Asian Journal of Computer Science and Technology
ISSN: 2249-0701 (P) Vol.8 No.1, 2019, pp.26-31

DOI: https://doi.org/10.51983/ajcst-2019.8.1.2123

A Novel Technique for Automatic Image Enhancement using HTHET Approach

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(Received 12 December 2018; Accepted 18 January 2019; Available online 27 January 2019)

***Abstract* - Image enhancement techniques are methods used for producing images with better quality than the original image. None of the existing methods increase the information content of the image, and are usually of little interest for subsequent automatic analysis of images. In this paper, automated Image Enhancement is achieved by carrying out Histogram techniques. Histogram equalization (HE) is a spatial domain image enhancement technique, which effectively enhances the contrast of an image. We make use of Transformation and Hyperbolization techniques for automatic image enhancement. However, while it takes care of contrast enhancement, a modified histogram equalization technique, Histogram Transformation and Hyperbolization Equalization Technique (HTHET) using optimization method is proposed using EQHIST and LINHIST.**
***Keywords:* Image, Enhancement, HTHET, Histogram, Equilization**

I. INTRODUCTION

Visual images are the probably the most important means by which human beings experience their environment. The information required however is often a very small part of the data in the image as represented in digitized form in a computer [1]. The human visual system has a huge capacity and extremely powerful processing capacity. Nevertheless, under certain circumstances it can be extremely inefficient in extracting special types of information.

Therefore, there is a demand for techniques that process the image after recording but before presentation to the human being. This may make it easier for him to extract the information needed [2]. It will involve processes like enhancement and simplification of images, images and a means of displaying a high-quality image to the viewer, making it as pleasant look in as possible.

Generally all these methods may be viewed as set or transforms, linear or non-linear, taking an image f(x, y) into a new image g (x, y) .The result is always a new image recorded in the same type of data structure as the original image .the most predicted methods for improvement of images are so called enhancement methods [3]. This includes methods for modifying the gray scale, de blurring and smoothing, as well as noise removing methods. Image enhancement techniques are methods used for producing images with better quality than the original image. Image enhancement methods are usually classified as contrast increasing method and edge sharpening methods.

A. Contrast Transformation

Image enhancement method based on transformation of the grey level distribution of the images in the grey level histogram is treated in [4]. A grey level renovation is used to increase the content in the original image. Histogram equalization transformation is often used for visual contrast enhancement, and as a preprocessing step for normalizing a step of images, thereby removing the effects of variations in exposure, development, digitization etc.

In [5], authors have shown that solution to the issues of minimizing the sum of data loss and the deviation of histogram from an ideal function, for continuous real-valued images, are solution to differential equations, which may be solved numerically. In [6], authors developed and transformed histograms should be designed to produce images with a uniform distribution of perceived brightness levels. A model of brightness percentage has been sed to predict that the distribution of the displayed brightness level should be hyperbolic. In [7] authors propose a method of local histogram modification, based on histogram equalization method tends to lighten dark and shadowed regions.

B. Edge Sharpening

Other method for visual quality improvement, are edge enhancement or sharpening techniques for improved visualization of edges. These methods include the calculation of first order different of density, applying the Laplacian transformation to emphasize the peak changes in the image, calculating the gradient at each point in the image, each. a simple edge enhancement technique is the use of Laplacian operator [8]. The Laplacian of an image may be computed at each point in the image by applying the formula

The final preprocessing step is performed by calculating the image

The problem with all operators of this type, is the that they tend to enhance the noise as much as the real edges and lines present in the images [9].

The study of digital image processing methods comes from two principal different application areas:

1. Improvement of the pictorial information for final human interpretation. This improves the enhancement and restoration of degraded pictures.
2. Processing of pictorial scenes for automatic machine interpretation. This includes picture segmentation and description.

The borders between these main applications areas are not distinguished [10]. In order to perform automatic machine interpretation of scenes, it is necessary to have different forms of preprocessing, normally used in the improvement of images for human visual interpretation. many of the enhancement methods are useful for subsequent image segmentation. on the other hand, borders between segmented areas may be superimposed the original image as an enhancement technique. In the following sections of this part we discuss some papers addressing both the above-mentioned areas. In this paper we are enhancing work of histogram transformation. Section 2 describes the related work of the studies using HE and Section 3 gives the proposed technique. Section 4 discusses the results and section 5 gives the conclusion.

