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Blood group Detection and RBC, WBC Counting: An Image Processing Approach

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Abstract: ***The human blood is a health indicator; it delivers necessary substances such as oxygen and substance that provides nourishment is necessary. Hence, segmentation of blood cells and identification of blood type is very important. The human blood consists of the RBCs, WBCs, Platelets and Plasma. Presently, lab technicians tests blood groups manually and they use a device called Hemocytometer and microscope to count blood cells. But this method is extremely time consuming, monotonous and leads to the inaccurate results due to human errors. To overcome the problems regarding time, accuracy and cost, a method is proposed based on processing of images acquired from laboratory. The image processing techniques such as Segmentation, Morphological operations and Circular Hough Transform are used. Accuracy of the system is high with very low execution time.***

Keywords: Digital Image Processing, SURF, GUI, Circular Hough Transform, etc.

1. Introduction

Blood grouping tells us what type of blood a person has. Everyone may have different blood groups. These differences in human blood groups are because of the presence or absence antigens and antibodies on the surface of blood cells. Individuals have different combinations of antigens and antibodies and therefore have different blood groups. According to ABO and Rh blood grouping systems there are 8 different blood groups: A Rh+, A Rh-, B Rh+, B Rh-, AB Rh+, AB Rh-, O Rh+ and O Rh- [1-2].

The complete blood count (CBC) evaluates the health of person and detects the disorders like anemia, infection and leukemia. CBC is very important in medical diagnosis [3]. RBCs, WBCs, platelets, plasma these are constituents of human blood. The complete blood count involves counting of these four types of cells. The count of these cells determines the ability of an organism to resist a particular infection and capability of the body system [4]. The normal count of these cells is different for men, women, and children, etc. Table 1 shows the standard CBC for healthy person [3].

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 - 12	4.5 – 12	K/µL
Platelets	150 – 450	150 - 450	K/µL
Hematocrit	36% to 45%	42% to 50%	%
Hemoglobin	12 - 15	14 - 17	gm/100 ml

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

White blood cells are an important part of immune system. They protect our body from viruses and bacteria. Low count indicates the presence of infection. High count indicates an existence of infection, leukemia or tissue damage [5]. RBC carries oxygen and collects carbon dioxide from lungs to the cells of body. An abnormal count of RBCs leads to anemia which results in mental tiredness, illness, weakness, dizziness [5].

2. Requirements and Experimental Setup

2.1 Hardware and software used

- The software we have used is MATLAB (version 7.10.0 R2010a)
- Hardware required:
  1. We have used a laptop of HP(64bit OS).
  2. Cell phone camera of 12MP, autofocus, LED flash and Display Resolution 540 x 960 pixels.
  3. USB cable.

(a) (b)

Figure 1: Image acquisition tool

The real time experimental setup for blood group detection requires only cell phone camera and a white paper for background. For RBC and WBC counting we require a digital microscope interfaced with laptop.

2.2 Database collection

For blood group detection digital images of blood samples are obtained from the laboratory consisting of a color image composed of three samples of blood and reagent. The image is captured with the help of a mobile phone camera of 12 MP. Simply a glass slide with blood sample is placed on a white paper and photo is taken by using a phone camera. The image is read from phone storage at the time of experimentation. The dataset used in RBC, WBC counting consisted of actual microscopic images of blood samples. The images were captured with a digital microscope interfaced with a computer. All of the images are in JPG format.

Experiments were carried out on 114 dataset images. To perform blood group detection 84 images of blood samples are taken. To examine the RBCs and WBCs 30 stained blood images are captured with the help of thin glass slides and Digital microscope. These 30 images are of 30 patients are taken. To obtain accuracy results of system are compared with the results obtain by manual method in laboratory. Figure 2 and 3 shows the database images collected.

