

A Real Time System for the Analysis of Sickle Cell Anemia Blood Smear Images Using Image Processing

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ABSTRACT: Sickle Cell Anaemia is a blood disorder which affects many people in various parts of the world. It not only includes Asia, Africa, Mediterranean region, USA but also in India. This disease mainly affects RBC's where the RBC will be Sickled in shape or half moon shaped. It is possible to cure this disease easily, if it can be detected at an earlier stage before severe complications occur. In the present paper we have designed a real time system for the diagnosis of sickle cell anaemia from blood smear images.

KEYWORDS: Sickle Cell Anaemia (SCA), Real time systems, Blood smear images, Digital image processing, Segmentation, Feature Extraction

I. INTRODUCTION

1. Real time processing systems

Real time processing systems are interactive processing systems. It is used to describe the interaction between a human and a computer device for a near instantaneous response of the device to an input by a human user. The result of processing appears effectively and instantaneously once the input is available. A real time system is one that processes information and produces a response within a specified time, else risk severe consequences including failure. Real time systems can be classified into two, soft real time systems and hard real time systems. Systems where failure to meet response time constraints leads to catastrophic system failure (Patient dying before corrective action is performed) are called hard real time systems. The systems where uncomfortably long response time are a nuisance but the system still function even if deadlines are sometimes not met are called soft real time systems. A real time image processing platform requires high resolution high frame rate video input, low latency operating system scheduling, high processing performance etc. The advantages of real time image processing are; it is fast and continuous, helps to eliminate user errors, allows automating the business if time is very limited, the customer can see the results immediately. The disadvantages of real time systems are a computer must be dedicated to the task and a computer must be continuously online. The applications of real time systems include region of interest processing, formulating the algorithm in a multi resolution framework, mobile robot, video based interfaces etc.

2. Blood smear image analysis

Medical image analysis mainly deals with two types of images. Macroscopic and microscopic images. Images of organs obtained from the output of modern imaging modalities such as MRI, CT scan etc falls on the first category. For studying details of microscopically small objects we use microscopic images. This is important in diseases which

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 4, April 2016

causes changes in blood cells. Sickle cell anaemia is a blood related disease which causes changes in shape of RBC. In this condition the shape of RBC will become sickle shaped or half moon shaped ones. Sickle cell anaemia is most commonly detected by the examination of RBC. Due to the development of Computer Science, computer vision, digital image processing and pattern recognition several automated methods have been developed by engineers and scientists which makes the analysis process accurate, faster, continuous and interactive within a very small interval of time. Computer based methods are now increasingly used to improve the quality of medical services. Artificial intelligence is the area of computer science focussing on developing machines that can engage on behaviours that humans consider intelligent. In microscopic image analysis we observe the image of blood cells through a microscope attached with a camera interfaced with a computer. Using these arrangements we can acquire the image in the computer. Using suitable algorithms, necessary software can be developed for the detection and diagnostic process, without human errors and relatively faster. Identification of disease is a critical step for curing the disease. Microscopic analysis of peripheral blood smears by medical professionals is an important test in the procedures for the diagnosis of any blood related disease. Accurate diagnosis of disease is critical for curing and controlling the disease. In olden days the process was only carried out by expert medical professionals alone. Now a days these works are carried out by automated systems based on digital image processing algorithms and computer vision methods.

3. Digital image processing

Digital image processing techniques are important in the analysis of medical images. It includes image enhancement, image filtering, segmentation, image masking, edge detection etc. Image enhancement consists of contrast stretching, unsharp masking, edge detection etc. Image filtering is mainly used for removing noise from an image. There are several filtering methods which include, mean filter, median filtering, Gaussian filter, Laplacian filter etc. Segmentation includes region growing, splitting and merging and thresholding etc. Segmentation subdivides an image into its constituent parts. Medical fields like bioinformatics and biomedical imaging are using several machine vision techniques require, image processing components with sufficient accuracy. This is true in biomedical image processing which has experienced vigorous growth. Digital image processing techniques are used today in a wide range of applications; share a common need for methods capable of enhancing pictorial information for human interpolation and analysis. In the image processing after acquiring a digital image, the main tasks are enhancement, segmentation, measurement and data analysis. Image enhancement methods are often used to emphasise certain features and to remove artifacts respectively. Two types of measurements are made; feature measurements are defined by a segmentation process and field measurements are obtained globally from complete images. Finally, these features and field measurements must be analysed.

