Counting of RBCs using circular Hough transform with median filtering

Asjad Nabeel
Government College Of Engineering Kannur

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P. Najiya Nasreen, A. Chempak Kumar and P.Asjad Nabeel

Abstract--- *Precise value of blood cell count plays a very important role in the disease diagnosis field. Increment or decrement in the count of blood cell causes many diseases to occur in the human body like leukemia and anemia. Conventional method involves the manual counting of the blood cells, it is very time consuming and inaccurate. LASER type hematology counters are very expensive and it may damage the cells. A fast and cost effective automated counter using digital image processing is proposed in this paper. It consists of the analysis and processing of microscopic image of the blood smear. The salt and pepper noise in the blood smear image is removed by median filtering and the blood cell count is obtained by circular Hough transform. The whole work has been done on the MATLAB 8.3 platform.*

Keywords--- Gray thresholding, Hough Transform, Image Segmentation, Median Filter

I. Introduction

HUMAN blood has various functions such as transportation of gases, immunity, temperature regulation etc. Blood consist of 55% by plasma and 45% by cells called formed elements. There are three types of cells such as red blood corpuscles (RBC), white blood corpuscles (WBC) and platelets. The five types of WBCs are monocyte, eosinophil basophiles, lymphocytes and neutrophil. The immunity is the important function of WBCs and blood clotting is the important function of platelets. By means of the hemoglobin contained in the erythrocytes, it carries oxygen to the tissues and collects the carbon dioxide (CO2) for purification. It also transports nutritive substances (e.g. amino acids, sugars, Mineral salts) through the body.

The analysis of individual blood components gives valuable information about the status of human body and can be used for the diagnosis of various disorders. There are conventional and automatic methods for the counting of blood cells. The conventional method is the manual counting of blood cells by the microscopic inspection. It is time consuming and produces a less accurate result. The current age popular haematological analyzing devices cannot identify morphological abnormalities in blood corpuscles with 100% precision as the detection part may subject to human error. LASER type haematology counters are very expensive and it may damage the cells.

Many digital images are being captured and stored such as medical images by hospitals and medical institutions every day. Blood smear images are also easily captured by the use of digital microscope. Currently, there are researches doing on the blood counting application in the image segmentation. Watershed segmentation algorithm, gray thresholding and edge detection algorithms are already used for the automated detection of RBCs. Red blood cell is measured by the amount of hemoglobin. Humans are suffering fatigue and short of breath when the level of hemoglobin is too low due to insufficient oxygen supply. The effect of high red blood cells in the human blood can be an indication of the undetected heart or lung problem. Therefore, RBC count is very important in the diagnosis of many diseases.

In this project, the aim is to count the total number of red blood cells in a microscopic image of blood smear using MATLAB. This work is an implementation of automated counting of blood cells using the image processing techniques. An image can be considered as a matrix of light intensity levels that can be manipulated using computer algorithms in MATLAB. Median filtering is used to remove noise which is added at the time of capturing the microscopic blood images. The Circular Hough transform is a specialization of Hough transform and is used for the detection of circles. Since the RBCs are of biconcave shape, circular Hough transform can be used to detect and count them.

The whole work has been done on MATLAB 8.3 platform. Finally, the count is normalized to get it per cubic millimeter, which is the normal practice by a medical practitioner.

A. Types of Blood Cells

The three blood cells are RBCs (erythrocytes), WBCs (Leukocytes) and the platelets (Thrombocytes). RBCs have biconcave shape and are red in color due to the presence of heamoglobin.4-6 million RBCs are present in 1 cubic milli meter of blood. RBCs are of size 6-8 μm and have a life span of 4 months. The main function of RBC is the transport of gases. The WBCs and the platelets have the functions immunity and blood clotting respectively and are colorless.

II. Proposed Methodology

In this project, the aim is to calculate the count of RBCs from the microscopic blood smear image. The block diagram and the flow chart of the method is shown in figure 1 and figure 4 respectively.

