Blood Group Detection using Image Processing Techniques

Supervisor: Dr. Jia Uddin

Sakib Rahman - 13101279

Md. Atifur Rahman- 13101273

Fariha Ashraf Khan- 13101262

Shabiba Binte Shahjahan- 13301021

Khairun Nahar-13101175

Department of Computer Science and Engineering,

BRAC University

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DECLARATION

We, hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researcher are mentioned by reference. This Thesis, neither in whole or in part, has been previously submitted for any degree.

Signature of Supervisor	Signature of Author
Dr. Jia Uddin	Sakib Rahman
	Md. Atifur Rahman
	Fariha Ashraf Khan
	Shabiba Binte Shahjahan
	Khairun Nahar

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ABSTRACT

Blood grouping is the first and foremost essentiality for many of the major medical procedures. Traditional ways of detecting blood group have remained analogue in this era of digitization and are therefore susceptible to human fallibility. So it would be very efficient and arguably a lifesaving approach if the process of detecting blood can be completed successfully in a cost-effective way with the technologies at hand and without the plausibility of man-made error. This proposition is expected to evaluate the Rh factor as well as the group of a sample blood with its computed image. The whole process excludes a major probability of human error while detecting the agglutination from the traditional method and it would get the task done within a fairly insignificant amount of time. The procedure will start by taking a photo of the sample blood slide followed by the application of a number of algorithms such as grayscale, binary and canny edge detection on it. After that, the detected edges will be counted and thus we will decide the agglutination. The method is established upon real-time dataset including 100 blood samples of people of different ages. The experimental result is almost accurate compared to the real time results from the sample dataset. It can, therefore, conclude the procedure with certain numeric values which were determined after real-time data analysis of images from a mobile camera, to make it simpler and more precise.

CHAPTER 01: INTRODUCTION

1.1 Motivation

According to a study conducted by the Accident Research Centre (ARC) of BUET, road accidents claim on average 12,000 lives annually and lead to about 35,000 injuries. In these accidents it is often necessary to perform urgent blood transfusion where it is essential to determine blood group of the victim rapidly. Besides, there are some other use cases where blood typing may be needed at the point-of-care such as public health centers, battle field, schools, veterinary care centers and forensic sites. Perhaps, the most telling need is in rural areas of developing countries where access to labs and trained technicians is simply not present. Unfortunately, Detection of blood group in disaster or remote areas where expertise is unavailable is challenge. As a result, Transfusions between blood groups can be catastrophic. Therefore, knowing the blood type of donors and recipients is of the utmost importance. The conventional system of blood typing may prove life taking due to lack of trained technicians .In real time, the health technicians, in these situations, must decide quickly what procedures they must apply, in order to guarantee the best treatment for the patient. In the mentioned emergency situations, where there is no time for human blood typing, the universal donor blood is administrated. As a result, some reactions may occur, risking the patient's life [19,20] and stock levels of blood from universal donor blood type decreases. This paper presents an automatic system which is able to perform this most basic and fundamental pre-transfusion test quickly, easily, in safe conditions, and with high reliability, even in remote locations. To this end, the data acquisition is based on image processing techniques to obtain results from an image of the glass slide and concluding with numeric values to maintain precision in conducting result.

1.2 Contribution Summary

The summary of the main contributions is as follows

There are several papers that have worked on Blood group detection method .However, in this paper it consists of a 4 step process which includes gray scale, binary conversion, segmentation and canny approach. Gray scale is conducted initially to convert the input image into a grayscale image where each of its pixels is representing a range of a particular amount of light. Followed up by binary conversion to make two possible values for each pixel. Then the Segmentation is done to divide the picture of the glass slide into three individual images. Lastly the Canny approach is a way of edge detection in image processing which works by detecting discontinuities in brightness (complexity of the shape) of the regions is evaluated. This model yielded an accuracy of 100%.

1.3 Thesis Orientation

The rest of the thesis is organized as following chapters:

- Chapter 02 consists of the review of previous works
- Chapter 03 introduces with proposed model
- Chapter 04 describes the complete experimental analysis and result.
- Chapter 05 concludes with results and future working plan.

CHAPTER 02: BACKGROUND INFORMATION

2.1 Literature Review

Blood is one of the most important element of the human body which works as a major connective tissue and keeps the circulation of many essential ingredient like oxygen and various nutrients. It is extremely necessary for various medical procedures to be well known about blood type and other features of blood such as the RBC count and CBC [1]. The traditional method of detecting the blood group is usually the plate test and the tube test [2]. Both of which are done by under complete analog procedures with human observation.

In the era of digitization, it is not an efficient way to handle such a basic yet essential medical procedure in a full analog environment. There are also a few techniques such as micro plate testing and gel centrifugation [2, 3]. These procedures are costly and those need to be done by people with strong skill set with some particular equipment. In a situation of emergency which might be a difficulty to afford with. Basically, the process of blood group analysis depends on the agglutination of a sample blood. The blood of a patient is mixed with three types of antigens, which are antigen A, antigen B and antigen D. The agglutination in any particular blood sample ensures the positivity of that blood belonging in that correspondent group.

The detection of the composite organisms from a sample blood slide has been done via image processing techniques like threshold morphological operations [4]. Errors can be occurred in these procedures if the detection of agglutinations is solemnly done with human eyes. Wrongly calculated blood group results in extreme situations in case of further diagnostics upon that decision. For determining the correct blood group we need an impeccable operation justified with

logical and mathematical calculations and flawless image processing to detect residual errors that evade corrective procedures [5, 6].

Image segmentation is one of the most fundamental techniques of image processing. In segmentation, a bigger image is divided into a number of sub images. While the algorithms run individually on the sub- divided images, the calculations occur more specifically and the result becomes more precise. There are several ways of image segmentation. Otsu method is one of them. Otsu is an automatic threshold selection region based segmentation method [7].

