Automatic Cytoplasm and Nucleus detection in the white blood cells depending on hisogram analysis

M H Mohammed, H G Daway and J Jouda

1, 2 Department of physics, College of Science, Mustansiriya University, Iraq, Baghdad.
3 Department of Biology, College of Science, Mustansiriya University, Iraq, Baghdad.

1hashimmohammed619@gmail.com, 2hazimdo@uomustansiriyah.edu.iq, 3jamela.jouda@uomustansiriyah.iwu.iq

Abstract. Programmed identification of white platelets (WBCs) stays an uncertain issue in medicinal imaging. The first step in this algorithm is to detect a white blood cell (Lymphocyte) and then segments the Cytoplasm and Nucleus in this cell. This was done by using image processing Techniques. The suggested method depending on the binary conversion of red, blue and hue compounds depending on threshes values. These values were calculated from histogram analysis within specific ranges. The proposed algorithm was compared with several other algorithms for detection by using an accuracy scale in the detection. where the proposed algorithm obtained a high distinction accuracy reached 98% compared to other methods.

Keywords: Cytoplasm detection, Nucleus detection, binary image, RGB color space and HSV transform.

1-Introduction

Image detection and classification technologies have an important role in many applications[1-3] In the therapeutic field, the examination of white blood cells(WBC) in the blood is of urgent noteworthiness for diagnosing sicknesses. Especially, changes in the course of the five sorts of white platelets [basophils(B), lymphocytes(L), neutrophils (N), monocytes(M), and eosinophils (E)] have a close by the relationship with the condition of the human invulnerable framework. To separate the five fragments of WBCs significantly, division and request should be performed. The standard strategy for gathering white platelets relied upon the impression of a blood smear through microscopy.where the unmistakable verification technique relies upon observable features, for instance, concealing and shape. Be that as it may, therapeutic overseers’ data and experience accept decisive employment in the exactness of WBCs investigation, making the strategy monotonous and variable [4]. Before, the assessment of blood spreads is an exceptionally mind boggling, monotonous, and time-consuming manual assignment. These days, with the quick improvement of PC helped techniques, a programmed cell investigation framework can bolster quicker and more reproducible picture examination than manual investigation. Programmed cell examination framework, by and large, incorporates four stages: picture procurement, cell division, include extraction and characterization. Cell division is regularly considered as the most significant and basic advance all the while, as it legitimately influences the precision and time multifaceted nature of ensuing advances[5]. In any case, such endeavor is attempting a direct result of the unpredictability of WBC shape that includes cytoplasm and center locale in which center is abiding inside the cytoplasm with a comparative concealing sort
anyway one of a kind level of intensity. The division is represented to be a huge task as the precision of WBC checking is extraordinarily dependent upon this procedure[6]. Leukocytes or White Blood Cells (WBC) are one of the cell's segments found in human blood similarly as Red Blood Cells (RBC) and platelets. Every cell has its very own ability. RBC, for example, helps transport oxygen from the lungs to all locales of the body. WBC limits are to control infections, infections and microbes [6]. Therapeutic picture preparing has turned out to be increasingly more significant in conclusion with the improvement of medical imaging and PC method. X-beam radiography, CT, and X-ray get enormous measures of therapeutic pictures. They give fundamental data to effective and precise analysis dependent on cutting edge PC vision procedures [8]. Generally, WBCs counts were performed manually by microscopic inspection of blood smears. Experienced technicians play out this work concentrated assessment. Albeit manual counts cells includes are still performed in certain circumstances, present-day hematology research facilities utilize mechanized hematology analyzers to perform cells counts[9]. The counts of the various kinds of WBCs give a decent quantitative record to assess the health status of individuals. Since an enormous number of blood tests are performed consistently around the world, programmed, the quick and precise methodology is truly called for [10]. The perception of WBCs from tiny pictures allows for the assessment and finding of numerous diseases such as Leukemia, a blood malignancy that can be recognized through the examination of leucocytes [11], Leucopenia, Neutropenia, lymphopenia, neutrophil, and eosinophilia [12]. WBCs are cells of the insusceptible framework and are found in all regions of the body, including bone marrow and blood. Since the quantity of WBC in the blood is frequently a marker of certain maladies, the tally of various classes of WBC, named differential checking, assumes a noteworthy job in the assurance of the patient wellbeing in various stages: finding, treatment and development [13]. In [14] He proposed an innovative way to automatically identify the white blood cells from the images. The nucleus was extracted and separated from the cytoplasm, The number of blood samples used in this method was (108 sample), The accuracy ratio was 92%. The results in this innovative cell classification showed that they were able to identify strongly and separate the cell components as well as separating the nucleus from the cytoplasm. In [6] They proposed a PC helped framework (CAS) that breaks down blood-joined pictures got from the magnifying lens, the chromatography method has been used to classify the promise of white blood cells, The number of images used in this way was 30 images, The accuracy ratio was (96.92), This method has proved in the classification that the detection of the nucleus was superior to the comparison with the detection of cytoplasm in white cells. In[5] They proposed a method of classification of white blood cells containing several points, algorithm division of white blood cells, Proposed strategy for effective cluster blood sampling, A vector motion for a color property that is a feature for merging the neural veneer of cells, The number of images used in this mode was 80 images, This method showed accurate results to accurately classify cells up to about 90%. In[4] They proposed the creation of a morphological method for the fragmentation and classification of white blood cells based on spectral and spatial analysis, The spectral range of this proposed path was between 550 nm - 1000 nm, The proportion of accuracy in this way is more than 90%. In[15] They proposes picture preparing calculations to perceive five kinds of white platelets in fringe blood consequently. Initial, a strategy dependent on Gram–Schmidt orthogonalization is proposed alongside a snake calculation to section core and cytoplasm of the cells. The outcomes exhibit that the proposed techniques are precise and adequately quick to be utilized in hematological labs.