Najiya Nasreen P. , M Tech Scholar, Department of ECE, College of engineering Thalassery, Kerala, India. E-mail:najiya09@gmail.com

Chempak Kumar A., Asst. Professor, Department of ECE, College of engineering Thalassery, Kerala, India. E-mail: chempak_kumar@yahoo.com

Asjad Nabeel P., Asst. Professor (Ad hoc),Department of CSE, GCE Kannur, Kerala, India. E-mail: asjadnabeel@gmail.com

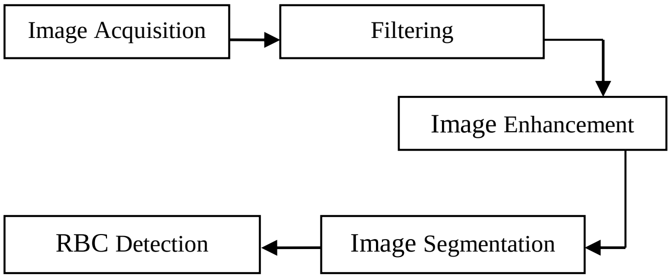

Figure 1: The Block Diagram for the Proposed Method

A. Image Acquisition

The digital microscope is interfaced to a computer and the microscopic images are obtained as digital images. The two image samples used for the project are shown below. The input image is in RGB format. For post processing, this image is to be converted in to gray scale format. Due to the consequences of converting the image in to gray scale, salt and pepper noise is added in the resultant image.

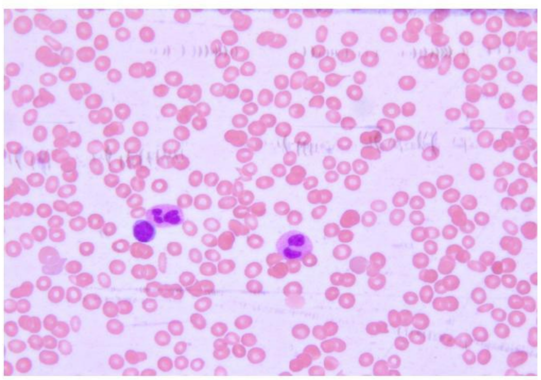

Figure 2: The Microscopic Blood Smear Image 1

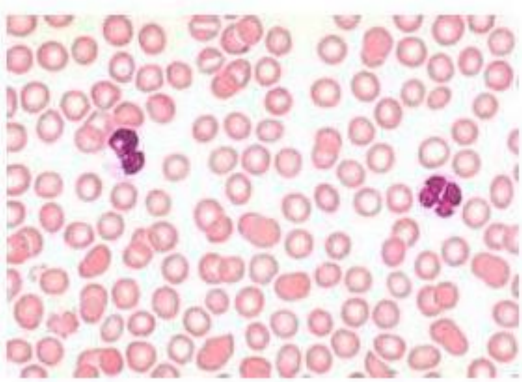

Figure 3: The Microscopic Blood Smear Image 2

B. Median Filtering

Median filtering is used to remove the noise which is added at the time of capturing the microscopic blood images. This noise can be the dust particles that are present on the blood slide while preparing the slides. Median filtering is a common image enhancement technique for removing salt and pepper noise [4]. Because this filtering is less sensitive than linear techniques to extreme changes in pixel values, it can remove salt and pepper noise without significantly reducing the sharpness of an image.

C. Image Enhancement

The input image has to be enhanced to obtain better segmentation; this improves the quality of the image. After filtering, the next step is the histogram equalization of imported image. We have used contrast-limited adaptive histogram equalization (CLAHE) which operates on small data regions (tiles), rather than the entire image [7].

D. Image Segmentation

Gray thresholding is done using *graythresh* function in matlab. This function uses Ostu's method, which chooses the threshold to minimize the intra class variance of the Black and white pixels [4]. The global threshold value is then used to convert an intensity image to a binary image with the function im2bw. The next step is to fill the holes present in the binary images.

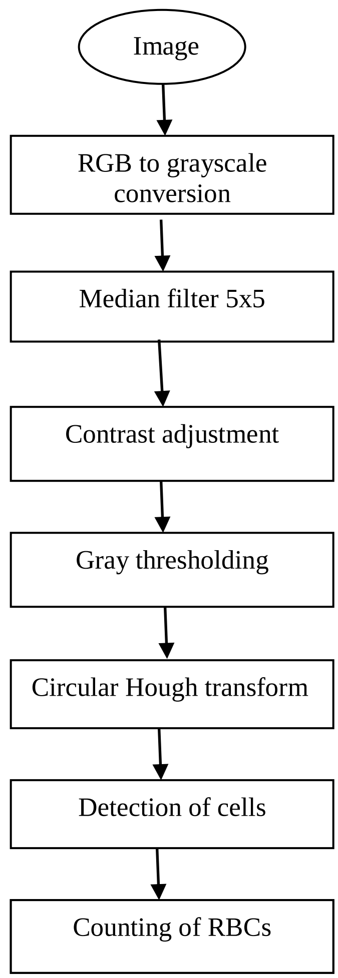

Figure 4: The Flow Chart for the Proposed System

E. The Hough Transform

The Hough transform is a feature extraction technique used in image analysis, computer vision and digital image processing. The purpose of the technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure [9]. This voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform; the simplest case of Hough transform is detecting straight lines. In general, the straight line $y = mx + b$ can be represented as a point (b, m) in the parameter space.