II. RELATED WORK

There are various image enhancement methods. The methods are selected for further study since they represent rather different approaches to the field of image enhancement. [11] We have divided the methods into the following different approaches

1. Histogram modification methods
2. Other contrast enhancement methods
3. Image enhancement by noise suppression

The authors of [12], viewed Image enhancement as the contents of image processing which is being used as a technique to manipulate images in a way to make them worthy for a particular use. The main purpose of image enhancement is to highlight certain features of that image which are required for some special purpose. By highlighting certain pixels of that image, we can achieve this. Here the image can be anything which is visible. The main objective of image enhancement is to process the image so that the result is more suitable than the original image for a specific application.

Histogram Equalization [13] is one of the most active method for contrast enrichment, but it fails to preserve the mean intensity of images. To overcome such disadvantages, several Bi and Multi-histogram equalization approaches are proposed. Among them, Bi-HE approach may preserve the intensity, but they present some unwanted artifacts in the processed image. Whereas, Multi-HE [14], [15] approaches may not produce undesirable artifacts in image but at the cost of either the intensity or its divergence. In this paper, we propose a multi segment weighted average HE technique using Gaussian filter to enhance the contrast of usual images while conserving brightness. It also diminishes the noise in the images. The proposed technique initially smoothens the global histogram and decomposes it into several segments using optimal thresholds, later on HE is applied to each sector individually. Simulation outcomes for some test images show that the projected method improves the contrast though preserving the mean brightness. The main objective of Image enhancement is to convert an image so that result is more suitable than original image for specific application as said in [16], [17]. It offers a wide variety of approaches for modifying images to achieve visually acceptable images. Image enhancement is basically improving the interpretability or perception of information in images for human viewers and providing better input for other automated image processing techniques. Different image enhancement techniques are as shown in following figure 1.

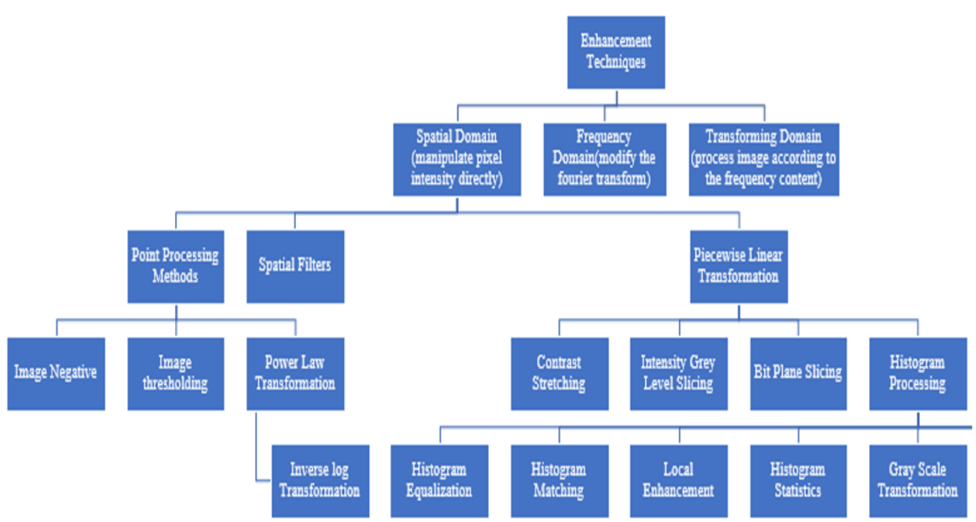


Fig. 1 Image Enhancement techniques

III. HISTOGRAM TRANSFORMATION AND HYPERBOLIZATION EQUALIZATION TECHNIQUE (HTHET)

A transformation is defined as one to one function mapping the range of f which are real numbers into new real numbers. The theoretical treatment of problems related to histogram modification fall into three categories:

1. Transforming an unceasing random variable into a new continuous variable.
2. Transformation of a Constant random variable to the discrete random variable
3. Transformation of discrete random variable to new discrete random variable

We develop the theory for first case and the other two cases as estimates to the continuous case.

