International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 3 | Issue 1 | ISSN : 2456-3307

# Segmentation and Classification Techniques of Acute Myeloid Leukemia using Image Processing: A Survey

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## ABSTRACT

The White blood cells or Leukocytes plays a major role in the diagnosis of different diseases (including leukemia). Leukemia is a type of blood disease or so-called cancer of the blood that begins in the bone marrow and usually caused by an excessive alterations in the production of malignant and immature white blood cells. Acute Myeloid leukemia (AML) is a subtype of acute leukemia, which is characterized by the accumulation of myeloid blasts in the bone marrow. Subtypes of AML i.e., M0–M7. AML is also called as Acute Myelogenous Leukemia, Acute Meroblastic Leukemia, Acute Granulocytic Leukemia and Acute No lymphocytic Leukemia. This paper provides a survey of several segmentation and classification techniques for detection of acute myeloid leukemia using image processing.

**Keywords :** Acute Myeloid Leukemia (AML), Segmentation, Feature Extraction, Classification

## I. INTRODUCTION

Leukemia is the eleventh most common cancer worldwide with more than 250,000-300,000 new cases each year. Leukemia is a type of blood cancer that originates in the bone marrow and is characterized by abnormal proliferation of white blood cells. Leukemia customarily occurs when a big portion of abnormal, immature white blood cells, called Leukemia cells("blasts") produced in the body by bone marrow.[1] Diagnosing leukemia is based on the fact that WBC count are increased with immature blast cells (lymphoid or myeloid), and neutrophils and platelets are decreased. Therefore, hematologists routinely examine blood smears under microscope for proper identification and classification of blast cells. The presence of the excess number of blast cells in peripheral blood is a significant symptom of leukemia.[6] Leukemia can be classified into two categories: (1) Acute Leukemia which progress quickly; and (2) chronic Leukemia which progress slowly. It can also be classified based on the affected cell type as (1)myeloid (myelogeneous) leukemia and (2)lymphocytic leukemia.[2] In this paper Acute myeloid leukemia(AML) is only considered.

Acute Myeloid leukemia (AML) is a subtype of acute leukemia, which is characterized by the accumulation of myeloid blasts (abnormal immature WBC which are derived from myeloid stem cell) in the bone marrow. "Acute" means that this leukemia can progress quickly if not treated, and would probably be fatal in a few months. "Myeloid" refers to the type of cell this leukemia starts from. AML starts in the bone marrow (the soft inner part of certain bones, where new blood cells are made), but in most cases it quickly moves into the blood. It can sometimes spread to other parts of the body including the lymph nodes, liver, spleen, central nervous system (brain and spinal cord), and testicles. AML is the second most common type of leukemia diagnosed in both adults and children. AML is confirm when bone marrow contains more than 30% blasts [2].

The FAB classification system divides AML into eight subtypes, M0-M7 based on the type of cell from which leukemia developed and degree of maturity [2,7].

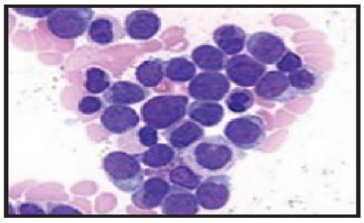

Figure 1. Myeloblast from AML patient [6]

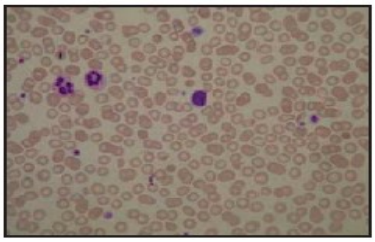

**Figure 2.** Healthy cells from non AML patient [6]

**Table 1.** Subtypes of AML

| **Acute Myeloid Leukemia (AML)** | **Descriptive Term** |
|---|---|
| M0 | Undifferentiated Acute Myeloblastic Leukemia |
| M1 | Acute Myeloblastic Leukemia With Minimal Maturation |
| M2 | Acute Myeloblastic Leukemia With Maturation |
| M3 | Acute Promyelocytic Leukemia (APL) |
| M4 | Acute Myelomonocytic Leukemia |
| M5 | Acute Monocytic Leukemia |
| M6 | Acute Erythroid Leukemia |
| M7 | Acute Megakaryoblastic Leukemia |

## II. RELETED WORKS

This section provides some essential work done by numerous researchers for leukemic cell segmentation and classification in microscopic blood cell images.