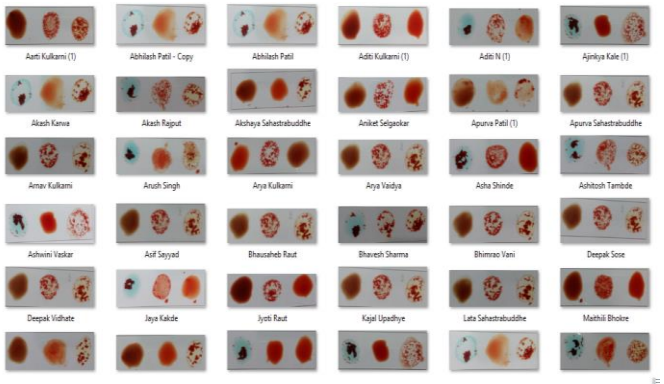

Figure 2: Database images for Blood Group detection

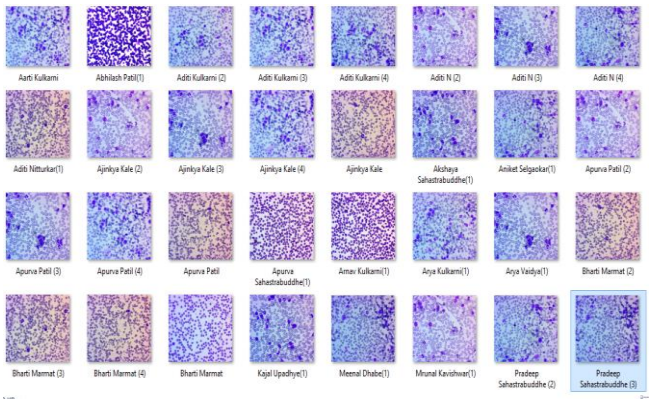

Figure 3: Database images for RBC and WBC count

3. Proposed System

The system is devided into three significant phases: Blood group detection, RBC counting, WBC counting. Figure 1 shows general block diagram of digital ımage processing. From control panel of system we have to select an option to perform required test i.e. Blood group detection, RBC counting, WBC counting. After this one window will appear from which we have to select an input image. All the images are stored by the name of patients. Then image undergoes some image processing techniques as mentioned below and we get the result in GUI edit window. Figure 4 shows general block diagram of Digital Image Processing.

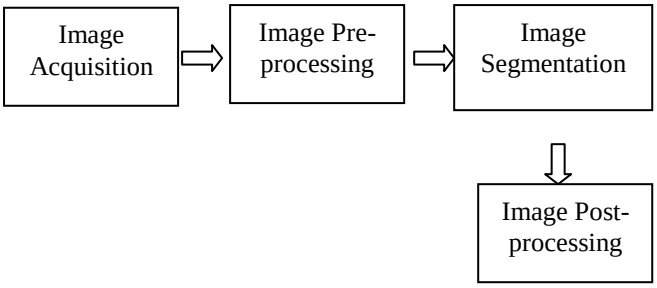

Figure 4: General block diagram of Digital Image processing

3.1 Phase-I: Blood Group Detection

This is the first phase of proposed system i.e. Blood Group detection. Figure 5 shows flow of blood group detection.

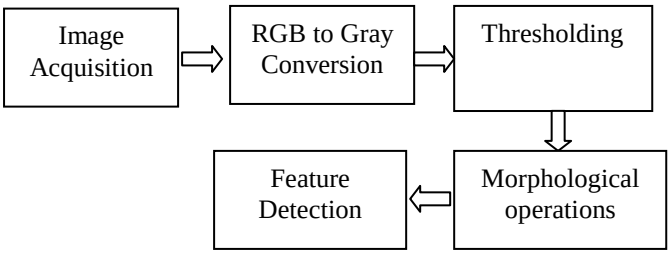

Figure 5: Block diagram for Blood Group Detection

In image acquisition of blood group detection images of blood samples are obtained from the laboratory consisting of a color image composed of three samples of blood and reagent. Simply a glass slide with blood sample is placed on a white paper and photo is taken by using a phone camera of 12MP. The image is read from phone storage at the time of system evaluation.