Another Significant and important image processing technique is thresholding. Thresholding does binarization on any image. Some special thresholding techniques also does denoising. In some cases, some segmented image becomes cloudy and the important information which is needed to be extracted become complicated to retrieve. In such situations thresholding is very helpful [8]. So, basically, thresholding techniques makes an image in black and white and it makes the image much clearer. One automated design was brought up where the researcher suggested [9] the whole test was done based on slide test for determining blood types and a software developed using image processing techniques. The image was processed by image processing techniques developed with the IMAQ Vision software from National Instruments [10]. This particular research introduced us with the very concept of developing numerical calculation over the processed image since this paper discussed standard deviation with respective mean value to detect the occurrence of agglutination which was concluded with the value 16. In this research every samples with standard deviation value below 16 were found as samples where no agglutination occurred and samples with standard deviation values greater than or equal to 16 are samples classified as agglutination occurred. While developing our method we intended to keep the calculation area simpler to ensure

its intelligibility. Although Ferraz has pursued with his research with blood grouping and image processing this paper led us to one of the crucial computation of our algorithm.

CHAPTER 03: PROPOSED MODEL

3.1 Introduction

In Fig 3.1 shows a detailed implementation of our proposed model. It demonstrates how the algorithm and the method of the detection is set up. It brings light to the process of numerical computation of edge detection from an image. In our proposed model, first of all we apply Grayscale conversion on the RGB image to Grayscale image and Binary Inversion on the image to get desired small bit output image. Then we apply Segmentation Method of image processing to part the image into three segment. Then after the end of Segmentation stage, we apply Caddy Edge Detection algorithm to detect the clotting edges from the image. Finally we implement that efficient Canny Edge Detection algorithm by using MATLAB.

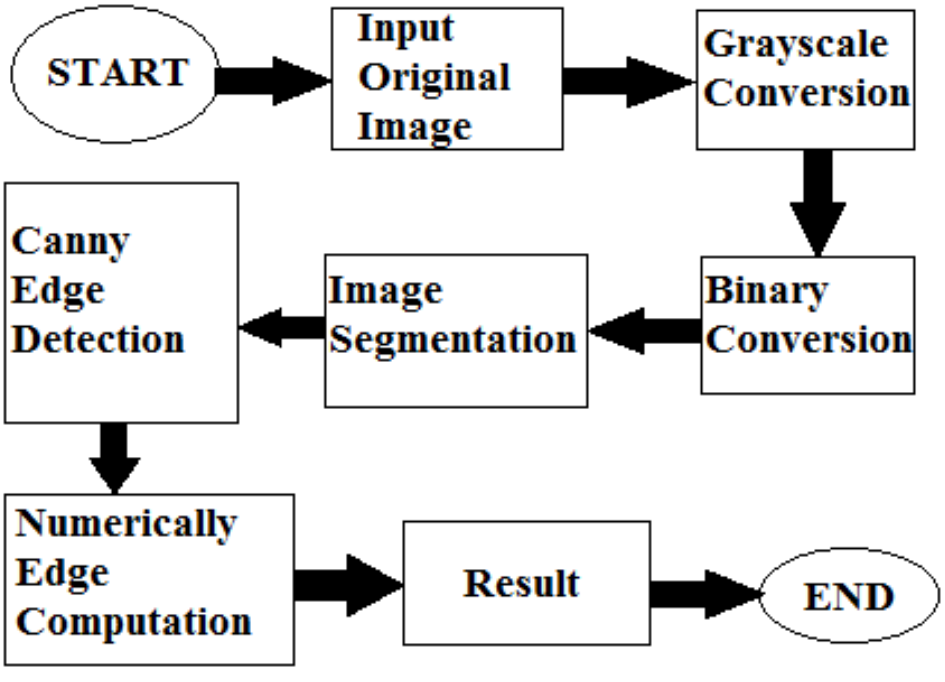


Fig 3.1 Block Diagram of Proposed Processing Method using Canny Edge Detection

3.2 Apply Grayscale Conversion

RGB image is based on RGB Color Model where Red, Green and Blue lights are combined together in numerous ways to reproduce a broad array of colors. The name of the model comes from these additive primary colors [12]. The main approach of this color model is representing and displaying the images in electronic system. It is a device dependent color model where different devices can detect a given RGB value through the color elements and properties and their response to the individual R, G, and B levels.

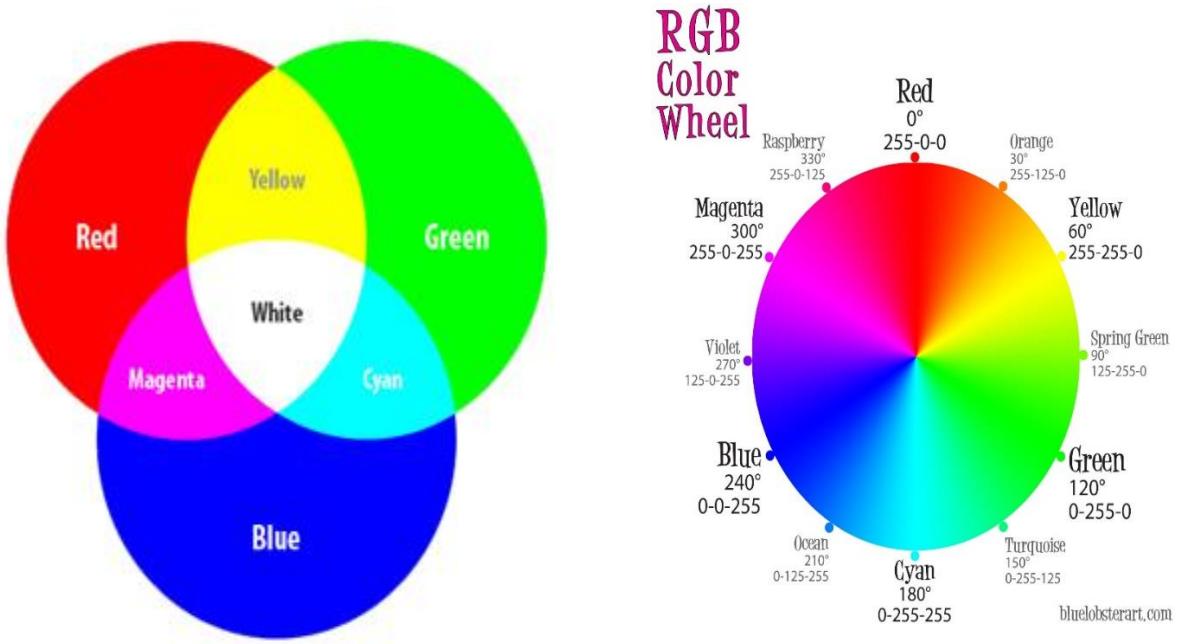


Fig 3.2 RGB Color Model

In Fig 3.2 demonstrate the RGB Color Model where these three light beam red, green and blue is known as component of that color. These three components have an arbitrary intensity. This color model is additive because the three light beam are added together, their light spectra is added for

