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Blood Cells Counting using Python OpenCV

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***Abstract*— Blood cells both white and red are important part of the immune system. These cells help fight infections by attacking bacteria, viruses, and germs that invade the body. White blood cells originate in the bone marrow but circulate throughout the bloodstream, while red blood cell helps transport oxygen to our body. Accurate counting of those may require laboratory testing procedure that is not usual to everyone. Generating codes that will help counting of blood cells that produce accurate response via images gives a relief on this problem. In this study, the images were processed and a blob detection algorithm was used to detect and differentiate RBCs from WBCs. A cell counting method was also used to provide an actual count of the RBCs and WBCs detected. The automation comes with a graphical user interface backed-up with a working database system to keep the records of the users (e.g. patients, respondents). The performance of the system was statistically described as accurate compared to the manual method of counting. Results show an accuracy of 100% for platelet, 96.32% for RBCs and 98.5% for WBCs. Hence, the proposed system can benchmark with the manual methods of detection and counting of platelets, RBCs and WBCs in blood samples.**

Keywords*— *blood cells, CBC, RBC, WBC, platelet, python, OpenCV, red blood cells, white blood cells, image

I. Introduction

Platelets are one of the blood cells that stops the bleeding in the body from blood clotting. Platelets can detect if any blood vessels are damaged. Red blood cells are also tiny blood cells that is also important in the health of human through carrying fresh oxygen throughout the body whereas white blood cells helps protect the body from infections. Complete Blood Count (CBC) involves blood testing to determine the healthiness of the major components of blood which are platelets, red blood cells and white blood cells. Abnormalities of result based from references of normal count of cells may indicate an underlying medical condition that needs further evaluation.

For this past few years, CBC counting is one of the most studied area of research due to accuracy problem. Laboratories in the hospital in the Philippines are still using the traditional method of counting blood cells. This was done in either manual method through hemocytometer or by automated method through flow-cytometer. In this study, it uses images of the blood to calculate the number of cells since research on medical images is new technology. Image processing is a method which involves signal processing and mathematical procedure to change the image into another form of desired image. Image analysis is the extraction of significant information from an image. Hence, this paper does not involve image processing only but analysis as well.

Nowadays, there are many ways of image processing and analysis of blood cell images. However, the quest for the highest accuracy is still one of the aims of the researchers. With so many studies, the researchers will present another way of counting blood cells through the use of strong level of algorithm with the help of python OpenCV programming language. This study used colour filtering to keep a specific hue while desaturating the rest of the image. It also involves image segmentation to convert the image into multiple parts to identify which of the cells are platelets, red blood cells or white blood cells. Blob detection plays important role in this study which primarily detects the differences of each blood cells before the cells will be counted.

II. Objectives

The primary objective of this paper is to present a more accurate counting of blood cells using the python OpenCV programming language. It covers image processing and analysis of platelets, red blood cells and white blood cells. This study was able presented a more accurate counting of the specified types of cell. Further, it has presented a new algorithm in counting these important types of cell found in the human body.

III. Review of Related Literature

Platelet count is one of the blood tests involved in the process of CBC to determine if the patient suffers from anemia, leukemia and etc. Plate counting is usually done manually but a recent study showed that this process can be done through Circular Hough Transform in a microscopic blood cell images. This process presented an accuracy rate of 96% compared with traditional manual counting [1]. Traditional white blood cell counting is a long process and contributes some inaccuracy. If more accuracy in white blood cell counting would like to obtain, an expensive haematological analysing machine is needed. Hence, a study about microscopic images of blood stained peripheral blood film for leukemia and normal condition was presented. It involves color space conversion, color thresholding, filtering, marker controlled watershed and morphological operations which got an accuracy of 88.57% [2].

Detection and counting of white blood cells in blood samples were also presented through computer-aided and mobile-cloud-assisted blood analysis. The paper propose a smartphone-based cloud-assisted resource aware framework for localization of WBCs within microscopic blood smear images using a trained multi-class ensemble classification mechanism in the cloud. Its algorithm includes segmentation, extraction of texture, statistical, and wavelet features and then categorized into five classes: basophil, eosinophil, neutrophil, lymphocyte, and monocyte.

Counting each type of cells was then accomplished [3]. Abnormalities in white blood cells were also studied by researchers through digital image processing. The study presented is fast and inexpensive that can detect kind of diseases like Chronic Obstructive Pulmonary Disease, Immune system disorders, Neutropenia, HIV/AIDS, Lymphocytopenia, leukemia etc. There are two proposed framework presented in the paper. The first framework determined the types of nucleus in WBC and the second framework is the counting of WBC and abnormal nucleus in the WBC. The result showed more than 85% accuracy [4].