The problem is formulated as follows:
Let f (x, y) be a continuous real function on a closed rectangle s in plane x-y. The probability distribution of the cumulative function is defined as

$$P_f(z) = Pr.\{(x,y) \in S \mid f(x,y) \leq Z\}$$

The range of f is in an interval (0,a). The continuous probability density function for the image histogram is given as

$$P_f(z) = \left(\frac{d}{dz}\right)(P_f(z))$$

The general problem of histogram modification is stated as Find a transformation t which maps the range of f the interval (0, a) such that the output image attained by applying t to every point in the input image has some specified histogram $P_g(z)$.

The transformation t is further supposed into single valued and monotonically increasing or decreasing function in the interval (0,a).This restriction is required to preserve the ordering relationship between the grey levels.

$C_1 C_f(T) + C_2 \int_0^a \left(P_T(f)^z - P_g(z)\right)^2 dz$; where c1, c2 are positive weighting constants.

The principal part of our work addresses the problem of minimizing the histogram error alone without any further constraints, by letting the constant c1=0. We have an input image with probability density function $P_f(z)$. A transformation T(z) should be found which on every pixel in I, produces a new image with probability function $P_g(z)$. Where $P_g(z)$ is a predefined function.

The probability distribution function $P_f(z)$ is given as

$$P_{f(z)} = \int_0^z P_f(z`)dz`$$

$$P_{f(z)} = \Pr\{(x,y) \in S \mid f(x,y) \in [0,z]\}$$

$$=\Pr\{(x,y) \in S \mid T(f(x,y)) \in T([0,z])\}$$

$$=\int_{T([0,z])} P_T(f)^{z`} dz`$$

For T monotonic increasing

$$= \int_{T(0)}^{T(z)} P_{T(f)}(z`)dz` = P_{T(f)}(T(z))$$

and for T monotonic decreasing

$$= \int_{T(z)}^{T(0)} P^z_{T(f)}` \, dz` = 1 - P_{T(f)}(T(z))$$

The constraints, $P_{f(0)} = 0$ and $P_f(a) = 1$, define the integration constants. For monotonic T it also follows directly:
$P_{T(f)}(T(z)) = P_f(z) / |T'(z)|$
The result then is:
$T(z) = P_g^{-1} P_f(z)$

For monotonic increasing transformation T (mapping large numbers onto large numbers, small numbers onto small numbers).
$T(z) = P_g^{-1}(1 - P_f(z))$
for monotonic increasing transformation T (mapping small numbers to large numbers and vice versa – the image grey levels are "inverted").

As an extension for the discrete case, the transformation which is continuous T_c is approximated by a mapping T, for the quantization levels $(y_0, \ldots, y_{n-1})$, where each quantization level y_i denotes a grey-level interval (x_i, x_{i+1}).

The approximate distribution function is then:

$$P_f(y_j) = \frac{(y_j - x_j)}{x_j + 1 - x_j} P_f(y_j) + \Sigma_{\substack{j-1 \\ i=0}} \, p_f(y_i)$$

Usually in a digitized image, the quantization levels y_i (the exact brightness values) are not available, only the index i representing the level. The domain of P_f is restricted to the conventional integers 0, 1, …, N-1 for images quantized to N discrete levels.

The discrete histogram amendment transformation for the quantized images is given as

$$T(k) = P_g^{-1}(P_f(k) + \Sigma_{m=0}^{k-1} P_f(m)$$

Where P_g^{-1} is a step function assigning all the standards between $P_g(k) = P_g(m)$ and $P_g(k+1)$ to the value k. y_j is the mid-point between x_j and x_{j+1}.

This may casually be implemented as a look-up table procedure on digital computers.
For the special case of histogram flattening, the last equation may be reduced to

$$T(K) = \lfloor (N-1).(P_f(k) + \Sigma_{m=0}^{k-1} P_f(m))\rfloor$$

Histogram flattening is the process of producing an output image with a uniform grey level distribution function (or "flat" histogram). It is shown by other authors that histogram equalization maximizes the zero-order brightness entropy.

When an image is quantized to a limited number of grey levels, the use of this equation is prone to give very crude approximation to the ideal flat histogram. The problem is impossible to solve as long as we do not split up the constant grey level sets.