Luis H. S. Vogado, et al. [1], proposed a new automatic leukemic cell segmentation technique that uses two-color systems, CMYK and L*a*b and the clustering algorithm K-means. Series of morphological operations are performed on segmented images to remove noise.

Fatemeh Kazmi et al.[2], presents an automatic technique for identification and detection of AML and its prevalent subtypes, i.e., M2-M5. Which performs processing including color correlation, segmentation of the nucleated cells, and effective validation and classification. At first, microscopic images are acquired from blood smears of patients with AML and normal cases. After applying image preprocessing, color segmentation strategy(k-means clustering) is applied for segmenting white blood cells from other blood components and then discriminative features, i.e., irregularity, nucleus-cytoplasm ratio, Hausdorff dimension, shape, color, and texture features are extracted from the entire nucleus in the whole images containing multiple nuclei. Images are classified to cancerous and noncancerous images by binary support vector machine (SVM) classifier with 10-fold cross validation technique.

Viswanathan P.[3], introduces the new approach for leukemia detection which consist of (1) contrast enhancement to highlights the nuclei, (2) morphological contour segmentation, and (3) Fuzzy C means detection of leukemia. The contract enhancement is done by simple addition and subtraction operation to separate the nuclei. The morphological contour segmentation detects the edges of nuclei and eliminate the normal white blood cells from the microscopic blood image. Then the texture, geometry, color and statistical features of nuclei is evaluated to determines the various factors of leukemia. Finally it is trained by Fuzzy C mean clustering of single row feature vector of each cell is used to classify leukemia from white blood cells. The nuclei and leukemia segmentation based on morphological contour processing is enhanced and

provided accurate segmentation of WBCs from the blood microscopic images. It is added with Fuzzy C mean classification trained with the extracted features row vector. The proposed system provided accurate segmentation of leukemia from blood sub images.

Huey Nee Lim et al.[4],presents a combination of color and morphological based segmentation techniques for blood cells segmentation on microscopic images. K-means clustering is implemented for color based clustering and primary segmentation of the image. The clustering is cascaded into two layers for cell recognition and background elimination. Morphological based segmentation is conducted using watershed transform based on gradient magnitude and skeleton by influence zone.
S.S.Savkare, S.P.Narote [5], presents a methods to segment the blood cells from microscopic thin blood images. This paper describes method for blood cell segmentation utilizing K-Mean clustering. Proposed method utilizes median filter for reduction of noise and laplacian filter for enhancement.

D.Goutam, S.Sailaja [6], proposed a system, which mainly composed of four main stages are preprocessed stage, segmentation stage, feature extraction stage and classification stage respectively. This system framework consists simple and known technique such as K-mean clustering, Local Directional path (LDP), and support vector machine (SVM) respectively.

Jakkrich laosai and Kosin chanongthai [7], proposed a system that takes as input, Color images of stained peripheral blood smears and identifies the class of each of the White Blood Cells (WBC). The process involves segmentation, feature extraction and classification. Their work focuses on classification of Foil of Bretagne (Lymphoid) and Almeida Lloyd (Myeloid).

Monica Madhukar et al. [8], presents a system to a) demonstrate that the classification of peripheral blood smear images containing multiple nuclei can be fully automated, b) to validate the segmented images using holdout cross validation method.

Reymond Joseph A. Cabrera et al. [9], introduces a system that will apply the different techniques of Image Processing and Genetic Algorithm, specifically in automating the detection of Leukemia. In the pre-processing stage, color extraction will be done by multiplying RGB color planes in order to extract the foreground or region of interest (White Blood Cells) from the background (Red Blood Cells).

