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IMAGE ENHANCEMENT THROUGH CONTRAST IMPROVEMENT USING LINEAR PARAMETERIZED GRADIENT INTERCEPT MODEL

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ABSTRACT

Quality of the image is not satisfactory in many cases to extract the useful information. Image enhancement process gives better visual quality either by increasing the contrast or suppressing the noise. As all enhancement techniques are application oriented, it is necessary to find a method which needs simple operations with effective enhancement and does not require complex operations like logarithmic, exponential, Probability Density Function. This paper proposes a method for image enhancement through contrast improvement using a linear Parameterized Gradient Intercept Model in spatial domain. The proposed method provides good results subjectively as well as objectively for both gray scale and true color images. The proposed method is useful for interactive image processing applications as it has a family of possible transformations for various enhancement levels.

Keywords: image enhancement (IE), and parameterized gradient intercept (PGI), probability density function (PDF), digital image processing (DIP).

I. INTRODUCTION

An image is supposed to provide information to the human viewers. Computers are faster and more accurate than human beings in processing numerical data. However, human beings score over computers in recognition capability. Human beings use all the five sensory organs to gather information about the outside world. Among these five perceptions, visual information plays a major role when compared to the other kinds of sensory information obtained from hearing, taste, smell, and touch. The old Chinese proverb ‘A picture speaks a thousand words’ rightly points out that the images are very powerful tools to provide information to the viewers in every field i.e., medical images for doctors, forensic images for police investigation, text images for readers etc. Contrast, refers to finer details of an image, is one of the essential factor responsible for image quality. In the process of image acquisition, image clarity is affected by lighting, weather, distance, or equipment used for image capture. Enhancement basically improves visual quality by providing clear images for human observer and/or for machine in automatic processing techniques.

2. RELATED WORK

Image enhancement operations can be done in spatial domain and/or frequency domain. Image enhancement in spatial domain means modifying the image pixels directly. We reviewed in our previous papers about enhancement techniques for gray scale images in spatial domain and implemented using MATLAB [1]. These techniques have been extended successfully to true color images also in [2]. The two important image enhancement techniques for improving contrast of an image in spatial domain are:

- Histogram processing operations
- Point processing operations

2.1 Histogram processing operations

Histogram of a gray level image is a graph of the frequency of occurrence of each gray level in an image so that it shows its global appearance. Histogram of a true color image gives number of times a particular color has occurred in the image so that it shows its color balance [3]. Even though histogram of an image contains no spatial information, image processing operations can be done based on histograms. Histogram processing operations are classified into two categories:

- Traditional Histogram Equalization (THE)
- Adaptive Histogram Equalization (AHE)

The method enhances the appearance of an image by spreading gray levels so that they are evenly distributed. Histogram equalization is quite useful but not suitable for interactive image enhancement applications as it gives only one resultant image shown in Figure-1.

AHE method moves the centre of a square mask from pixel to pixel over the entire image. For each neighborhood calculate histogram and map the centre pixel with the histogram equalization or histogram specification [4].

AHE method is useful for enhancing the details over the small areas in an image when compared to THE method, but for some images this local enhancement fails to give desired enhancement for dark and bright images as shown in Figure-2.

Let f (x, y) be a digital image of size MxN and g (x, y) be its enhanced image along with respective pixel values r and s, then transformation for Histogram equalization in the interval [0, L-1] is:

$$s_k = T(r_k) = (L-1)\sum_{j=0}^{k} P_r(r_j) \frac{(L-1)}{MN}\sum_{j=0}^{k} n_j \quad (1)$$

for k = 0, 1, 2,…, L-1.

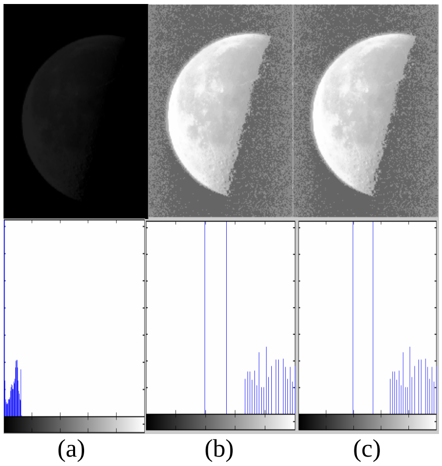

Figure-1. (a) Moon image, (b) Histogram equalized once (c) Histogram equalized twice, and their histograms.