wavelengths to negotiate and create the final color spectrum [12, 13]. This model is opposite of subtractive color model where colors are depend on reflecting the light. In the additive color model these three colors create white that is in obvious contrast of physical colors. Each component gives the darkest color (black) in zero intensity of light and full intensity of each color gives white. The quality of these colors depends on the primary light source nature. When all color components intensities are the same, the result can be a shade of gray depending on the intensity. When there are different light intensities occurs, the result can be more or less saturated depending on the difference of the strong and weak intensities of primary color. If one of the components has the strongest intensity, the color is a hue of primary color. When the two of the components have the same light intensity the color will be the hue of secondary colors. These secondary colors are the shade of cyan, magenta and yellow. These secondary colors are formed of the sum of two primary color who have the equal intensity. Cyan is formed with the combination of green + blue, Magenta is formed by red + blue, Yellow is with red + green. These secondary colors are the component of each primary colors and when the both primary and secondary colors are added together, they complements each other. Cyan complements red, magenta and yellow with green and blue. The n three kinds of light-sensitive human eye photoreceptor cells are cone cells. They respond much to the yellow (long wavelength), green (medium wavelength), and violet (short wavelength). These light peak wavelengths are near 570 nm, 540 nm and 440 nm, respectively [14]. In Fig 3.3 a color triangle image are shown. These primary color are respond to the cone cells of human retina and make a color triangle [14]. There are two models of RGB color RGB24 and RGB32.

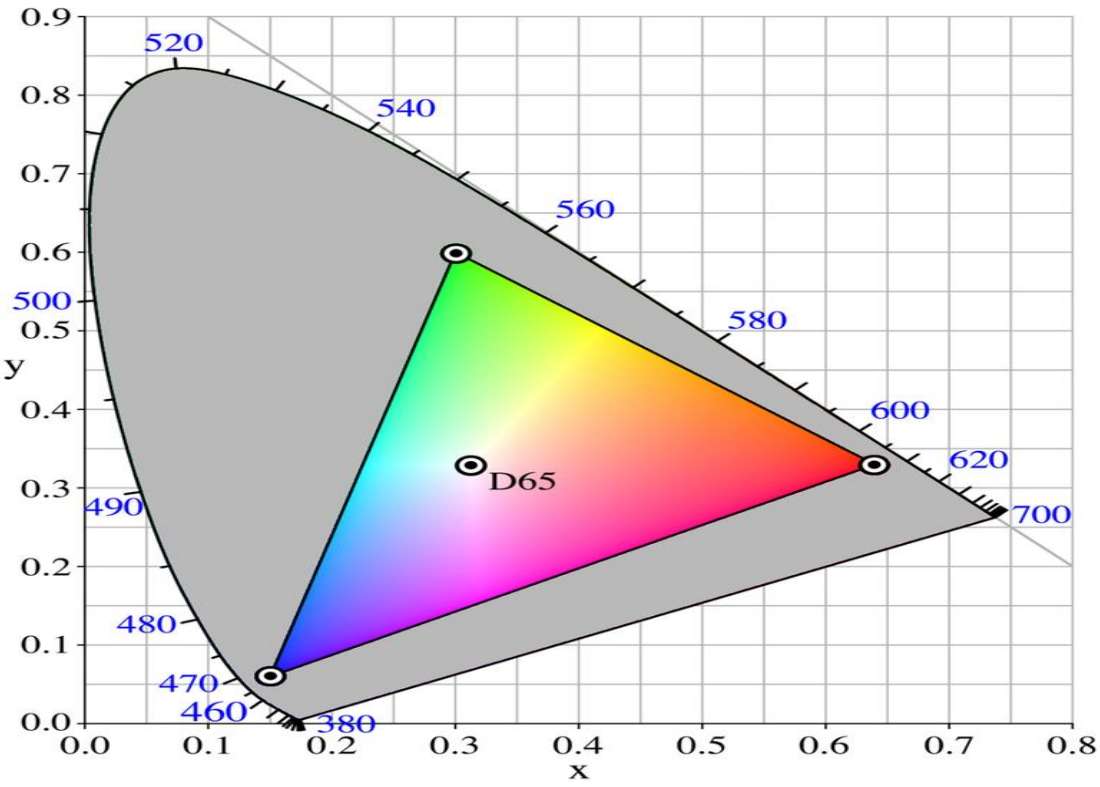
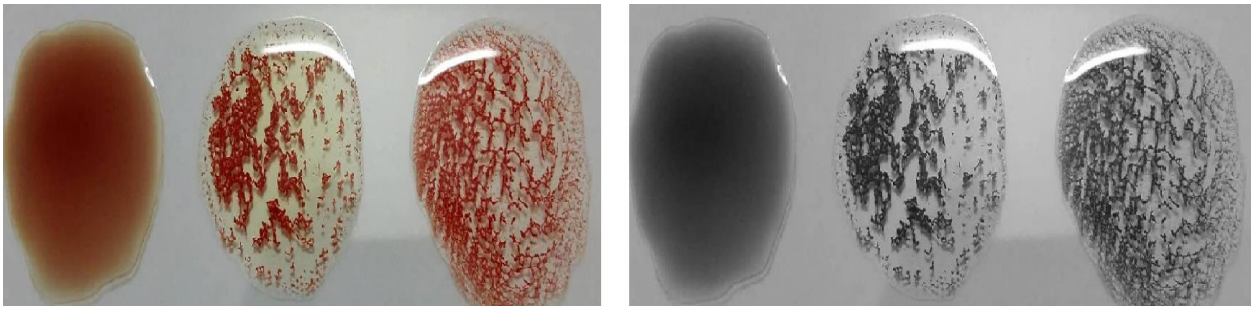


Fig 3.3 A set of Primary Colors in Color Triangle D65 white points are shown in RGB

To derive the numerical expression of RGB color model we need to calculate how much each of the red, green and blue is included. The expression of the color as an RGB triplet (*r*, *g*, *b*), such as component of each color can vary from zero to a defined maximum value. If all the color components are at zero the result is defined as black and if they are at maximum value thus the result is the brightest representable white. Conversion of an arbitrary color image to grayscale from our real data image which is shown in Fig 3.4



(a) (b)

Fig 3.4 (a) is the input RGB image, (b) Grayscale conversion of datasets output image.