However, vertical lines pose a problem. They would give rise to unbounded values of the slope parameter m. Thus, for computational reasons, it is proposed the use of the Hesse normal form. The linear Hough transform algorithm uses a two-dimensional array, called an accumulator, to detect the existence of a line described by the Hesse normal form:

$$r = x\cos\theta + y\sin\theta \tag{1}$$

The dimension of the accumulator equals the number of unknown parameters, i.e., two, considering quantized values of r and θ in the pair (r,θ). For each pixel at *(x,y)* and its neighbourhood, the Hough transform algorithm determines if there is enough evidence of a straight line at that pixel. If so, it will calculate the parameters (r,θ) of that line, and then look for the accumulator's bin that the parameters fall into, and increment the value of that bin. By finding the bins with the highest values, typically by looking for local maxima in the accumulator space, the most likely lines can be extracted, and their (approximate) geometric definitions read off [9]. The simplest way of finding these peaks is by applying some form of threshold, but other techniques may yield better results in different circumstances, determining which lines are found as well as how many. Since the lines returned do not contain any length information, it is often necessary, in the next step, to find which parts of the image match up with which lines. Moreover, due to imperfection errors in the edge detection step, there will usually be errors in the accumulator space, which may make it non-trivial to find the appropriate peaks, and thus the appropriate lines. The final result of the linear Hough transform is a two-dimensional array (matrix) similar to the accumulator -- one dimension of this matrix is the quantized angle θ and the other dimension is the quantized distance r. Each element of the matrix has a value equal to the number of points or pixels that are positioned on the line represented by quantized parameters (r, θ). So the element with the highest value indicates the straight line that is most represented in the input image.

F. *The Circular Hough Transform*

The circle Hough Transform (CHT) is a feature extraction technique for detecting circles. It is a specialization of Hough Transform. The purpose of the technique is to find circles in imperfect image inputs. The circle candidates are produced by "voting" in the Hough parameter space and then select the local maxima in a so-called accumulator matrix [3].

In a two dimensional space, a circle can by described by:

$$(x-a)^2 + (y-b)^2 = r^2 \tag{2}$$

Where (a, b) is the center of the circle, and r is the radius. If a 2D point (x, y) is fixed, then the parameters can be found according to the equation given above. The parameter space would be three dimensional, (a, b, r). And all the parameters that satisfying (x, y) would lie on the surface of an inverted right-angled cone whose apex is a (x, y, 0).

Hough based approach for object detection is flexible as the primary voting elements are not restricted to edge pixels, but can include interest points, image patches or image regions. Another attractive property is the simplicity of the learning procedure. In this work, the RBCs are detected and counted by this circular Hough transform.