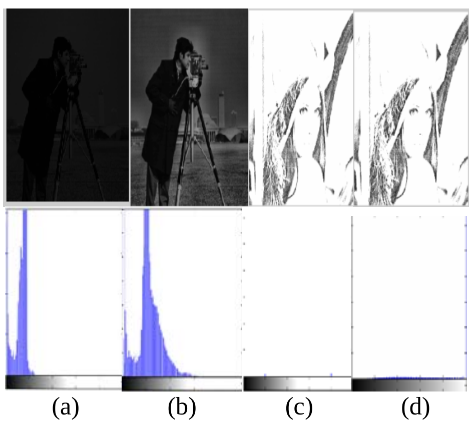

Figure-2. (a) Dark man image (b) Its AHE image (c) Bright Lena image (d) Its AHE image.

2.2 Point processing operations

Point processing operations are very simple because operations are performed on single pixel only at (x,y) as:

$$g(x,y) = T[f(x,y)] \Rightarrow s = T(r) \quad (2)$$

Different Point processing operations are: image negative, contrast stretching, thresholding, piece wise linear, intensity slicing, log, antilog, power law [5], and biplane slicing etc. among which some are linear, non linear and neither linear nor nonlinear. Some methods need less complex operations with poor contrast and other need more complex operations with good contrast. Method [6] requires local and global statistics where as method [7] needs mean edge gray value. Therefore it is necessary to find a method which needs simple operations with effective enhancement and does not require PDF calculations as in THE and AHE, need not require any other image as in Histogram matching.

3. PROPOSED METHOD

The relation between the pixels values of input and output images in the proposed method is given by the transformation as:

$$g(x,y) = G \times f(x,y) + I \quad \begin{cases} 0 \le x < M \\ 0 \le y < N \end{cases} \quad (3)$$

i.e $s = Gr + I$

where G is Gradient and I is Interception of the transformation. G and I values can be zero, positive, or negative. When G and/or I values are varied for improving the image contrast, above transformation becomes simple linear or nonlinear but not exponential or logarithmic as in traditional point processing methods.

The proposed method is given the name 'Linear Parameterized Gradient Intercept (PGI) model', as a family of possible transformations can be obtained for achieving effective image enhancement.

4. PGI ALGORITHM

The following are the steps involved in linear PGI algorithm simulation for image enhancement via contrast improvement gray scale and true color images.

Gray scale image

a) Read an input image i (x, y).
b) f (x, y) is a poor contrast image of i (x, y).
c) Select appropriate values of G and I.
d) Multiply f (x, y) with G and add with I.
e) If g (x, y) < 0, then adjust it to 0 else g (x, y) > 1, then adjust it to 1.
f) Observe the enhanced output image g (x, y).
g) If g (x, y) is not good in contrast change G and/or I, and then go to step c.

True color image

a) Read an input image i (x, y).
b) f (x, y) is a poor contrast image of i (x, y).
c) Extract Y components from f (x, y) using RGB to YIQ conversion i.e., l (x, y).
d) Select appropriate values of G and I.
e) Multiply l (x, y) with G and add with I.
f) If l (x, y) < 0, then adjust it to 0 else l (x, y) > 1, then adjust it to 1.
g) Get enhanced true color image g (x, y) using YIQ to RGB conversion.
h) Observe the enhanced output image g (x, y).
i) If g (x, y) is not good in contrast, change G and/or I, and then go to step e.

