamma Correction with Weighting Distribution	S.C. Huang et.al. (2013)	Two-dimensional (2-D) histogram is used. Gaussian mixture model (GMM) can also be used.	Invalid on bright region of image for contrast enhancement.
2	Efficient Contrast Enhancement with Truncated Adaptive Gamma Correction	L. Huang and Gang Cao (2016)	Contrast of input dimmed images could be improved without losing details in bright regions.	Image structure in local bright regions may be lost in enhancing dimmed images.
3	Contrast enhancement of brightness-distorted images by improved adaptive gamma	G Cao et. al. (2017)	Local over enhancement and structure distortion can be alleviated effectively.	Contrast enhancement limiting to dimmed and bright images only.

	correction			
4	Fuzzified Histogram Equalization based Gamma Corrected Cosine Transformed Energy Redistribution for Image Enhancement	H. Singh et. al. (2017)	A multi- level intelligence based non-iterative framework is proposed for local quality enhancement of weekly illuminated poorly acquired images.	We are unable to find any cons of this method.
5	Piecewise Gamma Corrected Optimally Framed Grumwald-Letnikov Fractional Differential Masking for Satellite Image Enhancement	H. Singh et. al. (2018)	Proposed method presented for quality enhancement of densely textured, remotely sensed dark satellite images.	Proposed approach is some-how iterative.
6	Homomorphically Rectified Tile – wise Equalized Adaptive-Gamma Correction for Histopathological Color Image Enhancement	R. Silpasai et. al. (2018)	An efficient approach for quality improvement of histopathology slides' images is suggested, along with proper luminance restoration and color-correction.	We are unable to find any cons of this method.
7	Retinal Fundus Image Enhancement using Piecewise Gamma Corrected Dominant Orientation based Histogram Equalization	P.S. Reddy et. al. (2018)	An advanced retinal fundus image enhancement method proposed by employing an efficiently modified and biologically inspired levy-flight firefly optimizer in association with a novel optimally weighted piecewise gamma corrected energy redistributed dominant orientation based texture histogram equalization framework for imparting overall quality improvement of retinal fundus images.	The approach is some-how iterative.
8	Optimal Gamma Correction Based Gaussian Unsharp Masking Framework for Enhancement of Histopathological Images	R. Silpasai et. al. (2019)	An optimal quality enhancement approach is proposed for Haematoxylin and Eosin stained histopathology images.	We are unable to find any cons of this method.
9	Gamma Corrected Fusion Framework of Dominant Orientation and Edge based Textural Histogram Equalization for Image Enhancement	P.S. Reddy et. al. (2019)	An optimal approach is proposed for the enhancement of textural images. An optimally weighted framework introduced for the improvement of textural and illumination based features of the images.	We are unable to find any cons of this method.
10	Piecewise Gamma Corrected Weighted Framework for Fuzzified Dynamic Intensity Equalization for Optimal Image Enhancement	A. Kumar et. al. (2019)	A new fusion based image enhancement framework is proposed by harvesting the swarm intelligence of Levy firefly optimizer.	We are unable to find any cons of this method.

4. Conclusion

In this chapter we have performed a systematic review of various AGC based methods. Initially we have discussed the concept of AGC method. Next we have provided a brief review of various AGC based digital image enhancement methods. After that a tabular comparison of pros and cons of the discussed methods is provided. Through this study we have realized that much work has been done in the field of AGC based digital image processing methods but there is still a need of real time AGC based image enhancement method that can enhance visibility of all types of gray scale and color images without distorting color or other meaningful details of the image.

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