Determination and Classification of Blood Types using Image Processing Techniques

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Determination and Classification of Blood Types using Image Processing Techniques

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ABSTRACT
Determining of blood types is very important during emergency situation before administering a blood transfusion. Presently, these tests are performed manually by technicians, which can lead to human errors. Determination of the blood types in a short period of time and without human errors is very much essential. A method is developed based on processing of images acquired during the slide test. The image processing techniques such as thresholding and morphological operations are used. The images of the slide test are obtained from the pathological laboratory are processed and the occurrence of agglutination are evaluated. Thus the developed automated method determines the blood type using image processing techniques. The developed method is useful in emergency situation to determine the blood group without human error.

Keywords
Blood samples; morphological techniques; Luminance; quantification..

1. INTRODUCTION
Before the blood transfusion it is necessary to perform certain tests. One of these tests is the determination of blood type. There are certain emergency situations which due to the risk of patient life, it is necessary to administer blood immediately. The tests currently available require moving the laboratory, it may not be time enough to determine the blood type and is administered blood type O negative considered universal donor and therefore provides less risk of incompatibility. However, despite the risk of incompatibilities be less sometimes that cause death of the patient and it is essential to avoid them. Thus, the ideal would be to determine the blood type of the patient. Secondly, the pre-transfusion tests are performed by technicians, which lead to human errors. Since these human errors can translate into fatal consequences, being one of the most significant causes of fatal blood transfusions is important to automate the procedure of these tests. Various blood type classification, diffusive reflectance, ABO Rh-D blood typing using simple morphological image processing[1]-[4].There is a scope for determining blood types using image processing techniques. Image segmentation algorithm for blood type classification and various image processing parameters are analyzed[5],[6],[9]. Image features, such as color, texture, shape are analyzed [7],[8]. Low quality ancient document images and antibody agent analysis using image processing is explained[10],[11]. The slide test consists of the mixture of one drop of blood and one drop of reagent, being the result interpreted according to the occurrence or not of agglutination. The combination of the occurrence and non-occurrence of the agglutination determines the blood type of the patient. Thus, the software developed in image processing techniques allows, through an image captured after the procedure of the slide test detect the occurrence of agglutination and consequently the blood type of the patient.

2. BLOOD AND ITS TYPES
A blood type (also called a blood group) is a classification of blood based on the presence or absence of inherited antigenic substances on the surface of red blood cells (RBCs). These antigens may be proteins, carbohydrates, glycoproteins, or glycolipids depending on the blood group system. Blood groups are identified by antigens and antibodies in the blood. Antigens are any substance that stimulates the immune system to produce antibodies. Antigens can be bacteria, viruses or fungi that cause infection and disease. Antibodies, also called immunoglobulin are proteins manufactured by the body that help fight against foreign substances called antigens. When antigens enter the body, it stimulates the immune system to produce antibodies. The antibodies attach or bind themselves to antigens and inactivate it. The role of antibodies is to bind with antigens and inactivate them so other bodily processes can take over, destroy and remove the foreign substances from the body. There are many types of blood group. But, the major two types of blood groups are,

- ABO blood system
- Rhesus blood system

The ABO blood system is the most important blood group system in human blood transfusion. The associated anti-A, anti-B antibodies are usually immune globin M, abbreviated as IgM antibodies. ABO blood system determines whether the person belongs to blood A or B or AB or O. There are four major blood groups determined by the presence or absence of two antigens A and B on the surface of red blood cells:

Group A – has only the A antigen on red cells

Group B – has only the B antigen on red cells

Group AB – has both A and B antigens on red cells

AB blood types have both A and B antigens and no A or B antibodies. As they lack antibodies, they can receive any type of blood and known as UNIVERSAL RECIPIENT.O blood have neither A nor B antigens, so their blood cells will not be agglutinated by any recipient's antibodies, therefore they are known as universal donor.

