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Efficient Method for Image Enhancement using Non-Uniform Revisory and Exact Histogram Equalization

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Abstract: ***This paper presents the Image Enhancement using Non-uniform Illumination Revisory and Exact Histogram Equalization. This technique is hybrid technique, which is a combination of two individual contrast enhancement techniques. One is Non-Uniform Illumination and the second one is Exact Histogram Equalization. Here Non-Uniform Illumination is used for to correct the illuminance and to differentiate the background and foreground in image. And Exact Histogram Equalization is used for the contrast enhancement.***

Keywords: Image Enhancement, Non-Uniform Illumination, Morphological Operators, Erosion, Dilation, Opening, Closing, Exact Histogram Equalization, Contrast per Pixel (CPP), Variance Value, Mean Value

1. Introduction

Recently, the image processing plays a very important role and function in different arena of research and engineering. Hence to increase the potency of this arena, merits of an image should be strengthen to brace the human sensitivity as well as for machine visualization. The contrast of an image is a subjective appraise of difference of gray levels available in the image. There are many numbers of individual methods available for image contrast enhancement, like Gamma Correction, Power law transformation, histogram equalization, Adaptive Histogram Equalization, Contrast limited AHE etc. they all are based on the principle of image statistics variation. In this project work a novel approach for image contrast enhancement is proposed using the non-uniform illumination Revisory and exact histogram equalization. The proposed technique is a hybrid method, which utilizes two individual contrast correction and enhancement techniques collectively.

In the past most of the contrast enhancement problems have been resolved using conventional histogram equalization (HE) and adaptive histogram equalization (AHE) techniques. These techniques basically work on one simple principle of assumption that the cumulative distribution function is consistently invertible but pragmatically this is not the case when the images are in discrete form. Where as in the continuous case, statistical models of histogram equalization/specification would provide exact results, their discrete correlative fails. This is due to the attribute that the cumulative distribution functions one concern with are not exactly invertible. Otherwise stated, exact histogram specification for discrete images is an ill-posed problem. Invertible cumulative distribution functions are acquired by translating the issue in a K dimensional space and furthermore producing a strict ordering in between image pixels. The proposed ordering refines the natural one.

Therefore the proposed technique basically concern with the equalization/ modification of poor contrast input image histograms is firstly correction of non-uniform illumination is done by morphological operators then followed by exact histogram specification processes for contrast restoration. The proposed method is basically single channel technique, so the second part of this project work is the implementation of the single channel proposed technique for color image contrast enhancement. For the implementation of proposed single channel technique this project work will utilize RGBcolor model. In this process the input poor contrast color image is first divided into red, green and blue constituent components and then their poor contrast is stretched by simultaneously applying proposed single channel method on each constituent component.

2. Mathematical Morphological Operators

Mathematical morphology is a method or technique which is used for the analysis or processing or to determine the shape of structures present in image. This theory or method based on the principle of lattice theory, set theory and random functions. Morphological operators are commonly used to differentiate between the foreground and background in a digital image. It is also used for doing correction of non-uniform illumination.

So in this project it is basically used for the correction of non-uniform illumination and for distinguishing between foreground and background. Morphological operators are of four types, these are EROSION, DILATION, OPENING AND CLOSING. The basic operators of morphological operators are Erosion and Dilation. Opening and Closing are the combination of Erosion and Dilation. Opening and Closing is opposite of each other. Here operators are discussed in brief,

1) Erosion: Erosion of a binary image A can be defined as the structure element set B's translation should be the

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subset or same set of A. The mathematical expression for Erosion is given below:

$$A \ominus B = \{z \in E | B_z \subseteq A\}. \quad (1)$$

where B_z is the translation of B by the vector z, i.e.

