Automated Counting of Platelets and White Blood Cells from Blood Smear Images

Chapter · November 2019

DOI: 10.1007/978-3-030-34872-4_2

4 authors:

Lipi B. Mahanta
Institute of Advanced Studies in Science and Technology
87 PUBLICATIONS **865** CITATIONS
SEE PROFILE

Kangkana Bora
Cotton University
34 PUBLICATIONS **320** CITATIONS
SEE PROFILE

Sourav Jyoti Kalita
Assam Engineering College
1 PUBLICATION **2** CITATIONS
SEE PROFILE

Priyangshu Yogi
Institute of Advanced Study in Science and Technology
1 PUBLICATION **2** CITATIONS
SEE PROFILE

Automated Counting of Platelets and White Blood Cells from Blood Smear Images

Lipi B. Mahanta[1(✉)], Kangkana Bora[2], Sourav Jyoti Kalita[3], and Priyangshu Yogi[3]

[1] CCNS, IASST, Guwahati 781035, India
lbmahanta@iasst.gov.in
[2] Department of Electronics and Electrical Engineering, Indian Institute of Technology, Guwahati 781039, Assam, India
kangkana.bora89@gmail.com
[3] Department of Computer Science and Engineering, Assam Engineering College, Guwahati 781013, India
kalitasouravl2@gmail.com, priyangshuy@gmail.com

Abstract. Platelet Detection and Count are one of the major analysis of the pathological test of the blood. Conventional methods of analysis involve observation of blood smear samples under the microscope and manually identifying and counting the numbers. This process is slow and tedious. This work presents a method to automatically detect and count the number of platelets. A sample size of 270 images collected indigenously is used for carrying out the experiments with the proposed methodology, which result in an accuracy of 95.59% for platelets and 100% for WBCs respectively.

Keywords: Platelet · WBC · Segmentation · Counting · Binary thresholding · Morphological operation

1 Introduction

Platelet count is a very important pathological analysis which assists in the identification of many diseases such as malaria, dengue, yellow fever, etc. and therefore in many cases, immediate diagnosis of platelet count is required to know the state of a person's health. Platelets are tiny blood cells that help our body to form clots to stop bleeding. Normal platelet count is 150,000 to 450,000 per microliter in human beings. But due to various factors, there may be deviations in the platelet count from the normal range. Medical conditions with abnormal platelets and platelet counts are listed in Table 1.

Similarly, White Blood Cell (WBC) count is also a very important analysis in pathology to identify various diseases. White blood cells are the infection-fighting cells in the blood. They are distinctive from the red blood cells which are oxygen-carrying and are known as erythrocytes. The normal range for the white blood cell count varies between laboratories but is usually between 4,300 and 10,800 cells per cubic millimeter of blood. Medical conditions with abnormal WBCs and WBC counts are listed in Table 2.

B. Deka et al. (Eds.): PReMI 2019, LNCS 11942, pp. 13–20, 2019.
https://doi.org/10.1007/978-3-030-34872-4_2

Platelets and WBC counts are achieved by observing the blood smears under a microscope and manually counting the cells. This is tedious and time-consuming. Also, it suffers due to the presence of a non-standard precision as it depends on the operator's skills. The main goal of this work is to develop a system for automatic detection and count of platelets and WBCs from blood smear images using image processing techniques. It would reduce the workload and time taken for analysis as well as reduce dependency on the non-standard operator skill.

Table 1. Medical conditions associated with platelets.

Sl. No.	Medical condition	Cause	Symptoms
1	Thrombocytopenia	Bone marrow makes too few platelets or platelets are destroyed	Bleeding from cuts or nose bleed won't stop, internal bleeding, etc.
2	Thrombocythemia	Bone marrow makes too many platelets	Blood clots might form and they may block the blood supply to the head and heart. It may cause heart attacks
3	Thrombocytosis	Not caused by bone marrow abnormality but by diseases or conditions stimulating the bone marrow to make more platelets	Headache, chest pain, dizziness, weakness
4	Platelet dysfunction	Platelet dysfunction may be due to a problem in the platelets themselves or to an external factor that alters the function of normal platelets	Easy bruising or excessive bleeding after minor injuries

Table 2. Medical conditions associated with WBC.