3. EXISTING BLOOD GROUP TEST

To work out blood group of a person, red cells of that person are mixed with different antibody solutions. If, for example, the solution contains anti-B antibodies and the person has B antigens on cells, it will clump together. If the blood does not react to any of the anti-A or anti-B antibodies, it is blood group O. A series of tests with different types of antibody can be used to identify blood group. If the person has a blood transfusion, the blood of the person will be tested against a sample of donor cells that contains ABO and RhD antigens. If there is no reaction, donor blood with same ABO and RhD type can be used. It indicates that the blood has reacted with certain antibody and is therefore not compatible with blood containing that kind of antibody If the blood doesn't agglutinate, it indicates that blood doesn't have antigens binding the special antibody in the reagent. In existing system, blood group is determined manually. In this system, adding solutions such as anti-a, anti-b, anti-d to the three samples of blood took place. After some time, agglutination may or may not occur. Depending upon the agglutination, blood group can be determined by the person manually. Disadvantages of this system are more chances of human errors are possible. Only experts can tell the blood type by seeing at the agglutination process.

4. PROPOSED SYSTEM

In our proposed system, reagents are mixed with three samples of blood. After sometime, agglutination may or may not occur. After the formation of agglutination, the slide is captured as an image and allowed to process in MATLAB image processing toolbox. By using this system, more chances of human errors can be reduced. Image processing techniques used for blood group identification are

- Pre-processing techniques
- Thresholding
- Morphological operations
- HSL Luminance plane
- Quantification

In this proposed work various pre-processing techniques such as color plane extraction, gray conversion were used. Image preprocessing can significantly increase the reliability of an optical inspection. Several filter operations which intensify or reduce certain image details enable an easier or faster evaluation. Users are able to optimize a camera image with just a few clicks. Filtering contains numerous image filters for image optimization miscellaneous filter for edge enhancement, noise suppression, character modification, etc. Image processing includes It includes several functions for image processing. Contrast increase by static or dynamic binarisation, lookup tables or image plane separation. Resolution reduction via binning. Image rotation. An image f(x,y) is composed of light objects on a dark background. This technique is used to extract the light objects from the dark background. It is done by using a threshold value T. Any image point (x, y) at which f(x,y) >T is called an object or foreground point; otherwise, the point is called background point.

The threshold of a binary image is defined as,

$$g(x,y) = \begin{cases} a, \text{if } f(x,y) > T \\ b, \text{if } f(x,y) \le T \end{cases} \quad \text{----------------------------------- (1)}$$

When T is constant over an entire image, the preceding equation is referred as global thresholding. When the value of T changes over an image, it is called as variable thresholding. The term local or regional thresholding is also used to denote variable thresholding in which the value of T at any point (x,y) in an image depends on properties of neighborhood of (x, y). If T depends on the spatial coordinates (x, y) themselves, then variable thresholding is often referred as dynamic or adaptive thresholding. Thresholding may be single or multiple. In single thresholding, the image consists of a single light object on a dark background. But in multiple thresholding, image consists of two or more light objects on a dark background. This multiple thresholding method classifies the pixel at (x,y) as belonging to the background if $f(x,y) \le T1$, to one object class if $T1 \le f(x,y) \le T2$ and to the other object class if $f(x,y) \ge T2$.

The threshold of a multiple threshold image is given by,

$$g(x,y) = \begin{cases} a \text{ if } f(x,y) > T2 \\ b \text{ if } T1 < f(x,y) \le T2 \\ c \text{ if } f(x,y) \le T1 \end{cases} \text{--------------------------- (2)}$$

Where a, b and c are three distinct intensity values.

4.1 Types of Thresholding

4.1.1 Global thresholding:

Generally in image processing, the preferred approach is to use an algorithm capable of choosing a threshold automatically based on image data. This thresholding is known as global thresholding. In Images with uniform contrast distribution of background and foreground like document images, global thresholding is more appropriate. The following iterative procedure is used in this technique.

1. Select an initial estimate for the global threshold T.
2. Segment the image using T. This will produce two groups of pixels: G1, consisting of all pixels with intensity values greater than T and G2, consisting of pixels with values less than or equal to T.
3. Compute the average intensity values m1 and m2 for the pixels in regions G1 and G2 respectively.
4. Compute a new threshold value:

$$T = \frac{1}{2}(m1 + m2) \text{ ----------------------------------- (3)}$$

Repeat steps 2 through 4 until the difference in T in successive iterations is smaller than a predefined value, ΔT. Parameter ΔT is used to control the number of iterations in situations where speed is an important issue. In general, the larger the ΔT is, the fewer iterations, the algorithm will perform. It can be shown that the algorithm converges in a finite number of steps, provided that the initial threshold is chosen between the maximum and minimum intensity levels in the image. In terms of segmentation, the algorithm works well in situations where there is a reasonably clear valley between the modes of the histogram related to objects and background.

