A SURVEY FOR AUTOMATIC IDENTIFICATION AND COUNTING OF BLOOD CELLS

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Abstract - *The blood consists of the RBCs, WBCs, Platelets and Plasma. The blood count defines the state of health. Blood may be a health indicator therefore segmentation and identification of blood cells is extremely important. Complete Blood Count (CBC) is counting of all the cells which determines person's health. The RBC and WBC count are vital to diagnose various diseases like anemia, leukemia, tissue damage, etc. Earlier, in the hospital laboratories were doing manual counting of blood cells using device called Hemocytometer and microscope. But this method extremely monotonous, laborious, time consuming, and results in the wrong results thanks to human errors. Also, there are some expensive machines like Analyzer, which aren't affordable by every laboratory. This produces a picture processing-based system which will automatically detect and count the number of RBCs and WBCs within the blood sample image. Image processing algorithm involves six steps. Also, it's supported segmentation process and a transfer learning process was applied to use this system to the microscopic detection of blood cells. The experimental results demonstrated that fast and efficient analysis of blood cells via automated microscopic imaging.*

Key Words*: *RBC, WBC, Platelets, Digital Image Processing, Morphology, Hough Transform, CHT, PCNN.

1. INTRODUCTION

Blood cell segmentation and identification is a vital task in the study of blood as a health indicator. A complete blood count is used to determine the state of a person's health based on the contents of the blood in particular white blood cells and the red blood cells. The main problem arises when massive amounts of blood samples are required to be processed by the hematologist or Medical Laboratory Technicians. The time and skills used for the task, limits the speed and accuracy of blood samples can be processed. To provide user-friendly software that allows quick user interaction with a simple tool for counting red and white blood cells from a provided image.

The complete blood count (CBC) is the blood test used to evaluate the health of person and to detect the disorders like anemia, infection and leukemia. In medical diagnosis Complete blood count is very important. There are three types of cells: Red Blood Cells (RBCs), White Blood Cells (WBCs) and Platelets. These cells can be differentiated using texture, color, size, and morphology of nucleus and cytoplasm. Cells count is required to determine the immunity and capability of the human. CBC is nothing but the counting of RBCs, WBCs, Platelets, Hematocrit and Hemoglobin component in the blood cell. Below Table shows the CBC for healthy person. CBC also contains white blood cells into five categories known as differential count. They are neutrophils, lymphocytes, monocytes, eosinophils and basophils. Their standard count is 60%, 30%, 5%, 4%, and 1% respectively [14].

Table -1: Standard CBC for healthy person

Blood cell type	**women**	**men**	**unit**
RBC	4-5	4.5-6.0	M/ µL
WBC	4.5-11	4.5-11	K/µL
Platelets	150-450	150-450	K/µL
Hematocrit	36%-45%	42%-50%	%
Hemoglobin	12-15	14-17	Gm/100ml

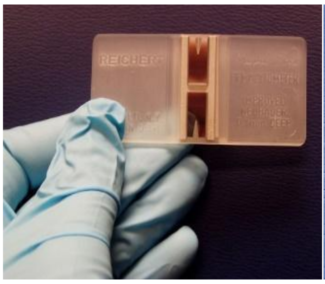
(Units: – M-Million, K-Thousand, µL-microliter, gm- grams, ml- milliliter, gm/100ml- gram per 100 milliliters.)

2. METHODS OF BLOOD CELL DETECTION AND COUNTING

The section has been organized based on the modality to which the method has been applied. This helps the human in understanding the potential and amount of research that have been carried in that field. An attempted in providing vivid and crisp technical details of each paper, for the benefit of researchers in this new field.

2.1 Traditional Approach

The conventional methods are used to count blood cells that is Hemocytometer. This device was designed for the complete blood count. Louis-Charles Malassez invented this hemocytometer. It consists of a chamber of certain dimensions. This chamber is of rectangular thick glass microscope slide. This chamber contains grid of perpendicular lines etched on it. To count the blood cells, microscope and hand tally counter is used [16]. The depth of the chamber and area bounded by perpendicular lines is determined. Hence, counting of cells based on the number of cells present in the fluid is possible and hence they calculated the concentration of cells in the fluid [17].