In pre processing rbg to gray conversion is performed. Next step is to detect SURF features that works on gray images. In computer vision, speeded up robust features (SURF) is a local feature detector and descriptor. It can be used for object recognition, image registration, classification or 3D reconstruction [6]. Here we have used SURF to detect the coaugulation formed in an image. Based on this detection of coaugulation we are detecting blood groups. Figure 6 shows the output images of SURF feature detection.

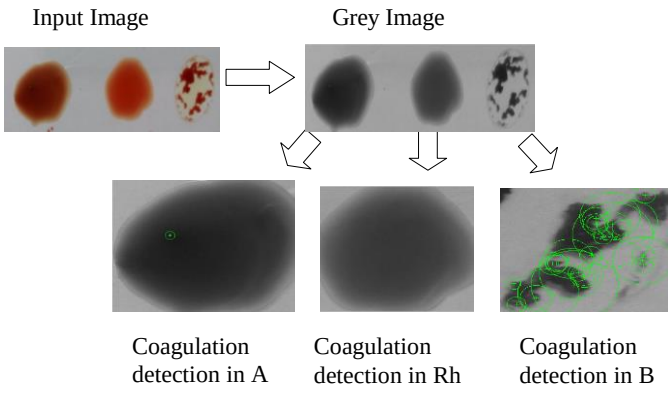

Figure 6: Output Images of Blood Group Detection

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3.2 Phase-II: Counting of RBC

This is the second phase of proposed system i.e. counting of RBC. Figure 7 shows flow of RBC counting.

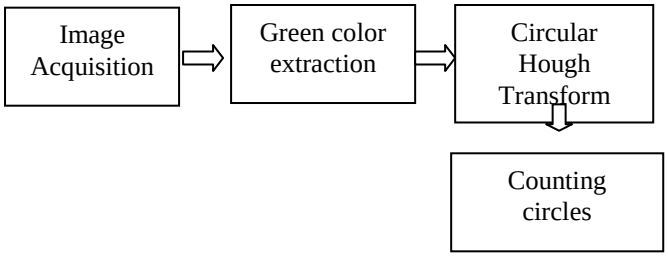

Figure 7: General block diagram of RBC counting

To examine the RBCs and WBCs blood images are captured with the help of thin glass slides and digital microscope.

In Digital Image Processing there are 3 color planes, R, G and B which contains color information in images. The green component is extracted because it contains maximum value [7].

3.2.1 Image Segmentation by Circular Hough Transform

The circular hough transform is then applied to green color image. This transform searches for the blood cells in the image and then detects them. The function "draw circle" draws circles around the detected cells. Even the overlapped circles are detected. Equation (1) is a standard equation of circle.

$$r^2 = (x - a)^2 + (y - b)^2 \quad (1)$$

Here *a* and *b* are the coordinates for the centre, and *r* is the radius of the circle.

$$x = a + r\cos(\theta)$$
$$y = b + r\sin(\theta) \quad (2)$$

Equation (2) represents parametric equations of circle. Circular hough transform detects edge points on each circle, and draws a circle with that point as origin and radius r. The circular hough transform uses a three dimensional array with the first two dimensions representing the coordinates of the the array and increases every time when circle is drawn with the desired radii over every edge point. An accumulator keeps count of how many circles pass through coordinates of each point, and finds the highest count [8]. The output images of each steps are shown in fgure 8.

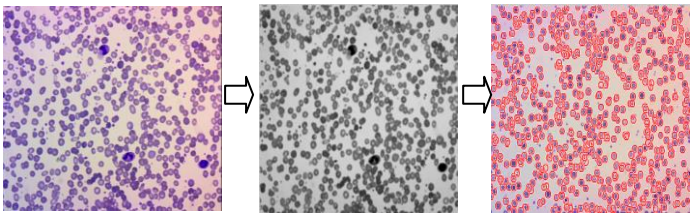

Figure 8: Input image, Grey image and output image of CHT

3.3 Phase-III: Counting of WBC

This is the third phase of proposed system i.e. counting of WBC. Figure 9 shows flow of WBC counting.