Generally, grayscale image indicates the image, where each of its pixels is representing a range of a particular amount of light. In MATLAB, a grayscale image is a data matrix whose values represent intensities within some range. MATLAB stores the image as an individual matrix, with each element of the matrix corresponding to one image pixel [15] .We converted the image which is shown in Fig 4.4 and the grayscale image where any given area of the image are given equal white points. Luminance is a defined standard model of human vision of preserving the luminance in the grayscale image also preserves other perceptual lightness measures, such as L^* (as in the 1976 CIE Lab color space)

$$Y_{linear} = 0.2126R_{\text{linear}} + 0.7152G_{\text{linear}} + 0.0722\,B_{\text{linear}} \quad \text{(i)}$$

Which is determined in equation (i) by the linear luminance Y itself (as in the CIE 1931 XYZ color space) which we will refer to here as Y_{linear} to avoid any ambiguity. Where C_{srgb} represents any of the three gamma-compressed sRGB primaries (R_{srgb}, G_{srgb}, and B_{srgb}, each in range [0, 1]) and C_{linear} is the corresponding linear-intensity value (R_{linear}, G_{linear}, and B_{linear}, also in range [0, 1]). Then, linear luminance is calculated as a weighted sum of the three linear-intensity values. The sRGB color space is defined in terms of the CIE 1931 linear luminance Y_{linear}.

3.3 Apply Binary Conversion

A binary image is a digital image that has only two possible values for each pixel. Determining the histogram of grayscale image binary conversion is performed. Histogram is 1-dimensional matrix that is used to represent the pixel intensity in frequency distributions. Statistic parameter is a value that is used to determine the number of image as segmentation result. We uses the mean and standard deviation as a reference for determining statistic parameter. Here mean and standard deviation is given by [16].

$$\overline{X} = \frac{X1+X2+X3+\cdots+XN}{N} = \frac{\sum X}{N} \qquad \text{(ii)}$$

$$\sigma = \sqrt{\sigma^2} = \sqrt{\frac{\sum(x-\overline{x})^2}{N}} \qquad \text{(iii)}$$

In equation (ii) $\overline{X}$ represents the sample mean which represents standard deviation and represents individual values, and Where N represents the total number of values in the sample. Matrix is a 1-dimensional binary matrix with the size 1 x 256 [17].

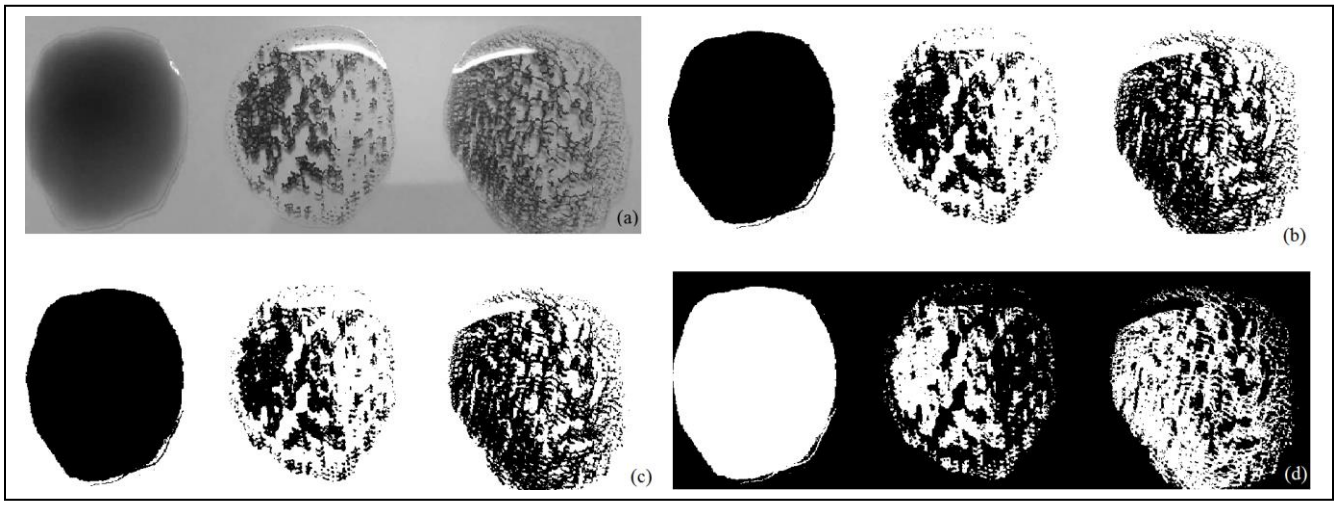
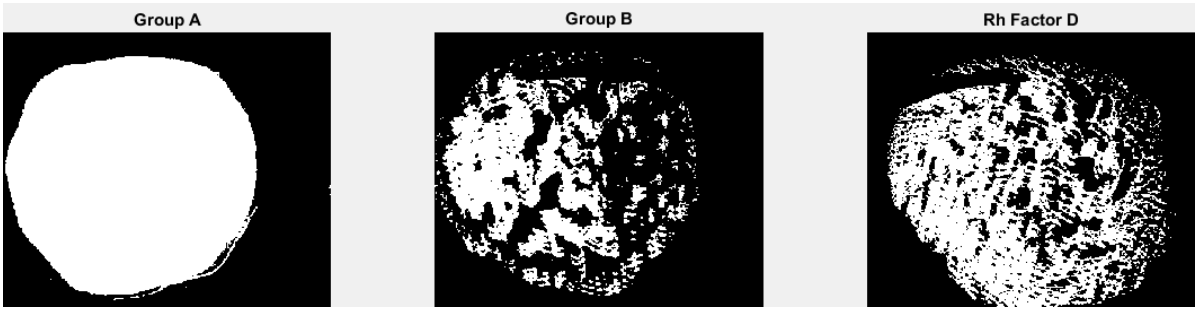


Fig 3.5 Binary Inversion (b) (c), technic is used on Grayscale Image (a), changing of white pixel in black pixel

In Fig 3.5 Our Grayscale image in converted into Binary Image and also inversion in performed to invert the black and white pixels of the image.

