Scientific Journal Impact Factor (SJIF) : 1.711
International Journal of Modern Trends in Engineering and Research
ISSN (ONLINE) : 2349 - 9745 ISSN (PRINT) : 2393 - 8161

Detection of Leukemia in Human blood sample through Image Processing: A Review

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Abstract—Leukemia is a blood disease, in which abnormal white blood cells (WBC) are increases in a large scale very fast, due to which WBCs could not perform its functions properly, so it needs quick detection. Blood slides are examined manually by the hematologist under microscope. This manual examination method has some drawbacks, it is time consuming and costly. Result may be affected by the factors such as hematologist experience and tiredness. The automation process overcome the above problems, images are cheap and do not require expensive testing and lab equipment. It needs automation to detect leukemia, which will gives standard result with minimum cost. For the automation process images are the inputs and for processing the images we need images processing techniques like image enhancement, image segmentation, Feature extraction and Classification etc. This paper study about the leukemia and reviews the image processing techniques used to detect leukemia.

Keywords—Blood smear images, White Blood Cells, Blast Cells, Leukemia, Microscopic images

I. INTRODUCTION

Medical imaging has become one of the most important visualization and interpretation methods in biology as well as medicine over the past decade. This time has witnessed a tremendous development of new, powerful instruments for detecting, storing, transmitting, analyzing, and displaying medical images. This has led to a huge growth in the application of digital image processing techniques for solving medical problems. The most challenging aspect of medical imaging lies in the development of integrated systems for the use of the clinical sector. Design, implementation, and validation of complex medical systems require a tight interdisciplinary collaboration between physicians and engineers. Main objective of analyzing through images is to gather information, detection of diseases, diagnosis diseases, control and therapy, monitoring and evaluation[1].

In blood diseases, the most dangerous disease is blood cancer i.e. leukemia. This study focused on leukemia detection because, it needs fast and accurate detection. Leukemia is a fast growing disease so it require quick detection, regular test & monitoring for control it and to evaluate the treatment properly.

Leukemia is detected by hematologist under microscope. This manual examination method has some drawbacks, it is time consuming and costly. Result may be affected by the factors such as hematologist experience and tiredness. The automation process overcome the above problems, images are cheap and do not require expensive testing and lab equipment.

In leukemia, bone marrow produces abnormal white blood cell. Compared with normal cells, abnormal white blood cell do not die when they should. Thus the number of abnormal white blood cell become numerous and interfere normal white blood cells to carry out their duties. This also causes an imbalance of blood system in human body.

Classification of Leukemia

Leukemia can be grouped on the basis of how quickly this disease develops and become severe. Leukemia is either Chronic or Acute.

Chronic Leukemia: In this type, leukemic cells are works as a normal white blood cell at earlier stage, but after that gradually they will become severe chronic leukemia.

Acute Leukemia: In this type, leukemia cells in blood will grow rapidly and become severe at a short time.

Generally, leukemia can be divided into 4 types that are:

- Acute Lymphocytic Leukemia (ALL) : Usually occurs in children aged 2-10 years. This type of leukemia is most common. It also always occurs in adults.
- Acute Myeloid Leukemia (AML) : This type of leukemia is common in children under the age of 1 year. It is extremely rare in teenagers. Even so it is mostly in adults aged 40 years.
- Chronic Lymphocytic Leukemia (CLL) : This type of leukemia often happened to older patents. It is extremely rare in patients under the age of 40.
- Chronic Myeloid Leukemia (CML) : This type of leukemia can occur in all but the most common is for adults age after 45 years.

The paper is structured in four sections. The related work describes in section II. Image Processing Techniques used is explained in section III. and conclusion followed by references.

II. RELATED WORK

Leukemia is a group of hematological neoplasia which usually affects blood, bone marrow, and lymph nodes. The excessive lymphoid blast or myeloid blast flows in the peripheral blood stream. Diagnosing leukemia is based on the fact that white cell count is increased with immature blast cells and decreased neutrophils and platelets. The presence of excess number of blast cells in peripheral blood is a significant symptom of leukemia.

Some work has been done in automating the process of leukemia detection. Blood smear images is input to this system. These images are processed using different image processing techniques like image enhancement, segmentation, sub imaging, feature extraction and classification etc. The system uses the features in microscopic images and examine changes on texture, geometry, color and statistical analysis [1].

In India, total 1,04,239 people suffer by blood cancer in year 2010 and according to Indian council of Medical Research (ICMR) by the year 2020, the expected sufferers of blood cancer are 77,190 for males and 55,384 for females[17]. Leukemia more common in children, young people and peoples over age of 60. The number of patients are more as compare to the number of hematologist. Leukemia needs the quick detection in earlier stage. Most of the leukemia deaths are due to the late diagnosis. So, it is necessary to make an automation of leukemia system.