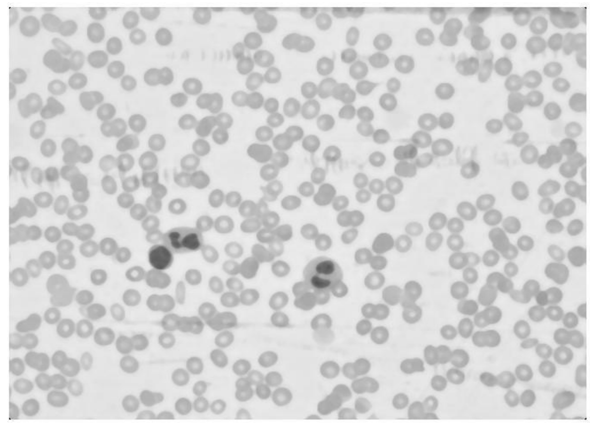

Figure 5: Median Filtered Gray Scale Image 1

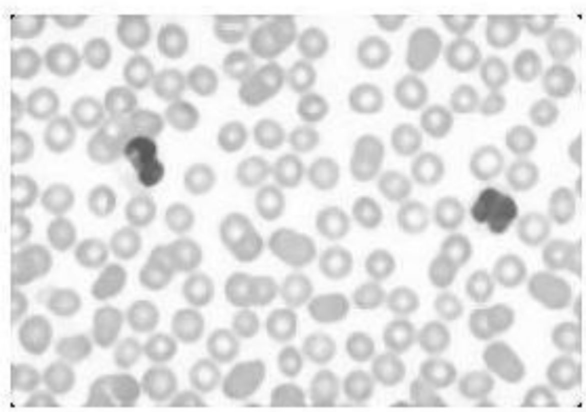

Figure 6: Median Filtered Gray Scale Image 2

III. Results and Discussions

The RBCs in the blood smear image are detected and counted by the circular Hough transform. However, blood count in medical terms means the number of blood cells (RBC or WBCs or platelets) in a cubic millimeter (cumm) of blood volume. So, the blood count in cumm is computed with the formula given below,

$$rbc\_c = (rbc\_cht / ((a/(m*m)) * ft)) * df \tag{3}$$

rbc_c=actual RBC count in 1 cumm
rbc_cht=RBC count obtained by circular Hough transform
a=input image area
m=magnification ratio
ft=film thickness
df=dilution factor

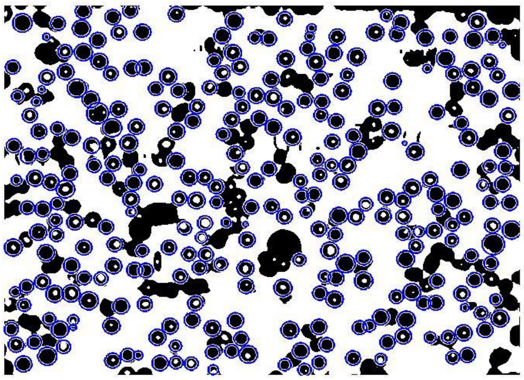

Figure 7: RBCs Detected in Image 1 by CHT

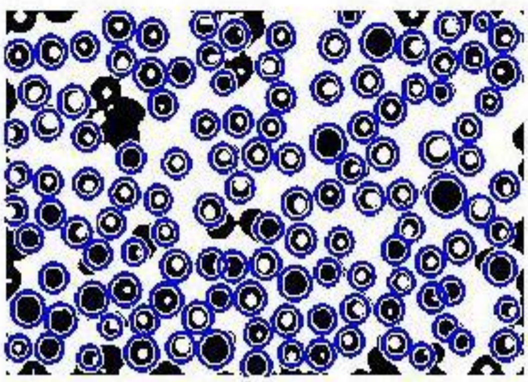

Figure 8: RBCs Detected in Image 2 by CHT

Table 1: Comparison between the Proposed Method and Manual Method

Image	Image 1	Image 2
Blood cell count by the proposed method per cumm (in millions)	5.66	4.61
Blood cell count by manual counting per cumm(in millions)	6.61	5.35

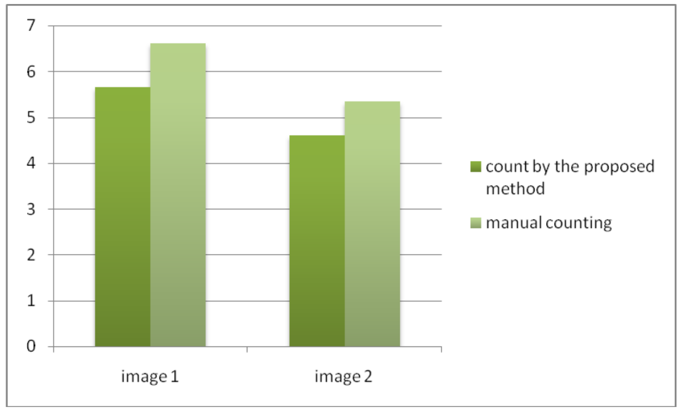

Figure 9: Graphical Representation of the Table 1

Conclusion and Future Enhancement

The manual counting of blood cells is time consuming. The proposed image processing method to calculate the blood cell count helps to do it faster within a fraction of few seconds. The accuracy of the algorithm depends on the camera used. Future works will be focused to obtain a more accurate blood count result by counting all the overlapped blood cells also. The circular Hough transform method can be extended to detect the various abnormalities of red blood cells and white blood cells such as Sickle cell anemia, leukemia using efficient image processing algorithms.

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