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Automatic Leucocytes Counting and Disease Detection System using Cuckoo Search Algorithm

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***Abstract*--- Complete Blood Count (CBC) is an important and primary blood test that is required by many physicians to get an overall view about the patients. The blood examination can indicate many diseases such as cancer, HIV/AIDS, diabetes, anemia and coronary heart disease which are popular diseases. No doubt that the manual microscopic evaluation is essential when there is a suspicious abnormality found in the blood smear. The CBC gives the concentration of Red Blood Cells (RBC), White Blood Cells (WBC), and platelets. The manual microscopic inspection takes time to complete the process. Leukemia is a type of the hematological disease that affects blood and bone marrow. The characteristics of hematological disease are the overproduction of abnormal white cells that are unable to fight infection. Early detection of the disease is necessary for patients to give proper treatment. The main objective of the project is to automatically count the leucocytes in the microscopic blood cell images and analyze a different kind of diseases to give an effective treatment for the patients. It also helps the doctors in accurate diagnosis of disease. The segmentation of white blood cells is done using graph cut segmentation, which is better than the existing system because of its efficient segmentation and less processing time. Features are extracted using GLCM (Gray Level Co-occurrence Matrix) and statistical features. Feature selection is implemented using Cuckoo Search Algorithm. Finally, the normal and abnormal blood cell images are classified using ANFIS (Artificial Neuro Fuzzy Interference System) which indicates the low level or high-level leucocytes of blood cell images. Early detection of disease is necessary for patients to give proper treatment.**

***Keywords*--- Complete Blood Count, Cancer, HIV/AIDS, Diabetes, Anaemia, Coronary Heart Disease, Red Blood Cells, White Blood Cells, Platelets, Leukemia, Hematological Disease, Bone marrow, Graph Cut Segmentation, GLCM, Cuckoo Search Algorithm, ANFIS Classifier, Leucocytes.**

I. INTRODUCTION

Hematological analysis has been an important research area during the last decades. Several diseases like Leukemia and Anemia or even tropical diseases like Malaria can be diagnosed using the information contained in the bloodstream. Leukemia is one of the top causes in child morbidity and the most frequent chronicle diseases in adults.

The main components in the blood are Red Blood Cells which transport oxygen, Platelets which stop bleeding and Leukocytes or White Blood Cells (WBC) which are the main defense systems of our body. Leukocytes are divided into five categories related to the morphological and genetic features contained in two major groups. There are Granulocytes and Agranulocytes, this division responds to the properties of the cell membrane. Granulocytes are divided in three groups, Neutrophils, Eosinophils and Basophils, each distinction made because of the color they showed with a special tinction called Romanowsky in each one of their granules. The agranulocytes are divided into two groups, the lymphocytes, and the monocytes; they contain no granules in their cytoplasm or membrane. A Leukocyte can be described using its nuclei color, number of lobes, size, visual texture, cell membrane, and shape. The proportion and morphology of each one of these cells are very important to diagnose diseases because they reflect the performance and current state of specific organs and tissues like the Bone Marrow.

White Blood Cells (WBC) in peripheral blood and bone marrow play a significant role in the auxiliary diagnosis of various diseases such as AIDS, leukemia and other blood-related diseases. The WBC counts also known as the Differential Blood Count (DBC), which is an indicator of certain diseases. In DBC, medical experts count 100 or 200 WBCs on slides stained with blood and accordingly compute the percentage occurrence of each type of WBCs. Traditional counting methods that involve the use of a microscope are time consuming, complicated, tedious, and prone to errors. Meanwhile, automatic recognition methods utilize a flow cytometry apparatus and a blood cell analyzer. These tools are mainly employed for routine blood examination rather than blood cell detection.

However, experts always employ blood smears from patients and a microscope to observe the shape of blood cells for the clinical diagnosis of blood diseases in patients. Blood contains different cell lines, the most important of which are the WBCs, platelet, and red blood cells (RBCs). WBC called as immune cells and it can help the body to fight infection and external matter. Collected image samples contain both WBCs and RBCs, thereby influencing the processing and selection of WBCs.

Fundamental Steps in Digital Image Processing

Image Acquisition is the process of the fundamental steps of digital image processing. Image acquisition could be as simple and given an image that is already in digital form. Image acquisition stage involves pre-processing phase such as scaling. Image Enhancement Technique is

simplest and to highlight certain features of the image in digital image processing.

