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AN AUTOMATIC SYSTEM FOR DETECTING AND COUNTING RBC AND WBC USING FUZZY LOGIC

Bhagavathi S. L. and Thomas Niba S.
Department of Electronics and Communication Engineering, Sathyabama University, Chennai, India
E-Mail: bhagavathi1992@gmail.com

ABSTRACT

Blood cell detection and counting is the initial process for detecting and diagnosing diseases. Several image processing algorithms are there for the blood cell classification and counting. The processed image helps to detect different blood related diseases. In all those algorithms several pre-processing steps are there for the process of detection and counting. Though all the algorithms give accurate results, the pre-processing steps are complex and time-consuming. This paper discusses about the RBC and WBC detection using fuzzy logic. Fuzzy logic toolbox software in MATLAB is used to develop the model on virtual platform.

Keywords: RBC, WBC, image processing, MATLAB, fuzzy logic.

INTRODUCTION

Image processing is a computer based technology, carries out automatic processing and it plays an important role in the field of science and technology with applications such as robotics, remote sensing, medical diagnosis, photography and also industrial applications. An image may be defined as a two-dimensional function f(x, y), where x and y are spatial co-ordinates, and the amplitude of 'f' at any pair of coordinates (x, y) is called the intensity and the gray level of the image at that point. Image processing in medical field helps doctors to see the interior portions of the body for easy diagnosis. A complete blood count is required for the overall health evaluation of the patient. Complete blood count test measures various components and features of the blood including RBC, WBC, Hemoglobin, Hematocrit and Platelets. There are various image processing algorithms are there for the classification and counting of blood cells. This paper focuses on extracting the RBCs and WBCs from the blood smear image. Image processing in MATLAB environment has been used for the digital image processing. The RBCs and WBCs are differentiated using the fact that WBCs has a nucleus in the middle while the RBCs have no nucleus. Fuzzy logic is the process of formulating the mapping from a given input to an output. The fuzzy logic approach in image processing allows the use of membership functions to define a degree to which a pixel belongs to an edge or a uniform region. A membership function is nothing but a curve that provides how each point in the input space is mapped to a degree of membership between 0 and 1. In fuzzy logic, a simple IF-THEN rule is used to make the conditional statements. Each and every step of fuzzy logic is described with some mathematical operations. Fuzzy logic in MATLAB environment has been developed to implement the algorithm on the sample blood smear image. The fuzzy logic toolbox provides MATLAB functions for analysing, designing and simulating systems based on fuzzy logic.

PROJECT OVERVIEW

The RGB image (input blood smear image) obtained is converted using gray scale image and the edges are detected using fuzzy logic rules. Now the centre of the circle is found and the radius is determined for each cell. Using this total number of blood cells is counted. Based on the presence of the nucleus the cells are determined if they are red blood cells or white blood cells and the count is displayed on the GUI i.e., graphical user interface. The steps involved are explained briefly below.

Gray scale conversion

Initially we have to import the blood smear image. For illustration I have used an image of a blood smear from a laboratory. The image is given in an RGB format. For RBC counting, we have to extract the RBCs. Since the RBCs are rich in red colour, 'adapthiseqfuction' is used to highlight the red component in the gray scale image so that we can get the clear identification of RBCs.

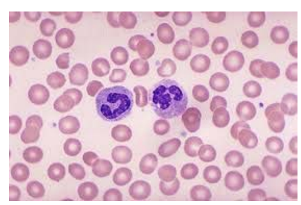

Figure-1. Blood smear image.

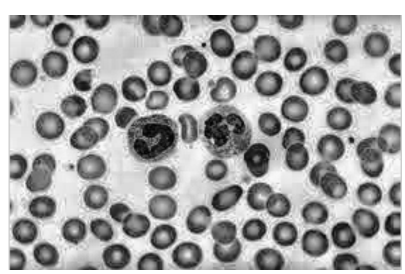

Figure-2. Gray scale image.

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Edge detection

The edges are determined using fuzzy rules. The x and y gradients are plotted. Now the rules are defined for the fuzzy inference system. The x and y gradients are shown in below figure.

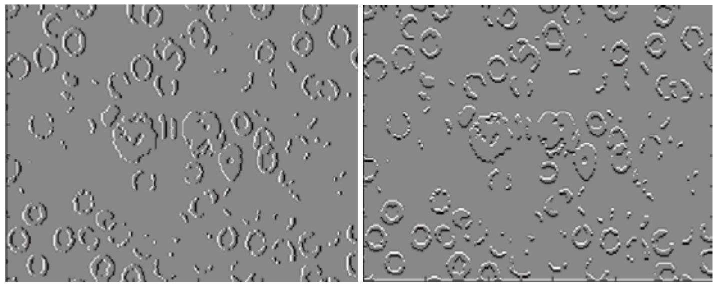

Figure-3. (a) X-gradient (b) Y-gradient.