Adnan Khashman and Hayder Hassan Abbas [10], presents a novel approach for acute lymphoblastic leukemia (ALL) blood cell identification using pattern averaging of whole cell images and neural network classifiers. The novelty in this work is not only in using a neural model as a classifier, but also in considering normal and abnormal (leukemic) blood cells as a whole without the need to extract local features. This in turn reduces the computational and time costs by avoiding segmentation and local feature extraction from the blood cell images. The proposed system is implemented to identify ALL-infected abnormal cells from normal blood cells.

Sonali Mishra et al. [11], proposed an acute lymphoblastic leukemia detection strategy from the microscopic images. The scheme utilizes all the steps associated with any other classification scheme, but their contribution lies on a marker-based segmentation (MBS), gray level co-occurrence matrix (GLCM) based feature extraction, and probabilistic principal component analysis (PPCA) based feature reduction. A new method of extracting the textural feature from the nucleus and cytoplasm region of the cropped image is described using gray level co-occurrence matrix. The relevant features are used in a random forest (RF) based classifier.

R.G Bagasjvara et al.[12], presents a various studies that have been conducted on leukemia detection using image processing. Based on the literature that

has been reviewed in this paper, the steps of detecting leukemia is divided into three stages, namely Segmentation, Feature Extraction and Classification. At the stage of segmentation, researchers to obtain results, which have a better classification of leukemia cells, have carried out various methods.

## III. COMPARATIVE ANALYSIS

**Table 2.** Segmentation Techniques

| Technique | Advantages | Limitations |
|---|---|---|
| FCM[ 3,12] | -Accurate<br>-Works well for noise free images.<br>-96.31% Accuracy[12] | -Apriori specification of no. of clusters.<br>-increase no. of iteration.<br>-sensitive to noise. |
| FLICM[13] | -enhance clustering performance.<br>-image detail preservation.<br>-effective and efficient | -Works on fixed distance.<br>Objective function is defined previously |
| KWFLICM[14] | -Better segmentation<br>-Better accuracy | -At each iteration it's necessary to calculate or update trade of fuzzy factor.<br>- Works on adaptive distance. |
| K-means[1,2,4,5,6,7,8,12] | Easy to implement and interpret clustering results. | Cluster size is manually added. It is not adaptive. |
| K-means with LAB[2,5,7,8] | -Luminosity and Color kept separate.<br>-Works batter for low intensity images. | -Proper Color and light is must needed to segment image object. |
| K-means with CMYK | -Segment Part into Extreme Level | -Not Work with Noisy images pre-processing should need. |
| K-means With CMYK-LAB[1 ] | Works with all Light Conditions.<br>-High Accuracy.98.59%<br>-Less Complex.<br>-Low Memory and time Consumption. | Post-Processing is Needed after segmentation. |

**Table 3.** Classification Techniques

| Classifier | Advantages | Limitations |
|---|---|---|
| 1. Naive Bayes [9] | - Data set is small then high bias low variance classifier like NB will work well. | -Data set is small than generative class will work well.<br>-large dataset can't use it. |
| 2. Neural Network[10] | -High degree of non-linearity possible. | -Hard to tune parameters.<br>-Takes time to build model. |

| | | |
|---|---|---|
| 3. SVM[1,6,7,8] | -High accuracy<br>-Easy to generate rules.<br>-Easy to understand. | -Hard to interpret<br>-It takes more time to predict the new instance. |
| 4. Random Forest [11] | -One of the most accurate learning algorithms available for most data sets<br>-It reduces over fitting and is - therefore more accurate.<br>-Easy to Implement<br>-works with all types of data.<br>-Multi classification Support. | It may not work if the dependent variables considered in the model are linearly related. Therefore, one has to remove correlated variable by some other technique. |

## IV. CONCLUSION

This paper presents various studies that have been conducted on acute leukemia detection using image processing. Segmentation is considered an important step in the automatic diagnosis of different computer systems. It was found that several methods in the literature have shown promising results. From literature review it was found that automatic segmentation technique that uses two-color systems and clustering algorithm k-means provides high segmentation accuracy and SVM and Random Forest classifiers has quite high accuracy results.

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