We suggest a technique to avoid some of this problem by letting the transformation be context sensitive. T then becomes a function of two or more variables, one variable corresponding to the grey level itself, the others to local context values. The overall effect is that each grey level is broken up into disjointed subsets based on context values, thus simulating the dequantizing of f into more grey levels, giving closer approximation to the continuous case.
Proposed context sensitive functions are i) local average of nearest neighbours, ii) a local textural measure (i.e. grainness of texture).

A grey level transformation is useful for increasing visual contrast, but may destroy some of the information in an image, if the image is to be used for subsequent image analysis.

The last part of this paper is devoted to the problem of histogram transformation, weighting the histogram error against the loss of information during the transformation. As mentioned above, this is performed as the minimizing of

$$C_1 C_f(T) + C_2 \int_0^a \left[P_{T(f)}(z) - P_g(z)\right]^2 dz$$

Where $C_{f\,(T)}$ is the “cost” of transforming f by T.
If f is subdivided into smaller parts, it is argued that C_f (T) must be an additive function over the set of partitions of f, and the cost of mapping z to T(z) must be some function of z, T(z), and the derivative of T. C_f (T) can then be given as an expression of the form

$$\int_0^a C\big(z, T(z), T`(z)\big) P_f(z) dz$$

For the case that z is continuous.
C (z, T(z), T’(z)) is the cost for a fixed grey level value. The histogram value factor, P_f (z), weights with the number of pixels with different grey level values.

The last part of the paper, only treats the continuous case, and no approximation to the discrete case is proposed. As simple models for the cost function C_f (T) are proposed as the mean square difference between f and T(f);

$$C\big(Z, T(z)\big) = \big(z - T(z)\big)^2$$

and the function C (z, T’(z)) =1/T’(z) which weights against compression of grey levels. More complicated models may take into account information theoretical measures.

The solution is obtained among the class of monotonic increasing transformations in (0, a) fixing endpoints and replacing T by T+eT_1. T_1 is differentiable in (0, a) with zero value at the endpoints. Differentiating with respect to e and setting the result equal to 0 gives after some tricks with mathematics, the differential equation for the simplest case of

$$C\big(z, T(z)\big) = \big(z - T(z)\big)^2$$

is T(z) = z+ (c_2/c_1) . (p_{f1} (z)/ p_f(z)) (p’$_{g1}$ (T(z))-p’$_{T.f1}$ T(z))). A numerical solution of this equation is a straightforward calculation.

In our system we have implemented two programs EQHIST and LINHIST – which are two methods of histogram linearization. The method called LINHIST, is an enhancement of the existing techniques in equalization. The range of grey levels in the input and output images are 0-255. As mentioned by our technique, the output histogram is not completely flat because the original image has been quantized into discrete grey levels.

Since grey levels of low occupation probability are merged together, some information is lost in the process. The number of single grey levels is reduced, but these are spread over the same range of grey levels as in the original image. Without doubt, there is some gain in visual improvement using the histogram flattening technique, but as a preprocessing step for further image recognition tasks, the histogram flattening is in my opinion dubious. Many scientists have found the histogram flattening method useful for image normalization as a preprocessing for certain texture analysis procedures.

The other histogram flattening procedure in our system, EQHIST, then transforms the grey levels to a new histogram being as flat as possible, but with a smaller number of separate grey level values in the output image then the input image. The number of output grey levels is selected from parameters to the program.