Command window

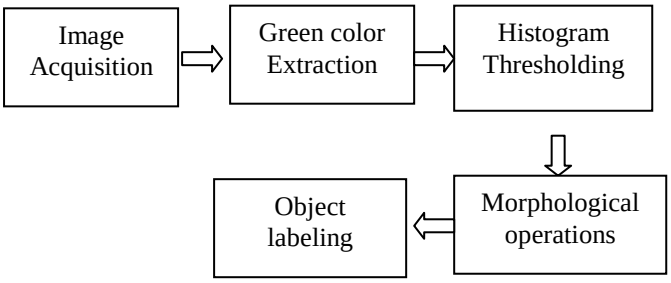

Figure 9: General block diagram of WBC counting

In thresholding if the image intensity $I_{x,y}$ is greater than some fixed constant T each pixel in an image is replaced with a black pixel and if the image intensity $I_{x,y}$ is smaller than some fixed constant T each pixel in an image is replaced with a white pixel [9].

$$G_{x,y} = \begin{cases} 1; & I_{x,y} > T \\ 0; & otherwise \end{cases} \quad (3)$$

Thus pixels labeled 0 corresponds to objects and pixels labeled 1 correspond to background. After thresholiding we have taken the complement of that image. And further morphological operation like erosion and dilusion are performed to smoothen the image and to fill the holes and gaps. Using Dilation and erosion secondary operations like closing and opening are performed. Closing operation is used to fill the holes and gaps. It is the process of dilation which is followed by erosion. Opening operation is used to smoothen the contours of cells and parasites. It is process in which erosion is followed by dilation.

Region labelling identifies the connected groups of pixels in a binary image that all have the same binary value. It scans the entire image to search the occurrences of pixels of the same binary value. In this it identifies WBCs in an binry image [10]. For blood cells counting we have used region counting algorithm. The output images of each steps are shown in fgure 10.

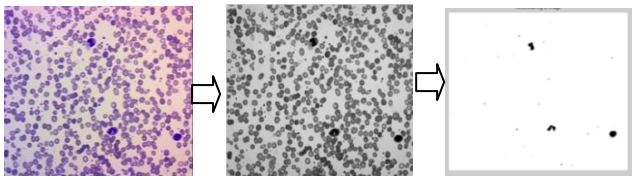

Figure 10: Original image, Green color extracted image and segmented image

4. Performance Analysis

Correct Recognition Rate/Recognition Accuracy:

$$\text{Recognition Accuracy} = \frac{\text{No.of correctlyrecognizedbloodsamples}}{\text{totalno.of bloodsamples}} * 100 \quad (4)$$

RR is calculated by equation (4). The performance for the system is evaluated using 10 ink samples to test the robustness

of system. The results of testing are as given below in Table 2.

Table 2: Recognition rate of Blood Group Detection

Blood Group	*Number of samples collected*	*Number of samples recognized correctly*	*Recognition Rate (%)*
A Positive	8	8	100
A Negative	6	6	100
B Positive	10	10	100
B Negative	7	7	100
AB Positive	10	10	100
AB Negative	9	9	100
O Positive	10	10	100
O Negative	5	5	100
Ink sample	10	10	100