Image Restoration improves the appearance of an image. Image Restoration Techniques is based on mathematical or probabilistic models of image degradation. Color Image Processing includes color modeling and processing in a digital domain etc.

Wavelets are used in compression of images. It gives great image quality and small image sizes. MultiResolution Processing is to make a very large image (often many Gigabytes) presentable on equipment that cannot hold all that data in memory. Image compression may be lossy or lossless.

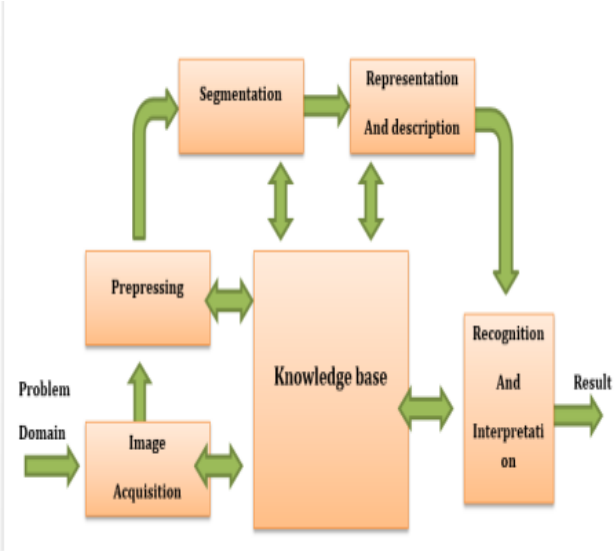

Fig 1 Fundamental Step in Digital Image Processing

Image Segmentation is the process of assigning a label to every pixel in an image and shares certain visual characteristics. It is used to change the representation of an image into something that is more meaningful and easier to analyze.

Representation and Description follow the output of a segmentation stage. It usually defines the raw pixel data, constituting either the boundary of a region. Representation deals with whether the data should be represented as a boundary or as a complete region. A method must also be specified the data so that features of interest are highlighted. Description or feature selection deals with extracting attributes that result in some quantitative information of interest are basic for differentiation one class of objects from another. Object Recognition is a process of identifying a specific object in a digital image or video. The algorithms rely on matching or learning new algorithms using appearance-based or feature-based techniques.

Knowledge can be defined as detailing regions of an image. The Knowledge Base can be quite complex, such as an interrelated list of all major possible defects in a material. An inspection problem or an image database containing high-resolution satellite images of a region in connection with change-detection applications.

II. REVIEW OF RELATED LITERATURE

In this chapter, we will demonstrate the various methods which involve different image processing techniques being currently implemented for the identification, segmentation and classifying of leukocytes.

A. White Blood Cells Identification and Classification from Leukemic Blood Image

The counting and classification of blood cells allow the evaluation and diagnosis of a vast number of diseases. ALL – Acute Lymphocytic Leukemia is a blood cancer that can be fatal and detected through the analysis of white blood cells (WBCs). Nowadays the morphological operation is performed manually by skilled operators. Thus identification and classification of WBC present a complete and fully automatic method for WBCs identification and classification from microscopic images. The proposed method extracts the morphological features for the final stage of classification. The whole work has been developed using the MATLAB environment.

Method

The morphological operation is performed manually by skilled operators.

Drawbacks

The morphological analysis methods involve numerous drawbacks, such as

- The slowness of the analysis,
- A non-standard accuracy and
- Dependent on operator skills.

B. Leukemia Detection using Digital Image Processing Techniques

The author proposed methods for the detection of leukemia. Various image processing techniques are used for the identification of red blood cell and immature white cells. A different disease like anemia, leukemia, malaria, deficiency of vitamin B12, etc. can be diagnosed accordingly. The objective is to detect leukemia affected cells and count them. According to the detection of immature blast cells, leukemia can be identified.

Methods

- Histogram equalization and linear contrast stretching are used to detect immature cells.
- Morphological techniques like area opening, area closing, erosion, and dilation.

Drawback

It produces excessive over-segmentation.

C. Red Blood Cell and White Blood Cell Classification using Double Thresholding and Blob Analysis

Malaria caused by the invasion of the parasite into human blood through the bite of an infected certain mosquito. In order to detect malaria parasite in human blood, the first important thing to do is to classify the red blood cell and white blood cell. So the detection method will not misplace the white blood cell as the infected red blood cell.

