International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Automated Blood Cell Counting System Using Customized Hough Transform

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Abstract: ***In this paper we tries to introduce an efficient and cost effective computer vision system for automatic blood cell counting using image based analysis, Which reduces the strain on the Technician and whose output is reliable and accurate. In this paper, a software based approach is used to count a number of blood cells from the blood sample's image taken by the digital camera attached with the microscopic setup. In the pre-processing step the original blood sample's image is converted into saturation image. Segmentation is done by histogram thresholding. Next step feature extraction is accomplished through differentiating a blood cell with each other and from background. The final step is to find out the number of blood cell from the blood sample's image by using Circular Hough Transform technique.***

Keywords: K - means clustering, Binarization, edge detection, Hough Transform and Circular Hough

1. Introduction

In this work, the focus of our study is on medical images. A large number of medical images in digital format are generated by hospitals and medical institutions every day. Consequently, how to make use of this huge amount of images effectively becomes a challenging problem. In the field of biomedicine, because of cell's complex nature, it still remains a challenging task to segment cells from its background and count them automatically. Counting problem arises in many real world applications including cell counting in microscopic images, monitoring crowds in surveillance systems and performing wildlife census. The microscope inspection of blood slides provides important qualitative and quantitative information concerning the presence of hematic pathologies. From decades this operation is performed by experienced operators, which basically performs two main analyses. The first is the qualitative study of the morphology of the cells and it gives information of degenerative and tumoral pathologies.

The second approach is quantitative and it consists of differential counting of the blood cells. Automated cell counter systems for example laser-based citometers are available in the market, but they are not image based or morphological and they destroy the blood samples during the analysis. Only few attempts of partial / full automated systems based on image processing systems are present in literature and they are still at prototype stage.

The human blood consists of three types of blood cells such as red blood cell (RBC), white blood cell (WBC) and platelets (PLT). The red blood cell or erythrocytes are the more number of blood cells in the human body. Usually doctors use one of the main information to diagnose various diseases is the blood cell count. According to American Cancer Society (2009), the normal red blood cells in our body is divided into four categories of ages, which are new born, children, women and men. Red blood is measured by the amount of haemoglobin. (The normal red blood cells in our body are shown in the table 1.1.) We suffered fatigue and short of breath when the level of haemoglobin is too low due to insufficient oxygen supply. The effect of high red blood cells in our blood can be indication of an undetected heart or lung problems. Therefore, RBC count is very important in diagnosis of many dieses. In this paper we focus on the problem of identification and counting of blood cells by microscopic images. The proposed work individuates the red blood cells from the other blood cells in the blood cell images by using Hough Transform method and subsequently it counts the number of red blood cells in the images. The whole work has been done on MATLAB platform. Finally, the count is normalized to get it per cubic millilitre, which is the normal practice by a medical practitioner.

Table 1.1: Normal range of red blood cell

Different categories of human being	Number of red blood cell per micro liter in million
New-born	4.8 to 7.2
Children	3.8 to 5.5
Women	4.2 to 5.0
Men	4.6 to 6.0

White blood cells help the body fight infection. The normal white blood cell count in healthy people is 5,000 to 10,000/mm^3. When the white blood cell count is low, it is easier to get an infection and harder to get over it and Platelets are blood cells that help stop bleeding by making the blood clot. A normal platelet count in healthy people is 150,000 to 400,000/mm^3. Bruising and bleeding often happen when platelet counts are low. A platelet transfusion may be needed when the platelet count is very low. [10]

2. Background and Related Work

2.1 Traditional System

In the microscopic-based evaluation an optical microscope is used to visualize a film, prepared using blood sample from a patient. Well trained laboratory person are then responsible for manually classifying and counting the cells of interest. While this method seems to be straightforward, it relies upon the expertise of the observer to classify the cells and might have results depending on the instantaneous capability of the technician to perform at his/her best performance potential. This reader-dependent performance varies along time mainly because visual quantification of cells through microscope is a repetitive and time-consuming task where the complexity and the unstructured nature of biological images present a unique set of challenges in data analysis and interpretation. Since, the old conventional method of Blood cell counting under microscope gives an unreliable and inaccurate result depends on clinical laboratory technician skill. This method puts a lot of strain on the technician.

