Estimation of White Blood Cells using Convolutional Neural Network

R.Beaulah Jeyavathana, P.Jose, R.Balasubramanian

Abstract: ***Normally blood samples contain red blood cells, white blood cells and platelets. White blood cells are also called as leukocytes and they are the cells of immune system. The measure of White Blood Cells is so important for the doctors in diagnosing various diseases like leukemia or tissue damage etc. So, counting of White Blood Cells plays an important role. The manual counting of White Blood Cells in medical laboratories involves a device called Haemocytometer. But this process is extremely monotonous, time consuming, and leads to inaccurate results. In this work, image processing and deep learning mechanisms are used to locate and classify the White Blood Cells based on their categories. The White Blood Cells which are classified are counted and compared with the standard range of the types available in the human blood sample. By comparing the availability of White Blood Cells types, the normal and the abnormal blood samples are predicted accordingly. The dataset of the normal blood sample is obtained from the laboratory in biotechnology department and the datasets used for training in Convolutional Neural Network are attained from the website Leukocyte Images for Segmentation and Classification (LISC). This will increase efficiency and reduce the doctor's burden as traditional manual counting is dull, tedious, and possibly subjective.***

Keywords: immune system, manual counting. White Blood Cells, Haemocytometer, Convolutional Neural Network.

I. INTRODUCTION

Image processing is defined as manipulating an image to achieve an aesthetic standard or to support a preferred reality. It can also be precisely defined as a means of conversion between human visual system and digital imaging devices. Prominent differences between the human and digital detectors will be shown for achieving translation. It can be loomed in a manner reliable with the scientific method so that others may reproduce one's results. Every human body has three types of blood cells RBCs, WBCs and Platelets. White Blood Cells l(WBCs), also called leukocytes or leucocytes, are the cells of the immune system. They are tangled in protecting the body against infectious diseases and foreign invaders. All White Blood Cells are produced and derived from multipotent cells in the bone marrow known as hematopoietic stem cells. White Blood Cells consists of five sub categories known as monocytes, lymphocytes, eosinophils, basophils and neutrophils. The differential WBC count in normal adult is as follows:

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- Neutrophils - 40 – 70 %
- Lymphocytes - 20 – 30%
- Monocytes - 2 – 15 %
- Eosinophils - 1 – 7%
- Basophils - 1 – 3%

The number of leukocytes in the blood is often an indicator of disease and an important subset of the complete blood count is the WBC count. The normal White Blood cell count is usually 4 x 10^9/L and 11 x 10^9/L.

Counting of WBCs can be done either manually or automatically. Counting large number of cells is done by automatic methods but the specialized equipment tends to be affluent. Manual methods involve a conventional light microscope setup and is more difficult, error-prone and very inexpensive.

The structure of our paper is organized as follows. Section II provides an overview of segmentation and counting of white blood cells techniques. Section III explains our new proposed scheme. Section IV examines our scheme in different dimensions. Section V accomplishes the paper with some observations.

II. RELATED WORK

The primary need for counting white blood cells is that the number of leukocytes in the blood is often an indicator of disease, and thus the WBC count is an important subcategory of complete blood count. Nowadays in segmentation and counting of WBC many new thoughts, concepts, and features are introduced. Yuehua Liu, Feilong Cao, Jianwei Zhao, and Jianjun Chu [1] introduced a new approach for locating the WBC and sub image segmentation. It is noted that almost all the WBCs have two characteristics 1) The compactness of edges in the edge map produced using the Canny detector is always concerted in regions with WBCs. 2) The darker colours of WBCs diverge from those of RBCs and the background. For cytoplasm segmentation, we can simply expurgated the WBC inside the subimage using Grab Cut algorithm, the entire WBC may not be entirely segmented because of high disparity between dark nucleus and light cytoplasm. To avoid these problems, a replace procedure is used to hone the sub image. The pixel values of cytoplasm are used to replace the pixel values of nucleus region. Accurate location and segmentation is made possible by multiple windows multi scale cues. Time Complexity is more when multiple windows multi scale cues are used for locating WBCs. Zhi Liu [2] proposed a method that emphases on gaining seed points. First, colour space transformation and image enhancement techniques are used to obtain nucleus groups as inside seeds. Second, mean shift clustering, selection of the C channel component in the CMYK model, and illumination