3.4 Segmentation

Segmentation is the process of dividing a digital image into multiple segments within the sets of pixels. Image Segmentation is generally based on two basic intensity values it has m number of rows add n number of columns. Each of the elements in this matrix representation is called a pixel. . If Image representation I = f(0,0) f(0,1)…….....f(0,N-1) f(1,0) f(1,1)…….....f(1,N-1) f(2,0) f(2,1)…….....f(2,N-1) f(M-1,0)f(M,1)..f(M-1,N-1). segmentation is to simplify the representation of an image into something that is more of a form on P(SI ᵘSJ)P(SI ᵘSJ) (S 1 ,S 2 ,…,S n) (Si ᶺ SJ) P(Si ᵘSJ). In Fig 3.6 the image is segmented into three parts Group A, Group B and Rh factor using the segmentation function



(a) (b) (c)

Fig 3.6 Segmentation of the blood image in section (a) Group A, section (b) Group B, in section (c) Rh-factor

3.5 Canny Edge Detection

Canny approach is a way of edge detection in image processing which works by detecting discontinuities in brightness [15]. Canny edge detection is a multistep detection algorithm which

can detect edges from the pixel image. Smooth the image with a Gaussian filter to reduce noise and unwanted details and textures through the equation

$$g(m,n) = G\sigma(m,n) * f(m,n) \quad \text{(iv)}$$

$$G\sigma = \frac{1}{\sqrt{2\pi\sigma^2}} \exp(-\frac{m^2+n^2}{2\sigma^2}) \quad \text{(v)}$$

Compute gradient $g(m,n)$ of using any of the gradient operations to calculate

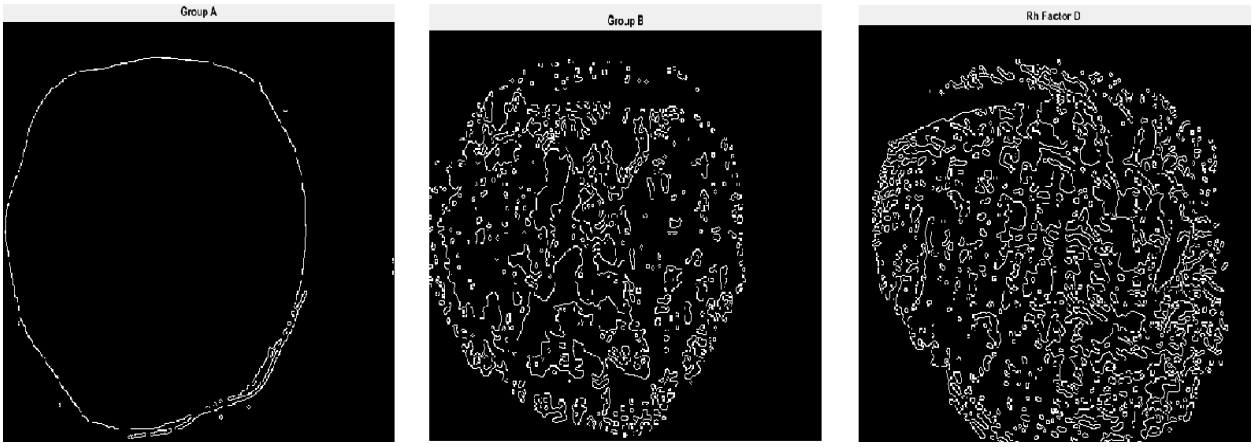
$$M(n,n) = \sqrt{G_m^2(m,n) + G_n^2(m,n)} \quad \text{(vi)}$$

$$\theta(m,n) = \tan^{-1}[g_n(m,n)/g_m(m,n)] \quad \text{(vii)}$$

And to calculate the threshold value the equation is

$$M_T(m,n) = \begin{cases} M(m,n), & if M(m,n) > T \\ 0, & otherwise \end{cases} \quad \text{(viii)}$$

Where T is all edge elements. Non-maxima pixels in the edges M_T calculated above to thin the edge ridges so non-zero of $M(m,n)$ is greater than its two neighbors along the gradient direction (m,n) . If $M_T(m,n)$ is kept unchanged or set it to 0. Link edge segments in $T2$ to form continuous edges. To do so, trace each segment in $T2$ to its end and then search its neighbors in $T1$ to find any edge segment in $T1$ to bridge the gap untill reaching another edge segment in $T2$ [18].



(a) (b) (c)

Fig 3.7 Application of Canny edge detection technic on image in figure (a) for Group A, Group B for (b) and (c) for Rh-factor.

Finally we have concluded with counting the existing edges after detection from the image, which is given in Fig 3.7 and decided on the numeric values as followed in

Group A: 18

Group B: 397

Rh factor: 492.

CHAPTER 04: RESULT ANALYSIS

4.1 Result

There are two parts of detecting a blood group. One part is detecting which group it belongs to like A, B or O and another part is detection of positive or negative type. Both test are done in single slide. From our proposed method we detect the agglutination of the blood sample when they are mixed with antigens. When agglutination occurs that means, that type of blood group is detected for the current sample. If the part A of the slide has agglutination and part B does not agglutinate then we decide the detected group for the sample blood is group A. Similarly, if part A do not have any agglutination and part B has agglutination then we decide that blood sample as group B. However, if there is no agglutination in any of parts then the detected blood group type is group O and if the agglutination has occurred in both part A and B then the detected group is AB.

To check if blood is positive or not, we focus on the Rh-factor part. If any agglutination occurs in Rh factor part then blood group is positive and if the agglutination does not occur then the blood group is negative.

In Table 1, All type of blood group and their pattern of agglutination has mentioned. Our proposed system detects the agglutination of the blood effectively. We are detecting blood group using the number of counted edges of the images. After using image processing techniques stated above, we have counted the total edges for Group A, Group B and Rh factor respectively.