$$B_z = \{b + z | b \in B\}, \forall z \in E. \quad (2)$$

2) Dilation: Dilation of a binary image A can be defined as the structure element set B's symmetricity's translation intersection with A should not be null-set. The mathematical expression for Dilation is given below:-

$$A \oplus B = \{z \in E | (B^s)_z \cap A \neq \varnothing\}, \quad (3)$$

Where B^s denotes the symmetric of B, that is,

$$B^s = \{x \in E | -x \in B\}. \quad (4)$$

3) Opening: Opening Operation is the combination of erosion and dilation in a certain way. In opening operation of A by B is obtained by erosion of A by B then followed by dilation of the resulting image by B:

$$A \circ B = (A \ominus B) \oplus B. \quad (5)$$

4) Closing: Closing operation is the combination erosion and Dilation. In closing operation of A by B is obtained by dilation of A by B then followed by erosion of the resulting image by B:

$$A \circ B = (A \ominus B) \oplus B. \quad (6)$$

3. Exact Histogram Equalization

The discrete genre of the statistical commence could have produced exact results (perfectly equalized/specified histograms) if CDFs had been irreversible [1]. In the discrete case, CDFs are staircase functions; in the discrete case hence they are not irreversible excluding in the case when pixels take definite values. Since the number of pixels in an image is usually considerably larger than the number of gray levels, the distinct pixel value case is irrelevant. The CDF of an RVz determines the probabilities $P\{Z \leq z\}$ and consequently, it depends on the ordering relation used. Otherwise stated, a discrete exact histogram equalization/specification problem is solved if the usual ordering is changed by a new ordering relation who produces a stern ordering in between image pixels. (Note that a strict ordering decreases the issue of the definite pixel case.)

Principle

Let f be a discrete NxM image and having L gray levels. Let $H = \{h_1, h_2, h_3 \cdots h_{L-1}\}$ be the histogram which is to be specified. Note that H is the non-normalized image histogram, i.e. h_l, is the number of pixels having gray level l. Let us further imagine that an ordering relation, $\prec$, is defined in between the pixels of f such that the induced ordering is stern. The exact histogram specification follows following three steps:

1) Ordering image pixels is done in ascending order:

$$f(x_1, y_1) \prec f(x_2, y_2) \prec \ldots \prec f(x_{NM}, y_{NM}). \quad (7)$$

2) Group the ordered string (7) from left to right in L number of groups, such as group j has h_j pixels.
3) For all the pixels in a group j, assign gray level j respectively. The exact equalization algorithm considers groups of NM/L no. of pixels in step 2).

The above mentioned technique produces exact results, namely the image is transformed to obtain exactly the desired histogram, provided that such a histogram is a valid one. The validity of The histograms is only valid when equality among the image size (number of pixels) and the sum of histogram bins is satisfied, i.e.,

$$\sum_{i=0}^{L-1} h(i) = N \times M. \quad (8)$$

Specific a histogram is equal to specifying a certain distribution whose PDF is absolutely the normalized image histogram. Hence histogram bins take integer values, for an N x M size image, PDFs cannot be specified at a resolution better than

$$\epsilon = \frac{1}{MN}. \quad (9)$$

In other words, given any desired continuous distribution, a N x M image can be transformed to approximate it with the precision defined in (3).

Equation (1) requires strict inequalities. On the other hand, the histogram specification algorithm described previously does not require an absolutely strict ordered sequence; it simply requires discriminating among L groups of pixels. Otherwise stated, problems appear when equal gray level pixels have to be separated (have to be assigned to different gray levels). Besides, even if two pixels or a small group of equal pixels have to be split into two distinct groups, the error is not significant. Therefore, we can relax the condition of stern ordering to nearly strict ordering. In fact, we could generally adopt that some small clusters of pixels are equivalent in the sense of the considered ordering.

4. Proposed Hybrid Technique

The proposed method uses a hybrid technique for efficient image enhancement. The flow chart representation of the single channel flow of the proposed work is shown in figure (a).

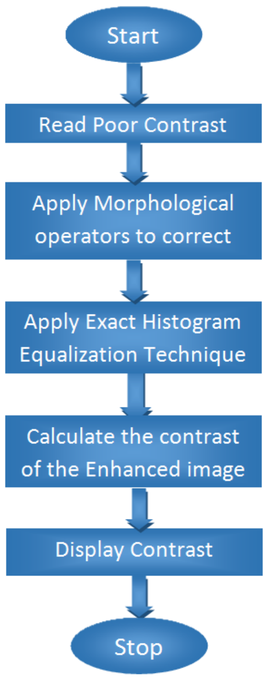

Figure (a): Flow chart of proposed methodology.