2.2 Automatic Haematology Analyser

Another method for Blood counting uses the automatic haematology analyser, for providing faster and reader-independent counting; automatic counting equipment's were developed. This method soon became a reference for automatic complete blood cell (CBC) counting and is still largely used in blood analysis laboratories. In the 1970s, automated human blood equipment's using microscopic image analysis with high throughput performance became commercially available however; there still exist aspects that need improvement. This machine is very costlier. So it is not possible all the hospital's clinical laboratory implement such an expensive machine to count the blood cell in their laboratory.

2.3 Venkatalakshmi B, Thilagavathi K, "Automatic Red Blood Cell Counting Using Hough Transform"[1]

In this paper the authors tries to introduce an efficient and cost effective computer vision system for automatic red blood cell counting using image based analysis, Which reduces the strain on the Technician and whose output is reliable and accurate.

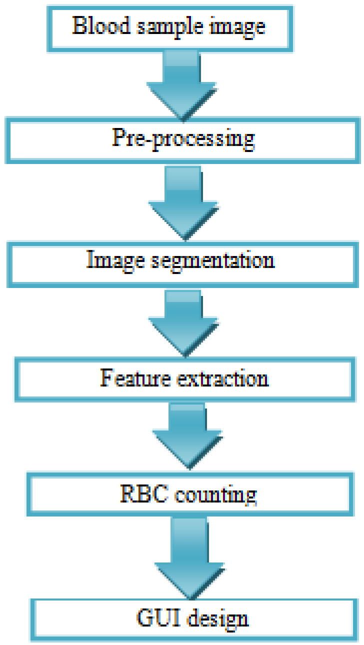
A software based approach is used to count a number of red blood cells from the blood sample's image taken by the digital camera attached with the microscopic setup. There are five steps involved in the process of estimating the red blood cells. These are:

1) Input image acquisition,
2) Preprocessing,
3) Segmentation,
4) Feature extraction, And
5) RBC counting.

In the pre-processing step the original blood sample's image is converted into saturation image. Segmentation is done by histogram thresholding. Next step feature extraction is accomplished through differentiating a red blood cell with other cells (WBC and platelets) and background. The final step is to find out the number of red blood cell from the blood sample's image by using Hough Transform technique.

The author gives the idea of future work, which will be focused on complete blood cell count like white blood cell and platelets using suitable segmentation and counting algorithm based on the shape and size of the cells.

Three main techniques are used to estimate the number of red blood cells in the blood smear image which are logical, morphological and Hough transform. Figure1shows the complete flow chart of proposed system.



2.4 Mausumi Maitra, Rahul Kumar Gupta and Manali Mukherjee, "Detection and Counting of Red Blood Cells in Blood Cell Images using Hough Transform"[11]

In this paper, the author's purpose of the work is to count the number of red blood cells in a given blood sample. For this he has applied various pre-processing techniques like edge detection, spatial smoothing filtering and adaptive histogram equalization to detect and extract the red blood cells from the images. Feature extraction has been done through the Hough Transform method which has been used to find out the red blood cells based on their sizes and their shapes. This isolates the red blood cells from the rest of the image of the blood sample so that further processes like counting can be applied exclusively on them.

