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A Novel Automatic Red Blood Cell Counting System using Fuzzy C-Means Clustering

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Abstract: **The red blood cells in normal human body are 5 million per cubic millimeter. In medical world most of the diseases are diagnosed based on the reference of red blood cells count only. This paper is the study of Morphological operations for counting of Red blood cells from a digital image. Filtering of image is processed by Fuzzy clustering in two stages i.e. one for background and second for white blood cells. The efficiency of algorithm is compared with Hough Transform and results demonstrate that Morphological operations are superior in terms of accuracy.**

Keywords: **Red blood cells, morphological operations, Filtering, Image segmentation, HSV, Fuzzy clustering.**

I. Introduction

The propagation of fluids in mammals is processed by blood stream that circulates in every millimeter of body. Blood is a connective tissue composed of plasma, cells and platelets. The most abundant small reddish cells are erythrocytes and called red blood cell [1]. In correspondence with the color of blood cells they are termed as red blood cells and white blood cells. The count white blood cells represent the immunity state of an individual. The Red blood cells deficiency could be the source of various diseases and thus is heavily employed in medical practices. The normal red blood cell count of a healthy person is divided on basis of age groups by American Cancer Society (2009) [2].

For identification of red blood cells among other cells many methods are discovered. Most specific method employed is the hemacytometer. This is a mechanical approach that places the blood unit in path of light. The cells disrupt this path and counter is incremented against it. The cost consideration for this method makes it impossible for most of medical centers (mainly in developing countries) to install it. Hence alternative methods of cell count came into existence. Counting RBC in this way is costly and time consuming. The method and mathematical formula for manual computation is given in works of Alaa Hamouda [4]. Diagnosis via imaging is a conventional approach. The internal parts of body are captured in form of image and analysis is made based on that. Automated counting via blood image (figure 2) is researched heavily by various researchers in this segment. Second section of this paper reviews such methods that also define the need of this research.

In this research Morphological operations are used for counting of image. The cells at the edge of images are considered based on the presence of vacant hole in center of cell and overlapping is determined based on area consumed by it. The image is cleaned and morphological operations were implemented before counting. The method for the input image resulted in total 81 red blood cells. The comparison with Hough Transform is made in the conclusion that also summarizes the superiority of proposed algorithm. The organization of paper is as follows: the second section of paper depicts the literature survey. III section is the proposed method followed by results in section IV. Conclusion is present at end of paper.

II. Literature Survey

Image based blood cell counting is a section of image segmentation in engineering domain. The image is processed to eliminate disturbances from the image and highlighting the required parameters. Further an automated mathematical computation algorithm is applied that counts the cells based on specific parameters. Till now, many optimization techniques were tested so far. Genetic Algorithm which is the

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replica of natural phenomenon for genetic development was applied [3] for counting of cells based on the previous result of counting. This algorithm was further improvised along with Neural Network specifically for Thalassaemia diagnostics [5]. Roy A. Dimayuga et. al [8] used the histogram thresholding to distinguish the nucleus of the leukocyte or white blood cells from the rest of the cells in the image. Ramin Soltanzadeh [9] has purposed feature extraction technique based on morphology in his three blood cell's experiments. Sanaullah Khan [6] proposed the method of histogram calculation for counting of cells. However, clear results are not present to support their claim. Another authors Xiaomin Guo and Feihong Yu introduced a method of automatic cell counting based on microscopic images [7]. Histogram information was used to calculate adjustable lower and upper threshold value. This value was used for segmentation of objects and background. Haider Adnan Khan et al. presented a framework for cell segmentation and counting by detection of cell centroids in microscopic images [10]. Preprocessing is done with Contrast-Limited Adaptive Histogram Equalization to get enhanced image. Next, cells are separated from background using global thresholding.

III. Proposed Methodology

A. The image is acquired from digital source for processing. The image is a normal microscopic image with white blood cells. The image for counting is needed to be processed.

B. Image Filtering

Median filtering is a conventional tool to minimize the noise of an image. A sliding window captures the median value of input arguments and publishes it as the output. This filtering is used for removal of noise in image.

Let $\{X_i\}$ is the m-directional sequence with index $i \in Z^m$. A sliding window $W \in Z^m$ has $W_i = \{X_{i+r}: r \in W\}$ at position i.

The Standard median (SM) filter for output Y_i at i^{th} location is given in the terms of W_i as:

$$Y_i = med\{W_i\} = med\{X_{i+r}: r \in W\} \qquad (1)$$

Where, $med\{.\}$ is the median operator.

The r^{th} order statistic of the samples inside the window W_i for odd number of r is:

$$[W_i]_{(1)} \leq [W_i]_{(2)} \leq \cdots \leq [W_i]_{(2N+1)} \qquad (2)$$

C. Erosion (morphological Operation)

It is a part of morphological operation that highlights the red color (color for red blood cell) in the image to clear the boundaries of cells.