4.1.2 variable or local thresholding

Global thresholding methods typically fail when the background illumination is highly nonuniform. One solution to this problem is to attempt to estimate the shading function, use it to compensate for the nonuniform intensity pattern, and then threshold the image using any global thresholding methods. Another approach is used to compensate for irregularities in illumination, or in cases where there is more than one dominant object intensity, is to use variable thresholding. This approach computes a threshold value at every point (x,y) in the image, based on one or more specified properties of the pixels in a neighborhood of (x,y).

4.1.3 Adaptive thresholding:
Adaptive thresholding typically takes a grayscale or color image as input and in the simplest implementation, outputs a binary image representing the segmentation. For each pixel in the image, a threshold has to be calculated. If the pixel value is below the threshold it is set to the background value, otherwise it assumes the foreground value. In the local adaptive threshold technique, a threshold is calculated for each pixel, based on local statistics such as range, variance, or surface –fitting parameters of the neighborhood pixels. It can be approached in different ways such as background subtraction, water flow model, mean and standard deviation of pixel values, and local image contrast. Some drawbacks of the local thresholding techniques are region size dependent, individual image characteristics, and time consuming. Therefore some researchers use a hybrid.

4.2 Morpholgical operations:
Morphology is a tool of extracting image components that are useful in the representation and description of region shape, such as boundaries, skeletons, and the convex hull. In morphological operation, there are two fundamental operations such as dilation and erosion, in terms of the union of an image with translated shape called a structuring element. This is a fundamental step in extracting objects from an image for subsequent analysis. The fundamental operations in morphological operations can be listed as

4.2.1 Dilation
Dilation is the process that grows or thickens the objects in an image and is known as structuring element. Graphically, structuring elements can be represented either by a matrix of 0s and 1s or as a set of foreground pixels. The dilation of A by B is set considering all the structuring element origin locations where the reflected and translated B overlaps at least one element. It is a convention in image processing that the first operand of AB be the image and the second operand is the structuring element, which usually is much smaller than the image.

4.2.2 Erosion
Erosion shrinks or thins objects in binary image. The erosion of A by B is the set of all points z. Here, erosion of A by B is the set of all structuring element origin locations where no part of B overlaps the background of A. In image processing applications, dilation and erosion are used most often in various combinations. An image will undergo a series of dilations and erosions using the same, or sometimes different, structuring elements. The most important combinations of dilation and erosion are opening and closing.

4.3 HSL luminance
HSL luminance stands for Hue, Saturation and Luminance. Hue is expressed in a degree around a colour wheel, while saturation and brightness are set as a percentage. Shade uses a standard window colour picker with a scale of 0 to 239(which can be regarded as 1 to 240) for each quality, which makes calculations easy. HSV stands for Hue, Saturation and Value. A third model, common in computer vision applications, is HIS. In each cylinder, the angle around the central vertical axis corresponds to hue and saturation. Hue in HSL and HSV refers to Saturation and differs dramatically. RGB devices has unique HSL and HSV spaces

Quantification:

Quantification is the measure of intensity of pixels to measure the region of interest. The first option is the measure of reposition region of interest, dynamically restores the region of interest based on the coordinate system defined. The second option is reference coordinate system allows selecting the coordinate system associated to the region of interest. These features identify the occurrence of agglutination in the blood sample and reagent based on the value of standard deviation. If no agglutination occurs in samples and the values of standard deviation do not exceed 16 then quantification takes the values between 0 and 10. If the standard deviation values greater than or equal to 16 then quantification shows the values between 20 and 70.