The Hough transform [14] is a feature extraction technique used in image analysis, computer vision and digital image processing. It was initially suggested as a method for line detection in edge maps of images, and then extended to detect general low-parametric objects such as circles [5, 13]. To detect a straight line in an n X n image, the simplest method is to compute all possible lines defined by every pair of points in the image and then find all subsets of points that are closed to particular line. The computation involved will be enormous because the maximal possible line is $n(n-1)/2 \sim n^2$ and then $(n)[n(n-1)]/2 \sim n^3$. Comparisons need to be performed for each and every point in the image. The problem is solved using Hough Transform that uses the parametric description of the shape to reduce the computation involved. Considering two points (x1, y1) and (x2, y2) in the x-y plane, the line equation is:

$$y_i = ax_i + b, \tag{1}$$

Rewriting the equation

$$b = -ax_i + y_i \tag{2}$$

Two points are represented in the x-y as well as a-b plane. The first point (x1, y1) and the second point (x2, y2) each yield a line in the a-b plane and both the lines intersect at a point and this is also true for all the points contained in the line. Using this unique feature a parameter space called as the accumulator cell or Hough space is created with a-axis and b-axis having a min and max of the expected range. The same method used for the detection of straight lines can also be extended for the detection of circle and the equation is:

$$(x-a)\ 2 + (y-b)\ 2 = r2 \tag{3}$$

Having successfully isolated the red blood cells we have applied a counter that has counted the number of RBC's in the image field.

3. Proposed System

Similar to the base paper, software based approach is used to count a number of blood cells i.e. red blood cell as well as white blood cell from the blood sample's image taken by the digital camera (CMOS camera) attached with the microscopic setup. There are five steps involved in the process of estimating the red blood cells. These are:
1) Input image acquisition,
2) Preprocessing,
3) Segmentation based on Feature,
4) Blood cell counting, and
5) GUI.

In first step, i.e. in Input image acquisition blood sample's image taken by the digital camera attached with the microscopic setup. The digital camera attached with the microscopic setup is CMOS camera, which gives in uniformly focused image of blood sample not only centrally focused like in any ordinary digital camera. The figure 3 shows CMOS camera. The resolution of the Microscope is 40X or 100X, for clear vision the Microscope have one more lens attached on head part called as eye piece. To attach the CMOS camera we remove the eye piece of Microscope and fix it to the CMOS camera as shown in figure 4. The eye piece resolution is 5X or 10X.

Figure 3 CMOS Camera

Figure 4: CMOS Camera attached with Microscope

Then in 2nd step i.e. pre-processing step the original blood sample's image shown in figure 5 is processed. In this process the filtering and de-noising techniques are applied. For this technique similar to the K - means clustering are applied. Segmentation based on Feature is the 3rd step, in which color feature of image is used. In this the de-noised image is converted in different color feature like RGB color form as shown in figure 6 and HSV color form as shown in figure 7.

Then the image is converted to gray form as shown in figure 8, then this gray image is converted into binary image i.e. binarization technique is applied on the gray image, this is done by histogram thresholding. The binarized image is shown as figure 9.

Now at this stage the binary image is available, this image is given as input to the Segmentation based on shape feature, in which we finds the edges of the all shape in the image of blood sample as shown in the figure 10.