Sl. No.	Medical condition	Cause	Symptoms
1	Leukocytosis (High WBC Count)	Infection, immunosuppression, emotional stress, injury	Weight loss, fever, stomach ache, chest pain
2	Leukopenia (Low WBC count)	Bone marrow disorders or damage, Radiation treatments for cancer, infections	Fever and chills, swelling and redness, pain or burning when urinating

2 Literature Review

A lot of work has been done in the segmentation of RBCs and WBCs but not much on platelets. On the basis of our survey, Prasannakumar et al. [1] used gray conversion, median filter, Gaussian filter, normalization in pre-processing and Fuzzy C means in segmentation to obtain an accuracy of 96%. Dela Cruz et al. [2] used HSV conversion and HSV thresholding and obtained an accuracy of 90%. Dey et al. [3] used RGB to LAB conversion and Chromaticity layer extraction, binary thresholding, and morphology and obtained an accuracy of 92.71%. Adapting an iterative structured circle detection algorithm for the segmentation and counting of WBCs and RBCs Alomari et al. [4] achieved an average accuracy of 95.3% for RBCs and 98.4% for WBCs.

3 Objective

The objective of this work is to develop a computer-aided system to detect and count the number of platelets and WBCs from a given blood smear image using image processing techniques.

4 Methodology

This method proposes a means to segment the platelets and WBCs from the blood smear images and provides a method of counting the number of platelets. We captured 270 microscopic blood smear images from 12 different blood sample slides, collected from few pathological laboratories in the city, viz. Guwahati, Assam, India. The microscope used was Leica (Leica ICC 50 HD microscope, 24-bit color depth). The images with very less number of platelets, improper stained platelets or hazy images were rejected. Thus from the 270 images in the dataset, a total of 249 images were selected for our work. The resolution of the image is 2048 × 1536 pixels. The algorithm is implemented in Python 3.6.5 using opencv 3.2.0. The ground truth labeling was done separately for platelets and WBCs using MS-Paint.

The block diagram (Fig. 1) shows the overall workflow of the method. The proposed work is implemented in 4 steps: (A) Image Preprocessing (B) Image segmentation (C) Post-processing (D) Platelet and WBC count.

A. **Image pre-processing:** In this step, Gaussian filter using a window of size (5 × 5) was applied to remove the random noise in the image. The image was converted after that to LAB color space. The L*a*b color space comprises of three different layers namely luminosity layer 'L*', chromaticity layers 'a*' and 'b*' (Fig. 2).
B. **Image segmentation:** The transformed image was binarized by the method of masking the pixels having values under a certain threshold. The threshold value was determined experimentally by hit and trial method. Morphological operation of the opening was performed on the binarized image and over that, dilution was performed using a structuring element of radius 3px to remove the noise occurred during binarization. The contours having a size less than 162 pixels (found out

experimentally) are drawn using the function *drawContours()*. This image now contains all the platelets. Bitwise AND is then performed to get the image containing all the WBC.

