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BINARY IMAGE ENHANCEMENT TECHNIQUE USING PSI MODEL FOR CONTRAST IMPROVEMENT IN SPATIAL DOMAIN

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ABSTRACT

Binary Image Processing means processing of binary images by using a computer via algorithms. While acquiring images sometimes their contrast will be poor because of viewing distance, weather condition or lighting intensity. As human beings and machines can distinguish grayscale and true color images, but for some applications binary images are more useful as they need less memory space for storage and lower computational cost. Hence it is necessary to find a method which needs simple operations with effective enhancement and does not require complex operations. This paper proposes a method for binary image enhancement technique using PSI Model for contrast improvement in spatial domain. Subjective results like images and objective like mean square error are good for the proposed method.

KEYWORDS: Binary Image Processing (BIP), Image Enhancement (IE), and Parameterized Slope Intercept (PSI), Mean Square Error (MSE)

INTRODUCTION

Image enhancement process enhances the details from their corrupted versions either by increasing the contrast and/or suppressing the noise. As a popular Chinese proverb say's that 'A picture speaks a thousand words', binary images play vital role to provide information to the human viewers and automatic machines in every field. Image enhancement operations can be done in spatial domain and/or frequency domain. We reviewed enhancement techniques for gray scale images in spatial domain and implemented them using MATLAB [1]. These techniques have been extended to true color images also in [2]. We proposed different image enhancement models for gray scale and true color images in spatial domain [3-7].

Binary or bi-level or two level images is a digital image in which each pixel has only two possible values: black and white. Sometimes any two colors can also be used to generate a binary image from true color images. The color used for the object(s) in the image is the foreground color while the rest of the image is the background color.

All the methods developed for binary image enhancement [8-12] are very much problem oriented: a method suited for one binary image may not be completely suited for another. This paper proposes method for contrast improvement using parameterized slope intercept model for binary images in spatial domain.

RELATED WORK

Image enhancement in spatial domain means modifying the image pixels directly. Two important image enhancement techniques for improving contrast of binary image in spatial domain are:

- Histogram processing operations
- Point processing operations.

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 [13]. 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) and 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. 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.

AHE method is useful for enhancing the details over the small areas in an image when compared to THE method. This local enhancement also fails to give required information from some corrupted images like dark images and bright images.

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.

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)] **(2)**

$\Rightarrow$ s=T[r]

Different Point processing operations[14] are: image negative, contrast stretching, thresholding, piece wise linear, intensity slicing, log, antilog, power law, 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 requires local and global statistics where as method 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.

PROPOSED METHOD

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

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

$$\Rightarrow s = Gr + I$$

where S is Slope and I is Interception of the transformation. S and I values can be zero, positive, or negative. When S 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 '**P**arameterized **S**lope **I**ntercept (PSI) model', as a family of possible transformations can be obtained for achieving effective image enhancement.

PSI ALGORITHM

The following are the steps involved in PSI algorithm simulation for image enhancement via contrast improvement binary images.

- Read an input image i(x,y)
- Get binary image b(x,y) of i(x,y)
- Corrupt binary image to get f(x,y)
- Select appropriate values of S and I.
- Multiply f(x,y) with S and then add with I to get g(x,y)
- If g(x,y) is not good in contrast change
- S and/or I, then go to step 5
- Get the enhanced binary output image

RESULTS

The PGI model performance can be compared to that of THE and AHE methods by enhancing different binary images. Consider six binary images of file TIFE type: Moon (537x358), Lena (512x512), Text (269x393), Number plate (247x361), Signature (165x657), and Finger print (165x140). Original non binary images are first converted into binary images. These images have been corrupted differently to get their poor contrast images. Corrupted images are then enhanced by THE, AHE, and PSI methods. Contrast improvement can be judged by visual inspection of the resultant images and also by evaluating the mean square error for each method.

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

Objective results: MSE and computational time for each method are given in tables. Subjective results: resultant images in which 'G' means Gradient i.e. Slope 'S' are shown in figures (Fig. 1-5).

Table 1: Mean Square Error

Image Name	MSE			
	Original	THE	AHE	PSI
Moon	0.2622	0.3422	0.2519	2.0e-5
Lena	0.6660	0.1079	0.6373	1.0e-6
Text	0.7930	0.1584	0.7554	1.6e-5
Number plate	0.8386	0.1595	0.8059	8.1e-5
Signature	0.9344	0.2137	0.8986	6.4e-5
Fingerprint	0.6608	0.1078	0.6222	4.0e-6

Table 2: Computational Time (Sec)

Image Name	Computational Time(Sec)		
	THE	AHE	PGI
Moon	0.259161	0.262466	0.202470
Lena	0.320033	0.321705	0.229865
Text	0.272524	0.239470	0.192324
Number plate	0.352071	0.255473	0.206065
My signature	0.241941	0.282869	0.224452
Fingerprint	0.315286	0.319635	0.189204