The erosion of the colour image A by the structuring element B is defined by:

$$A \ominus B = \{z \epsilon E | B_z \subseteq A\} \qquad (3)$$

Where, B_z is the translation of B by the vector z, i.e.,

$$B_z = \{b + z | b \in B\}, \forall_z \in E \qquad (4)$$

The erosion of A by B is also given by the expression:

$$A \ominus B = \bigcap_{b \in B} A_{-b} \qquad (5)$$

D. HSV Transformation

HSV color transform gives three folds benefits: closer to human perception; user friendly and better color conversion accuracy [11]. The hue revolves in the range of complete 360 degrees and determines specific color for every degree. Saturation is measured from 0 to 1.0. The more is the saturation more will be the color intensity. Luminance value (V) is brightness in range 0 to 1 determines the brightness in form to black to white. More is the luminance more will be the white color.

The precise transformation between RGB and HSV colour space is reference in [12].

F. Fuzzy Clustering

Fuzzy clustering involves the pixels that belong to degree of freedom. The point a belongs to the cluster $w_k(x)$ with degree k. According to this degree the mean of all pixels is centroid of cluster. A primary benefit of this approach is the consideration of cells at the edge of image. For N data objects, a set is signified as

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$$x_k = [x_{1k}, \dots \dots, x_{nk}]^T \in \mathbb{R}^n \quad (6)$$

Where,

x_k= Feature vectors

N is the number of data objects

A set of N feature vectors is then represented as a $n \times N$ data matrix

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1N} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nN} \end{bmatrix} \quad (7)$$

This approach classifies red blood cells from background and white blood cells.

G. Morphological Operations

The processing based on the orientation of image is termed as morphological operations. The size of input and output arguments for an image is same. The pixels values are compromised based on the comparison with corresponding pixels of input image and its neighbouring pixels. The morphological operation can be constructed belonging to the sensitivity of specific input image. The four steps of operations are depicted as follows:

- Erosion: It is the process of colour enhancement and highlights the red blood cells of given image.
- Dilation: Change a background pixel to foreground if it has a foreground pixel as a 4-neighbor.
- Opening: Eliminates all pixels in regions that are too small to contain the structuring element.
- Closing: Consists of a dilation followed by erosion and can be used to fill in holes and small gaps.

Figure 1 presents the overall flow chart of proposed algorithm. The image considered is an open source and is taken from physionet.org. The proposed architecture is constructed and tested on MATLAB platform. The final counting process after morphological operations is done using a simple MATLAB code developed for cell counting.

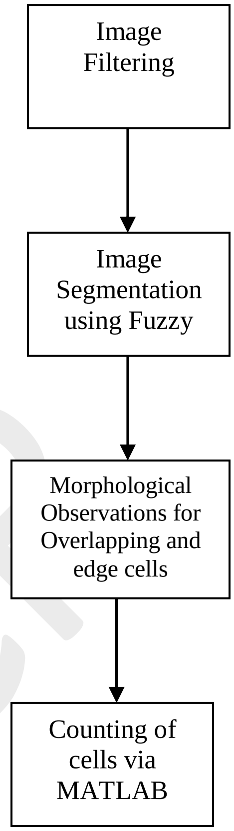

Figure 1: Flowchart of RBC Counting Process

IV. RESULTS

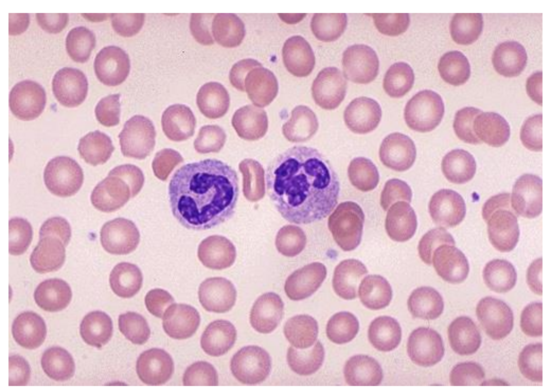

Figure 2: Original Image

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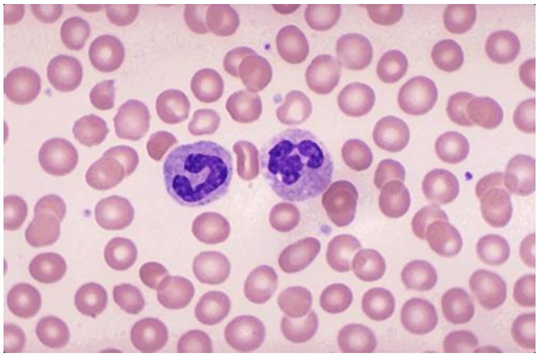