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In the proposed algorithm first step is to correct the non-uniform illumination using morphological operators followed by the second step, which utilizes exact histogram equalization to efficiently increase the contrast of the input image.

5. Performance Evaluation and Simulation Results

The proposed scheme / technique i.e., Image Enhancement Using Non-Uniform Illumination Revisory and Exact Histogram Equalization is implemented in MATLAB 7.10.0(R2010a) version software. For performance evaluation or quality of the output image, we have considered the three parameters, they are:

1) Mean: Mean value gives the benefaction of particular pixel intensity for the whole image & Its mathematical expression for Mean is as follows,

$$\mu = \frac{1}{N}\sum_{i=0}^{N-1} X_i \qquad (10)$$

Where μ is a Mean value, N is total no. of pixels and the value of i ranges from 0 to N-1. Mean value of any enhanced image should be closed to the exactly half of the size of the image. For 256×256 image the mean value should be equals to or nearly to 128.

2) Variance: The variance is a measure of how far a set of numbers pixels are spread out. Mathematically variance is given by,

$$\sigma^2 = \frac{1}{N-1}\sum_{i=0}^{N-1}(X_i - \mu)^2 \qquad (11)$$

Where σ, is the Variance value, μ is a Mean value, N is total no. of pixels and the value of i ranges from 0 to N-1. The value of variance should be maximum as possible.

3) Contrast per Pixel: Contrast-per-pixel measures the average intensity difference among a pixel and its adjacent pixels. Mathematical expression is give below,

$$C = \frac{\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}\left(\sum_{(m,n)\in R_3^{(i,j)}}|\gamma(i,j)-\gamma(m,n)|\right)}{M*N*8} \qquad (12)$$

Where $\gamma(i,j)$ is the image and $\gamma(m,n)$ is the kernel. M and N are the rows and columns of image $\gamma(i,j)$. The value CPP should be high as much possible.

Let's taking a standard image which is known as Barbara (256×256), which is shown figure(b) below, its contrast reduced image and its Histogram graph in figure(c) & figure(d).

Figure (b)

Figure(c)

Table 1

Mean	Variance	CPP
11.7906	27.7347	1.571

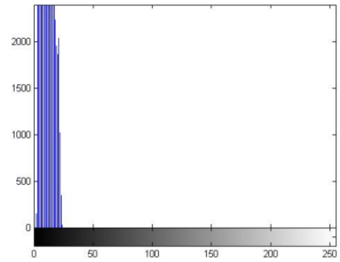

Figure (d)

The value of Mean, Variance and CPP of the Contrast reduced image is given in the above Table (1). Now we will apply the proposed technique i.e., **Non-Uniform Illumination and Exact Histogram Equalization** in the poor contrast image figure(c) we will get the following result which is shown in figure (e), (f) and Table (2).

Figure (e) Enhanced Image

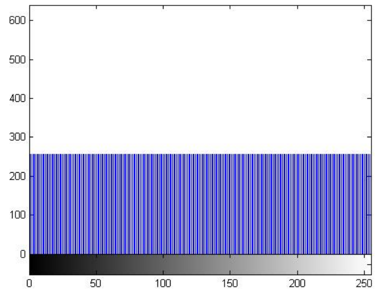

Figure (f) Histogram graph

Table 2

Mean	Variance	CPP
127.5	5461.334	16.9882

As we can see the result for the proposed technique we get mean value 127.5 which very closer to the ideal mean value, variance 5461.334 and CPP which is 16.9882 is very good result. And form the Histogram we can see that the pixels are uniformly distributed all over the graph, which shows the good result.

6. Conclusion

In this paper, we have discussed about the image enhancement a technique which is hybrid method i.e., Image Enhancement using Non-Uniform Revisory and Exact Histogram Equalization with many more techniques to increase the efficiency. Histogram equalization gives

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under contrast enhancement and Adaptive Histogram Equalization gives over contrast enhancement. To another method is given to overcome from over contrast enhancement namely Contrast Limited AHE.

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