Wavelet based image enhancement by using local, partial , dark and bright contrast for leukemia images.

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ABSTRACT

Leukaemia is a malignant disease (cancer) that affects people in any age either they are children or adults over 50 years old. Nowadays, there are screening system guidelines for leukaemia patients. The screening result from looking at asample of patient blood, can determine the abnormal levels of white blood cells,which may suggest leukaemia for further diagnostic stage. Therefore, medical professional using medical images to diagnose leukemia. However, there are blurness and effects of unwanted noise on blood leukaemia images that sometimes result in false diagnosis. Thus image pre-processing such as image enhancement techniques are needed to improve this situation .

In this paper ,three techniques are proposed based on wavelet transform and local contrast, dark contrast ,bright contrast and partial contrast. All techniques applied on the leukaemia images. The comparison for all the proposed image enhancement techniques was carried out to find the best technique to enhance the acute leukaemia images. The results show that the wavelet based partial contrast stretching is the best technique that helps to improve the image quality .

Key Word : Enhancement, contrast, leukemia, wavelet, PSNR, AMBE, visual Quality.

1-introduction

Medical image processing is a field of science that is gaining wide acceptance in healthcare industry due to its technological advances and software breakthroughs. It plays a vital role in disease diagnosis and in improved patient care. It also helps medical practitioners during decision making with regard to the type of treatment. Several state-of-the-art equipments produce human organs in digital form which includes X-ray-based devices, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), Ultrasound (US), Positron Emission Tomography (PET) and Single Photon Emission Computed Tomography (SPECT). Irrespective of the equipment used, the raw images produced by such devices have to be processed so that the visual appearance of the image has to be converted to a form which is better suited for image analysis and understanding. The techniques and methods used for this purpose are often termed as 'Image Enhancement Techniques' and are widely used in research field. These techniques aid in the improvement of an image appearance by enhancing image features or by decreasing ambiguity between different regions of the image [1].

Image enhancement refers to the process of performing a set of operations on an image to improve its visual appeal. This involves an increase of the contrast range or an improvement of the perceptibility of the various details present in an image. There exist a variety of spatial and frequency domain methods that achieve the same.[2]

To date, several research groups have focused on the development of computerized systems that can analyze different types of medical images and extract useful information for the medical professional [3]. Most of the proposed methods use images acquired during a diagnostic procedure . Medical professional use medical images to diagnose leukemia. Leukemia is the common malignancy in childhood and is second only to accidents as the major cause of most

death in childhood in the age group 1-15 years . It is characterized by the uncontrolled accumulation of immature white blood cells. Leukemia begins in a cell in the bone marrow, it becomes immature cell and functionless in the blood. However, in some cases, the leukemia images are blurred, low contrast, hazy and afflicted by unwanted noises[4]. These problems can hide and cause difficulty to interpret the important leukemia morphologies, hence increasing false diagnosis. The main purpose of image enhancement is to bring out detail that is hidden in an image or to increase contrast in a low contrast image. Whenever an image is converted from one form to other such as digitizing the image some form of degradation occurs at output[5]

2- Discrete Wavelet Transform (DWT)

The wavelet transform has become an essential tool for many applications. However, the wavelet transform has been presented a method representing a time-frequency method, continuous wavelets transform (CWT), and the wavelet transform generally has used for the decomposition of the signal into high and low frequency components. The wavelet coefficient represents a measure of similarity in the frequency content between a signal and a chosen wavelet function. These coefficients are computed as a convolution of the signal and the scaled wavelet function, which can be interpreted as a dilated band-pass filter because of its band-pass like spectrum [6] .

The result of the DWT is a multilevel decomposition, in which the signal is decomposed in approximation and detail coefficients at each level . This is made through a process that is equivalent to low-pass and high passes filtering, respectively.

If a signal, $x(t)$, decomposed into low and high frequency components, that they are respectively named as approximation coefficients and detail coefficients, $x(t)$ reconstructed as;

$$x(t) = \sum_{m=1}^{L}\left[\sum_{k=-\infty}^{\infty} D_m(k)\psi_{m,k}(t) + \sum_{k=-\infty}^{\infty} A_l(k)\phi_{l,k}(t)\right]$$

Where $\psi_{m,k}(t)$ is discrete analysis wavelet, and $\phi_{l,k}(l)$ is discrete scaling, $D_m(k)$ is the detailed signal at scale $2m$, and $A_l(k)$ is the approximated signal at scale $2l$. $D_m(k)$ and $Al(k)$ is obtained using the scaling and wavelet filters .