Methods

- The proposed work is a combination method of Double Thresholding and Binary Large Object (BLOB) analysis to classify white blood cell and red blood cell using data from the Department of Health of Central Borneo Province.
- Recursive Grass-Fire Algorithm is used in BLOB analysis to find large objects and its centroid.
- Annular Ring Ratio (ARR) is used to compute the cell area. From the cell area, size information is used to classify the cell into red blood cell or white blood cell.

D. A Comparative Study of Segmentation and Classification Techniques in WBC

The immune system in our body is made up of cells, tissues, and organs that work together to protect from the virus. One of the important cells involved is white blood cells, which is also known as leukocytes. The white blood cells are classified into Monocots, Neutrophils, Basophils, Eosinophils, and Lymphocytes. The variation of counts in the white blood cells leads some other disease. Suppose you have a disease, you wanted to test for blood very effective and accurate manner. Basically, test for blood diagnosing is based on the count of White blood cells.

Methods

The various techniques are used in white blood cells segmentation and classification using machine learning. It gives deep knowledge which can be used in cell segmentation and classification process.

Drawbacks

The manual method for blood test takes more time to process and inefficient.

E. Recent Advances of Malaria Parasites Detection Systems Based on Mathematical Morphology

Malaria is an epidemic health disease accurate diagnosis is necessary for proper intervention. Pathologists examine the bloodstained slides for malaria diagnosis. This kind of visual inspection is time-consuming. To overcome the issues mathematical morphology is used. Mathematical morphology is a powerful tool for computer-aided malaria detection and classification. The proposed method aims to present a review of recent mathematical morphology based on malaria parasite detection and identification in stained blood smears images.

Methods

- Mathematical morphology is a very powerful technique widely used for image processing purposes.
- Morphological operation employed successfully in biomedical image analysis, especially in pre-processing and segmentation tasks.
- Microscopic image analysis, particularly malaria detection and classification can greatly benefit from the use of morphological operators.

F. Segmentation of White Blood Cell from Acute Lymphoblastic Leukaemia Image using Dual-Threshold Method

The author proposed a dual-threshold method based on a strategic combination of RGB and HSV color space for white blood cell (WBC) segmentation. The performance of the proposed method is better than the single-threshold approach in RGB and HSV color space. The overall single WBC segmentation accuracy reaches 97.85%.

Methods

- ➢ The proposed method consists of Pre-processing,
- ➢ Threshold segmentation and
- ➢ Post processing.

G. White Blood Cell Segmentation using Fuzzy C Means and Snake

A Blood cell is a cell produced through hematopoiesis. Red blood cells carry oxygen to all parts of the body and carbon dioxide using hemoglobin. White Blood Cells are formed an immune system of the body which fight against foreign infections in the body. As WBC is the immune system it is very important that WBC number plays major in disease diagnosis.

Methods

- Manual segmentation consumes a lot of resources hence, one of the automated segmentation is proposed in which fuzzy c means and the snake algorithm is used.
- Fuzzy will divide the data points into a number of clusters and the snake algorithm will attract the snake points towards the feature of images. Hence the WBC Count values obtained will show better results.

H. White Blood Cell Segmentation by Colour-Space-based K-Means Clustering

The author proposed a novel method for the nucleus and cytoplasm segmentation of WBCs for cytometry. A color adjustment step was completed before segmentation. Color space decomposition and k-means clustering were

combined to use for segmentation process. A database including 300 microscopic blood smear images was used to evaluate the performance. The proposed segmentation method achieves 95.7% accuracy for nucleus segmentation. 91.3% accuracy for cytoplasm segmentation.

Methods

- A new WBC segmentation method is used for color-space-based k-means clustering.
- The color components of RGB, HSI, and CMYK color spaces were applied to form the feature vectors of the k-means cluster.

Drawbacks

- The proposed method achieves high overall accuracy in cytoplasm segmentation, small leak, and false detection ratios.
- The traced boundaries of the proposed method are more accurate than k-means clustering. Moreover, the proposed method is immune to light conditions to some extent and is robust.

I. Overlapping White Blood Cell Segmentation and Counting on Microscopic Blood Cell Images

The proposed method identifies and counts the number of overlapping cells similar to manual white blood cell counting. Overlapping WBC identification on microscopic blood cell images is proposed for increasing the accuracy of segmentation and counting. The overlapping cells have a different characteristic such as area and shape with a single cell of microscopic cell images.