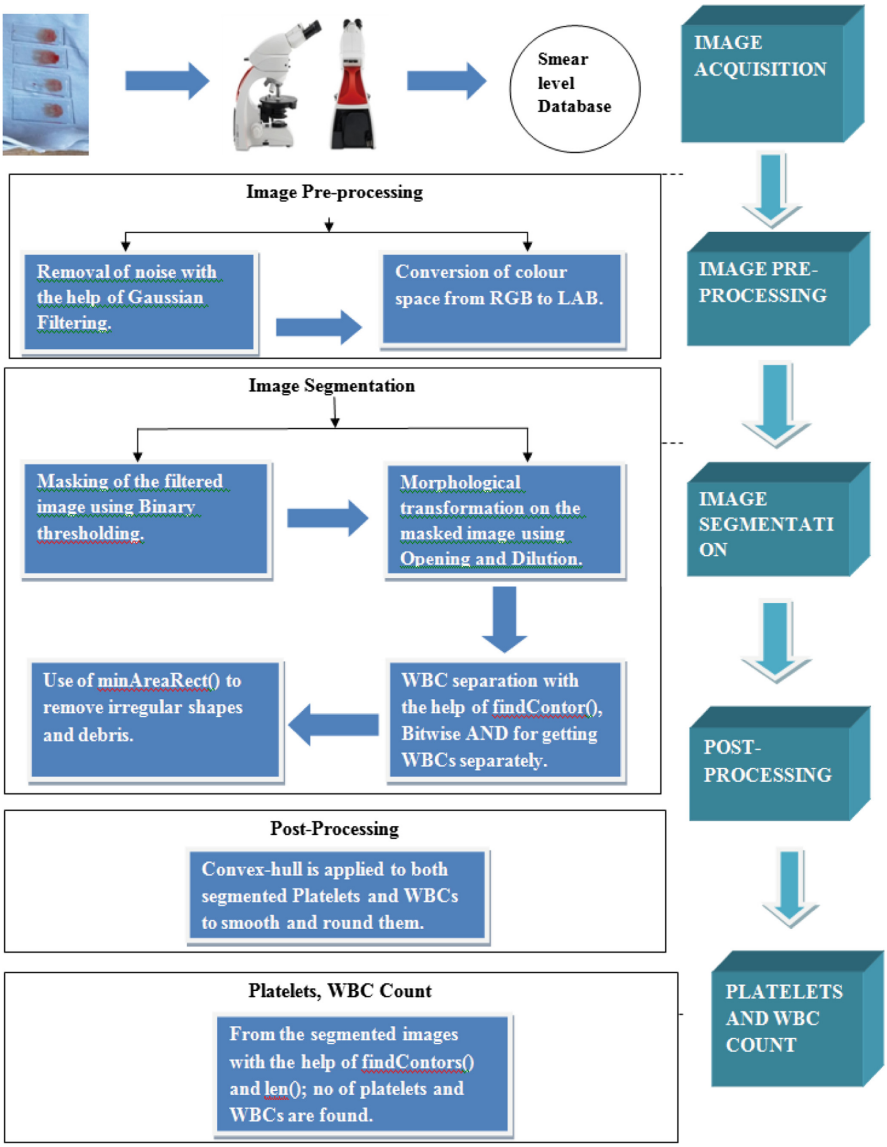

Fig. 1. Block diagram of the proposed methodology

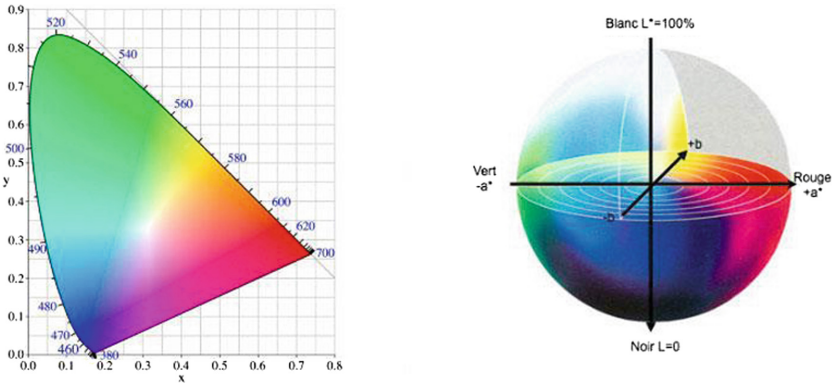

Fig. 2. Chromaticity layers of LAB color space

To remove the small debris, the same method is used to eliminate the contours having a size less than 18 pixels. To remove the objects of irregular shapes which may be stains or other debris, *minAreaRect()* function is used which draws a rectangle bounding the object. The aspect ratio, which is the ratio between the width and height of the rectangle is then measured. If the ratio is less than 0.65 or more than 1.35, the object is eliminated. These values are determined experimentally.

C. **Post-processing:** Convex hull was applied to both the platelet images and WBC images. This rounds up the irregularities and the objects become smoother and circular. These are stored as final images in our directory.

D. **Platelets and WBC count:** The number of objects in the segmented image is counted giving us the platelet count of the blood smear sample. For this, the contour detection function of opencv was *findContours()*. After storing the contours in a matrix (say contours), its length was found out using *len()* function of python. This gives us the required platelet count. The count values are tested for statistical significance using Karl-Pearson's t-test and further analysed by Box and Whisker plot, using SPSS (version 17.0).

