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Anaemia cells detection based on shape signature using neural networks

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ABSTRACT

Anaemia becomes more famous and public disease in our life. Many methods have been examined on red blood cells to detect this disease. This paper has been presented an algorithm for detecting anaemia kinds; such as sickle and elliptocytosis dependent on their geometrical shape signatures method. The proposed algorithm presents Circular Hough Transforms, watershed segmentation, and morphological mathematics functions as effective methods to detect the normal blood cells; but the anaemia kinds have been classified based on their shape signatures. Some difficulties have been faced through the detection process; the adhesion of cells may be not belonging to one of previous mentioned kinds of anaemia then they considered cells with unknown shapes. The results of the proposed algorithm have been achieved high precision in all processes steps on experimented 30 colourful microscopic images and the rates have been achieved to 100% and 100% based on three neural networks for all anaemia kinds.

1. Introduction

Anaemia is so dangerous disease causes distortion of red blood cells (RBCs) by reducing the existence of iron. It happens; when the number of red cells is lower than the normal or deficiency of haemoglobin on them. In fact, the lungs supply haemoglobin by the oxygen that transported by RBCs to whole body and clean the waste product, which is carbon dioxide [4,6–8,18]. Generally, this mechanism is depending on the normal life of RBCs; 120 days, to give the spongy marrow, which is located inside the bones, a chance to renewing them. When the anaemia kinds attack, the RBCs life will reduce and the spongy marrow will not be able to renew them in the rate of cells' dying [5,13].

There exist many kinds of the anaemia disease. One of them is named sickle cell; this name comes from the shape of deformed RBC; if the disk shape of it distorted into a crescent. The danger of sickle cells is summarized into the obstruction of blood flow in the veins, limbs, and organs. This resistance or obstruction of blood flow can cause some symptoms like pain; organ hurt, and push the probability of illness. Sickle cells lives around ten to twenty days before the ability of spongy marrow to create other RBCs for replacing that died ones [17]. Additionally, this kind of anaemia is most famous in Africans around the Mediterranean Sea, Panama, Caribbean, India, and Saudi Arabia. In the United States only, the number of sickle cell patients is ranged 70,000–100,000 [8,16].

Another kind of anaemia categorized as one of the hereditary conditions in 1932 and described in 1904 named elliptocytosis. A large number of RBCs are elliptical rather than the normal disc shape. The diagnosis of hereditary elliptocytosis is usually made by coupling a family history of the condition with an appropriate clinical presentation and confirmation on a blood smear. Elliptocytosis has incidence higher in areas endemic for malaria than in non-endemic areas because of relative resistance of elliptocytes against malaria. In equatorial Africa, the incidence is approximately 0.6%; in Malayan aborigines, the incidence is as high as 30%. However, the true incidence is unknown because many patients do not have any symptoms [10]. About 60–150 cases per 10,000 are estimated incidence of African and Mediterranean, whereas in the USA estimated between three and five cases per 10,000, and Malayan natives its incidence is 1500–2000 cases per 10,000 [3,14].

In reality, the danger of anaemia ailment have pushed to work in this paper for giving some aid in resistance and diagnosis. The extraction of information from microscopic images represents a big challenge. The regularization of images, image segmentation followed by feature extraction and its classification have included in this type of research. The proposed algorithm begins by classifying the normal RBCs and abnormal ones especially sickle, elliptocytosis cells based on their shape signatures on blood smears [9]. Watershed segmentation, Circular Hough Transform (CHT), and morphological functions have used through detection process to

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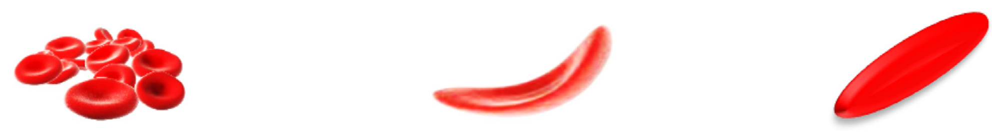

(a) The shape of normal red cells (b) the shape of sickle cell (c) the shape of Elliptocytosis

Fig. 1. The changes in the shape of normal and anaemia cells.

select and marked the normal cells. In this manner, the abnormal cells have distinguished from the normal ones and based on cell shape signatures, as in Section 3. Through this operation of abnormal cells' identification, the data that related to them have formed as input variables to be suitable for use in the neural network. These variables are Areas, Convex Area, Perimeter, Eccentricity, Solidity, Ratio, absolute deviations, denoted by AVD, and variable of absolute subtractions among input and saved signature values (see Eqs. (2), (3), (6), (7)). The neural network has applied to get an evaluation for the decision that has been taken by the process of abnormal cells detection and the amount of agreement [2,10]. All differences in the shape of Normal, Sickle, and Elliptocytosis cells have shown in Fig. 1.