Table 1: Agglutination Table

Group A	**Group B**	**Rh Factor**	**Result**
Not Agglutinated	Not Agglutinated	Not Agglutinated	O-
Not Agglutinated	Not Agglutinated	Agglutinated	O+
Not Agglutinated	Agglutinated	Not Agglutinated	B-
Not Agglutinated	Agglutinated	Agglutinated	B+
Agglutinated	Not Agglutinated	Not Agglutinated	A-
Agglutinated	Not Agglutinated	Agglutinated	A+
Agglutinated	Agglutinated	Not Agglutinated	AB-
Agglutinated	Agglutinated	Agglutinated	AB+

When the number of edges in the image is very high it means that agglutination has occurred and when the number of edges is low in number then we can presume the absence of agglutination. On the basis of the analysis on 100 blood samples, we have seen that agglutination occurs when there are more than 32 edges found in any particular group. Using our dataset we have counted edges for several images. In Table 2, number of edges of 8 different images are shown.

Table 2: Number of counted edges for A, B, Rh from eight samples of bloods from datasheets

Sample No	**Number of edges in part A**	**Number of edges in part B**	**Number of edges in part Rh factor**
1	166	2	14
2	232	248	5
3	18	397	492
4	2	6	128
5	3	1	1
6	4	144	4
7	155	352	343
8	250	17	121

From our proposed model, we got the information stated in Table 2. Using this information from the Table 2, we will do further calculations.

Let us declare three variables $N_{A,}$ N_B and N_{RH} for part-A, part-B and part of Rh-factor respectively.

Where,

N_A= number of detected edges in part A

N_B= number of detected edges in part B

N_{RH}= number of detected edges in part of Rh-factor

Now we will check if N_A>32.If the statement is true then agglutination has happened and we are setting value of N_A=1.Or if the statement is false then agglutination did not happen and we are setting value of N_A=0. Again, we will check if N_B>32.If the statement is true then agglutination has happened and we are setting value of N_B=1.Or if the statement is false then agglutination did not happen and we are setting value of N_B=0.Lastly, we will check if N_{RH}>32. If the statement is true then agglutination has happened and we are setting value of N_{RH}=1.

Or if the statement is false then agglutination did not happen and we are setting value of N_{RH}=0.

Here we are considering,

1= “agglutinated”

0= “Not agglutinated”

Now, from the data we get from here will be compared to the Table1 data and from the pattern of Table1 we will get the result.

Table 3: Result of the sample mention in Table2

Sample No	Value of N_A	Value of N_B	Value of N_{RH}	Result
1	1	0	0	A-
2	1	1	0	AB-
3	0	1	1	B+
4	0	0	1	O+
5	0	0	0	O-
6	0	1	0	B-
7	1	1	1	AB+
8	1	0	1	A+

For Sample no1 of the Table 2, how it was calculated is given as example below:

In sample no 1, the number of edges for part A is 166 so here (N_A=166)>32. Here the blood sample for Type A has been agglutinated. Similarly, number of edges for part B is 2.Here (N_B=2) <32, therefore the blood sample did not agglutinated. As well as for Rh factor, the detected edge is 14. (N_{RH}=14)<32 which means the sample blood is not agglutinated. Thus, we found A- blood Type. By combining all the outcomes, we finalize the accurate blood group of the input blood sample. All the other samples were measured in the same way.

Table 4: Accuracy Table

Sample No	Real Time Result	Proposed model's Result	Result Matched
1	A-	A-	Yes
2	AB-	AB-	Yes
3	B+	B+	Yes
4	O+	O+	Yes
5	O-	O-	Yes
6	B-	B-	Yes
7	AB+	AB+	Yes
8	A+	A+	Yes

From Table 4 we can see that all the result of our proposed method has matched with the real time result. Here we have shown every calculation for the sample of Table2. In real, we have tested our method for 100 images and every time the result of our method matched with the real time result.

Algorithm: Classification of blood group

1: **Input:** Image ***I***

2: **Output:** Classification of Blood Group using color Image *I*

3: gray = rgb2gray (*I*)

4: B=im2bw (*I*)

5: *I* = *I*'; Compliments of the Image

6: [nrows ncols dim] = size (invImg); slices columns wise split equally img1,img2,img3

7: D= edge (img1,'canny')

8: imshow(D);title('Group A')

9: E= edge (img2,'canny')

10: imshow(D);title('Group B')

11: F= edge (img3,'canny')

12: imshow(D);title('Rh Factor D')

13: Counting of edges using bwlabel() at D,E,F

14: Resultant edges are num, num1, num2

15: if num > unit then flag = 1 else flag =0

16: if num 1> unit then flag = 1 else flag =0

17: if num 2> unit then flag = 1 else flag =0

18: for i = 1: length(array) ; blood strings are taken

19: if (strcmp(temp,str{i}))

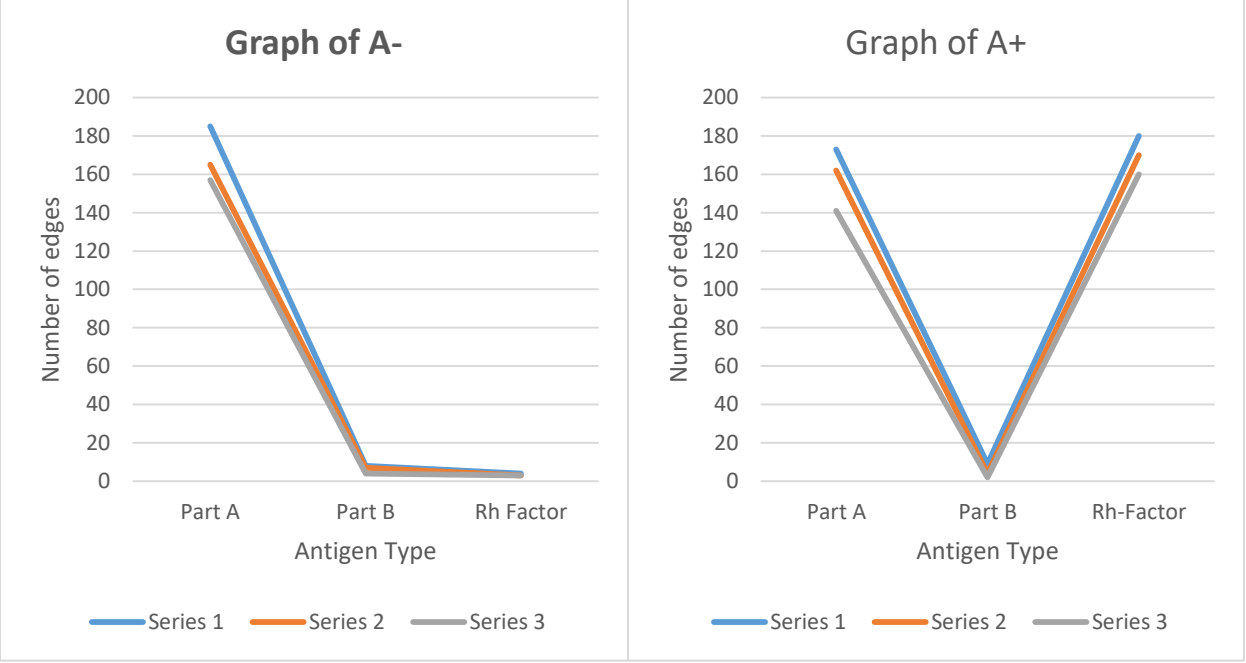
20:rst = str{i-1};