The same method is used to count the number of WBCs.

5 Results

Following the methodology mentioned above the results of the experiment are presented in Fig. 3. Further, comparing the processed images with the ground truth labelled images, TRUE-POSITIVE (TP), TRUE-NEGATIVE (TN), FALSE-POSITIVE (FN) and FALSE-NEGATIVE (FN) values are determined. The result of ten samples is shown in Table 3 and depicted in Fig. 4. From the sample size of 270 images, we have obtained an accuracy of 95.59% for platelets and 100% for WBCs respectively (Table 4). The *P* value of t-test for the samples is 0.6598. Since *P* value is >0.5, we can conclude that the means of the two sets of data have are not significantly different.

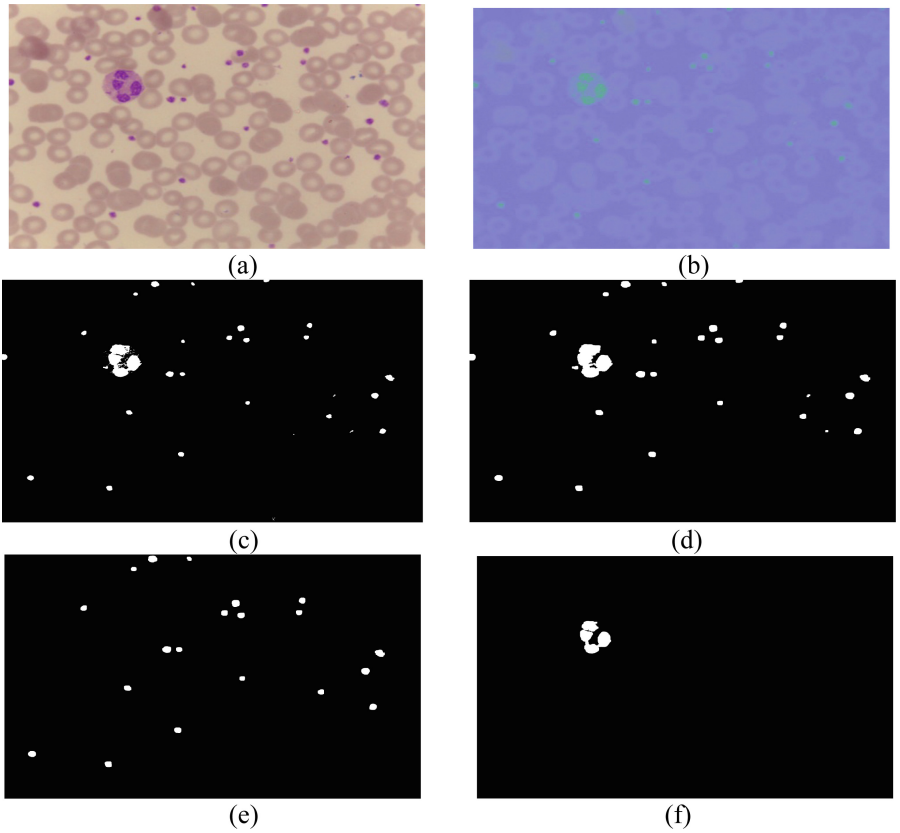

Fig. 3. (a) Original image, (b) LAB color space image, (c) Binarization, (d) Morphology, (e) Platelets, (f) WBC

Table 3. Comparison of manual count and automated count for platelets.

Sl. No.	TP	TN	FP	FN	TC(original)	TC(processed)
1	11	1	0	0	11	11
2	13	1	0	2	15	13
3	7	1	1	0	7	8
4	9	1	0	0	9	9
5	8	1	0	0	8	8
6	6	1	0	0	6	6
7	9	1	0	0	9	9
8	8	1	1	0	8	9
9	11	1	1	0	11	12
10	10	1	1	0	10	11

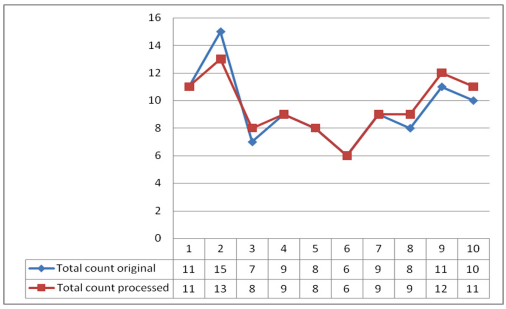

Fig. 4. Graph showing comparison of platelet count before and after segmentation.