Methods

- The WBC segmentation is divided into three processes,
  - Nucleus segmentation,
  - Overlapped cell identification and
  - Cytoplasm segmentation
- Nucleus segmentation is easier to identify the location of white blood cell and overlapped cell.
- The overlapped cells are larger and more oval than the single cells. Therefore the geometry features such as area and eccentricity are used to identify the overlapping cells.
- After identifying the nucleus and overlapped cells, the final process is cytoplasm segmentation.

J. Identifying Computer Graphics using HSV Color Model and Statistical Moments of Characteristic Function

The statistical moments of the characteristic function of the image and wavelet subbands are used to distinguishing computer graphics from photographic images. To investigate the influence of different image color representations, it gives feature effectiveness. RGB and HSV color models give efficiency. The best color model gives an optimization solution.

Drawbacks

One of the features have been derived, it is possible that there may be redundant. It gives an unwanted noise.

III. METHODOLOGY

Leukocyte extravasations are the movement of leukocytes out of the circulatory system and towards the site of tissue damage or infection. The low level and high level of leukocytes in the blood can induce some health problem such as anemia, chemotherapy, HIV/AIDS, hypersplenism (an abnormality of the spleen causing blood cell destruction) and Leukemia. So the automatic detection of leukocytes count in a blood cell is needed to implement for early diagnosis of disease. The Leukocytes blood cell images count diseases like anemia, leukemia, and leucopoenia using digital image processing techniques.

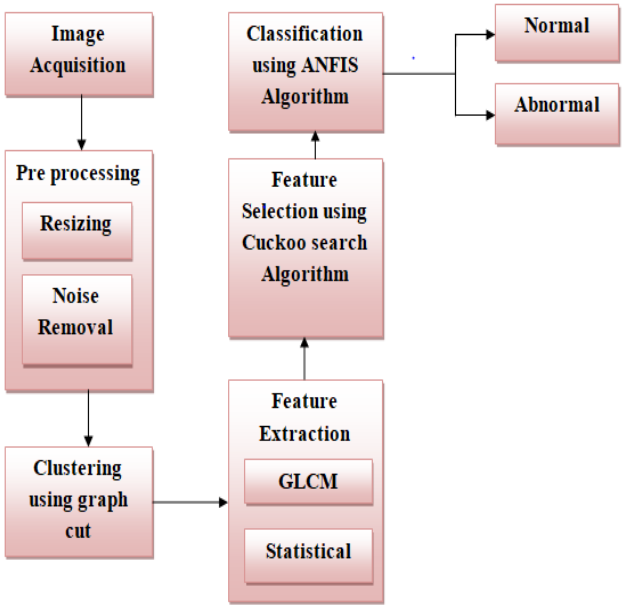

Fig. 2 Block Diagram of Proposed System

A. Image Acquisition and Pre-Processing

In this Module, the extraction of images will be based on the pre-processing method. Image Acquisition is getting input for automatic leukocytes counting and different disease detection from microscopic blood cell images using digital Image processing algorithms. The aim of pre-processing is an improvement of image data that suppress unwanted image data distortions or enhance some image features important for further processing.

B. Segmentation

Segmentation is an important part of image analysis. Segmentation is the process of partitioning a single image into multiple segment images. For assigning a label to every pixel in an image and the same label will share the certain visual characteristics. The goal of segmentation is

to change the representation of an image and easier to analyze.

C. Segmentation using Graph cut

The goal is to segment the main objects out of an image using a segmentation method based on graph cuts. We used MAXFLOW - software for computing the mincut/maxflow of a graph. A graph-based approach used an efficient solution of the maxflow/mincut problem between the source and sink nodes in directed graphs.

D. Feature Extraction using Statistical Feature

Statistical and GLCM features for a segmented image are extracted.

The Statistical features are

1. Mean
2. Standard Deviation
3. Variance

E. Feature Extracted using GLCM

GLCM is a Gray Level Co-occurrence Matrix and it is used to extract texture features. The texture is one of the important characteristics used to identify an object or region of interest (ROI) in an image. GLCM is applied in images as coarseness and regularity and it gives image brightness.

F. Feature Selection using Cuckoo Search Algorithm

The cuckoo search algorithm gives an optimization solution. Cuckoo search algorithm was inspired by some cuckoo species by laying their eggs in the nests of other host birds (of other species). For example, if a host bird discovers the eggs are not their own, it will either throw these alien eggs away or simply abandon its nest and build a new nest elsewhere. Cuckoo search idealized such breeding behavior. It can be applied for various optimization problems. Here this algorithm is used for selecting the efficient features from extracted features.