The image signal is considered as rows and columns as if they are one dimentional signals. In DWT, firstly each row of the image is filtered, then each column is filtered. After each filtering, the subsampling is realized. The result of this process gives four images, approximation, horizantal details, vertical details and diagonal details. Because of subsampling after each filtering, the result sub images of the original image has the quarter size of the original image [7].

3- Contrast

Image enhancement processes consist of a collection of techniques that seek to improve the visual appearance of an image or to convert the image to a form better suited for analysis by a human or machine [8]. Meanwhile, the term image enhancement means as the improvement of an image appearance by increasing dominance of some features or by decreasing ambiguity between different regions of the image .

Contrast stretching is the image enhancement technique that commonly used for medical images. To date, contrast stretching process plays an important role in enhancing the quality and contrast of medical images [9].

3-1- Local Contrast Stretching

Local contrast stretching is an enhancement method performed on an image for locally adjusting each picture element value to improve the visualization of structures in both darkest and lightest portions of the image at the same time. The local contrast can be performed by using the formula :

$Ip\ (x, y) = 255 * (Io\ (x, y) – min) /(max - min)$

Where :

Ip(*x*, *y*) is the color level for the output pixel(x, y) after the contrast stretching process.

Io(*x*, *y*) is the color level input for data the pixel(x, y).

max - is the maximum value for color level in the input image.

min - is the minimum value for color level in the input image [10].

3-2 Partial Contrast

Partial contrast is an auto scaling method. It is a linear mapping function that is usually used to increase the contrast level and brightness level of the image. This technique will be based on the original brightness and contrast level of the images to do the adjustment.

The input images are the RGB model, so it is necessary to find the average for the red, blue and green intensities, for upper and lower color values by using the formula :

$min_{TH}=(min_{Red} + min_{Blue} + min_{Green})/3$

$max_{TH}\ (max_{Red} + max_{Blue} + max_{Green})/3$

max_{Red}, max_{Blue} and max_{Green} are the maximum color level for each red, blue and green color palettes, respectively. min_{Red}, min_{Blue} and min_{Green} are the minimum value for each color palette, respectively, max_{TH} and min_{TH} are the average number of these maximum and minimum color levels for each color space. The max_{TH} and min_{TH} will be used as the desired color ranges for all the three color palettes.The function that can be used for the pixels transformation, which is based on the concept of the linear mapping function [11].

$$out(x,y)=\begin{cases}\dfrac{in(x,y)}{minTH}*Nmin TH & for\ \ in(x,y)>minTH\\ \left[\dfrac{(Nmax TH-Nmin TH)}{maxTH-minTH}*(in(x,y)-f\min)\right]+\min & for\ \ minTH<in(x,y)<maxTH\\ \dfrac{in(x,y)}{maxTH}*Nmax TH & for\ \ in(x,y)<maxTH\end{cases}$$

Where :

in(*x,y*) is the color level for the input pixel .

out(*x,y*) is the color level for the output pixel .

min_{TH} is lower threshold value .

max_{TH} is upper threshold value .

Nmin_{TH} is the new lower stretching value .

Nmax_{TH} is a new upper stretching value. The pixel within the range of min_{TH} and max_{TH} will be stretched to the desire range of *N*max_{TH} to *N*min_{TH}, whereas the remaining pixels will experience compression. By this stretching and compressing proceses, the pixels of the image can be mapped to a wider range and brighter intensities, as a result the contrast and the brightness level of the raw images are increased. Figure (1) illustrates the compression and stretching processes for partial contrast method. [3]

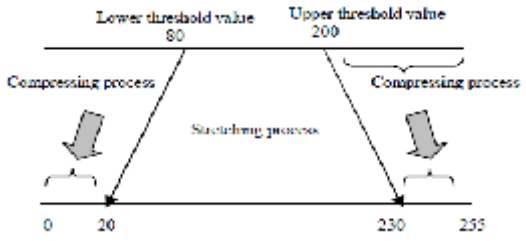


Figure (1) Partial contrast method

3-3. Bright Contrast Stretching

Bright stretching is a process that also used auto scaling method which is a common linear mapping function to enhance the brightness and contrast level of an image. [12]. The bright stretching process is implemented based on the following equation :

$$out(x,y)=\begin{cases}\dfrac{in(x,y)}{TH}*NewTH & for\ in(x,y)<TH\\ \left[\dfrac{(in(x,y)\ \ TH)}{255\ \ TH}*(255-NewTH)\right]+\min & for\ in(x,y)>TH\end{cases}$$

where,

TH : threshold value

New_{TH} : bright stretching factor, it is a new range of bright stretching pixel for the threshold value of red, green and blue.

in(x,y) is a value of color level at pixel *(x,y)* from the input image[3].