intensity adjustment are hired to acquire WBCs as outside seeds. Third, the seeds and NMWO are employed to precisely determine WBCs and solve the cell adhesion problem. Morphological operations are further used to improve segmentation accuracy. This method hires different color spaces to identify WBCs, as well as mean shift clustering, C channel

component selection, illumination intensity adjustment and image enhancement techniques to obtain a complete set of WBCs. Watershed transformation is also applied to address cell adhesion problem. This method also shows high sturdiness and reasonable performance for WBC segmentation in peripheral blood and bone marrow images. Adhesion segmentation accuracy is the second advantage of the proposed method over traditional methods. A novel contrast normalization of the input image, the WBCs are segmented by thresholding in the first step.

Next, k-means method is applied for nucleus segmentation. Then, to solve the problems of all connected nuclei and cells, two modified watershed algorithms are implemented, and all of them are separated. For cell splitting, the watershed algorithm cannot separate cells correctly. Therefore, another modified watershed transform based on gradient method is used. For achieving best accuracy in cell splitting, at first, RGB image of WBCs which is extracted from cell segmentation step, is converted to the gray level image. Next, the Sobel operatoris applied to obtain gradient image. To prevent over segmentation, watershed algorithm based on marker-controlled using the gradient image is utilized.A simple novel combination image processing method was proposed for the automatic segmentation of both cells and nuclei of WBCs in three steps based on thresholding, k-means clustering, and modified watershed algorithms. In addition, the statistical analysis by linear regression was performed that verified high correlation and consistency between automatic and manual results.

III PROPOSED SYSTEM

This section provides the detailed description of the proposed Estimation of White Blood cells using image processing techniques. The microscopic image of the blood sample is taken as the input where blood samples contains RBCs, WBCs and platelets. The first step involved is preprocessing where the RBCs and platelets are removed.

The proposed system works as follows.

A. Preprocessing

Preprocessing step involves

1. Removal of RBCs
2. Removal of Platelets

1.Removal of RBCs

- Microscopic image of the blood sample is taken as the input for the removal of RBCs.
- Removal of RBCs is done by green intensity value where the green intensity is more for RBCs when compared with WBC.
- If the green intensity is low then the pixel is changed to black colour and the pixel with high green intensity is made white.

2.Removal of Platelets

- After partially removing the RBC, the platelets along with the whole of RBC are removed considering each pixel and counting the black and white pixel from the particular considered pixel.
- If the white pixel value is more it is considered as RBC and platelets and are removed accordingly as the area of WBC is more when compared with RBC and platelets.

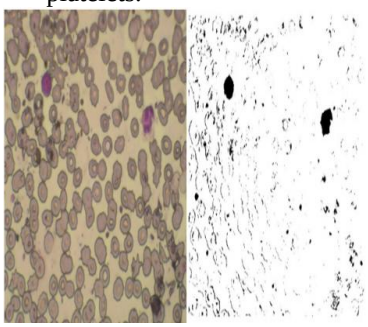

Figure 3.1 Removed RBC image

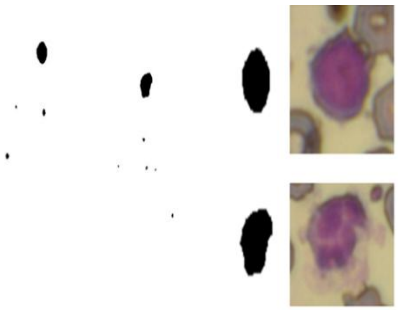

Fig3.2 Located WBC

*B.**Classification of WBC***

- The classification of WBC is performed by Convolutional Neural Network. The 5 types of WBC images are trained by the layers available in CNN and the features are extracted accordingly
- The located WBC in a window is given as the input to the trained CNN and the particular type located is classified. Layers used in CNN are
  1. Input Layer
  2. Convolution Layer
  3. Batch Normalization Layer
  4. Rectified Linear Unit Layer
  5. Max Pooling Layer
  6. Fully Connected Layer
  7. Softmax Layer
  8. Classification Layer