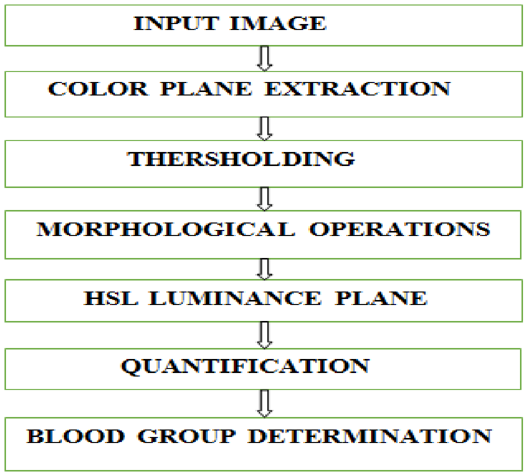

Fig 1: Steps for determining blood types

5. METHODOLOGY AND ANALYSIS
The image for analyses is collected from the laboratory and digital images stored in JPEG format. These images are pre-processed using color plane extraction. The riginal slide test image is shown in figure.

Fig.2. Input image

5.1 Color plane extraction
The color plane contains the color information in images. The foreground and background color of each image has different values. In this work only green color component is extracted because it contains the maximum value in the RGB color plane. The green plane extraction is shown in figure.

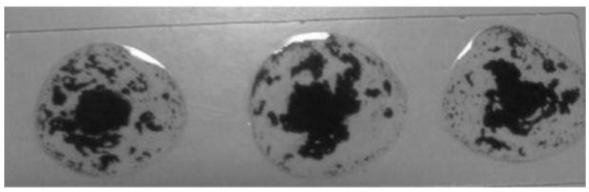

Fig.3. Color plane Extraction

5.2 Thresholding

It is the simplest method of image segmentation. From a gray scale image, thresholding is used to create binary images. The gray scale samples are clustered as background and object. It may be viewed as an operation that involves test against a function T of the form

$$\mathrm{T} = \mathrm{T}[\mathrm{x}, \mathrm{y}, \mathrm{p}(\mathrm{x}, \mathrm{y}), \mathrm{f}(\mathrm{x}, \mathrm{y})] \quad \text{----------------------------- (4)}$$

Where f(x, y) is a gray level at the point (x, y) and p(x, y) denotes some local property of the point. A threshold image is defined as,

$$\mathrm{g}(\mathrm{x}, \mathrm{y}) = \begin{cases} 1, \text{if } \mathrm{f}(\mathrm{x}, \mathrm{y}) > T \\ 0, \text{if } \mathrm{f}(\mathrm{x}, \mathrm{y}) \leq \mathrm{T} \end{cases} \quad \text{----------------------------- (5)}$$

Thus pixels labeled 1 corresponds to objects and pixels labeled 0 corresponds to background. Based on T dynamic and adaptive conditions are chosen. When T depends only on f(x,y) and the value of T solely relates to the character of pixels, this thresholding technique is called global thresholding. Clustering is the task of grouping a set of objects in such a way that objects in the same group are more similar to each other than to those in other groups. It can be observed that both background and object are separated as shown in figure.

Fig 4. Thresholding

5.3 NIblack thresholding

Niblack's algorithm calculates a pixel-wise threshold by sliding a rectangular window over the gray level image. The computation of threshold is based on local mean and standard deviation s of all pixels in the window and is given by the equation

$$\mathrm{T}_{\text{niblack}} = \mathrm{m} + (\mathrm{k} \times \mathrm{s}) \quad \text{--------------------------------- (6)}$$

Where m is the average value of the pixel, and k is fixed to -0.2 and s is the standard deviation. If threshold T depends on both f(x,y) and p(x,y),this thresholding is called local thresholding. This method divides an original image into several sub regions. It can be observed only the segmented part of an image shown in figure.

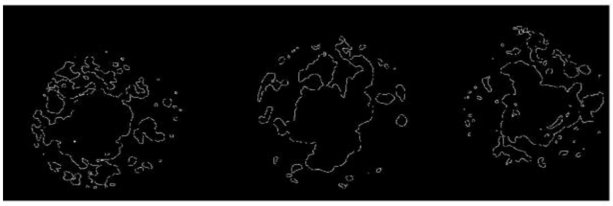

Fig 5. Niblack thresholding

5.4 Morphology

It includes pre or post processing operations such as dilation, erosion, morphological filtering and granulometry. The fundamental operations are dilation and erosion. The erosion operation uniformly reduces the size of the objects in relation to their background and dilation expands the size of the objects. By using dilation and erosion, secondary operations like opening and closing can be done. Morphological operations are used to eliminate noise spikes and ragged edges. Closing operation is used to fill the holes and gaps. It is the process of dilation which is followed by erosion. It can be observed that the segmented image is filled using operation is shown in Figure.