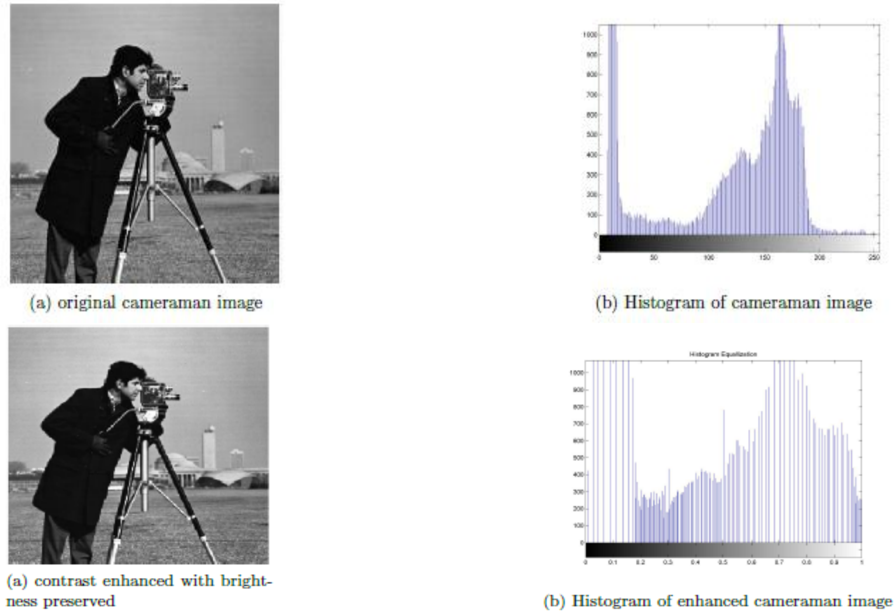
We have combined the EQHIST transform with a context sensitive transformation of the original image by calculating local sum of nearest neighbors adding to large multiple of the center pixel. The effect is a requantized picture with a much larger range of grey levels, more closely approximating the discrete case.

IV. RESULTS AND DISCUSSION

Enhancement and restoration techniques are applicable as a preprocessing step for subsequent manual interpretation, as well as later machine interpretation. The general preprocessing steps are

1. Correction of know geometrical degradations
2. Removal of film grain noise
3. Enhancement of visual details.

The Histogram and its original cameraman image are shown in figure. It shows that results produced using standard histogram equalization in which contrast is enhanced, but lacks brightness. Whereas in the next pictures, we can see the optimized Histogram transformation and Hyperbolization technique, where Contrast Enhancement and brightness are preserved. The results of processing the original image and the enhanced automatic image using HTHET approach are shown in following figures 2 and 3.



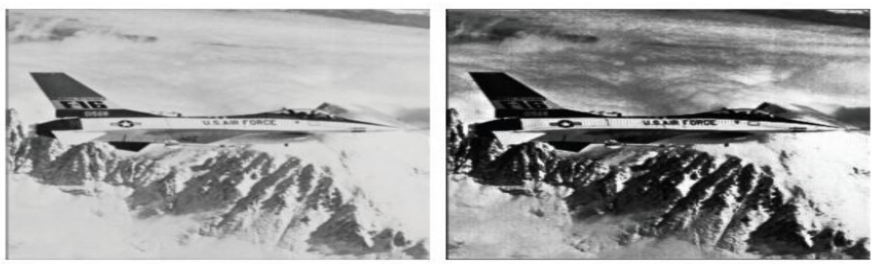
(a) original cameraman image

(b) Histogram of cameraman image

(a) contrast enhanced with brightness preserved

(b) Histogram of enhanced cameraman image

Fig. 2 (a) and (b) HTHET approach for image enhancement for original cameraman and enhanced image



(a) Original image (b) HE

Fig. 3 Comparison of original image and optimized histogram equalization image

The image enhancements techniques play a major position in digital image process. It's shown during this study that the nonlinear image may be utilized to boost the standard of a blurred image by exploitation the conception of the supply refinement. However, within the most of techniques it's been found that the offered technique doesn't give higher ends up in multiple lightweight sources as a result of no modification is completed on the hue and saturation. As mentioned previously the automatic image enhancement technique will be accelerated by inscription of the hue and saturation. It's aiming to give higher outcome than the prevailing ways. Proposed technique entails the process of a picture for its visualization for one in all a sort application. This method involves process the image by its structural options like distinction and determination. Several image improvement techniques are offered however the selection of procedure can rely on utility that image is being processed and image modality.

V. CONCLUSION

As we know, the equalization technique is self-made in up image distinction, however they ordinarily fail to preserve the input image brightness. The proposed HTHET technique has proven to beat this downside effectively. The planned methodology accomplishes an ideal balance between automatic improvement and brightness preservation. HTHET procedure quality is incredibly higher when compared to original images as seen in results. When having solved the matter of issues of improvement and brightness preservation, we tend to had another task of deciding that improvement algorithmic rule to decide on for higher results. Based on the obtained results, we tend to see that the HTHET made higher ends up in less range of generations, so proving for automatic image enhancement.

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