B. Counting of WBC

After the WBCs are classified according to their types the available WBCs in blood sample are counted.

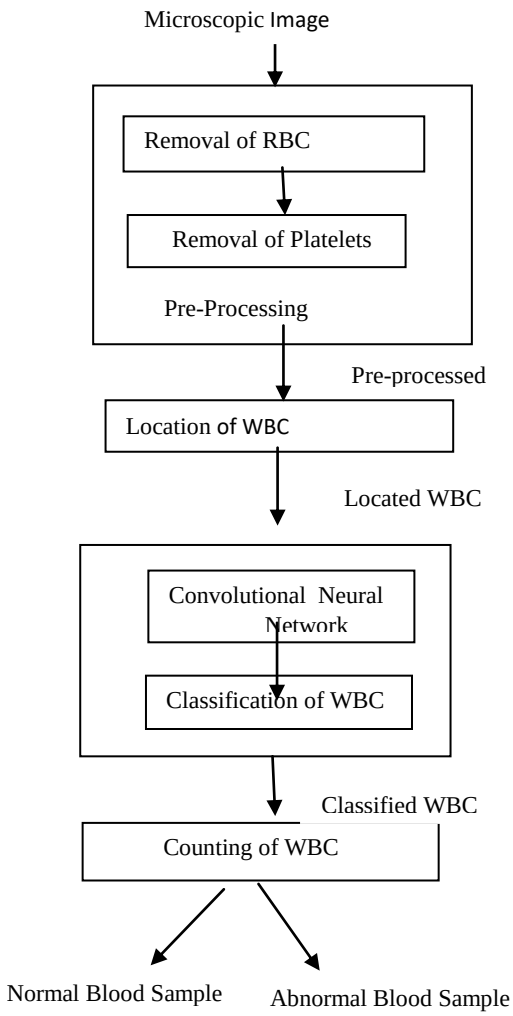

Fig 3.3

For each type of WBC, the percentage available in the blood sample is calculated and the result is compared with the standard range of availability in blood samples. Through this the normal and the abnormal blood samples can be identified.Fig. 3.3 shows a overall system design. From the microscopic image the RBCs and the platelets are removed. After removal of RBCs and platelets the WBC is located by multi window. The located WBCs are

IV. RESULTS

The dataset for the Estimation of White Blood Cells is obtained from the website LISC. The accuracy obtained during training process by the Convolutional Neural Network is 97%. The counted WBC based on the types are compared with the standard range and is predicted whether normal or abnormal.

V. CONCLUSION AND FUTURE WORK

The WBCs are located and classified according to their types by the trained CNN. The classified WBCs are counted from the blood sample and percentage of each WBC types is calculated. After calculating the percentage, the result is compared with the standard range of available WBCs and the blood sample is predicted whether normal or abnormal. By using the overlapping patches for location, the WBC is located accurately in a single window and is further processed. The Convolutional Neural Network extracts the features from the training images implicitly and so the classification of each type is made accurate. The proposed method will reduce the doctor's burden in counting. It reduces manual error and gives high accuracy. This method is cost efficient and it can also be used in hospitals, laboratories of schools and colleges with high efficiency. The Convolutional Neural Network use a variation of multilayer perceptron, if we use more number of hidden layers the classification results will be accurate. The proposed system uses multi window for locating the WBC, but it consumes more time. In future enhancement of multi window algorithm can be done to reduce time complexity.

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