Another method in counting and classification of white blood cells was also introduced using Artificial Neural Network (ANN). This method decreases the time of executing the segmentation and classification of WBC. Nucleus enhancement by finding the intensity maxima improves the detection and classification of Leukocytes and then classified based on various features extracted from segmented images. ANN was used to classify and confirm the white blood cells. The steps involved image acquisition, image segmentation, feature extraction and classification using ANN and counting. It was concluded that this new method was better in terms of accuracy and efficiency while considering the time and cost in dealing with this process [5].

Morphological features of cells make the counting of white blood cells easy. The extraction of nucleus of WBC can provide information about different kinds of diseases. After contrast stretching and histogram equalization of image, segmentation of nucleus from blood smear images using Otsu's thresholding technique was applied. It was then followed by minimum filter for reducing noise and increasing brightness of nucleus through mathematical morphological procedure [6]. Separation and counting of blood cells using geometrical features and distance transformed watershed was also introduced in a study. The proposed method operates on binary images taken from initial segmentation and consists of several detailed steps. Canny edge detection, the most popular edge detection, was done in the image. Morphological operations, the connectedness of the pixels in the image, were then performed. After that, the feature was extracted. After extraction, classification was done. Then clumped cells were separated. Finally, cell counting was established [7].

RBC microscopic images and Matlab are employed as a method in counting RBC. The mask of the RBC was used to count the number of RBC in a blood smear. It involves separation of color components in the image, then histogram was performed. Thresholding was done after the histogram. If object area is greater than the desired value, area from the image corresponding to the triple line square is then extracted. Finally, number of RBCs will be counted from the extracted area of the image. Further, blood smears are stained with Leishman stain. Images are acquired using light microscope connected to digital camera. Images are converted to their three colors components. Initial Segmentation is based on green component. Final RBCs segmentation and counting is based on the histogram of objects areas in the image [8].

Red blood cells can be counted based on other classification algorithms. In segmenting blood cell image, spectral angle mappings (SAMs) and support vector machines (SVMs) can be used. Identifying RBCs can be identified using standard RBC model based on SAM classification algorithm. This process obtained an accuracy of 93%. To improve this accuracy, SVM classification was performed and it resulted to 98% after applying the additional process [9]. Overlapping cells can now be counted using morphological watershed transformation and regional maxima computation. Matlab was used in simulation of counting red blood cells, white blood cells and platelets. In the study, microscopic blood cell image must be obtained with high resolution. The image must be smoothened. Then the preprocessed image is converted to YCbCr and Grayscale image formats. After which, WBC and Platelets mask was done by applying morphological operations on Cb component. The RBC mask was obtained by applying morphological operations and thresholding operation. Then, computation was done for regional maxima points. Finally, it performed watershed segmentation on masks and compute count values. The minimum efficiency for the dataset was found to be 94.44%. [10].

A paper was presented to segment and count overlapped red blood cells image. It uses the combination of Pulse Coupled Neural Network (PCNN) and template matching algorithm. The isolated area was considered as a template. The steps done are converting the image from RGB to gray, segmentation using PCNN, eliminating unwanted objects, segmentation using template matching, count isolated blood cells, count overlapped cells and final counting. The researchers concluded that their algorithm performs better in counting overlapped red blood cells in comparison with the existing counting system [11]. Clinical decision support system for cells counting and classification is existing nowadays. A computer aided system can simulate a human visual inspection to automate process of detection and determination of WBCs and RBCs from blood sugar smears. This method has been tested on public datasets of blood cell images and demonstrated a reliable and efficient system for differential counting. The result obtained accuracy value of 99.2% for WBC and 98% for RBC [12].

IV. METHODS AND RESULTS

The algorithm used in this study includes five (5) steps: Image Uploading, Color Filtering, Image Segmentation, Blob Detection and the Cell Counting as shown in Fig. 1.

Fig. 1. Algorithm

A. Image Uploading

The ten (10) square subdivision images of the of the blood specimen were uploaded in the Python based program, processed and analyzed. In order for a python program to process image processing, OpenCV function must be imported and the “cv2” must be appended on each line code.

Images used in both WBC and RBC programs were samples captured using 40x magnification setting of a microscope while in Platelet program, 100x magnification images were used. High magnification was necessary for platelet counting since among the three cells, platelet cells are the smallest as shown in Fig. 2.