Based on the input values an FIS editor will be created and the rules are set to detect the circles. The circular shapes will be detected on the gray scale image and the circle will be drawn on the detected pixels.

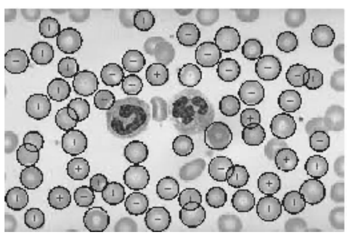

Figure-4. RBC detected image.

If radius of the circle is in the given range, then it is identified as pixel 1 and the circle is drawn. If the radius of the circle is not in the given range, then it is identified as pixel 0. In case of concentric circles, multiple radii may be detected corresponding to a single centre position. To detect the concentric circles multiple radiant argument is used. By default the value is 0.5. An accumulator array, centre and radius of the circle will be obtained as the output arguments. An accumulator array has the same dimension as the input image. The centre position is an N-by-2 matrix with each row contains the (x, y) positions of the circle. For concentric circles (with the same centre position) say k of them, the same centre position will appear k times in the matrix. The estimated radius will be an N-by-1 column vector with a one-to-one correspondence to the obtained radius. A value 0 for the radius indicates the failed detection of the circle's radius. In addition to these a mask also obtained as output for debugging purpose. It is used for the search of local minima in the accumulation array. The image obtained from the output of the fuzzy logic has the white background and the black boundary.

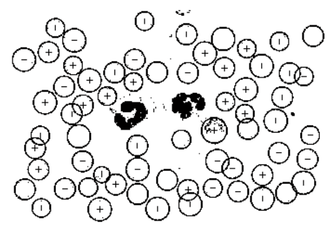

Figure-5. RBC mask obtained from fuzzy logic.

The obtained image is complemented for better identification and the resultant image is shown in Figure-6. Hole filling operation and labelling is performed on the resultant image and is shown in Figure-7.

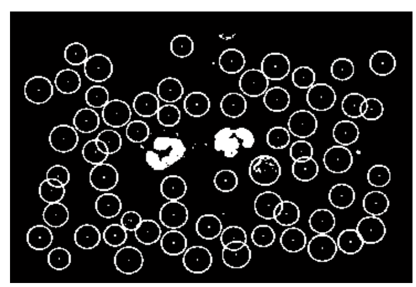

Figure-6. Complemented image.

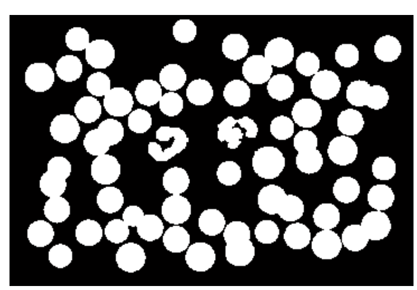

Figure-7. Hole filling process.

Differentiation of RBC and WBC

Based on the presence of nucleus and the intensity values WBCs are differentiated from the RBCs. Erosion is applied on the nucleus of the WBC and the

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WBC cells are separated from the RBC. The extracted WBC masks are shown in Figure-8.

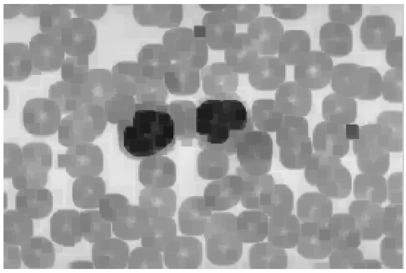

Figure-8(a). Erosion on input blood smear image.

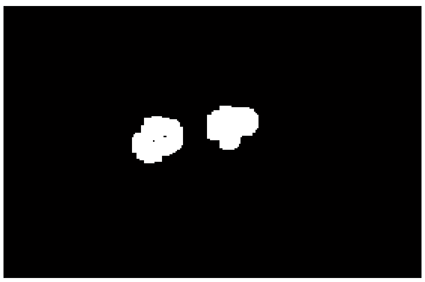

Figure-8(b). WBC mask.

Counting of blood cells

The counting process is done based on the obtained centre and the radius values by using a simple MATLAB code developed for cell counting. The respective RBC and the WBC counts will be displayed. A graphical user interface is created for the developed model and the RBC and WBC masks are shown and the respective RBC and WBC counts will be displayed. The Figure-9 shows the GUI which shows the accurate RBC and WBC counting.