The rest of the paper is organized as follows; Section 2 focuses on related studies. The shape signature of cells is presented in Section 3. Section 4 introduces the proposed algorithm, and the effectiveness of the experimental results are detailed in Section 5. The conclusion is presented in Section 6.

2. Previous related work

Recently, research using image processing has increased especially on the blood cells detection and the determination of illnesses. In October 2016, Marek Wdowiak and others have presented a new approach to the problem of a membrane staining determination in HER2 (Human Epidermal growth factor Receptor 2) images of breast cancer. It is dependent on the representation of the small membrane sections by the defined linear patterns of dissimilar shapes, which combined allow representing the complex shape of the membrane staining. The discovered linear structures existing in the image are localized and recognized applying the specially devised masks sliding over the completely analysed image. The method is strong against the noise inherent in the image and to the changing details complication of the image. Its usage in HER2 image processing was verified on examples of the HER2 images of the breast cancer representing different grades of membrane staining [19].

Xun Xiao and others, in August 2016, have introduced a string segmentation technique based on B-spline vector level-sets and a linear model for the pixel intensity statistics. They have shown that the resulted optimization problem is convex and can be solving with global optimality. This algorithm computed such string segmentations and provided an open-source implementation as an ImageJ/Fiji plug-in. Furthermore, they derived an information-theoretic lower bound on the string segmentation error, quantifying how well an algorithm could do given the information in the image and the algorithm approximately reached this bound in the spline coefficients. They validated their work in benchmarks, showed the applications from fluorescence, darkfield microscopy, phase-contrast, and compared with other methods [20].

In April and June 2016, two papers have presented algorithms for counting and detecting healthy and many of unhealthy human blood cells on a smear based on circular Hough transform. These cells have detected and classified into normal and different kinds of anaemia like a sickle and microcytic. The neural network has applied on their extracted data to evaluate the algorithm [6,7]. Experimentally, the results have been verified high precision, and the proposed algorithm has realized the detection dependent on CHT and only morphological methods [9]. In this paper, the algorithm has used with the addition of shape signature method and some modifications for helping in the detection process.

Sheriden Keegan and others, in April 2016, presented an algorithm suggest that the FCB-DM (Fresh Capillary Blood-Dark field Microscopy) elliptocytosis parameter valid marker of low iron levels and that anisocytosis is a valid marker of low levels of cobalamin. The main objective is introducing a process of validating this technique in screening for nutritional shortages of cobalamin and iron. They suggested additional research into all FCB-DM parameters. In brief, the FCB-DM screenings used on 29 of volunteer patients who were probable to be suffering from poor in cobalamin or iron. To calculate the complete analysis of cell size and morphological functions, the FCB-DM screenings photographed. The availability of the pathology results not allowed until the complete of all FCB-DM data analysis. All the Data coming from the FCB-DM screenings compared and correlated with the results of tests in pathology blood and they used for the diagnosis of cobalamin and iron shortages. FCB-DM parameters for detecting low cobalamin or iron levels used to calculate the specificity and sensitivity functions [12].

In January 2016, Pramit Ghosh and others tried to design a system can be used in telemedicine and count of white blood cells in slides of human blood smear sample. In their system, the images of blood sample highlighted the white cells for segmentation process. The segmentation of interested region procedure includes scaling of background and excessive region removal. The usage of gradient dependent on the increasing region by the effect of neighbourhood restored the more precise region boundary after the segmentation process. The classification of separated regions is dependent on colour, size, shape and texture features. Their final decision dependent on merging these results of classification as a kind of hybridization. The specificity and sensitivity functions generated for the classification decision and recorded 79.6% and 96.4%, respectively. The system applied on 150 blood smear slides samples collected from different health centres of Kolkata Municipal Corporation, Kolkata, India [11].

3. Cell shape signature

Shape signature method introduced in April 2015. It is simply working on the construction of individual signature to every input geometrical shape without depending on its region size or location in the image [9]. The constructed input shape signature is comparing with the saved shape signatures in the system under the constraint rate of error. The distance between the boundary points of any shape and its centroid is the constructed shape own signature. After the operation of signature construction done, a process of matching among signatures begins to exactly know the shape it is described.