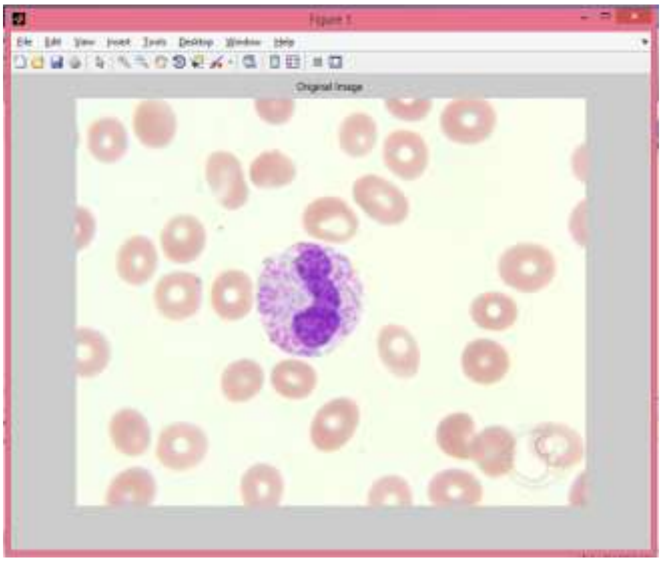


Figure 5: Original blood sample's image

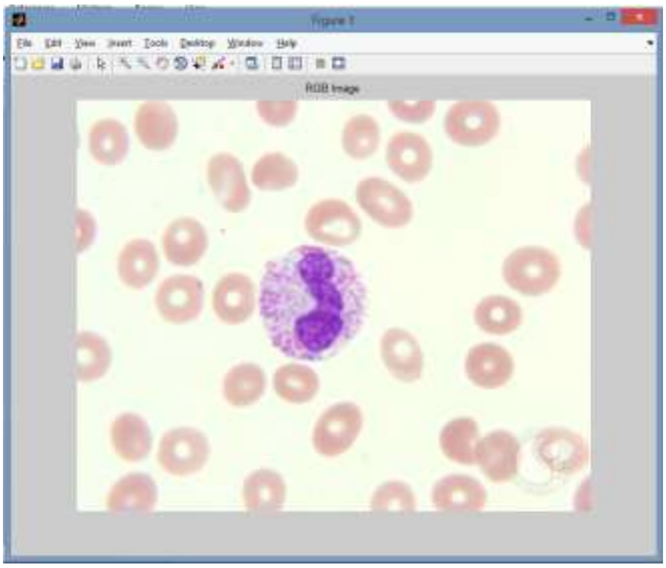


Figure 6: RGB image

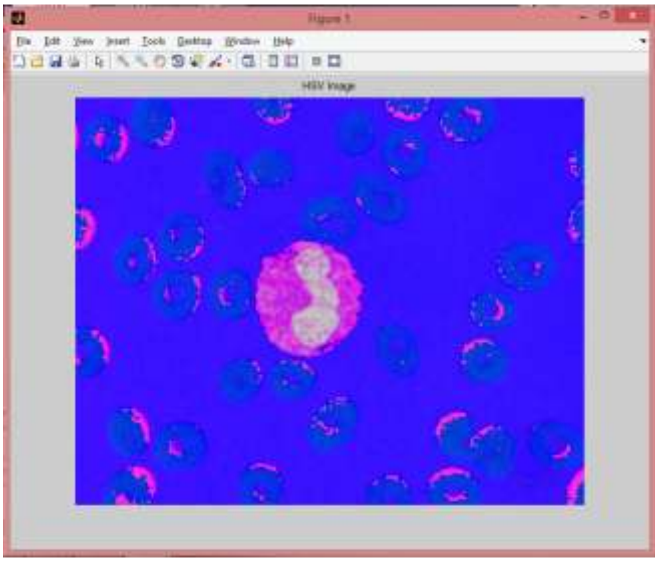


Figure 7: HSV image

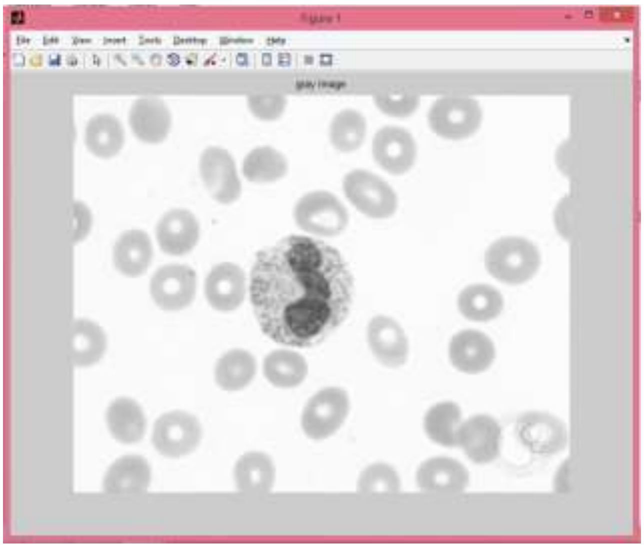


Figure 8: Gray image

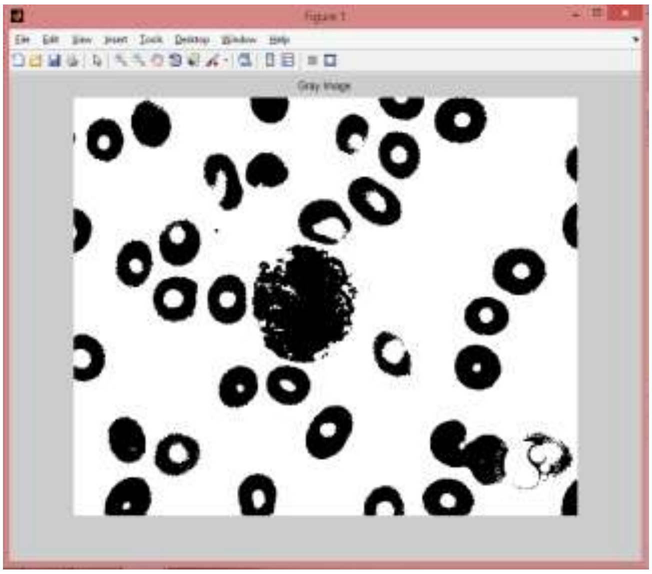


Figure 9: Binarized image

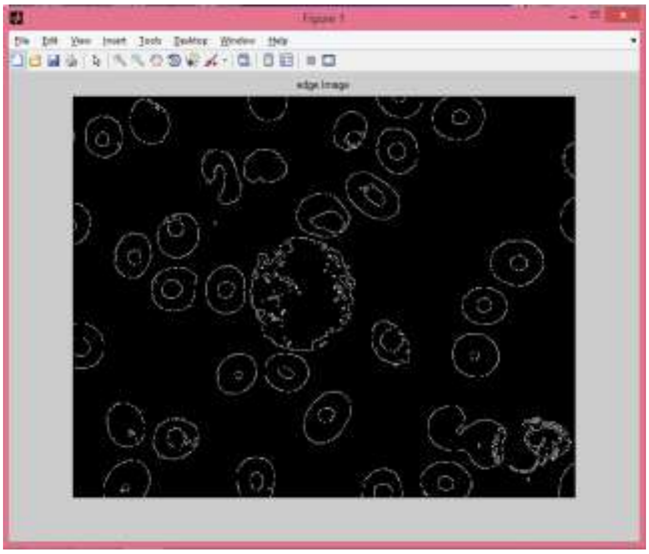


Figure 10: Edge image

Then with the help of this edges and other feature, the extraction is accomplished through differentiating a red blood cell with other cells (WBC and platelets) and background and we differentiate white blood cell from others and background as well. The final step is to find out the number of red blood cell and white blood cell from the blood sample's image by using Hough Transform technique more clearly by using circular Hough transform.

Similar to base paper three main techniques are used to estimate the number of red blood cells and white blood cell in the blood smear image which are logical, morphological and Hough transform. Figure shows the complete flow chart of proposed system.

In the figure 11 the GUI of the software is shown. The GUI is basically divided into two parts in first part, there is a provision to upload the image and then there are buttons for the Calculation of the existing system and proposed system. Second part of the GUI consist a provision for the Output to be display in which Figure is shown in container at right side and the Total count of the Red Blood cell and Total count of the White Blood cell.