2. Suggested Method:

Leukocytes can be extracted from the blood cell using several methods [8]. In this study, the cytoplasm will be distinguished from the nucleus by using the proposed algorithm that can be divided into two parts.

2.1 Cytoplasm detection algorithm:
depends on converting the image to binary using the threshold limits for the compounds (H, S and V) and on the morphological operation as shown in the following steps:
a. Input a WBC image
b. Convert the image from space (RGB To HSV) [14]
   HSV: Hue saturation value. RGB: Red, Green, Blue.

c. convert image to binary By eq (1).

\[
\begin{align*}
\text{If} & \quad T_1 < H < T_2 \\
& \quad T_3 < s < T_4 \\
& \quad T_5 < V < T_6 \\
I_b(x,y) &= 1 \\
\text{Else} & \\
I_b(x,y) &= 0
\end{align*}
\]  

\( T_1 = 7, \; T_2 = 3, \; T_3 = 6 \)

d. We note in this picture there are some important gaps within the cytoplasm region that can be filled at a certain limit if the value of (th) is the largest value (fill region).

\( \text{file all holes regions.} \)

e. In order to delete unwanted areas where Dilate the region at size 5*5.

f. Final Cytoplasm detects. Figure(1,2)

\[\text{Figure (1): Stages of cytoplasm detection (a) Original image, (b) binary images, (c) fill holes regions, (d) dilate images.}\]
2.1 The nucleus detection algorithm

The nucleus region is determined by relying on converting the original image to binary based on (hue, blue, red) compounds at specific threshold limits and depending on (morphological operation) which includes the following steps:

a. Input a WBC image
b. Find Hue value by using. [11,12]:

\[ H = \max(r, g, b) \]  \hspace{1cm} (2)

c. Convert image to binary according to conditions:

\[
\begin{align*}
&\begin{cases}
If & T1 < R < T2 \\
& T3 < B < T4 \\
& T5 < H < T6 \\
& lb(x, y) = 1 \\
Else & lb(x, y) = 0
\end{cases}
\end{align*} \hspace{1cm} (3)
\]

T1= 50, T2= 70, T3= 0.7

d. The unwanted areas and the largest (i=70 pixels) are deleted by using ,Eq (4)
if $I_b(x,y) < 70$

\[ bi(x,y) = 0 \]  

\[[4] \]

e. Final nucleus detects as binary regions. Figure (3 and 4)

Figure (3): in an input original image, b, binary images, c fill region, d nucleus detect.

Figure (4): Block diagram of the Nucleus detection algorithm.
3- Quality evaluation:

Quality was calculated based on the accuracy measurement between its comparison in determining the region of the cytoplasm and the nucleus of white blood cells, in theory, automatic diagnosis of these regions through the proposed algorithm. The diagnostic accuracy of the cytoplasm and nucleus is calculated from the following precision, sensitivity, and specific equations [3].

\[
\text{Acc} = \frac{TP + TN}{TP + FP + FN + TN} \tag{5}
\]

\[
\text{Sp} = \frac{TN}{TN + FP} \tag{6}
\]

\[
\text{Se} = \frac{TP}{TP + FN} \tag{7}
\]

TP: True positive, TN = true negative, FP = false positive, FN = false negative.

TP: Is the area that has been WBC discovered as WBC.

TN: A non-White blood cell area that has been identified as non-White blood cell.

FP: A non-White blood cell region that has been identified as White blood cell

FN: A White blood cell zone that is identified as a non-White blood cell dependent.