Figure 2: Image filtration using Median Filtering

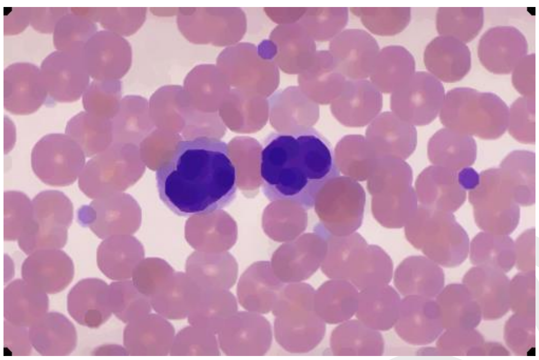

Figure 3: Image erosion for color enhancement

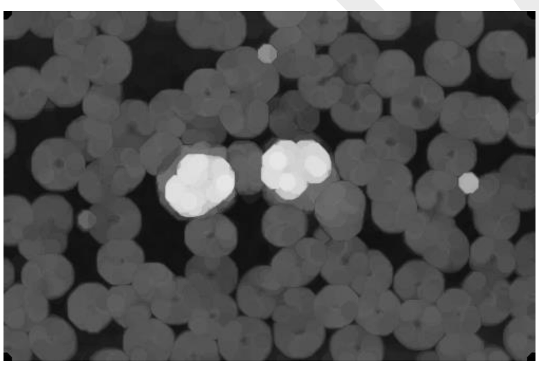

Figure 4: Image Saturation using HSV color transform

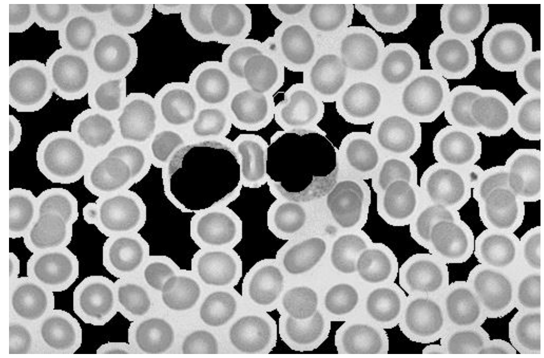

Figure 5: Fuzzy clustering for background removal

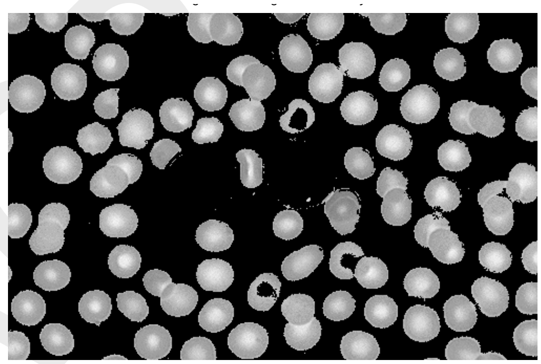

Figure 6: Second Level Fuzzy for removal of white blood cells

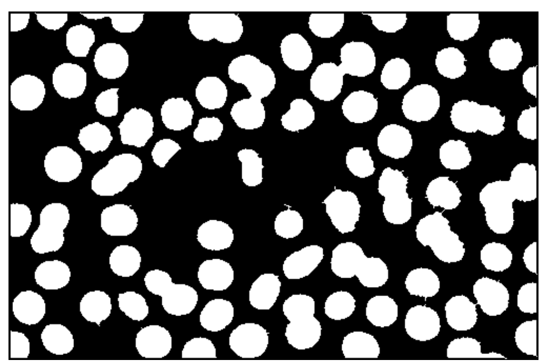

Figure 7: Grey to binary conversion for Morphological Operations

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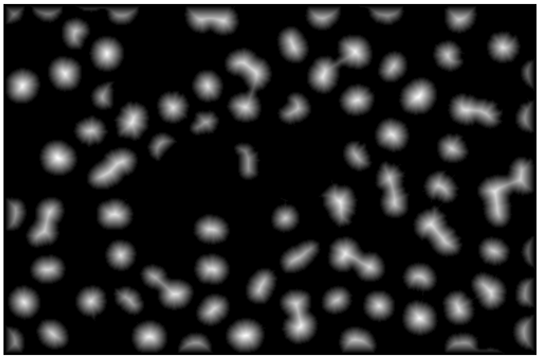

Figure 8: Pixel connectivity after morphological operations

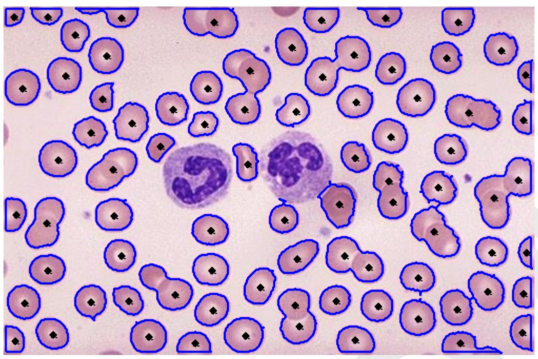

Figure 9: Counting of cells which is equal to 81

V. CONCLUSION

This paper researched the Morphological Operations for red blood cell counting. The four stage method covered the issues of overlapping and cells at the edge of image. Though the image for comparison with Hough Transform was different, yet the considerations were resolved in proposed architecture. This on other hand implicated the superior performance over proposed algorithm. The subject of red blood cell count is thoroughly addressed and more than 95% accuracy resolves the considerations related with it. In future this research could be extended to counting of white blood cells and platelets.

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