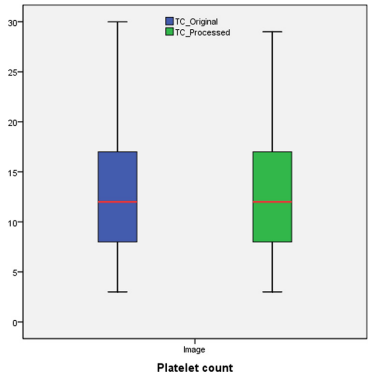

Fig. 5. Box and whisker plots of the original and estimated TC (platelet) values.

To highlight the similarity between manual count and automatic count based on the proposed methodology, box and whisker plots of the Total count values are illustrated in Fig. 5. It is seen that the median count, as well as the first and third quartile, of the proposed approach, coincide well with the manual count. Again, between these two methods, the proposed method has a slightly lower upper whisker, indicating lower variation in the counts.

Table 4. Performance evaluation for platelets and WBC over our collected dataset.

Type	TP	TN	FP	FN	Accuracy	Sensitivity	Specificity	Precision
Platlet	3159	249	50	107	95.59%	96.72%	83.27%	98.44%
WBC	106	249	0	0	100%	100%	100%	100%

6 Discussion

Though we have obtained an accuracy of around 96%, it could be better if we use cleaner blood slides. Our proposed method was applied to the LISC (Leukocyte Images for Segmentation and Classification) [4] dataset over 64 images after eliminating the bad quality images. We have obtained an accuracy of 87.56% on platelets and 100% on WBCs (Table 5).

Table 5. Performance evaluation for platelets over the LISC dataset.

Type	TP	TN	FP	FN	Accuracy	Sensitivity	Specificity	Precision
Platelet	464	64	13	62	87.56%	88.21%	83.11%	97.27%
WBC	71	64	0	0	100%	100%	100%	100%

The performance depletion is due to the color variation in the blood smear images of our dataset with the LISC dataset. By changing the thresholding values in our method, the performance level can be increased.

It is to be also noted Roy et al's [5] paper has reported the highest accuracy among the studied papers (98.8%). The methodology adopted by the study was applied over our dataset but the result was not good. The dataset they used is unknown and might be different from ours in many aspects. This might be the reason for poor performance.

7 Conclusion

Platelet and WBC detection and count is a very important pathological analysis. It can be used as an effective aid to detect various disorders and diseases. We have used 249 images from the dataset and obtained an accuracy of 95.59% for platelets and 100% for WBCs. Thus we conclude that this method can be taken forward and applied in the medical field.

References

1. Prasannakumar, S.C., Puttamadegowda, J.: White blood cell segmentation using fuzzy C means and snake. In: International Conference on Computational Systems and Information Systems for Sustainable Solutions (2016)
2. Cruz, D., et al.: Determination of blood components (WBCs, RBCs, and Platelets) count in microscopic images using image processing and analysis. In: IEEE 9th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment and Management (HNICEM), Manila, pp. 1–7 (2017)
3. Dey, R., Roy, K., Bhattacharjee, D., Nasipuri, M., Ghosh, P.: An automated system for segmenting platelets from microscopic images of blood cells. In: Proceedings of 2015 International Symposium on Advanced Computing and Communication (ISACC), Silchar, India (2015). https://doi.org/10.1109/isacc.2015.7377347
4. Alomari, Y.M., Sheikh Abdullah, S.N., Zaharatul Azma, R., Omar, K.: Automatic detection and quantification of WBCs and RBCs using iterative structured circle detection algorithm. Comput. Math. Methods Med. **2014**, 979302 (2014). https://doi.org/10.1155/2014/979302
5. LISC: Leukocyte Images for Segmentation and Classification. http://users.cecs.anu.edu.au/~hrezatofighi/Data/Leukocyte%20Data.htm. Accessed 20 Mar 2019