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Detection of Abnormalities in Leukemia Images Using Contrast Enhancement

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ABSTRACT: An intelligent Image Processing Technique employed in a system can be very helpful for radiologist in detecting and diagnosing micro calcifications' patterns earlier and faster than typical screening programs. Image Enhancement takes important part in medical image processing. Contrast enhancement is important and useful for medical images. One of the widely accepted contrast enhancement method is histogram equalization (HE). Histogram Equalization usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. By contrast enhancement and analyzing its corresponding histograms in a statistical representation it is helpful to early diagnose the disorders. In this work the main area of processing is various medical imaging modalities involved in Leukemia. For this purpose the tools used are MATLAB and MIPAV.

KEYWORDS: component; Histogram Equalization; CLAHE Image Enhancement; Medical Imaginary

I. INTRODUCTION

Image enhancement improves the quality (clarity) of images for human viewing. Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations. For example, an image might be taken of an endothelial cell, which might be of low contrast and somewhat blurred. Reducing the noise and blurring and increasing the contrast range could enhance the image. The original image might have areas of very high and very low intensity, which mask details. An adaptive enhancement algorithm reveals these details. Adaptive algorithms adjust their operation based on the image information (pixels) being processed. In this case the mean intensity, contrast, and sharpness (amount of blur removal) could be adjusted based on the pixel intensity statistics in various areas of the image. Image processing technology is used by planetary scientists to enhance images of Mars, Venus, or other planets. Doctors use this technology to manipulate CAT scans and MRI images.

Image Enhancement can be done in two methods. They are Spatial Domain Method and Frequency Domain Method. The term spatial domain refers to the aggregate of pixels composing an image and spatial domain methods are procedures that operate directly on this pixels. Spatial domain may be divided as Contrast Enhancement and Point Processing. Contrast Enhancement again classified as Histogram Equalization and CLAHE (Contrast Limited Adaptive Histogram Equalization). The concept of filtering is easier to visualize in the frequency domain. Therefore, enhancement of image $f(m,n)$ can be done in the frequency domain, based on its DFT $F(u, v)$.

II. CONTRAST ENHANCEMENT

Contrast enhancement process plays an important role in enhancing medical images quality. Several previous studies proved that contrast enhancement techniques capable to clean up the unwanted noises and enhance the images brightness and contrast. The resulting enhanced medical images provided clearer and cleaner images for better and easier disease screening process by doctor. Pap test is the most popular and effective screening test for cervical cancer. Contrast is one of the factors that influence the accuracy of interpretation of cervical cancer cells on Pap smear images by pathologist. Blur and highly affected by unwanted noise on Pap smear images could give rise in false diagnosis rate. The current study combined moving *k*-means clustering algorithm and linear contrast enhancement to be used as contrast enhancement technique. Then, the proposed technique was used to enhance the contrast of Pap smear images. The results indicated that the proposed method could enhance the contrast of Pap smear images better than conventional linear contrast enhancement technique as well as using moving *k*-means clustering algorithm alone. The

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changes of grey level, size and shape of cervical cells' nucleus and cytoplasm were enhanced and thus, provide clearly seen Pap smear images for better cervical cancer screening process by pathologist.

Contrast enhancement does this by setting all color components below a specified lower bound to zero, and all color components above a specified upper bound to the maximum intensity (that is, 255). Color components between the upper and lower bounds are set to a linear ramp of values between 0 and 255. Because the upper bound must be greater than the lower bound, the lower bound must be between 0 and 254, and the upper bound must be between 1 and 255.Contrast Enhancement is classified as two types. They are HE(Histogram Equalization)and CLAHE(Contrast Limited Adaptive Histogram Equalization).

III. CONTRAST ENHANCEMENT TECHNIQUES

A. Histogram Equalization:

The histogram of a discrete gray-level image represents the frequency of occurrence of all gray-levels in the image. Histogram equalization (HE) is widely used for contrast enhancement in digital images. However, this technique is not very well suited to be implemented in consumer electronics, such as television, because the method tends to introduce unnecessary visual deterioration such as the saturation effect. One of the solutions to overcome this weakness is by preserving the mean brightness of the input image inside the output image. For improving the contrast in digital images, Histogram Equalization (HE) is one of the common methods used for contrast enhancement. Some applications may benefit from a uniform distribution of the pixel intensities over the whole range of the interval [0,1].We can use the normalised histogram function to compute an intensity transformation function giving a more uniform distribution of the intensities. This process is called histogram equalisation. Histogram equalization is a specific case of the more general class of histogram remapping methods. These methods seek to adjust the image to make it easier to analyze or improve visual quality.