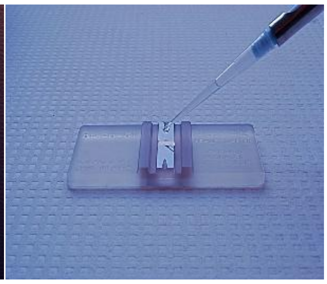


Fig - 1: A Hemocytometer **Fig - 2: Load a chamber**

Drawbacks of the manual method:

1. It is time-consuming and laborious.
2. Counting overlapping blood cells is a major problem.
3. It is difficult to get accurate results from visual inspection.

2.2 Image processing approach

Many of the researchers have worked on the blood cell images and it's counting methods with the use of image processing. There are six major steps involved in blood cells estimation.

2.2.1Image Acquisition

Image acquisition requires digital images of blood samples which is either .jpeg or .png format. These images are in RGB color plane. These are microscopic image that are obtained from hospitals or from laboratories using digital microscopes or using a digital camera placed at the eye piece of a microscope. To examine the RBCs, WBCs and platelets stained blood images are captured with the help of thin glass slides and Digital microscope. Giesma stained thin blood film image is taken so that platelets, RBCs and WBCs can be easily differentiated. To differentiate RBCs from WBCs and Platelets, RBCs are less stained as compare to WBCs and platelets leaving a bright patch with intensity value similar to background value.

2.2.2 Image Pre-Processing

In this method the adjusting of images is done and improved the quality of the image and made them suitable for the next step of process. Image pre-processing is nothing but removing of noise, contrast enhancing, isolating regions and use of different color models grayscale image [15] and HSV image [16], [19], Binarization. Grayscale image gives the intensity of the image. As obtained images are of low contrast and because of clustered white blood cells noise get included. To reduce these effects contrast enhancement is used [8]. After doing contrast stretching image is converted into grayscale and noise get added into resultant image is salt n paper noise.

2.2.3 Image Enhancement

This method improves the quality, contrast and brightness characteristics of an image, also sharpen its details. Histogram plotting, histogram equalization, image negation, image subtraction and filtering techniques, etc. are basic Image enhancement techniques. In [19] Hue saturation value is used for an image enhancement. The histogram thresholding is used to differentiate the nucleus of the leukocyte or WBCs from the remaining blood cells in the image [20]. Pre-processing is required to get enhanced image with Contrast-Limited Adaptive Histogram Equalization is used by Haider Adnan Khan et al. [21].

2.2.4 Image Segmentation

The segmentation is used to separate object from the background. Different segmentation methods are available. Segmentation is done by using Histogram Thresholding, Otsu Adaptive Thresholding [15], Global Thresholding [16], Hough Transform [14] and Watershed transform algorithm [24], as well as by K- Means Clustering, nucleus segmentation is by Gram-Schmidt Orthogonalization and a snake algorithm. The Circular Hough Transform detects unnecessary circles because of cell overlapping, hence by removing one of the overlapping circles and taking average count of both the methods which provides very accurate results. Circular Hough transform is a frequently used method for detecting circles in an image, it also suffers from degradation in the performance, especially in terms of speed, because of this large amount of edges given by complex background or texture. To classify WBC automatically another advance work also is done in term of calculating area, major axis length over minor axis length, perimeter, circularity and ratio of areas between nucleus and cytoplasm [23].

2.2.5 Image Post –Processing

Image post processing includes Feature extraction and morphological operations. Morphology includes dilation, erosion, granulometry and morphological filtering. Closing operation is used to fill the holes and gaps and opening operation is used to smoothen an image. Different types of structuring of elements are there for dilation and erosion. Shape features are: areas, cell perimeter, and ratio of nucleus to overall cell area, boundary of the nucleus and circularity factor [22]. Texture features are entropy, homogeneity and contrast. Color features includes color histogram, mean and standard deviation of the color components in CIE-Lab domain. Circular Hough Transform (CHT) is technique used in image analysis to detect the objects in circular form. Classifiers like Nearest Neighbor (NN), K-Nearest Neighbor (KNN), W-KNN, Bayes, Support Vector Machine (SVM), Neural Network (NNet), Artificial Neural Networks (ANNs) and Local Linear Map (LLM), Fuzzy Cellular Neural Networks are added in feature extraction and are often used to classify blood cells. Before doing labelling, borders are removed. Cells containing borders contain less information. Therefore, borders have to be removed to reduce complexity used "imclear" function to clear the borders in an image.

2.2.6 Blood Cells Counting

Counting algorithm is used to measure the number of RBCs and WBCs. The method used for counting is connected component labeling. Counting of RBCs and WBCs is done by finding number of connected components in segmented image. This labels the connected objects in an image. P. S. Hiremath et al. [22] used these labels for the subsequent feature extraction procedure. CHT is also a popular method for counting RBCs in an image. CHT counts number of circular objects i.e. RBCs in an image.