The detection of leukemia is completely manual process. Blood smear slides are observed by heamatologist under microscope. If the number of WBCs are more & size of WBCs get changed, then it detect as a leukemia. But now a days, number of leukemia cases are increased per day so they need automation process of leukemia detection for faster and accurate results. First, the blood smear images are captured with the help of microscope. These images are not visually clear, due to variable staining & uneven lighting. So it needs to enhance. It is first & very important step towards the automation process of leukemia. The different groups [6][7][8][9] worked on the enhancement process. The three contrast enhancement techniques are partial contrast, bright stretching and dark stretching. Among [6][7][8][9] which partial contrast is the best technique to improve the image visibility. The another enchancement method [1] is by using selective median filtering followed by unsharp masking. It gives better result to remove noise in images. In another method, color images are converted to gray scale. The gray scale images are enhanced[3] in two different stages, before

segmentation and after segmentation. For before segmentation enhancement method, Gaussian filter was used on the original image & for after segmentation enhancement method, removing pixel techniques and Gaussian filter is used. It removes the small spots in binary image.

After the enhancement of images, segmentation are also performed in different ways. Images are converted into grayscale, then with the help of histogram & thresholding (Edge based) method [3] segmentation is done. In another approach [4] grayscale contrast enhancement if combined with filtering & thresholding technique (Otsu's method) is used. It gives result 79.7%. it has also a limitation due to non homogeneous lighting & over staining for segmentation.

In color images, to focus blast cell and nucleus , HSI (Hue Saturation Intensity) color space method [6] [10] is also used with contrast enhancement technique. This method improve image visibility and has successfully segmented the leukemia images while preserving significant features. The another approach of segmentation is, k-means clustering [11] used leukocyte or WBC from other blood components. K-means clustering is a semi supervised technique. The author used different segmentation methods. Rough k-means clustering [12] is also used. Two stages [13] segmentation i.e. fuzzy clustering technique followed by nearest neighbor classification in L*a*b space is proposed. L*a*b means Lab color space. It is a color-opponent space with dimension L for lightness and a and b for the color-opponent dimensions, based on nonlinearly compressed coordinates. Some automated systems are also reported. Automatic morphological analysis system for acute leukemia identification was developed. In which [14] Otsu's thresholding method for segmentation and feed forword neural networks used for feature classification. For color segmentation, two methods are combined to identify WBC. L*a*b color space & gray level thresholding method [16]. Mean cell diameter is also measured. This method allows to easily extract the features of white cells for subsequent automatic diagnosis of leukemia.

Linear contrast technique and segmentation based on HSI color space was combine used [18] for WBC segmentation. In this method, it has accuracy for segmented WBC is 99.02%. for nucleus 99.05% is measured. Another system for blast cell detection & counting has reported. In which Edge sensitive variational thresholding & Otsu's thresholding methods are combined for segmentation. Morphological operations and connected component analysis are used to count the number of blast cells present in the images.

III. IMAGE PROCESSING TECHNIQUES USED

The following figure shows the common flow of image processing techniques used in detection of leukemia.

3.1 Image acquisition

This is the first step to acquire image. The images were captured with a digital microscope under 100X oil immersed setting and with an effective magnification of 1000.

3.2 Preprocessing

Preprocessing is required due to excessive staining or shadow in image. This is the second step shown in the above figure. The image has three different parts for observation, one RBC, Second WBC and third background. In the image, area of interest is WBC. The WBCs are examined to check whether they are infected or not. There are two different methods for input images, color images & gray scale images. Selective median filtering & unsharp masking& Contrast Enhancement techniques are used. For color images contrast enhancement techniques, partial contrast, bright stretching and dark stretching are used [6]. Based on the result, the partial contrast stretching method is considered as the best technique among all contrast stretching techniques that helps to improve quality of image [8].

3.3 Image Segmentation

After the preprocessing segmentation is a next step. Segmentation of white blood cell (WBC) and determine ROI that is nucleus for WBC only. This is because in leukemia cell images, the cytoplasm is scanty. So, focus will be on nucleu of WBC only [1]. For color images some researchers used K-means clustering algorithm [2].

