ADV MATH SCI JOURNAL
Advances in Mathematics: Scientific Journal **9** (2020), no.6, 3325–3329
ISSN: 1857-8365 (printed); 1857-8438 (electronic)
https://doi.org/10.37418/amsj.9.6.12 Spec. Issue on RDESTM-2020

CONTRAST IMAGE CONSTRUCTION TECHNIQUE FOR MEDICAL IMAGING

A. SHARMA[1] AND J. SOMASEKAR

ABSTRACT. We propose and experimentally demonstrate a contrast image construction technique for medical imaging with special reference to low contrast malaria microscopic imaging. This simple technique increases the contrast of an image and hence, reveals significant information about malaria infected cells for diagnosis. The proposed method experimental results along with other existing methods results are demonstrated and reveal the efficiency of the proposed method moth qualitatively and quantitatively.

1. INTRODUCTION

Malaria is a critical healthcare problem worldwide. According to the world malaria report of 2019 published by WHO, an estimated worldwide 228 million cases and 40,500 deaths from malaria in which 67% of deaths are children aged under five years [1]. Approximately, a total of 197 million patients worldwide are tested for malaria by microscopic examination. The microscopic blood images taken under normal exposures suffer from lack of contrast under low light conditions and hence, target object pixels are easily immerged in large quantity of low contrast background pixels. So it is difficult to detect the infected cells from the low contrast images for diagnosis. In order to enhance the contrast of microscopic images, we proposed a contrast image construction technique

[1]*corresponding author*

2010 *Mathematics Subject Classification.* 94A08.

Key words and phrases. Medical Imaging, Contrast enhancement, Diagnosis, Low contrast images.

(CICT) for low contrast malaria color microscopic images. In the rest of the article: the proposed CICT, Experimental Results and Conclusions are presented in sections 2 and Section 3, respectively. The conclusions are drawn in section 4.

2. THE PROPOSED CICT

Microscopic blood images are commonly acquired using a digital camera with a blood smear attachment. The input blood color image f(x,y) of size $m \times n$ has three channels Red, Green and Blue, is denoted by the following mathematical expression.

$$f(x,y) = \{[(f_R(x,y)f_G(x,y)f_B(x,y))]^T : \\ (x,y) \in \{0,1,2,,m-1\} \times \{0,1,2,,n-1\}\}.$$

The CICT is the process of transforming the image f(x,y) into an image g(x,y) so that it retains all the relevant information of the original image to improve the contrast of the image for diagnosis. The three channels in the contrast constructed image g(x,y) of an image f(x,y), by using the following proposed mathematical equation.

$$g(x,y) = [(g_R(x,y)g_G(x,y)g_B(x,y))]^T$$

$$= D\left(\begin{bmatrix} \left[\frac{f_R^{max}(x,y) - f_R^{min}(x,y)}{f_R^{max}(x,y) + f_R^{min}(x,y)}\right] \\ \left[\frac{f_G^{max}(x,y) - f_G^{min}(x,y)}{f_G^{max}(x,y) + f_G^{min}(x,y)}\right] \\ \left[\frac{f_B^{max}(x,y) - f_B^{min}(x,y)}{f_B^{max}(x,y) + f_B^{min}(x,y)}\right] \end{bmatrix} + \begin{bmatrix} \delta_R \\ \delta_G \\ \delta_B \end{bmatrix}\right)^T \otimes \left(D\begin{pmatrix} f_R(x,y) \\ f_G(x,y) \\ f_B(x,y) \end{pmatrix}^T \otimes \begin{pmatrix} \left[(mn)^{-1}\left(\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f_R(x,y)\right)\right]^{-1} \\ \left[(mn)^{-1}\left(\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f_G(x,y)\right)\right]^{-1} \\ \left[(mn)^{-1}\left(\sum_{x=0}^{m-1}\sum_{y=0}^{n-1} f_B(x,y)\right)\right]^{-1} \end{pmatrix}\right)$$

where D(.) is a diagonal matrix, the operator $\otimes$ is a matrix multiplication and T indicates transpose of a matrix. In the above equation, the parameter $\delta_\theta \vartheta \varepsilon R, G, B$ is to control the level of contrast and is obtained by using the equation (3) with $f_\vartheta^{\max}(x,y) = \max f_\vartheta(x,y)$ and $f_\vartheta^{\min}(x,y) = \min f_\vartheta(x,y)$,

$$\begin{pmatrix}\delta_R\\ \delta_G\\ \delta_B\end{pmatrix} = \begin{bmatrix}\frac{9f_R^{\min}(x,y)-f_R^{\max}(x,y)}{5f_R^{\max}(x,y)+5f_R^{\min}(x,y)}\\ \frac{7f_G^{\min}(x,y)-f_G^{\max}(x,y)}{4f_G^{\max}(x,y)+4f_G^{\min}(x,y)}\\ \frac{9f_B^{\min}(x,y)-f_B^{\max}(x,y)}{5f_B^{\max}(x,y)+5f_B^{\min}(x,y)}\end{bmatrix}$$

3. EXPERIMENTAL RESULTS

In order to evaluate the performance of the proposed CICT quantitatively by edge-based contrast measure (EBCM) [6] [7].In this study, the proposed technique will be compared with some other our implementation methods, which includes Histogram Equalization (HE) [2-4] and Contrast Limited Adaptive Histogram Equalization (CLAHE) [5][8]. The EBCM measures the intensity of edge pixels in enhanced image. In general, The EBCM value of enhanced image is more than original image indicates better enhancement performance [6][9]. Table 1 shows EBCM for the tested images using various methods. Table 1 reveals that the EBCM value of the proposed method have higher values than original image and ensure for good and natural enhancement of image when compared to other methods. In Assessment of visual quality, Fig.1 compares the low contrast malaria infected microscopic image results of different methods. Fig. 1(a) shows the original color image; we can see that the low contrast image is acquired. From Fig. 1(b) and 1(c), we can see that all methods not yields proper enhanced image while proposed as shown in Fig.1(d) yields proper enhanced image for diagnosis.