4. Experimental All Results:

In this study we suggest an innovative algorithm to separate the cytoplasm and nucleus region from white blood cells. The algorithms were tested on microbiological images of blood smears at 2592 x 1944 pixels. The test was performed using a sample of 50 images obtained from digital camera photography in the same lighting conditions. All matlab (R2013a) algorithms were used, which is a technique for screening white blood cells in images obtained from color blood samples obtained from the hematology center at Al-Mustansiriya University and the hematology center at Baghdad Medical City. These pictures are shown in Figure (5). The proposed algorithm determined the region of the cytoplasm and the nucleus region and separated it from the white blood cells. The accuracy rate in this algorithm used was 85%. Image sensitivity is 93%, and quality is 67%. The results of the proposed algorithm showed the images resulting from the process of separating the cytoplasm and the nucleus from the white blood ball, as shown in Figures (6 and 7) the performance of the proposed method.
Figure (5): original image.

Figure (6): Result Nucleus detect.
Figure (7): Result cytoplasm detect.

5. Discussion and Conclusion

We suggest an innovative algorithm for determining the region of the cytoplasm and nucleus in WBCs by relying on converting the microscopic color image into a binary image using the threshold limits for compounds (hs and v), as well as by relying on (morphological operation) and threshold limits (hue, blue, red) with respect to delimiting a region The nucleus, and using the equations for calculating accuracy, specificity, and sensitivity, the proposed algorithm showed values for the determination of accuracy and detection of regions for the cytoplasm and nucleus (Acc = 0.85, SP = 0.93, Se = 0.66). During the analysis of the results of the system, it was found that the algorithm showed high results in accuracy and sensitivity and this shows that the proposed method is a good method in terms of the accuracy of detection and identification of both the nucleus and the cytoplasm in the white blood cell.

Reference:

[1] H. G. Daway, I. T. Al-Alawy, and S. F. Hassan, (2019),“Reconstruction the illumination pattern of the optical microscope to improve image fidelity obtained with the CR-39 detector,” AIP Conference Proceedings, vol. 2144, no. 1, pp. 030006.
[2] Daway, Hazim G., and Ahmed Rafid Hashim. (2018) "Pupil Detection Based on Color Difference and Circular Hough Transform.” International Journal of Electrical and Computer Engineering (IJECE) 8, no. 5.
[3] Ameer, Z.S.A.-A., Daway, H.G., Kareem, H.H., (2019), "Enhancement underwater image using histogram equalization based on color restoration“, Journal of Engineering and Applied Sciences, 14(2) Page No.: 641-647.
[4] Wang, Q., Li, MeiZhou, Q n, H Liu, F Guo. (2016), A spectral and morphologic method for white blood cell classification. Optics & Laser Technology., 84: p. 144-148.
[5] Zheng, X. W Yong, Wangc G, Jia Liuc. (2018), Fast and robust segmentation of white blood cell images by self-supervised learning. Micron, 107: p. 55-71.
[6] Safuan, S.N.M., M.R.M. Tomari, and W.N.W. Zakaria, (2018),White blood cell (WBC) counting analysis in blood smear images using various color segmentation methods. Measurement., 116: p. 543-555.
[7] E Cuevas, M Díaz, M Manzanares, D Zaldivar, and Marco P C. (2013), An improved computer vision method for white blood cells detection. Computational and mathematical methods in medicine.

[8] Chabot-Richards, D.S. and T.I. George, (2015). White blood cell counts: reference methodology. Clinics in laboratory medicine, 35(1): p. 11-24.

[9] López-Puigdollers, D., V.J. Traver, and F. Pla, (2019). Recognizing white blood cells with local image descriptors. Expert Systems with Applications., 115: p. 695-708.

[10] Putzu, L., G. Caocci, and C. Di Ruberto, (2014), Leucocyte classification for leukaemia detection using image processing techniques. Artificial intelligence in medicine., 62(3): p. 179-191.

[11] Patel, N. and A. Mishra, (2015), Automated leukaemia detection using microscopic images. Procedia Computer Science., 58: p. 635-642.

[12] Dorini, L.B., R. Minetto, and N.J. Leite. (2007), White blood cell segmentation using morphological operators and scale-space analysis. in XX Brazilian Symposium on Computer Graphics and Image Processing (SIBGRAPI 2007). IEEE.

[13] Putzu, L. and C. Di Ruberto. (2013), White blood cells identification and counting from microscopic blood image. in Proceedings of World Academy of Science, Engineering and Technology. World Academy of Science, Engineering and Technology (WASET).

[14] Hassan S.F., Daway H. G., Al-Alaway I. T., (2018)" Improving an Illumination System in the Microscopic Imaging of Nuclear Tracks Using Light Emitting Diode”, Indian Journal o f Public Health Research & Development, V. 9, NO. 12, P. 1282-1287, December.

[15] Rezatofghi, S.H. and H. Soltanian-Zadeh, (2011), Automatic recognition of five types of white blood cells in peripheral blood, Computerized Medical Imaging and Graphics., 35(4): p. 333-34.