4. Segmentation

Otsu's segmentation

Otsu's method is a type of global thresholding in which it depend only gray value of the image. Otsu method was proposed by Scholar Otsu in 1979. Otsu method is global thresholding selection method, which is widely used because it is simple and effective. Otsu's thresholding chooses the threshold to minimize the intraclass variance of the thresholded black and white pixels. The algorithm assumes that the image contains two classes of pixels following bi-modal histogram (foreground pixels and background pixels), it then calculates the optimum threshold separating the two classes so that their combined spread (intra-class variance) is minimal, or equivalently (because the sum of pairwise squared distances is constant), so that their inter-class variance is maximal.

Watershed segmentation

In the study of image processing a watershed of a grayscale image is analogous to the notion of a catchment basin of a height map. In short, a drop of water following the gradient of an image flows along a path to finally reach a local minimum. Intuitively, the watershed of a relief corresponds to the limits of the adjacent catchment basins of the drops

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

of water. There are different technical definitions of a watershed. In graphs, watershed lines may be defined on the nodes, on the edges, or hybrid lines on both nodes and edges. Watersheds may also be defined in the continuous domain. There are also many different algorithms to compute watersheds. Watershed algorithm is used in image processing primarily for segmentation purposes. The watershed transform can be classified as a region-based segmentation approach. When simulating this process for image segmentation, two approaches may be used: either one first finds basins, then watersheds by taking a set complement; or one computes a complete partition of the image into basins, and subsequently finds the watersheds by boundary detection. To be more explicit, we will use the expression 'watershed transform' to denote a labelling of the image, such that all points of a given catchment basin have the same unique label, and a special label, distinct from all the labels of the catchment basins, is assigned to all points of the watersheds. Watershed transform is not applied to the original image, but to its (morphological) gradient. This produces watersheds at the points of grey value discontinuity, as is commonly desired in image segmentation. Segmentation by watershed transform is a fast, robust and widely used in image processing and analysis, but it suffers from over-segmentation. Watershed represents the boundaries between adjacent catchments. The minimum can be interpreted as markers of watershed regions and the watershed can be interpreted as contours. Many pre-processing techniques are proposed by the different researchers (filters, morphological operators) were then designed to reduce the number of regions not significant. The key points of this method are; Morphological reconstruction, Extract the markers of regions application of watershed transform.

5. Feature extraction

Feature extraction deals with extracting features that result in some quantitative information of interest of features that are basic for differentiating one class of objects from another. There are two types of feature extraction geometrical feature extraction and textural feature extraction. The textural feature extraction include either Herralicks features such as energy, entropy, angular second moment, inverse difference moment, etc. or Conner's features. Geometrical features are extracted in this paper. The area, perimeter, major axis length, minor axis length, formfactor, compactness are calculated for a single sickle cell.

II. BLOCK DIAGRAM FOR DIAGNOSIS BASED ON IMAGE PROCESSING TECHNIQUES

Images of sickle cell anemia affected blood samples, which is collected from Government hospitals are used for analysis. With the help of camera attached microscope using the software Prog Res, interfaced with the computer will directly display the image on the computer monitor. This picture of blood smear image is used for further processing. In any image processing work, pre-processing is an essential and necessary task for enhancing the image. After pre-processing the image filtering removes the noise present in the image so that we get a better image with all the noise removed. The selection of suitable filter is also one of the important criteria. Here we used median filtering for noise removal. Then the final step is the image segmentation which is a high level vision technique. The sickle cell disease affected blood smear image consists of normal RBCs, abnormal RBCs, sickled RBCs etc. One of the main problems with this type of RBCs is that they cling together and block the blood vessels. For segmentation purpose, we use Otsu's method and Watershed segmentation method. From the work, we found that watershed segmentation gives better segmentation result.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