2.3 Segmentation

We surveyed the various segmentation methodologies that are proposed by different authors in order to detect and count the blood cells. Some authors are worked only on red blood cell counting, some worked on only white blood cell counting but they were unable to get 100% counting accuracy. Hence, we are researching in the area for getting 100% counting accuracy in both RBC as well as WBC counting.

2.3.1 Mathematical Morphology

Morphology is the set of image processing operations that processes images based on its shapes. Morphological operation is applied to a structuring element of an input image, output image is created with the same size. In the morphological operation, the pixel value of the output image is taken based on the comparison of corresponding pixels in the input image with its neighbors. From an image the number of pixels is added or removed from the object. Which is dependent on the size and shape of the structuring element. Authors [1], [2], [4] used this method to detect and count red blood cells. They first thresholds the gray scale image to obtain binary image using Otsu's method then perform hole filling process and finally counts the RBCs. Author [11] used the same for white blood cells detection and counting and got 85% accuracy.

2.3.2 Feature Extraction

In this some important features are extracted from various types of images, on the basis of these features the system is trained [3]. The features extracted are from blood cell images are index, location, intensity, symmetry. These features have more than thirty characteristics, which are of great use to segment and classify blood cells in later work. Feature matching could be used to detect particular type of blood cells. Authors applied this technique on leukemia blood smear.

2.3.3 Enhanced Threshold Based Technique

This suggest thresholding technique that enhances the overall blood smear image and filters the gray scale image contrast [5] [10] [12]. First transform the input color smear image into gray scale image. Different filters are used by different authors to remove noise from the image. Then thresholding technique of Otsu's method is used to convert image into binary image. This help in separating foreground from the background, hence clear blood cell detection is possible. Here authors successfully done the detection and counting of blood cells and many of them get the 80%-90% overall counting accuracy.

2.3.4 Gram-Schmidt Orthogonalization

Segmentation technique which is based on enhancing the color of target object, nucleus, and filtering the image. Small sized unwanted objects are removed from the image [7]. Gram-Schmidt Orthogonalization is a technique which transforms, set of non-orthogonal and linearly independent vectors into an orthogonal basis over an arbitrary interval with respect to an arbitrary weighting function w(x). By using this method, the white blood cell is counted and they got 85.4% accuracy with the same.

2.3.5 Contour Feature-Point Tagging

In Contour feature-point tagging technique for segmentation, while taking blood smear image from microscope, some clumps are presents that degrade the performance of the automated cell counting techniques [8]. This problem is solved by using contour feature-point tagging technique. In this technique the occlusion is spitted so that it resolves the problem of overlapped cells, dissimilar sized cell occlusion and uneven cell contours. Here feature points and approximate center of individual cells are calculated.

2.3.6 Circular Hough Transform (CHT)

Circular hough transform as a technique which works on the principal of detecting circular objects on the basis of radius range [13]. There are various steps used by CHT in order to detect circular objects. Firstly, any of the edge detection technique is used like prewit, canny, sobel or other operation like morphology. Next it draws the circle on desired radius range at each edge point. Circular hough transform works on two cases which is detecting a circle with known radius and unknown radius. By using this method authors get 91% accuracy in detecting blood cells.

2.3.7 Pulse-Coupled Neural Network (PCNN)

Pulse-Coupled Neural Network (PCNN) for segmentation which is very powerful image processing tool [9]. It could be used to well segment blood cell images as well as to eliminate disturbed objects which will serious impact the blood cell counting step. It is also able to segment specific isolated cells from its background. PCNN is differ from conventional Artificial Neural Networks by having the significant autowave characteristic. Sometimes PCNN is also used in combination with template matching which gives better result [6].

3. TYPES OF BLOOD CELLS

There are four categories of cells: Red Blood Cells (RBCs), White Blood Cells (WBCs), Platelets and Plasma. These groups are often differentiated using texture, color, size, and morphology of nucleus and cytoplasm. Cells count is vital to work out the immunity and capability of the body system. The abnormal count of cells gives the presence of disease and hence indicates person needs medical help.