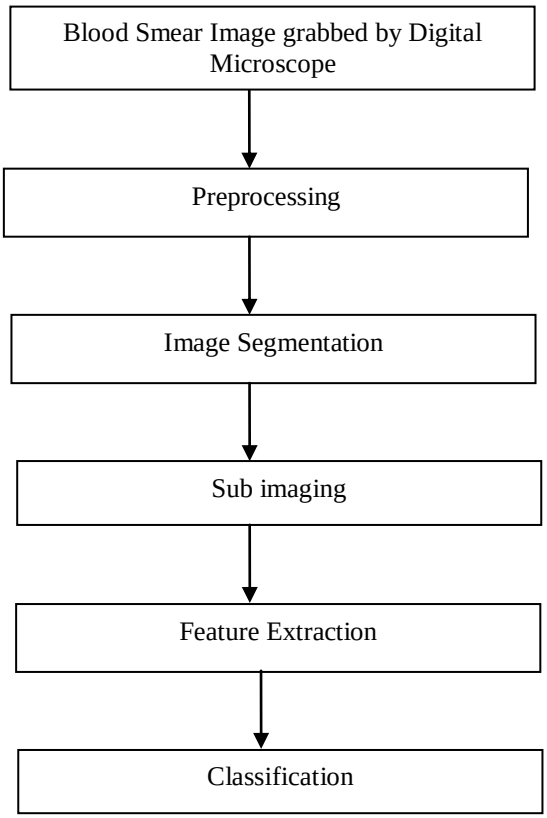

Figure 1. System overview

3.4 Sub imaging

Blood smear images are large. After determining the blast cells, it is necessary to examine features of each nucleus. We are separating these nucleus from image and different features are extracted from it.

3.5 Feature Extraction

Feature extraction in image processing is a technique of redefining a large set of redundant data into a set of features (or feature vector) of reduced dimension. This transformation of the input data into the set of features is called feature extraction. Fractal dimension, Shape, Color features are extracted. Perimeter roughness of nucleus represents a lymbhoblast or a mature lymphocyte. Fractal geometry is a more convenient way to parameterize the cell boundary surface in comparison to Euclidean geometry.

3.5.1 Shape Feature

According to hematologist the shape of the nucleus is an essential feature for discrimination of blasts. Region and boundary based shape features are extracted for shape analysis of the nucleus. All

the features are extracted from the binary equivalent image of the nucleus with non-zero pixels representing the nucleus region. The quantitative evaluation of each nucleus is done using the extracted features under two classes: region based and boundary based. The features are Area, Perimeter, Compactness, Solidity, Eccentricity etc

3.5.2 Texture Features

Nucleus texture measurements were performed on gray scale version of the nucleus images. These features were computed from the co-occurrence matrices for each nucleus image. This includes Homogeneity, Energy, Correlation & Entropy.

3.6 Classification

Classification is the task of assigning to the unknown test vector, a label from one of the known classes. [2] There are different classifiers like Naïve Bayesian (NB), K-Nearest Neighbor (KNN), Multilayer Perceptron (MLP), Radial Basis Functional Network (RBFN), and Support Vector Machine (SVM).

3.6.1 Naïve Bayesian (NB)

Naive Bayes is a simple technique for constructing classifiers models that assign class labels to problem instances, represented as vectors of feature values, where the class labels are drawn from some finite set. It is not a single algorithm for training such classifiers, but a family of algorithms based on a common principle: all naive Bayes classifiers assume that the value of a particular feature is independent of the value of any other feature, given the class variable. [33].

3.6.2 K-Nearest Neighbor (KNN)

The k-Nearest Neighbors algorithm (or k-NN for short) is a non-parametric method used for classification. In k-NN classification, the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of that single nearest neighbor. [34]

3.6.3 Multilayer Perceptron (MLP)

A multilayer perceptron (MLP) is a feed forward artificial neural network model that maps sets of input data onto a set of appropriate outputs. A MLP consists of multiple layers of nodes in a directed graph, with each layer fully connected to the next one. Except for the input nodes, each node is a neuron (or processing element) with a nonlinear activation function. MLP utilizes a supervised learning technique called back propagation for training the network. MLP is a modification of the standard linear perception and can distinguish data that are not linearly separable. [35].

3.6.4 Radial Basis Functional Network (RBFN).

In the field of mathematical modeling, a radial basis function network is an artificial neural network that uses radial basis functions as activation functions. The output of the network is a linear combination of radial basis functions of the inputs and neuron parameters. Radial basis function networks have many uses, including function approximation ,time series prediction, classification, and system control. [36].

3.6.5 Support Vector Machine (SVM).

In machine learning, support vector machines (SVMs, also support vector networks are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. Given a set of training examples, each marked for belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. [37]

IV. CONCLUSION

As per literature survey, most of the attention given to the enhacement part, which is essential for further detection. Contrast enhancement technique is mostly used by many, which gives better results. Edge based segmentation i.e. thresholding is used. It is simple technique for segmentation but has some limitations. As per the statistical data available in future spreading of leukemia in India, it needs automation system for identification of leukemia. Now a days, commonly identification of leukemia is done manually. Very few automation systems are available, but it has costly. So, it needs simple, user friendly and cost effective automation system for identification of leukemia.

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