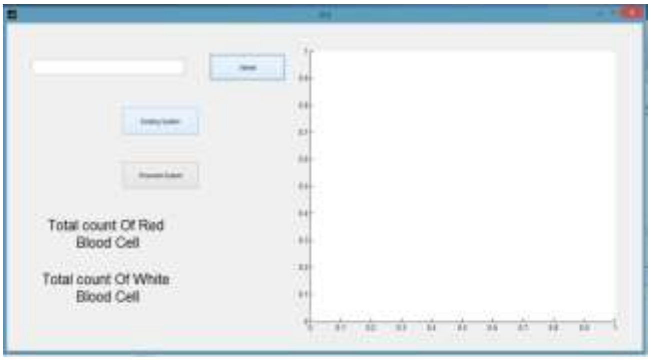


Figure 11: GUI of software

After uploading an image the image is shown in the Software it is displayed on the output window as shown in the figure 12.

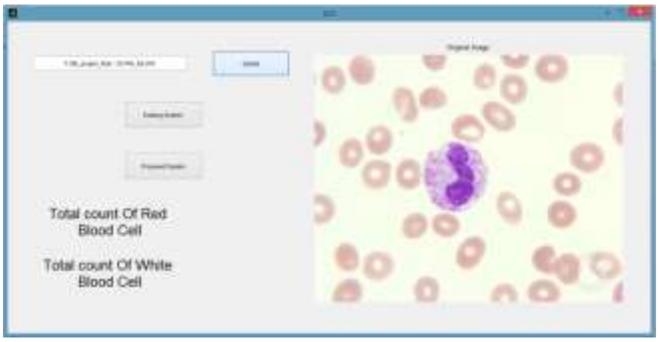


Figure 12: After uploaded in software

4. Result/Discussion

The results of this system is effective and efficient system, which is also a low cost system, which reduces the stress on the technician and it count the total number of Cells in the blood that is red blood cell and white blood cell.

Existing system counts only the red blood cell and the results are also poor the total count of the red blood cell is not a perfect count. The figure 13 shows the results of the existing system.

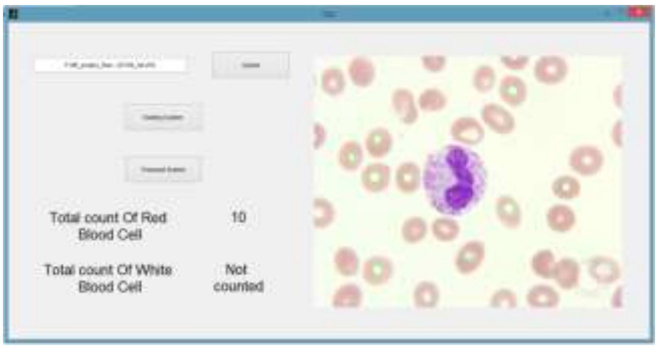


Figure 13: After execution of Existing System in software

Our system calculates or counts the Red blood cells and the White blood cells in the image. The figure 14 shows the results after execution of proposed system.

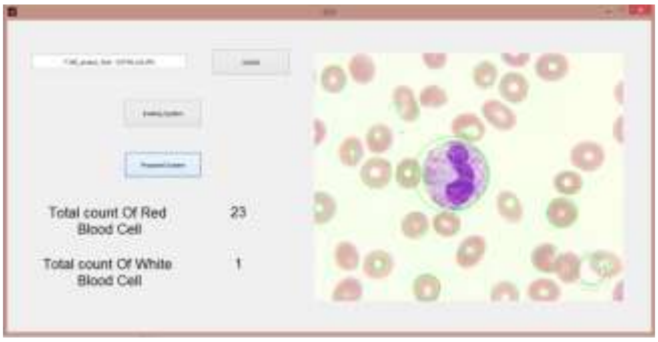


Figure 14: After execution of Proposed System in software.

5. Conclusion

The goal of this research work is to produce cost effective and efficient computer vision system for automatic Detection of Desired patterns from blood sample's microscopic images. Compare to manual counting it is less time consuming method. Manual counting method is tedious job and also gives inaccurate result, which is improved in this system. Automatic Haematology analyser is there to count blood cells but it is very costlier, when we are comparing with this system. This computer based automatic method will be implemented in real time microscopic image captured from the digital camera attached with microscopic setup, so blood cells are also not damaged.

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