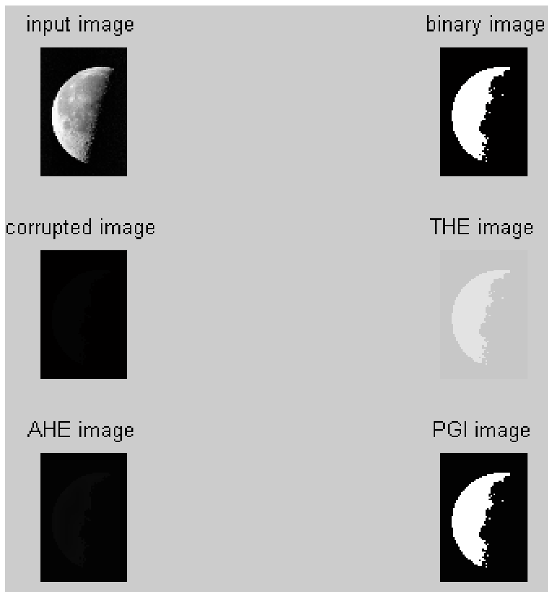

Figure 1: Moon Image

Figure 2: Lena Image

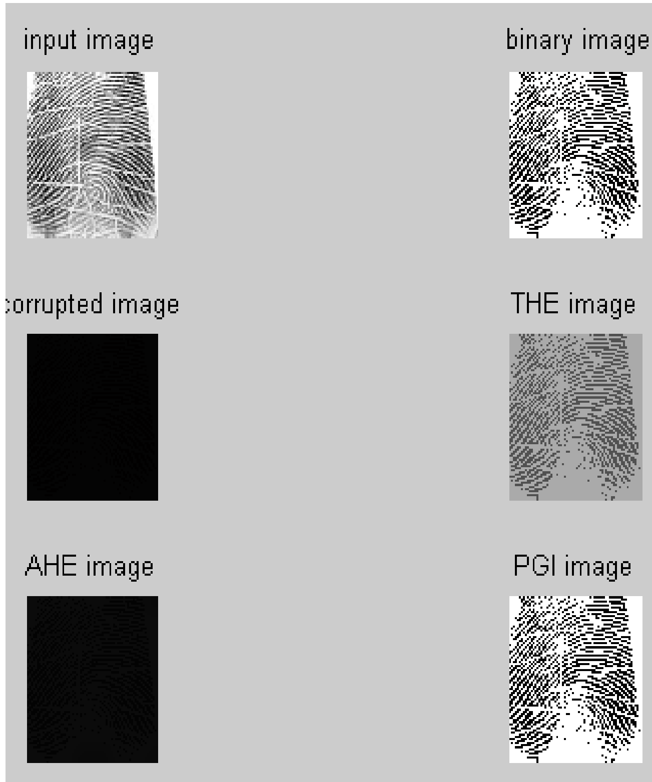

Figure 3: Fingerprint

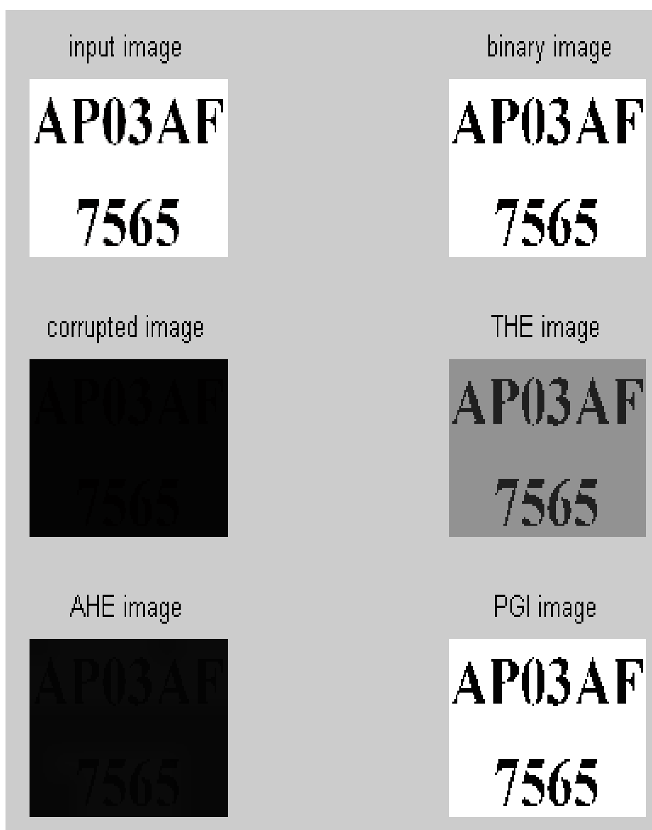

Figure 4: Number Plate

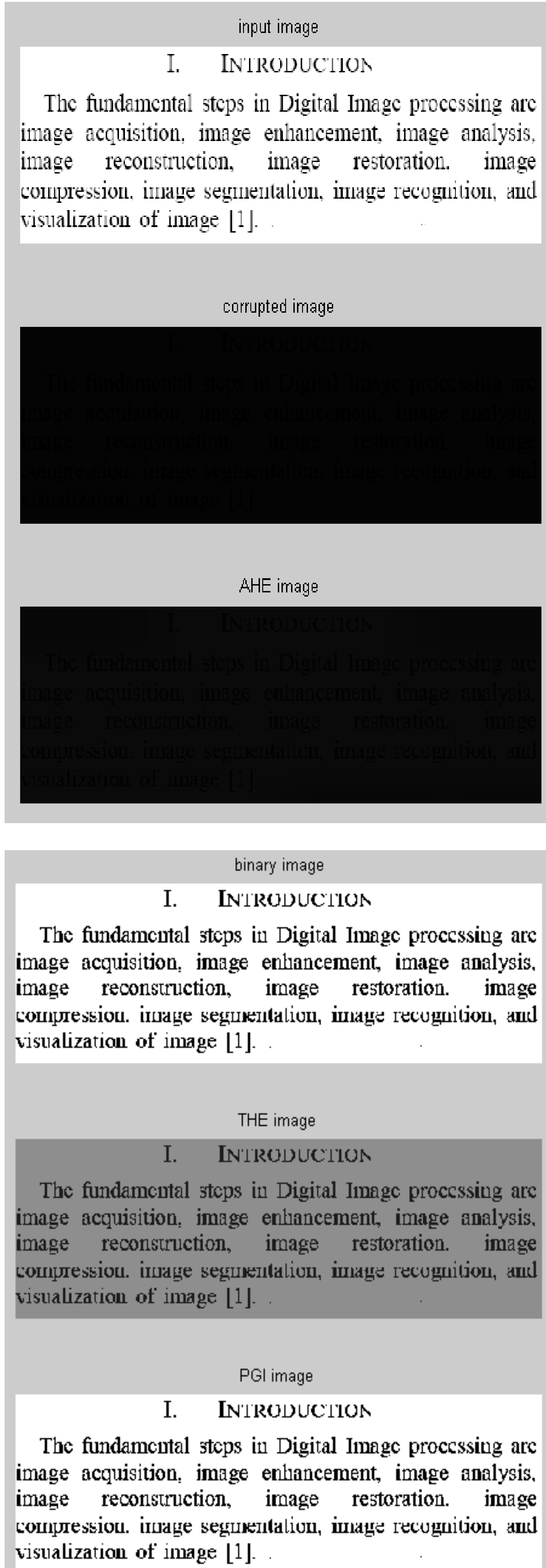

Figure 5: Text

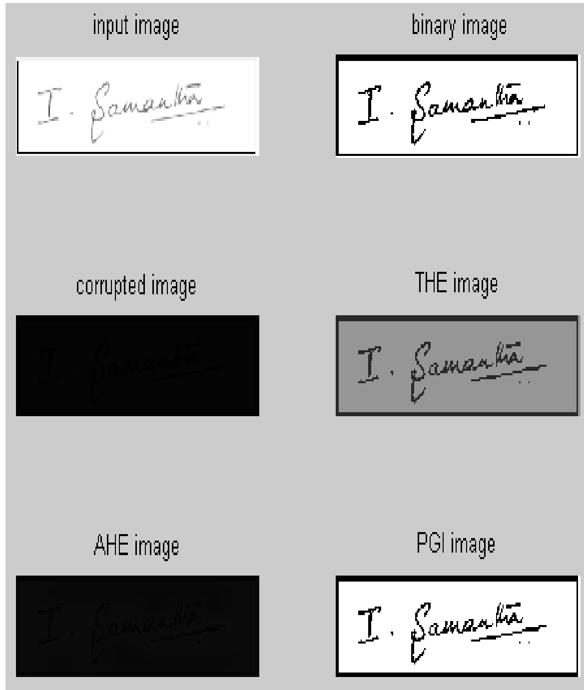

Figure 6: Signature

DISCUSSIONS

Visual inspection of subjective results indicates that THE and AHE fail to enhance images details from corrupted binary images. GHE method improves contrast but some gray shades are there apart from 0's and 1's from which an automatic machine fails to authenticate. Proposed PGI model works very well by providing enhanced binary images. Visual inspection of objective results shows that PGI method has smaller mean square error and computational complexity when compared to THE and AHE methods. Simulation results are restricted to only black and white images derived from gray scale images and fail to enhance binary images using any two colors. This limitation can be overcome extending proposed algorithm to R, G, and B components simultaneously to the binary images derived from true color images.

CONCLUSIONS

Binary image enhancement technique using PSI Model for contrast improvement in spatial domain has been successfully implemented. Choice of S and I depend on the type of image. Proposed PSI method can be used as a tool for editing image processing software by providing two sliding bars for selecting for S and I. Sometimes binary image can be corrupted by unwanted noise. The future scope will be the development of parameterized noisy model for achieving image enhancement through noise suppression from noisy binary images.

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