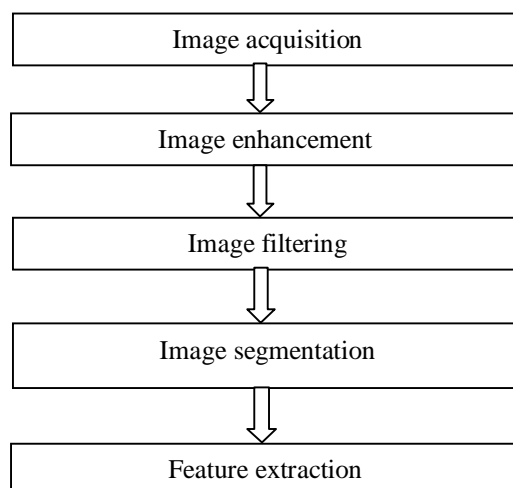


Fig 1 Block schematic of proposed image processing system

III. RELATED WORK

Biomedical images can be classified into macroscopic and microscopic images. Examples of macroscopic images are images of internal organs such as liver, kidney, pancreas etc. Microscopic images include microscopically small objects such as blood cell images. For the diagnosis of blood cell related diseases microscopic image analysis is very important. Many researchers have developed automatic diagnostic systems for the analysis of red blood corpuscles [1-8]. Some other researchers have developed automatic and semiautomatic systems for the study of white blood corpuscles [9-10].

Medical professionals have developed a series of methods for the treatment of sickle cell anemia [11-15].

IV. RESULTS AND DISCUSSIONS

In the present paper a real time system have been designed, developed and implemented. The system makes use of image processing techniques for visualization along with feature extraction to collect quantitative information from images. Image quality have been improved or enhanced with the help of developed software so that the physician involved in the treatment of this disease can observe the images carefully and based on his/her observation, suitable changes can be made in their treatment methodology. Based on the signs and symptoms first of all the physician will do the diagnosis. By means of a camera attached microscope interfaced with the computer the observed images can be visualized or stored in the memory for further processing.

Blood cell images of sickle cell anemia affected patients have been collected from various Government hospitals where people came for treatment purpose. A data base has been prepared with the help of physicians and data analysis is made use for getting the results obtained in this section. Another data set of sickle cell anemia affected patients has been obtained from Gonzalez Hidalgo's group working in this field. Grey scale images and colour images have been used for image analysis purpose. Image features are extracted from input images and they are tabulated. Image analysis is performed by making use of these features.

The original image is shown in fig. 2(a). Image pre-processing is performed by means of some image processing steps for improving the quality of input image. Image enhancement step is added using un-sharp masking as shown in fig. 2(b) which is one of the most simple and reliable method for implementing in clinical environment. Another basic

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

image operation filtering which provides good quality input images for the observer. We have implemented few image filtering methods but it is found that median filtering as in fig 2(c) is the one which is more suitable for this work.

After performing these simple pre-processing steps image segmentation is done with the help of watershed segmentation fig 2(d) and Ostu's segmentation fig 2(e). We could get good segmentation by making use of this method. The region of interest analysis has been implemented for getting better segmentation. Segmentation is a high level image processing technique used in machine vision and image processing which provide very good segmentation result. In this work few image features are estimated such as form factor and compactness.

$$\text{Form factor} = 4 * \pi * \text{area} / \text{perimeter}^2 \quad (1)$$

$$\text{Compactness} = \text{Perimeter}^2 / \text{Area} \quad (2)$$

Form factor gives the classification as normal cell, abnormal cell and sickle cell. The form factor one means the cell is a normal cell. If the form factor is less than one then cell is abnormal. If the form factor is far less than one, then the cell is sickle cell. It is a dimensionless quantity. Compactness is the measure of shape.

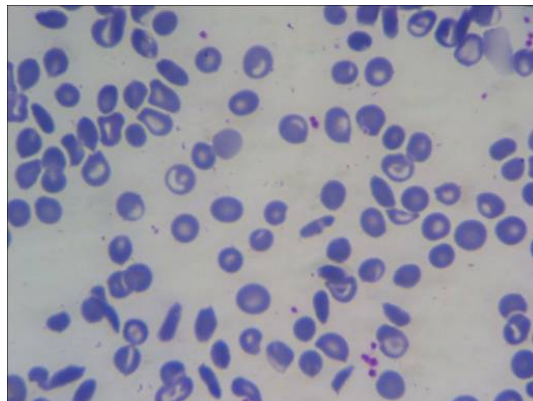
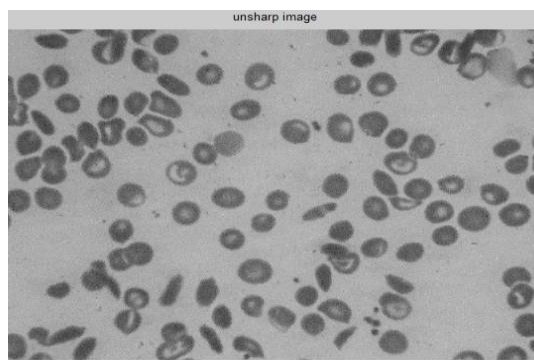