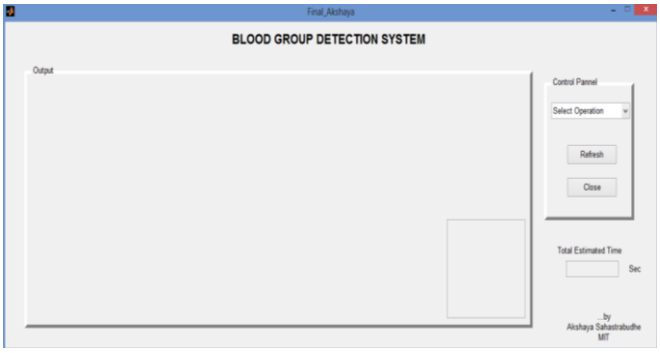

Figure 11: GUI representation of system

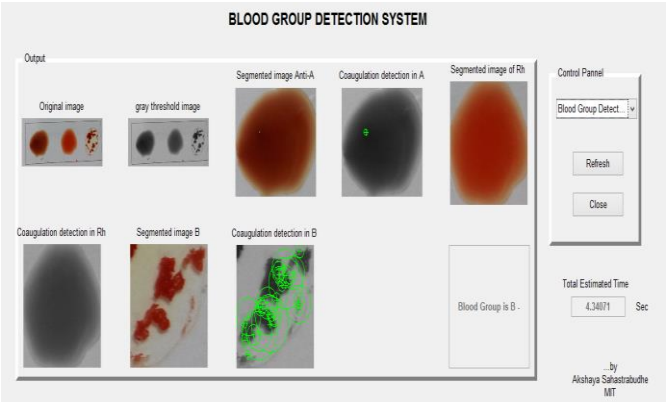

Figure 12: GUI output of Blood group detection

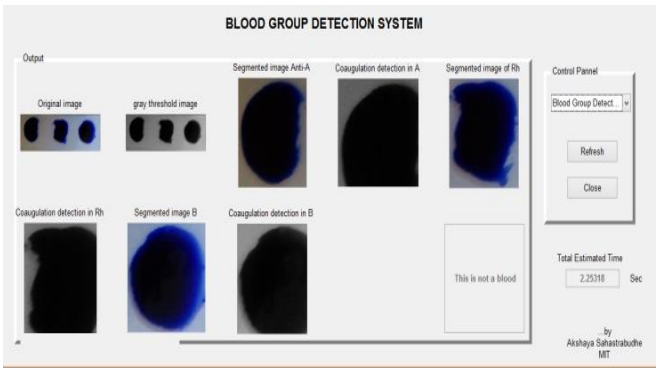

Figure 13: GUI Output of ink saple

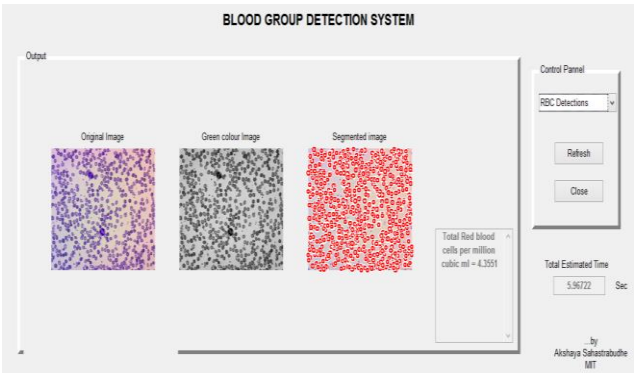

Figure 14: GUI Output of RBC counting

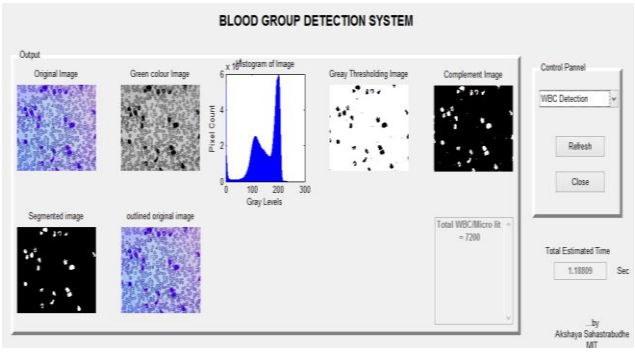

Figure 15: GUI Output of RBC counting

The results are compared with the reports obtained by Automated Analyzer. Table 3 shows the manual and experimental results of 5 patients.