5. RESULTS

The PGI model performance can be compared to that of THE and AHE methods by enhancing gray scale 'Man' and true color 'Lena' images as shown in Figure-3 and Figure-4 with their respective histograms

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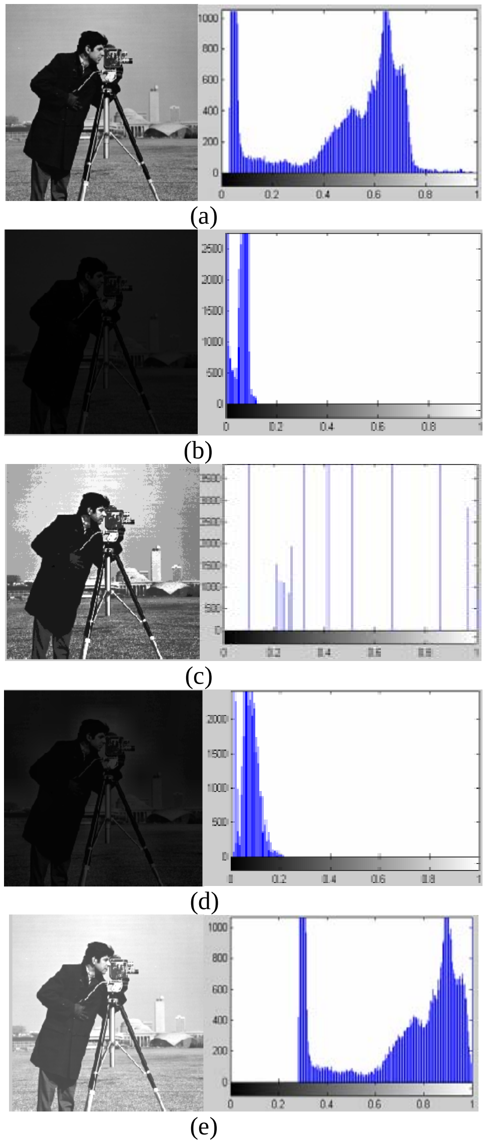


Figure-3. (a) Man image (b) darken image (c) THE image (d) AHE image (e) PGI image.

Consider three gray scale images of file TIF type Man (256x256), Lena (512x512) and Moon (512x512) for getting simulation results. Contrast improvement can be judged by visual inspection of the resultant images along with their histograms and also by evaluating the mean square error (mse) and computational time (t_c) for each method.

$$mse = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j) - g(i,j)]^2 \quad (4)$$

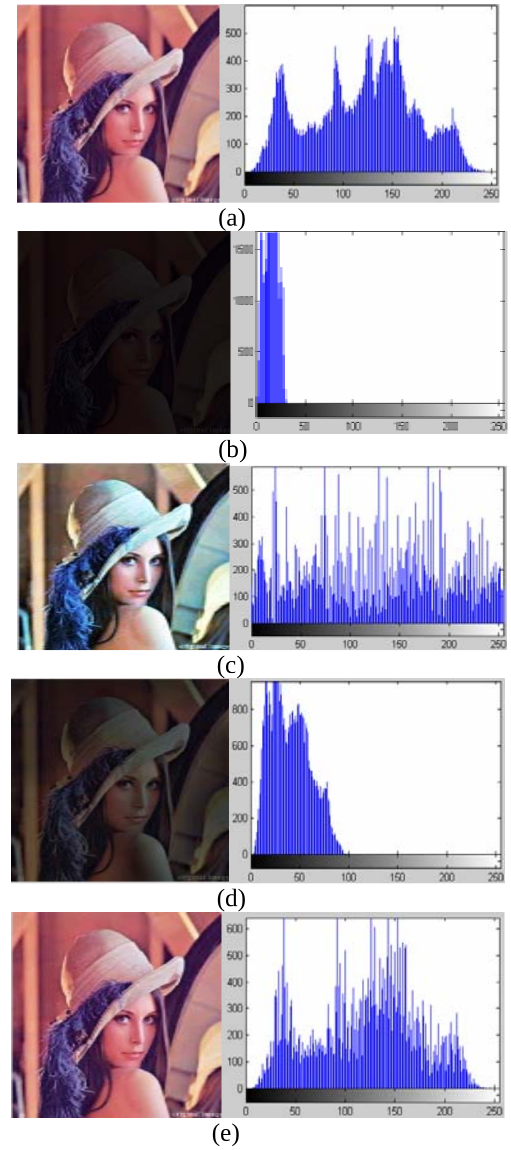


Figure-4. (a) Lena image (b) darken image (c) THE image (d) AHE image (e) PGI image.