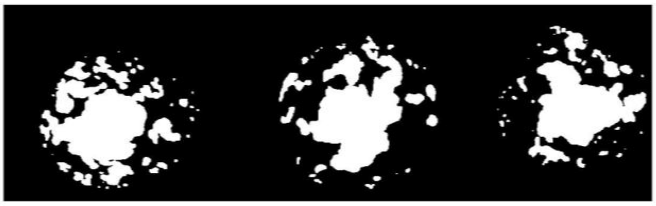

Fig 6. Filling Holes

Opening operation is used to smoothens the contours of cells and parasites. It is process in which erosion is followed by dilation. Therefore, the opening is the dilation, followed by the erosion of the result. It can be noticed that it smoothens the contours of cells by removing small objects is shown in Figure.

Fig 7. Removing small objects

5.5 HSL luminance plane

It stands for hue, saturation and lightness. In this cylindrical coordinate representation of points in RGB color plane is used. The result of HSL plane is shown in figure

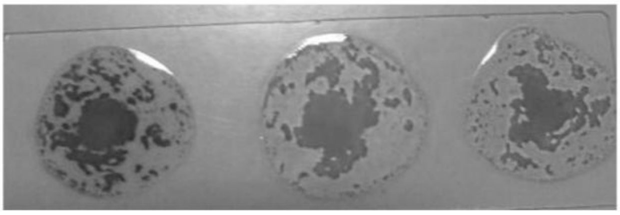

Fig 8. HSL Luminance Plane

5.6 Quantification

Quantify function expressed as a number or measure of quantity. It measures intensity only in the region of interest selected. Area (percentage of surface examined for full image), mean (average value of the pixel), standard deviation, minimum and maximum values of pixel intensity are determined. Using the value of standard deviation, occurrence of agglutination is identified. If standard deviation value does not exceed 16, it is confirmed that no agglutination occurs. If the standard deviation value is equal or greater than 16, it is confirmed that agglutination occurs. The result of quantification is shown in Figure.

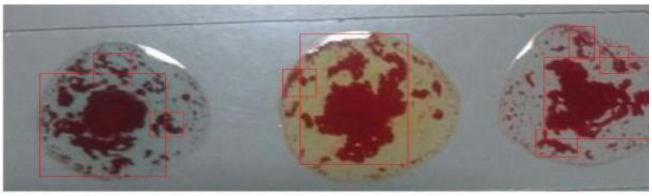

Fig 9. Quantification

6. RESULTS

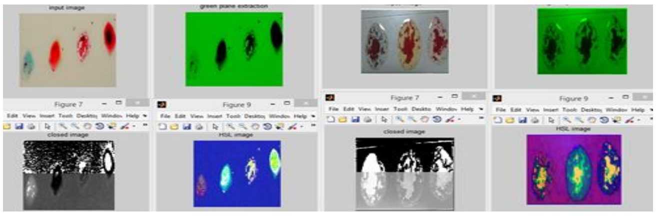

Fig.10. Sample blood sample analysis

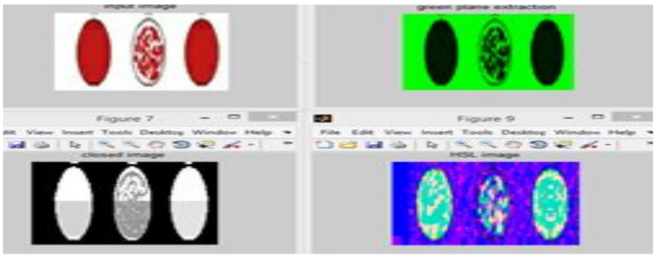

Fig.11. Blood sample morphology analysis

The method developed proves that it is effective and efficient method to detect the agglutination and determines the blood type of the patient accurately. The use of image processing techniques enables automatic detection of agglutination and determines the blood type of the patient in a short interval of time also helpful in emergency situations. In future it is intended to improve the system developed by making it smaller so that it can be portable and incorporate GSM technology, to send a message to the mobile of technician of the laboratory in order to avoid unnecessary travel.

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