Consider for a moment continuous functions, and let the variable r represent the gray levels of the image to be enhanced. In the initial part of our discussion we assume that r has been normalized to the interval [0, 1], with $r = 0$ representing black and $r = 1$ representing white. Later, we consider a discrete formulation and allow pixel values to be in the interval [0, L-1].

For any r satisfying the aforementioned conditions, we focus attention on transformations of the form

$$S = T(r) \qquad 0 \le r \le 1 \qquad (1)$$

that produce a level s for every pixel value r in the original image. For reasons that will become obvious shortly, we assume that the transformation function T(r) satisfies the following conditions:

(a) T(r) is single-valued and monotonically increasing in the interval $0 \le r \le 1$; and

(b) $0 \le T(r) \le 1$ for $0 \le r \le 1$.

The requirement in (a) that T(r) be single valued is needed to guarantee that the inverse transformation will exist, and the monotonicity condition preserves the increasing order from black to white in the output image. A transformation function that is not monotonically increasing could result in at least a section of the intensity range being inverted, thus producing some inverted gray levels in the output image. While this may be a desirable effect in some cases, that is not what we are after in the present discussion.
Finally, condition (b) guarantees that the output gray levels will be in the same range as the input levels. The inverse transformation from s back to r is denoted

$$r = T^{-1}(s) \qquad 0 \le s \le 1 \qquad (2)$$

It can be shown that even if T(r) satisfies conditions (a) and (b), it is possible that the corresponding inverse $T^{-1}(s)$ may fail to be single valued.

The gray levels in an image may be viewed as random variables in the interval [0, 1]. One of the most fundamental descriptors of a random variable is its probability density function (PDF). Let pr (r) and p_s (s) denote the probability density functions of random variables r and s, respectively, where the subscripts on p are used to denote that pr and ps are different functions. A basic result from an elementary probability theory is that, if pr(r) and T(r) are

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known and T^{-1} (s) satisfies condition (a), then the probability density function p_s(s) of the transformed variable s can be obtained using a rather simple formula:

$$p_s(s) = p_r(r)\,\left|dr/ds\right| \qquad (3)$$

Thus, the probability density function of the transformed variable, s, is determined by the gray-level PDF of the input image and by the chosen transformation function. A transformation function of particular importance in image processing has the form

$$S=T(r)=\int_0^r pr\,(w)dw \qquad (4)$$

Where w is a dummy variable of integration. The right side of Eq.4 is recognized as the cumulative distribution function (CDF) of random variable r. Since probability density functions are always positive, and recalling that the integral of a function is the area under the function, it follows that this transformation function is single valued and monotonically increasing, and, therefore, satisfies condition (a). similarly, the integral of a probability density function for variables in the range [0, 1] also is in the range [0, 1], so condition (b) is satisfied as well.

Given transformation function T(r), we find ps(s) by applying Eq.3. We know from basic calculus (Leibniz's rule) that the derivative of a definite integral with respect to its upper limit is simply the integrand evaluated at that limit. In other words,

$$\frac{ds}{dr} = dT(r)/dr$$
$$= \frac{d}{dr}\left[\int_0^r p_r(w)dw\right]$$
$$= p_r(r) \qquad (5)$$

Substituting this result for dr/ds into Eq.3, and keeping in mind that all probability values are positive, yields

$$p_s(s) = p_r(r)\left|\frac{dr}{ds}\right|$$
$$= p_r(r)\left|\frac{1}{p_r(r)}\right|$$
$$= 1 \quad 0 \le s \le 1 \qquad (6)$$

Because ps(s) is a probability density function, it follows that it must be zero outside the interval [0, 1] in this case because its integral over all values of s must equal 1. We recognize the form of ps(s) given in Eq.6 as a uniform probability density function.

B. CLAHE:

CLAHE stands for *contrast limiting adaptive histogram equalization.* CLAHE was originally developed for medical imaging and has proven to be successful for enhancement of low-contrast images such as portal films. The CLAHE algorithm partitions the images into contextual regions and applies the histogram equalization to each one. This evens out the distribution of used grey values and thus makes hidden features of the image more visible. The full grey spectrum is used to express the image. Contrast Limited Adaptive Histogram Equalization, CLAHE, is an improved version of AHE, or Adaptive Histogram Equalization. Both overcome the limitations of standard histogram equalization.