3-4 Dark Contrast Stretching

Dark stretching is known as part of partial contrast stretching. This process is also used auto scaling method which is the reverse process of bright stretching process. Dark stretching can be described by the following equation:

$$out(x,y)=\begin{cases}\dfrac{in(x,y)-TH}{255-TH}*NewTH & for\ in(x,y)<TH\\ \left[\dfrac{(in(x,y)-TH)}{255-TH}*(255-NewTH)\right]+\min & for\ in(x,y)>TH\end{cases}$$

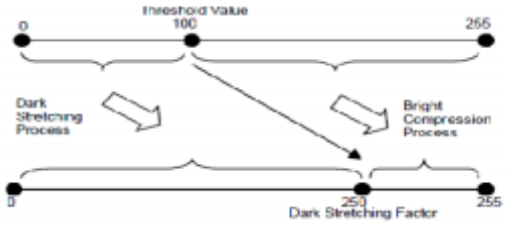
Where:

in(x,y) : value of pixel color level located at *(x,y)* input image

TH : threshold value.

New_{TH} : dark stretching factor

Figure (2) shows the dark stretching process with the value of 100 is used as an example of threshold value and 250 as a dark stretching factor [9] .



Figure(2) Dark contrast Stretching .

4- Metrics for enhanced images .

4-1 Peak-signal-to-noise-ratio (PSNR) .

PSNR is the evaluation standard of the reconstructed image quality, and is important measurement feature. PSNR is measured in decibels (dB) and is given by:

$PSNR= 10*\log_{10}(255^2/MSE)$.

where the value 255 is maximum possible value that can be attained by the image signal. Mean square error (MSE) is defined as [2]:

MSE= $\left[\frac{1}{MN}\sum_{x=0}^{M-1}\sum_{y=0}^{N-1}[\hat{f}(x,y)-f(x,y)]^2\right]^{\frac{1}{2}}$

Wher:

M*N is the size of the original image

$\hat{f}(x,y)$: is the enhanced image.

$f(x,y)$: is the original image

Higher the PSNR value is, better the reconstructed image.

4-2 Absolute mean brightness error (AMBE).

It is the difference between original and enhanced image and is given as[5]:

AMBE= |E(x) - E(y)|

Where E(x)= average intensity of input image, E(y)=average intensity of enhanced image . Lower the value of (AMBE), lower the value of the error .

4-3. Contrast.

Contrast defines the difference between lowest and highest intensity level. Higher the value of contrast means more difference between lowest and highest intensity level[5].

4-4. Visual Quality .

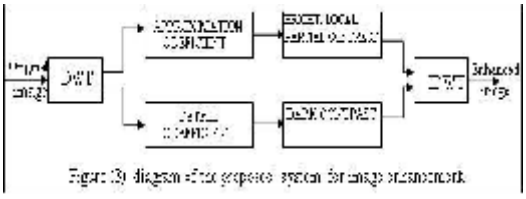
By looking at the enhanced image, one can easily determine the difference between the input

image and the enhanced image and hence, performance of the enhancement technique is evaluated.

5- Proposed Methods

This study proposes technique for image enhancement based on wavelet transform using local contrast, partial contrast, bright and dark contrast. The proposed method takes the advantage of wavelet transform in which the approximation coefficient have the most important information of the original image ,these coefficients must be improved and stretched by using contrast methods (partial contrast, bright contrast and local contrast) .

Contrast is used to increase the levels of bright of the coefficients ,by these stretching, the pixels of the image can be mapped to wider range and bright intensities, as a result the contrast and the brightness level of the approximation coefficient of the raw image are increased . The detail coefficients have less information of the image and the values of these coefficients will be small as compared with approximation coefficients values because it represents the darkness information of the image and we can increase the information of these coefficients , these coefficients can be stretched by using contrast for the lowest level of the coefficient ,this process is the reveres of the bright stretching process which stretch the low level and compress high level, this process is called dark contrast. Figure (3) shows the stages of the proposed methods for image enhancement.



5-1 Proposed Algorithm

We used matlab language in the proposed algorithm and there are five steps involved in the purposed algorithm which are:

1-select image with different characteristics for the leukemia images.

2-decompose the image by using wavelet transform to get the approximation and detail subband coefficients.

3-apply bright, local and partial contrast to the approximation subband of the wavelet coefficients.

4-apply dark contrast to the detail subband of the wavelet coefficients .

5-reconstruct the images by using inverse wavelet transform and determine the performance of the enhanced image using metric of enhanced image.