Table-1. Comparison of mean square error.

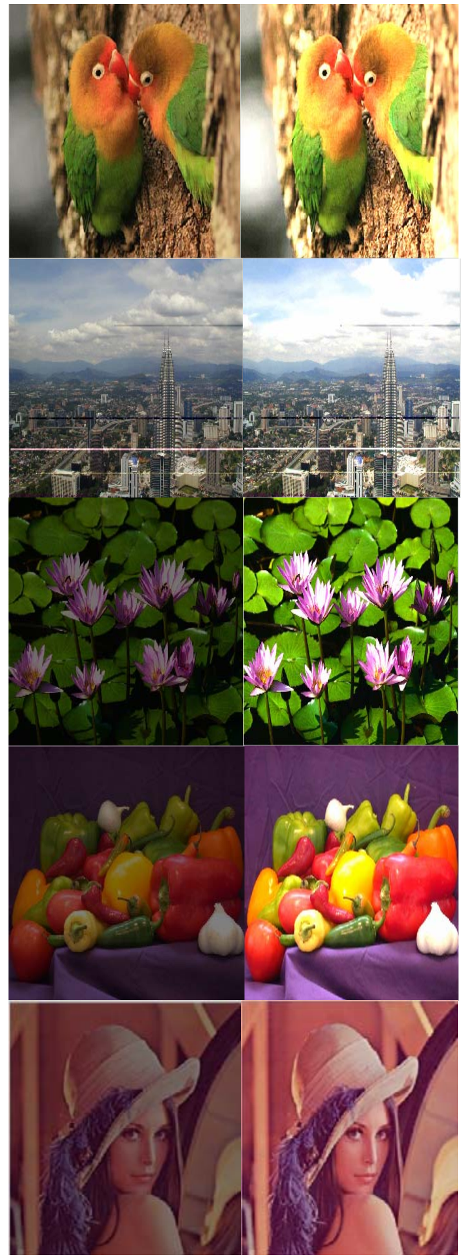
Image	THE	AHE	PGI
Moon	0.1587	0.0737	1.5625e-006
Man	0.0124	0.0972	2.5000e-009
Lena	0.0464	0.0056	8.0072e-008

Table-2. Comparison of computational time.

Image	THE	AHE	PGI
Moon	0.030469	0.076155	0.001571
Man	0.005721	0.033473	0.000306
Lena	0.010890	0.037636	0.001343

(a) (b)

Figure-5. (a) Original gray scale images
(b) PGI model enhanced images



(a) (b)

Figure-6. (a) Original true color images.
(b) PGI model enhanced images.

Table-3. PGI model for different images.

Gray scale image	G	I	True color image	G	I
lena	1.5	0.5	birds	1.75	-0.75
moon	1.25	0.75	pepper	2.75	-1.25
man	825	0.125	lilies	2.75	-1.75
pout	1.75	2.0	city	1.5	-0.75
circuit	2.75	2.75	lena	1.75	-1.25

5. CONCLUSIONS

Image enhancement through contrast improvement using linear parameterized gradient intercept model have been successfully implemented for both gray scale and true color images in spatial domain using MATLAB. PGI model works well for a gray scale image and results are much more pronounced for true color image by preserving maximum color details. This paper considers images from different fields and choice of G and I depend on the type of image. Results show that mean square error and computational cost of PGI method is smaller when compared to THE and AHE methods. PGI method can be used as a tool for Photo editing software like Photoshop or any existing image processing software by attaching two sliding bars for G and I. Proposed algorithm with slight change using image segmentation rules can also enhance corrupted images that are not distorted uniformly. The future scope will be the development of nonlinear parameterized model for achieving image enhancement through noise suppression from noisy images.

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