G. Classification

In order to classify a set of data into different classes, ANFIS Classifier is used for classifying the different types of diseases. An adaptive Neuro-fuzzy inference system or adaptive-network-based fuzzy inference system (ANFIS) is a kind of artificial neural network. ANFIS integrates both neural networks and fuzzy logic principles; it has the potential to capture the benefits of both in a single framework. ANFIS is considered to be a universal estimator.

H. Performance Analysis

To analyze the performance of microscopic images and identifying the different diseases like anemia, leukemia using digital image processing techniques. Final result consists of normal and abnormal characteristics of the microscopic cells. So, it is useful for the doctors for the earlier diagnosis of the diseases caused by low level and high-level leukocytes in the blood.

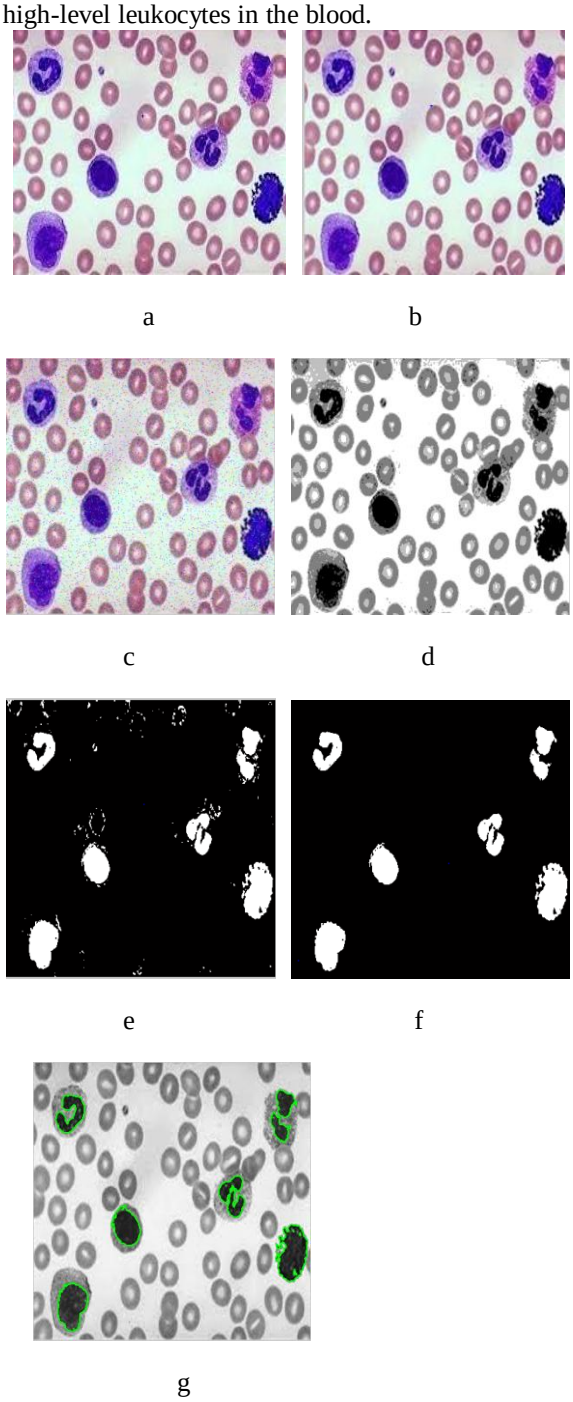

Fig. 3 Detection of leukocyte nucleus (a) Original Image (b) Resized Image (c) Salt & pepper (d) Segmented Image (e) Extracted Leukocytes (f) Detected Image (g) Leukocytes Boundary

IV. CONCLUSION

The blood cell images were collected and unwanted noises from the images were removed using the pre-processing technique. The graph-cut Segmentation method partitioned the images into multiple one for better results.

Finally, the features were extracted using GLCM, identifies the local spatial variations in image brightness. Cuckoo search algorithm gives an efficient and optimum solution. The ANFIS (Artificial Neuro Fuzzy Interference System) classifier is used to classify blood cells into normal and abnormal blood cell images. The leukocytes blood images automatically detect the low level and high level blood count. Thus the low-level and high-level of blood cells indicates the diseases as leukemia or leucopoenia of blood cells. Finally, the prescription and guidelines should be provided to overcome the disease. Future research may consider that there are identified different types of white blood cells such as Monocytes, Lymphocytes, Neutrophils, Basophils, and Eosinophils is applicable.

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