A variety of adaptive contrast-limited histogram equalization techniques (CLAHE) are provided. Sharp field edges can be maintained by selective enhancement within the field boundaries. Selective enhancement is accomplished by first detecting the field edge in a portal image and then only processing those regions of the image that lie inside the field edge. Noise can be reduced while maintaining the high spatial frequency content of the image by applying a combination of CLAHE, median filtration and edge sharpening. This technique known as Sequential processing can be recorded into a user macro for repeat application at any time. A variation of the contrast limited technique called adaptive histogram clip (AHC) can also be applied. AHC automatically adjusts clipping level and moderates over enhancement of background regions of portal images.

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IV. EXPERIMENTAL RESULTS

Leukemia (leukemia in Commonwealth English) is a cancer of the blood or bone marrow characterized by an abnormal proliferation of blood cells, usually white blood cells (leukocytes). It is part of the broad group of diseases called hematological neoplasms. Leukocytes or white blood cells, protect the body against infections and participate in many types of immunologic and inflammatory responses. There are two main types of leukocytes: lymphocytes, which are responsible for antibody production and cell-mediated immunity, and phagocytes, which are responsible for the ingestion and killing of microorganisms. In this report the main problem considered is about the classification under Lymphocytes named "Hodgkin's Lymphoma".

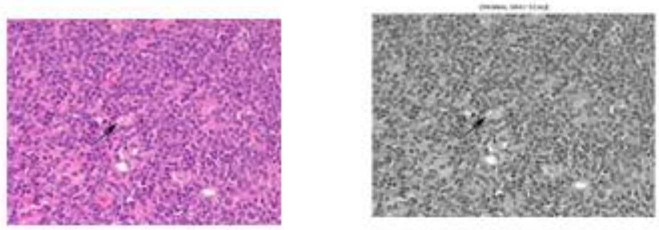

Fig 1:Colour image of pop corn cell and its original gray scale image

Fig1 is a microscopic image of effected cells with Hodgkin's disease. This image consists of lymphocytes,RS cells, neutrophils, leukocytes etc..,and all these cells present in a bone marrow. The original color image is converted in to original gray scale image inorder to apply enhancement techniques.

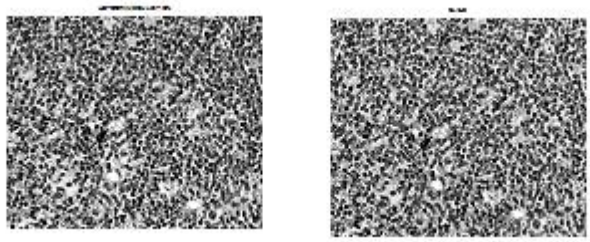

Fig 2: HE and its CLAHE

The original gray scale image is enhanced by Histogram Equilization(HE) method.This image shows the wide range of the intensity in a high contrast image.HE changes the appearance of an image.The arrow marks indicate the popcorn cells which were unable to identify in original image.The pop corn cells are originated from the normal cells when they are effected to the earlier dicussed abnormality Hodgkin's disease. This image shows the contrast enhancement .CLAHE has the tendency to overamplify the image.Contrast increases at light color cells while the contrast decreases at dark color cells.

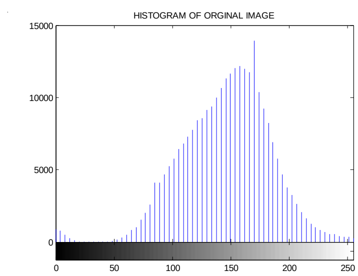

Fig 3:Histogram of original image

Figure3 shows the histogram of original gray scale image.The gray scale range is 0 to250.Histogram has a narrow shape which indicates that the image having low contrast.

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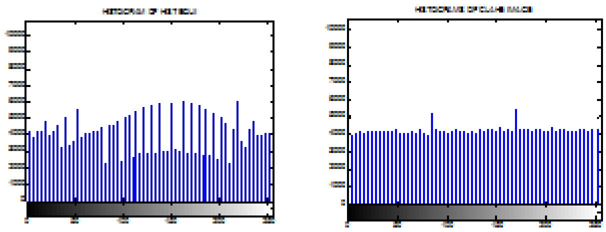

Fig 4: Histogram of HE and CLAHE

Figure4 shows the histogram of image after histogram equalization and CLAHE methods.This figure shows a histogram with significant spread to an image with high contrast.But,the histogram is not flat and the distribution of pixels is somewhat not uniform.Significant spread of histograms shows that the image contrast is enhanced..The Histogram of CLAHE figure shows a histogram with significant spread to an image with high contrast.Observe that the histogram is flat and the distribution of pixels is more uniform.

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