6- Results and Discussion

To verify the efficacy of the proposed method, the results of applying the different proposed techniques must be compared, we must compare between the image enhancement techniques, the comparison of image before and after enhancement is needed. The proposed enhancement techniques were applied to two leukemia images labeled as (image1) and (image2), those images were categorized based on the human visual interpretation.

6-1 Results of image1

Figure(4) shows the visual quality for the real image (image 1) and the enhanced images using three different image enhancement techniques . Table (1) describes the performance of these techniques which evaluated in terms of PSNR, AMBE and contrast measurements.

In terms of quality, the proposed techniques give best results as shown in the values of (PSNR) in Table(1), the value of PSNR is increased from (31 dB)in contrast method to(33.11, 33 and 33.36 dB)in bright contrast based wavelet ,partial contrast based wavelet and local contrast based wavelet, respectively, also the value of contrast factor are increased from (142.67) to (163.33,178.67 and 163),respectively, for the proposed techniques, which means that the

proposed techniques give high description for the images, while the error in (AMBE) measure are decreased from (46.41) to (29.47,1.25 and 28.52), respectively, for the proposed techniques.

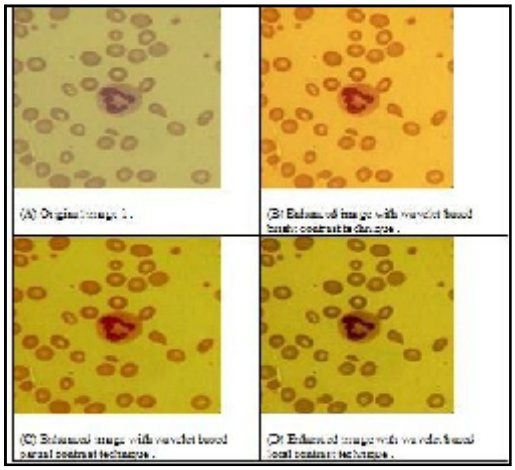


Figure (4) Enhancement Images for image1 by the proposed methods .

Table 1shows comparison of various techniques for image 1

Method	PSNR (dB)	AMBE	CONTRAST
Contrast method	31.006	46.4136	142.666
Bright contrast based wavelet	33.116	29.47	163.333
partial contrast based wavelet	33.003	1.2574	178.67
local contrast based wavelet	33.362	28.52	163.000

6-2 Results of image 2

Figure (5) shows the visual quality for the real image (image 2) and the enhanced image using three different image enhancement techniques .Table 2 describes the performance of these techniques in terms of PSNR ,AMBE and contrast measurements.

Table (2) shows that the proposed techniques gives good results in terms of (PSNR), the value of PSNR is increased from (32.59 dB)in contrast method to(32.88 dB) in partial contrast based wavelet and increased to(34.8dB) in local contrast based wavelet, also the value of contrast factor are increased from (111.67) to (212.33, 214.67 and 216) in bright contrast based wavelet ,partial contrast based wavelet and local contrast based wavelet, respectively, which means high description for the image, while the proposed techniques give low values in (AMBE) values ,especially by using wavelet based partial contrast techniques .

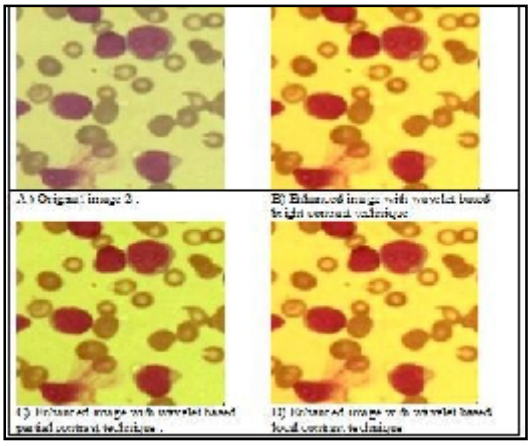


Figure (5) Enhancement Images for image2 by the proposed methods .

Table 2 shows performance of various techniques for image 2.

Method	PSNR	AMBE	CONTRAST
Contrast	32.593	17.4155	111.6667
Bright contrast based wavelet	32.595	28.8819	212.3333
partial contrast based wavelet	32.885	2.2068	214.6667
local contrast based wavelet	34.801	14.5040	216.0000

From Figure(4) and Figure(5), the two types of images are become brighter and clearer than original images. Characteristic of nucleus and cytoplasm of the immature white blood cells after applying these techniques was good.

Table (1) and Table(2) show that the wavelet based partial contrast gives the best results in terms of contrast and absolute mean bright error . In the leukemia images dark area is refer to nucleus, therefore the nucleus is clearer because of the stretching step in dark stretching method,

that used for the darkness coefficients in the proposed system .