21: (' BLOOD GROUP is %s',str{i-1});

22: end

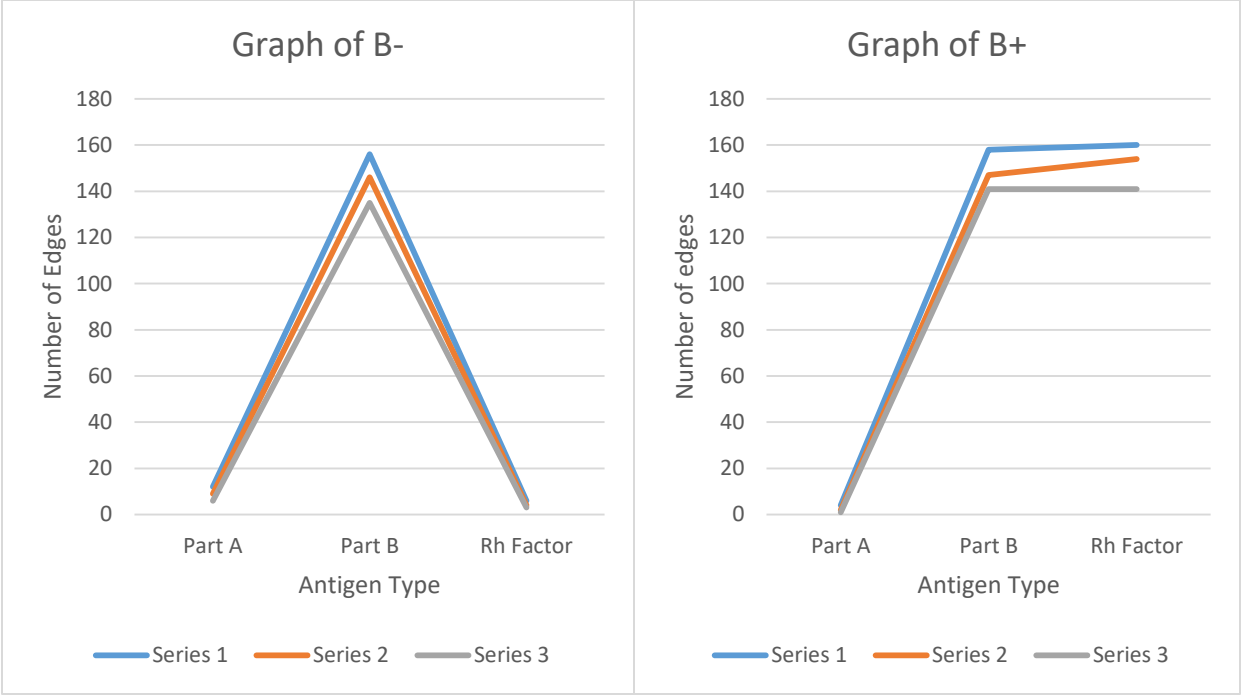
23:end

We have plot the values of detected edges in a graph for each and every type of Blood group. So we get 8 graphs for 8 types of blood group. The shape of every different type of blood group is different from each other but the shape of the same blood groups are similar. In Fig: 4.1(a) (b)-4.4(a) (b) different type of blood group is showed



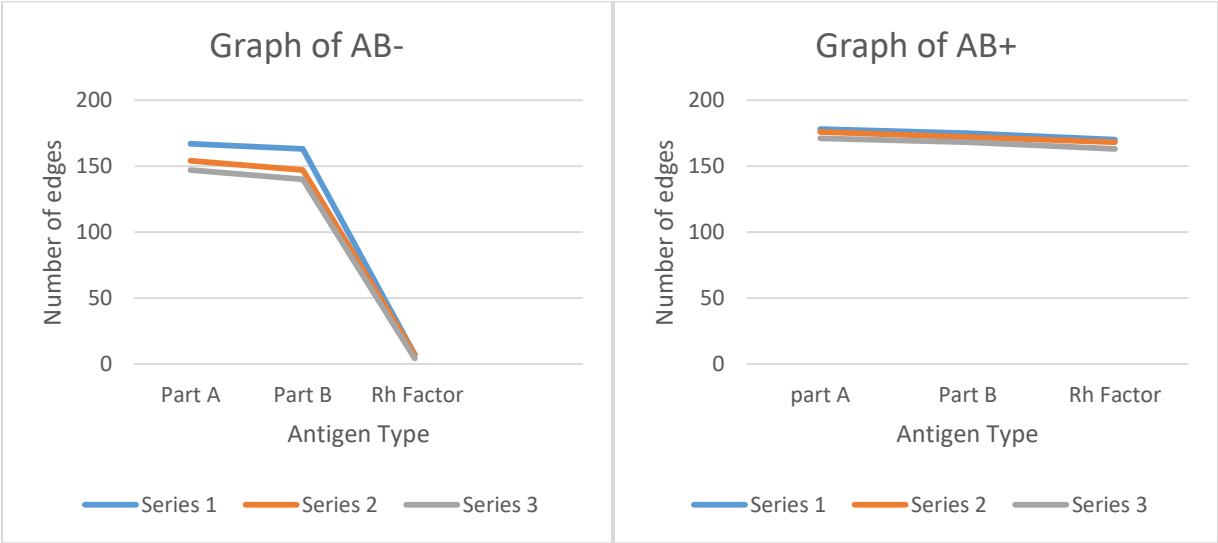
(a) (b)