Fig 2 (a) Input image

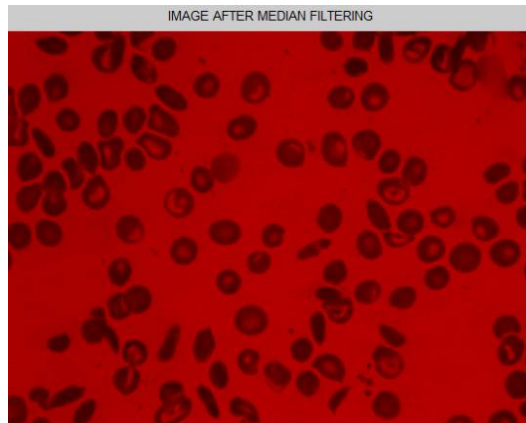


(b)Unsharp masking

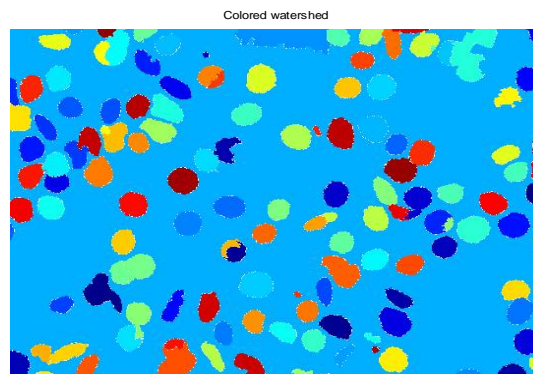
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

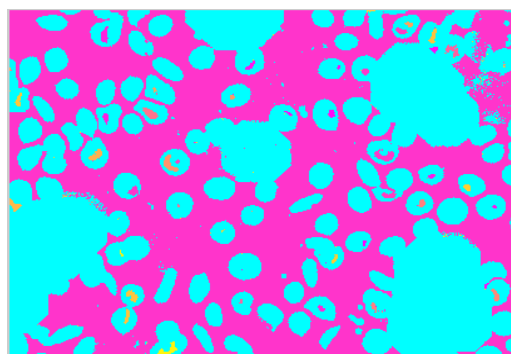
Vol. 5, Issue 4, April 2016



(c)Median filtering



(d)Coloured watershed for visualisation



(e)Ostu's segmentation

In the table 1 for feature extraction the information about a single sickle cell is studied its area in pixels, perimeter in pixels, major axis length, minor axis length formfactor, compactness are found. This table helps to understand the nature of a single cell. The form factor classifies a cell into three categories normal, abnormal, and sickled cell.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 4, April 2016

Table1:Table for feature extraction of sickle cell

CELL NO.	Area in pixels	Perimeter in pixels	Major axis length	Minor axis length	Form factor	Compactness
1	419	84.42	34.42	15.68	0.7389	17.01
2	531	94.08	36.86	18.51	0.7538	16.66
3	443	99.49	40.91	14.49	0.5623	22.34
4	413	86.52	32.78	16.37	0.6932	18.12
5	473	101.01	35.06	17.66	0.5825	21.57
6	468	109.01	42.59	14.39	0.4949	25.39
7	409	90.08	31.79	16.77	0.6334	19.84
8	489	98.32	31.38	20.17	0.6356	19.77
9	493	94.18	35.11	18.19	0.6984	17.99

V. CONCLUSION

Computer aided disease diagnosis system are gaining importance due to their accuracy, reliability fast and continuous operations. Diagnosis is the process of identifying a disease by its signs, symptoms and from the results of various diagnostic procedures. The conclusion reached through this process is called a diagnosis. In this work we have developed a simple, reliable and accurate real time system for the diagnosis of blood cell related disease such as sickle cell anaemia. Image processing techniques are utilised for drawing the clinical information along with other signs and symptoms. For removing the noise necessary filters have to be implemented. For segmenting the images a modified form of watershed algorithm and a thresholding method is utilised.

We have tested this system through two databases .The first one is the data set given by Gonzalez et.al. The second database is collected from the local people affected by sickle cell anaemia with the help of medical professionals who are involved in the treatment of this in the government hospitals. More properties of this model have to be investigated and should be tested on several more databases. However, databases are proprietary and difficult to obtain. Trained and experienced expert services are also required to evaluate the quality of diagnosis performed by the system followed by the adjustment of utilities.

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Vol. 5, Issue 4, April 2016

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