TABLE 1. Quantitative measurement results as EBCM.

Image ID	Original	HE	CLAHE	Proposed
1	246.06	179.82	224.41	249.71
2	140.05	133.78	125.22	252.43
3	152.34	144.17	156.29	252.85
4	230.61	232.26	167.43	244.78
5	243.28	213.02	243.211	244.67

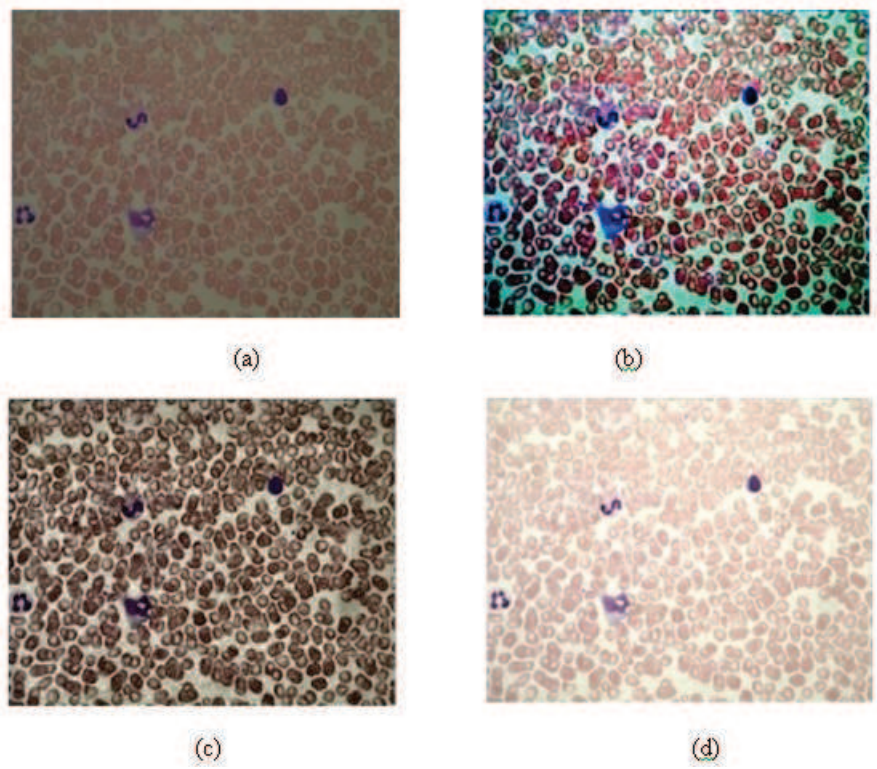

FIGURE 1. Enhanced results of a low contrast color microscopic malaria image using different methods. (a) Original image (b) HE, (c) CLAHE, and (d) proposed.

4. CONCLUSION

In this paper, a simple Contrast Image Construction technique for low contrast microscopic imaging with special reference to malaria images has been presented. Comprehensive comparison experiments carried out on low contrast malaria infected color images and hence, our technique has controllability of the enhancement low contrast images. Experimental results show that the proposed technique outperforms the standard enhancement techniques HE, CLAHE through qualitative and quantitative analysis.

REFERENCES

[1] *World Malaria Report-2019*, World Health Organization (WHO), Geneva, Switzerland, 2015.

[2] R. C. GONZALEZ, R. E. WOODS: *Digital image processing*. 2nd ed. Reading, MA. Addison-Wesley, 1992.

[3] ACHARYA, RAY: *Image Processing: Principles and Applications*, Wiley-Interscience, 2005, ISBN 0-471-71998-6.

[4] RUSS: *The Image Processing Handbook: Fourth Edition*, CRC 2002, ISBN 0-8493-2532-3.

[5] ZUIDERVELD, KAREL: *Contrast Limited Adaptive Histogram Equalization, Graphic Gems IV*. San Diego: Academic Press Professional, 1994, 474–485.

[6] T. CELIK, T. TJAHJADI: *Automatic Image Equalization and Contrast Enhancement Using Gaussian Mixture Modeling*, IEEE Transactions on Image Processing, **21**(1) (2012), 33-44.

[7] G. SENTHAMARAI, K. SANTHI: *Dynamic multi-histogram equalisation for image contrast enhancement with improved brightness preservation*, Proc. IEEE Int. Conf. Electron. Commun. Syst., 2015, 1205–1209.

[8] J. SOMASEKAR, A. RAMA MOHAN REDDY, L. SREENIVASULU REDDY: *An Efficient Algorithm for Automatic Malaria Detection in Microscopic Blood Images*, Global Trends in Information Systems and Software Applications, (2012), 431–440.

[9] J. SOMASEKAR, B. ESWARA REDDY: *A novel two-stage thresholding method for segmentation of malaria parasites in microscopic blood images*, J. Biomed. Eng. Med. Imaging, **4**(2) (2017), 116–118.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
MAHARISHI MARKANDESHWAR ENGINEERING COLLEGE
MAHARISHI MARKANDESHWAR (DEEMED TO BE UNIVERSITY)
MULLANA, AMBALA, INDIA.-133207
E-mail address: asharma@mmumullana.org

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
GOPALAN COLLEGE OF ENGINEERING AND MANAGEMENT
BANGALORE, INDIA- 560 048.
E-mail address: jsomasekar@gmail.com