7-Conclusions

The present research work focus on developing image enhancement techniques designed specifically for leukemia images. All the proposed techniques are effective in enhancing the leukemia images, from those techniques the partial contrast based on wavelet transform gives the best results and hopefully could give extra information for nucleus and cytoplasm of acute leukemia image, the experimental results proved that the proposed techniques produce significant improvement for leukemia images that have been applied to this techniques and lead to be clearer and hopefully would use further analysis by hematologist.

REFERENCES

[1] K. Karthikeyan, C. Chandrasekar, "Wavelet-based Image Enhancement Techniques for Improving Visual Quality of Ultrasonic Images", International Journal of Computer Applications (0975 – 8887), Vol.39, No.17, p.p.49-53, February 2012.

[2] Rakhi Chanana, Er.Parneet Kaur Randhawa, Er.Navneet Singh Randhawa ، "Spatial Domain based Image Enhancement Techniques for Scanned Electron Microscope (SEM) images" , International Journal of Computer Science Issues(IJCSI), Vol. 8, Issue 4, No 2, p.p.580-586, July 2011.

[3] N.R.Mokhtar, Nor Hazlyna Harun, M.Y.Mashor, H.Roseline , "Image Enhancement Techniques Using Local, Global, Bright, Dark and Partial Contrast Stretching For Acute Leukemia Images", Proceedings of the World Congress on Engineering , Vol. 1, London, U.K, July 2009.

[4] Rangaraj M.Rangayyan , "Biomedical Image Analysis", the Biomedical Engineering Series, University of Calgary, Calgary, Alberta, Canada, 2005.

[5] Rajesh Garg, Bhawna Mittal, Sheetal Garg, "Histogram Equalization Techniques For Image Enhancement", International Journal of Electronics & Communication Technology(IJECT) Vol. 2, Issue 1P.P.107-111, March 2011.

[6] Ganesh naga sai Prasad. V , Habibullah khan ," Image enhancement using Wavelet transforms and SVD", International Journal of Engineering Science and Technology (IJEST),ISSN , Vol. 4 ,No.03,P.P.1080-1087, March 2012 .

[7] Alfaouri, M. and K. Daqrouq , "ECG signal denoising by wavelet transform thresholding." , American Journal of Applied Sciences ,Vol.5,No.3, 276-281, 2008.

[8] William K.Pratt,"Digital Image Processing" , Los Altos, California, 2007

[9] Mat Isa, N.A.,Mashor, M.Y. & Othman, N.H. , " Contrast Enhancement Image Processing on Segmented Pap Smear Cytology Images", Information and Signal Processing, p.p.118 – 125,2003 .

[10] Nor Hazlyna Harun ,N.R.Mokhtar ,M.Y. Mashor , H.Adilah, "Color image enhancement techniques based on partial contrast and contrast stretching for acute leukaemia images", ICPE, 2008.

[11] Lena Costrarido, " Medical image Processing and Analysis for CAD Systems", Taylor & Francis, p.p. 51-86, United Stated o America,2005.

[12] R.W.Jr. Weeks, " Fundamental of Electronic Image Processing ", Bellingham, SPIE Press ,1996.

[13] M.A.A. Moustaf, H.M. Ismaiel, "Quantitative and qualitative evaluations of image enhancement techniques", 46th IEEE International Conference on Circuits and Systems, Vol.2, Pg.No.664-669, December 2003 .

الخلاصة

ان مرض ابيضاض الدم من الامراض الخطيرة (السرطانية) والتي تصيب الانسان في مختلف الاعمار من الاطفال وحتى بعمر 50 سنة . هناك انظمة تصويرية لتشخيص هذا المرض , تقوم هذه الانظمة بفحص عينات دم المريض ويمكن ان تجدد المستوى غير الطبيعي من كريات الدم البيض والذي قد يعطي مؤشر لهذا المرض , لذلك فأن المختصين يستخدمون الصور الطبية لتشخيص هذا المرض , الا ان الضبابية وتأثيرات الضوضاء غير المرغوب بها ربما تؤدي الى تشخيص غير صحيح ولهذا السبب فأن تقنيات تحسين الصورة مطلوبة في هذه الحالات . تم اقتراح ثلاث تقنيات في هذا البحث اعتمادا على تحويلة المويجة وطرق التباين المختلفة وهي التباين المحلي , تباين السواد , تباين الوضوح و التباين الجزئي وطبقت جميع التقنيات على صورتين مختلفتين وتمت المقارنة بين نتائج الطرق المقترحة, وق تبين ان الطريقة المعتمدة على التباين الجزئي هي الافضل في تحسين الصورة .