Fig 4.1(a) Graph of A- blood group, (b) Graph of A+ blood group



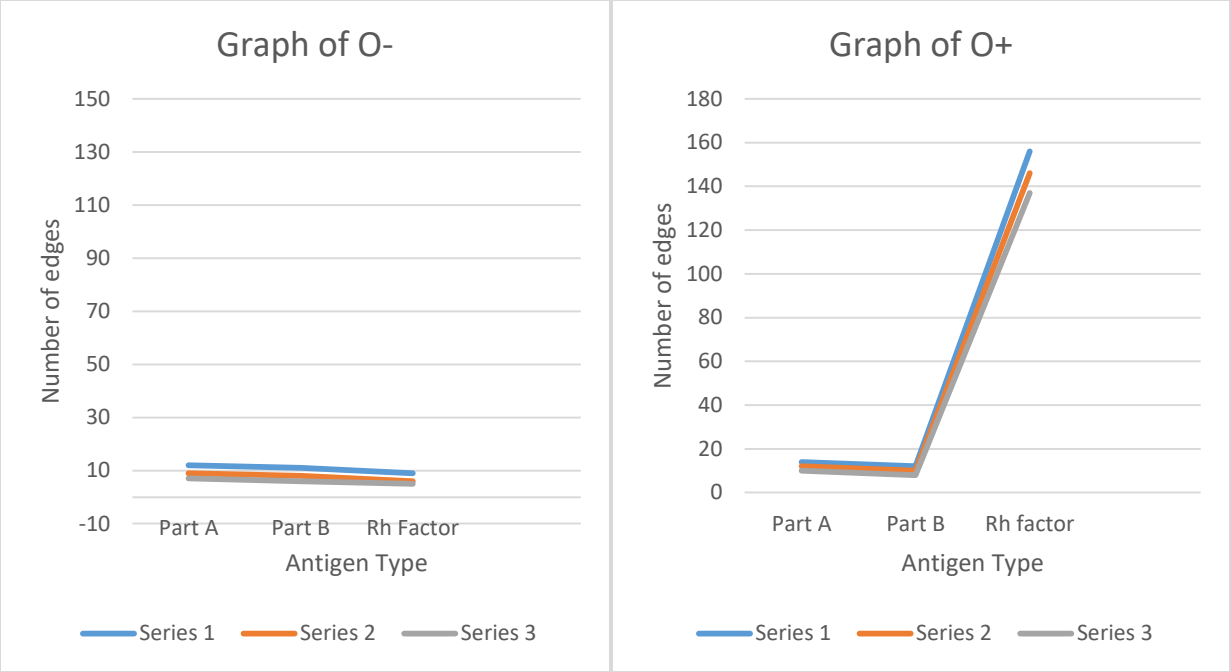
(a) (b)

Fig 4.2(a) Graph of B- blood group, (b) Graph of B+ blood group



(a) (b)

Fig 4.3(a) Graph of AB- blood group, (b) Graph of AB+ blood group



(a) (b)

Fig 4.4(a) Graph of O- blood group, (b) Graph of O- blood group

4.2 **Comparing with other models**

There are some existing model of blood group detection. A. Ferraz proposed an idea that he took the threshold value of the image and used quantification method. And he determined some standard deviation values to detect agglutination. He set the standard deviation value to 16 for the agglutination. If the standard deviation value exceed 16 then the agglutination has occurred and if it does not exceed 16 then agglutination do not happened [4, 9].But some other group following the same formula suggested that the standard deviation value should be set as 20 instead of 16[11].Both of them were correct on their own dataset but if we exchange the dataset and then apply then it starts to give wrong result. In the margin of 16 to 20 the result varies. None of models

of the researchers were 100 % accurate because of this problem. The blood group detection should be correct in any kind of dataset. Our proposed method is different from others. Rather than calculating minimal, maximal, mean and standard deviation, we tried for a different approach. When the blood agglutinate it creates many small edges.

We counted that edges and then on the basis of that took the decision.

CHAPTER 05: CONCLUSION

5.1 Conclusion and Remarks

In this thesis, a new and efficient process of digitally blood group detection model is proposed which is applied for the image sets that we can collect from hospitals. Image sets are captured by a mobile device and then processed through the image processing methods and algorithms. We counted the edges for each images and by analyzing the data we computed blood type from our sample captured real life image. Both, experimental result with of our collected dataset and comparison with the real time diagnostic result indicate promising process of effective performance. This paper presents a new and efficient model of blood group detection with image processing techniques. We worked on a real time dataset that consists of 100 blood samples. The blood sample was segmented in three parts and then we applied Canny edge detection method. After that, we counted the detected edges to determine the blood group of the sample. The experimental result with of our collected dataset and comparison with the real time diagnostic result indicate promising process of effective performance.

We will try to detect blood group from microscopic images by using shape and pattern detection method of the specific antibody in the blood cell that reacts with the antigen which will not require any pathology tests for blood group detection. Our method for blood group detection is feasible for common people. Diagnostic centers can capture the images for collecting data and gives accurate results.

5.2 Future Works

The potential future directions of our research based on the results which is presented in this thesis can be categorized into the following sections.

5.2.1 Microscopic Blood Images

Collecting the datasets of microscopic blood images instead of chemical used pictures.

5.2.2 Feature Extraction By Shape Detection and Classification

1. Shape Detection of Feature Extraction can be used in near future where the structural shape of the specific Antibody may detect in the blood cell instead of applying chemical antigen to identify blood group.
2. The use of microscopic image will lead us to a new device which can be able to capture instant picture of blood drops and can give the result in few seconds time limit. Our future approach will be developing a system with a device which will eliminate the use of chemical in blood group detection.

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