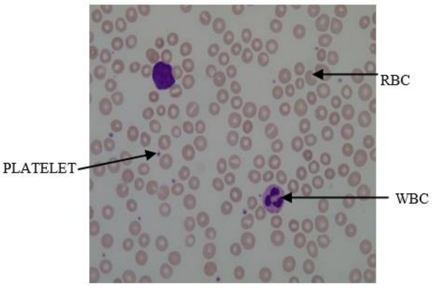

Fig. 2. Blood cell specimen

B. Color Filtering

In Color Filtering process, color determination was done to distinctively characterize the WBC, RBC and Platelet cells from each other. Specific color pixel values were identified and were converted from BGR to HSV in order to get the correctly processed the setting of upper and lower bounds as the range of color values only needed for image segmentation. Sample result for color filtration is shown in Fig. 3.

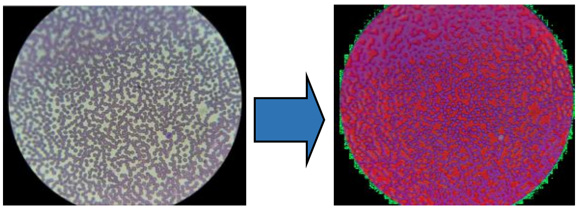

Fig. 3. BGR to HSV Result Sample

C. Image Segmentation

In Image segmentation process, we first masked out the resulting HSV image to separate objects from the background using a pixel feature value. In our study, we used Otsu’s binarization technique for thresholding purpose. In this technique, it automatically calculates threshold values from the two peaks of the histogram of a bimodal image using the formula shown below in (1). It actually finds a value of t which lies in between two peaks such that variances to both classes are minimum. Sample result of image segmentation process is shown in Fig. 4.

$$\sigma_w^2(t) = q_1(t)\sigma_1^2(t) + q_2(t)\sigma_2^2(t) \quad (1)$$

Fig. 4. Image Segmentation process Result Sample

D. Blob Detection

A Blob is a group of connected pixels in an image that share some common property (e.g grayscale value). The goal of blob detection is to identify and mark these regions.

Blob detection provides methods for segregating those samples by thresholding, grouping, merging and radius calculation. Thresholding converts the source images to several binary images by applying the source images the threshold from minimum to maximum threshold. Grouping is identifying binary images connected with pixels or binary blobs. Merging is computing the center of the binary blob located closer than minimum distant between blobs and the last radius calculation by computing radii of the new merge blobs.

OpenCV provides a convenient way to detect blobs and filter them based on different characteristics using its built-in function called SimpleBlobDetector. Its algorithm is controlled by parameters in terms of Color, Size and Shape where Shape parameter has three specific parameters: Circularity, Convexity and Inertia shown in Fig. 5. Circularity measures how close to a circle the blob while Convexity is defined as the (Area of the Blob /Area of its convex hull) where Convex Hull of a shape is the tightest convex shape that completely encloses the shape. And finally, Inertia measures how elongated a shape is. These parameters were configured to attain the optimum results in classifying WBC, RBC and Platelet images. Sample output of using SimpleDetectorBlob function is shown in Fig. 6.

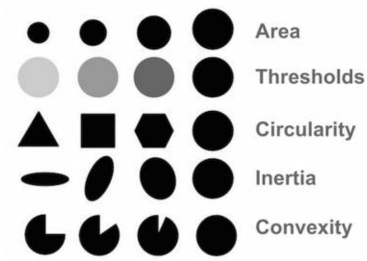

Fig. 5. Blob detection parameters

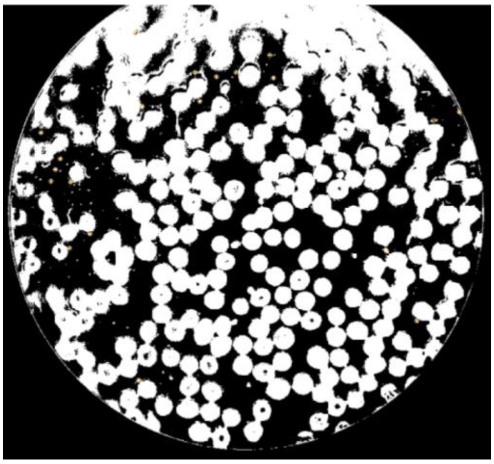

Fig. 6. SimpleDetectorBlob function Output sample

E. *Cell Counting*

Having successfully isolated the cells for RBC, WBC and Platelet cell counter, each of the 10 images were process separately. The number of cells per image are summed up and were accordingly configured to get the correct results which are expected to achieved close to the expected text results if not the same.