- WBCs—These also are called leukocytes. These cells are a crucial a part of system. These protects body by removing viruses and bacteria during a body. Medical term use to explain low count is Leukopenia. Leukopenia indicate the presence of infection. Medical term use to explain high count is Leukocytosis. Leukocytosis gives an existence of infection, leukemia or tissue damage.
- RBCs— These also are referred to as erythrocytes. The function of RBC is to hold oxygen and collects CO_2 from a lung to the cells of body. They contain protein called hemoglobin. The inner and outer layers of protein give red color to blood. Hemoglobin do the work of carrying oxygen. An abnormal count of RBCs cause anemia which ends up in mental tiredness, illness, weakness, dizziness. If it's not treated immediately it results into more serious symptoms like malnutrition and leukemia. RBC indices gives information about size and shape of cells and also are useful in differentiating sorts of anemia.
- Platelets— These also are called as thrombocytes. The function of the platelets is to prevent bleeding by clumping and clotting vessel injuries. a coffee platelet count is named thrombocytopenia. It avoids blood coagulation and causes an individual to bleed. High platelet count is named thrombocytosis. It clots blood inside vessel and stops blood from flowing properly. Therefore, for correct blood flow platelets count must be in normal range.

4. LITERATURE SURVEY

Researchers are performing on automatic Cells identification and counting to make a far better and more efficient summary.

Tiancheng Xia *et al.* [1] The proposed work is predicated on Faster Region-based Convolutional Neural Networks (Faster RCNNs), and a transfer learning process was applied, to use this system to the microscopic detection of blood cells. that they had discussed about in-vitro detection of white blood cells using deep neural networks. However, test results on the well-selected samples should yet to be limited.

Acharya and Kumar [2] the proposed method shows a picture processing technique for RBCs count. It processed the blood smear image to count RBCs alongside the identification of normal and abnormal cells. They used the K-medoids algorithm to extract WBCs from the image and granulometric analysis to separate the RBCs from WBCs then counted the number of cells using the labeling algorithm and a circular Hough transform (CHT).

Sarrafzadeh *et al.* [3] The proposed technique is circlet transform to count RBCs on the greyscale image. They were used iterative soft-thresholding method for identification and counting purposes.

Kaur *et al.* [4] This proposed method to count platelets automatically by applying a CHT during a microscopic blood cells image. They used the dimensions and shape features of platelets from the CHT within the counting process.

Cruz *et al.* [5] The proposed method is a picture processing system to count blood cells. For the identification and counting of blood cells they were used the hue, saturation, value thresholding method, and connected component labeling.

Acharjee *et al.* [6] proposed a semi-automated process by applying a Hough transform to count RBC by detecting their oval and biconcave shape.

Lou *et al.* [7] provided a way to automatically count RBCs using spectral angle imaging and support vector machine (SVM).

Zhao *et al.* [8] proposed an automatic identification and arrangement for WBCs using the convolutional neural network (CNN). Firstly, they were detected WBCs from the microscopic images, then CNN was wont to detect sorts of WBCs.

Habibzadeh *et al.* [9] presented a system for classifying five differing types of WBCs. They were used three classifiers, which include two different SVMs and one CNN classifier.

Xu *et al.* [10] employed patch size normalization on pre-processed images then applied CNN to classify RBC shapes from microscopy images of patients of red blood cell disease.

5. FINDINGS OUT OF LITERATURE SURVEY

This literature review is written as a part of summarized information of existing related work. We reviewed previous work supported different methods like image processing, cell classification, cell image segmentation and deep learning. with this review we define the research problem, search for the new ways of study and track the support for," Automatic identification and counting of blood cells". This review helps to exploring the connection between design and development, significance of the matter and research outcomes. Different aspects that are explicit during this chapter are problem formation, data collection, data evaluation analysis and interpretation, previous used methods and result obtain with existing research. This chapter not only gives summarized most relevant information but it discussed the steps to conducting qualitative, quantitative and effective research work. This chapter also finds the limitation of the previous research that helps us to determine advances research add the sector blood corpuscle images used for cell identification and counting.

6. CONCLUSION

In this survey paper we've studied about different cell detection techniques and studied various sorts of different activity. This also includes the survey & different techniques. This presents a review on software-based solutions for counting the blood cells. Image processing method of cell counting is used. Which is fast, cost effective and produces accurate results. The accuracy of a system depends upon the standard of input image. Image processing is that the best way for counting of blood cells which has greater efficiency and need less time. Preprocessing pays an important role and works as a primary step in any blood corpuscle image segmentation. The segmentation process is employed to spot the precise components of blood from background.

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