RESULTS AND DISCUSSIONS

Several works have been proposed in the field of processing the blood cell image and counting blood cells. In all the existing algorithms like Hough transform if the cells are overlapped they are counted as a single cell. Though watershed algorithm overcomes this limitation it has too many processing steps. This fuzzy logic approach helps to obtain the different masks of RBC and WBC and it also overcomes the limitation of overlapping. Due to the incompleteness of the circle drawing, all the RBCs are not counted. To determine the accuracy different sample images are tested and the results are shown in Figure-10.

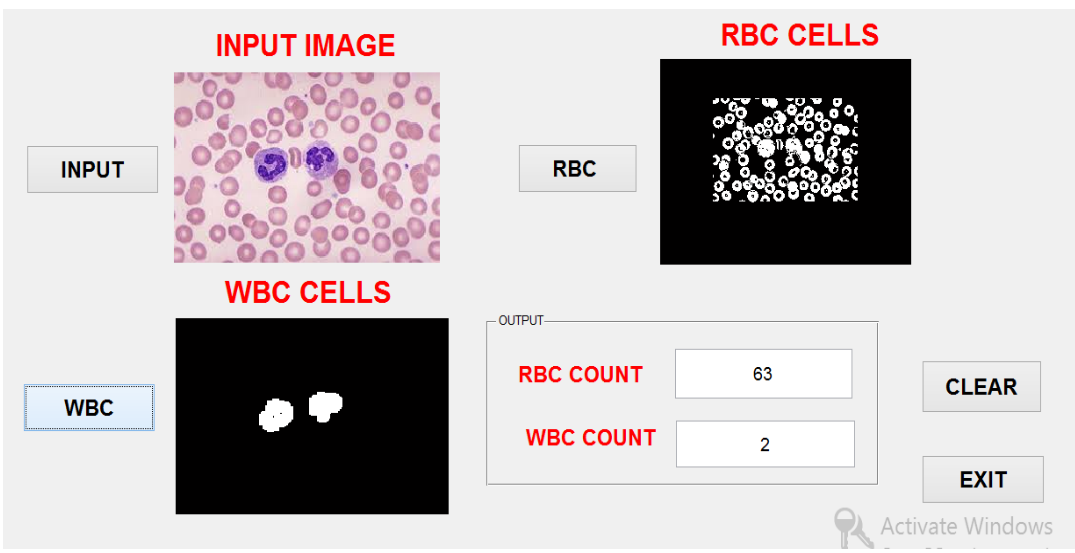

Figure-9. Graphical user interface.

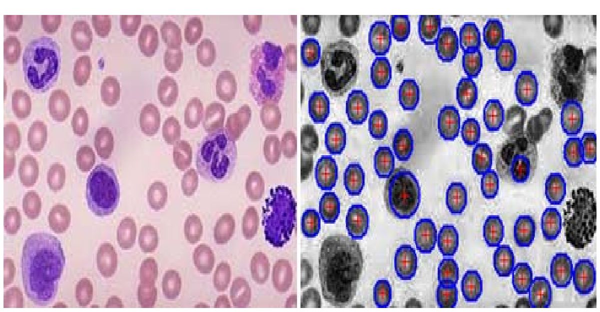

Figure-10. (a) Input blood smear image. (b) RBC mask.

Figure-10. (c) WBC mask.

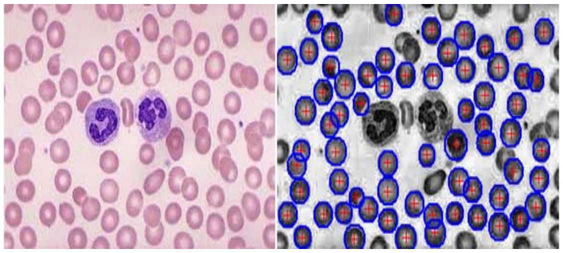

Figure-11. (a)Input image (b) RBC mask.

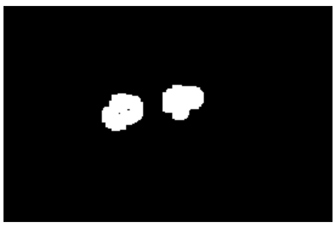

Figure-11. (c) WBC mask.

CONCLUSIONS

The goal of this research work is to produce cost effective and efficient computer vision system for automatic counting of blood cells from the blood smear microscopic image. In this paper we have detected RBCs and WBCs using fuzzy logic and the count is displayed. This algorithm provides accurate count and the time taken to complete the process is also very less.

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