In WBC Counter, the total sum of the cell counts from the ten images needs to be multiplied with 0.1 to get the final WBC test results as shown in formula (2). Whereas for RBC Counter, the total sum of the cell counts from the ten images needs to be multiplied with 0.001 to get the final WBC test results as shown in formula (3). Finally, for platelet count,

$$WBC_T = \sum(\text{Cell count (1), Cell count(2)…Cell count(10)x 0.1}) \quad (2)$$

$$RBC_T = \sum(\text{Cell count (1), Cell count(2)...Cell count(10)x 0.001}) \quad (3)$$

$$PLT_T = \sum(\text{Cell count (1), Cell count(2)...Cell count(10)}) \quad (4)$$

The results provide accurate reading as per laboratory result. Compared with the traditional counting of blood cells, white blood count resulted to 98.5% accuracy, platelet count with 100% accuracy while red blood count got 96.32% accuracy.

V. CONCLUSIONS

The researchers presented more accurate blood cell counting using a new algorithm with the help of python OpenCV programming language. The implementation of image processing and analysis for the platelet, red blood and white blood cells was made possible and resulted to high level of accuracy. The algorithm was able to meet the margin of error of less than 10%. Furthermore, improved accessibility and portability of the software used were obtained through its on-line database support and free ware feature.

REFERENCES

[1] P. Kaur, V. Sharma, N. Garg, “Platelet Count using Image Processing”, 2016 International Conference on Computing for Sustainable Global Development, 2016, pp. 2574-2577.

[2] R. Ahasan, A.U. Ratul, A.S.M. Bakibillah, “White blood cells nucleus segmentation from microscopic images of strained peripheral blood film during leukemia and normal condition”, 2016 5th International Conference on Informatics, Electronics and Vision, ICIEV 2016, pp. 361-366.

[3] M. Sajjad, S. Khan, Z. Jan, K. Muhammad, H. Moon, J.T. Kwak, S. Rho, Seungmin, W. Sung I. Mehmood, “Leukocytes Classification and Segmentation in Microscopic Blood Smear: A Resource-Aware Healthcare Service in Smart Cities”, IEEE Access 2017, pp. 3475-3489.

[4] K.K. Jha, B.K. Das, H.S. Dutta, “Detection of abnormal blood cells on the basis of nucleus shape and counting of WBC”, Proceeding of the IEEE International Conference on Green Computing, Communication and Electrical Engineering, ICGCCEE 2014.

[5] S. Manik, Lalit, M. Saini, N. Vadera, “Counting and Classification of White Blood Cell using Artificial Neural Network (ANN)”, 1st IEEE International Conference on Power Electronics. Intelligent Control and Energy Systems (ICPEICES-2016, pp. 1-5.

[6] Gautam, Anjali, Bhadauria, Harvindra, “Classification of White Blood Cells Based on Morphological Features”, 2014 International Conference on Advances in Computing,Communications and Informatics (ICACCI), pp. 2363-2368.

[7] J. Hari, A.S. Prasad, S.K. Rao, “Separation and counting of blood cells using geometrical features and distance transformed watershed”, Proceedings of the IEEE International Caracas Conference on Devices, Circuits and Systems, ICCDCS 2014 pp. 1-5.

[8] S. Abbas, “Microscopic images dataset for automation of RBCs counting”, Data in Brief 5 2015., pp. 35-40.

[9] J. Lou, M. Zhou, Q. Li, C. Yuan, H. Liu, “An automatic red blood cell counting method based on spectral images”, 2016 9th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), pp. 1391-1396.

[10] Tulsani, Hemant, Gupta, Rashmi, Kapoor, Rajiv, “An Improved Methodology for Blood Cell Counting”, IEEE Impact 2013, pp. 88-92.

[11] S.S. Adagale, S.S. Pawar, “Image Segmentation using PCNN and Template Matching for”, IEEE 2013.

[12] Loddo, Andrea, Putzu, Lorenzo, Ruberto, Cecilia DI, Fenu, Gianni, “A Computer-Aided System for Differential Count from Peripheral Blood Cell Images”, Proceedings - 12th International Conference on Signal Image Technology and Internet-Based Systems, SITIS 2016, pp. 112-118.