Table 3: Comparative results of system

Patient No.	*Results of proposed method*			*Results of Manual method*		
	Blood Group	*RBC (M/µL)*	*WBC (/µL)*	*Blood Group*	*RBC (M/µL)*	*WBC (/µL)*
1	B-ve	4.16	7200	B -ve	4.30	7500
2	B +ve	4.19	11490	B +ve	4.32	12600
3	B +ve	4.21	11500	B +ve	4.54	13000
4	AB +ve	4.09	6300	AB +ve	4.4	7300
5	B +ve	4.16	1700	B +ve	4.36	1700

4.1 Accuracy:

We have calculated accuracy of each patients for RBC and WBC counting by using equation (5) and graphs are plotted as shown in figure 16 and 17.

$$\text{Accuracy of system} = \frac{\text{Cell count obtained from system}}{\text{Cell count obtained from laboratory}} * 100 \quad (5)$$

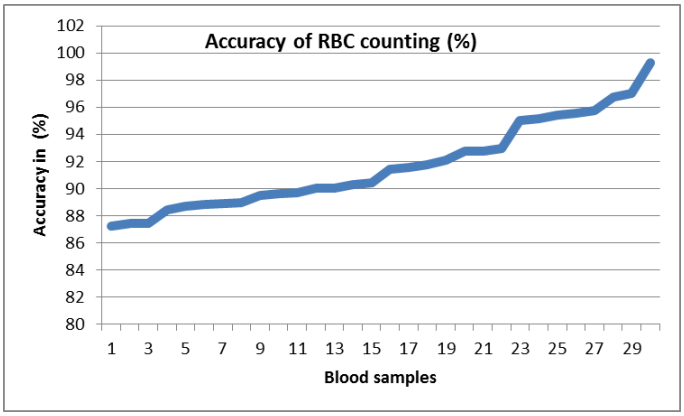

Figure 16: Accuracy plot of RBC Counting

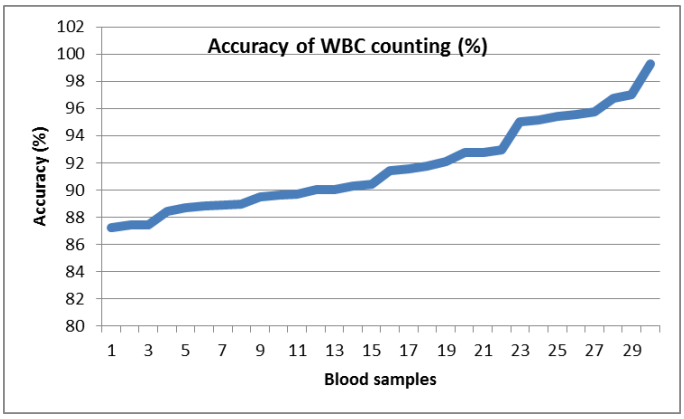

Figure 17: Accuracy plot of WBC Counting

The average accuracy of the system is calculated by taking an average of all the accuracies calculated for each patient. We have recognized all the blood groups correctly therefore accuracy of blood group detection is 100%. A graph in figure 18 shows average accuracy of system.

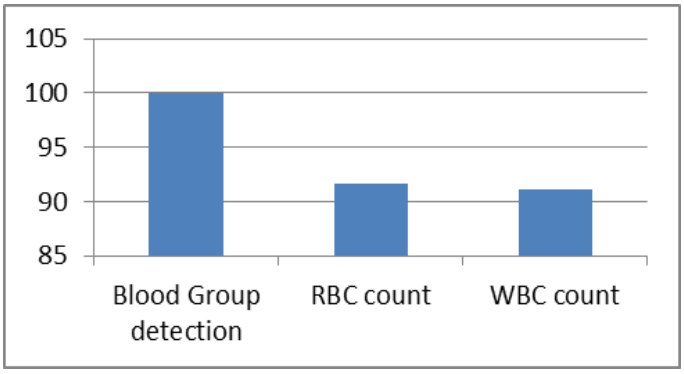

Figure 18: Average accuracy of three phases of system

5. Conclusions

An image processing system has been developed which is capable of detecting blood group and counting of red blood cells and white blood cells. As it is semi-automatic, only MATLAB software is used, it is cost effective and simple. The system gives over all accuracy above 90%. System takes 4 to 6 seconds to execute the outcomes and hence is time efficient. We have also created the Graphical User Interface to perform three tests. The interface aids the user in easy access and displays the results of every step. The project currently works efficiently for count of blood cells, in future researchers can work upon the detection of various disorders (Leukemia, anemia and likewise) related to the abnormal blood cell count.

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