

paper 3

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Submission date: 21-Mar-2023 11:20PM (UTC+0700)

Submission ID: 2042762364

File name: Supriyanti_2020_IOP_Conf._Ser._Mater._Sci._Eng._982_012006.pdf (565.47K)

Word count: 3306

Character count: 17336

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To cite this article: Retno Supriyanti *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **982** 012006

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Unsupervised Method for Calculating Diameter and Number of Leukocyte Cells

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Abstract. Leukocyte has an essential role in the body. Leukocyte has functioned as the body's immune system function to protect the body from viruses, bacteria, and pathogens. Under normal circumstances, leukocyte has a relatively constant amount. If the number of leukocytes exceeds or is less than usual, health problems can occur. So that the leukocyte cell counts as an indicator of abnormalities and diseases. Digital image processing is an alternative method to identify leukocyte in addition to a hematology analyzer or manually by medical personnel by processing blood images so that the desired information is obtained. Blood images have a variety of lighting conditions, staining time, and cell thickness that cause the various attributes of the blood image. This experiment segmented leukocyte using unsupervised method especially the K-Means clustering method on the hue component of the image after being transformed into HSV color coordinates by grouping leukocyte cell images (great hue value) into one cluster. The results show that the performance of our system as follows, sensitivity 84%, specificity 94%, and accuracy 97%.

1. Introduction

Blood is a liquid in the body that functions to carry the oxygen needed by cells throughout the body. Blood also supplies body tissues with nutrients, transports metabolic waste, and contains various ingredients that make up the immune system that aims to defend the body from various diseases. Blood cells consist of red blood cells erythrocytes, leukocytes, and platelets. Leukocytes are blood cells that function as the body's immune system. Increasing or decreasing the number of leukocytes in the blood, indicating various disorders and diseases. The number and diameter of leukocytes in the body could apply for the classification of types of leukocyte cells as well as indicators of abnormalities that can help medical staff diagnose diseases. On the other hand, the development of information technology, especially in terms of digital image processing, is also proliferating. This field is also widely used in the health sector, namely the field of medical image processing. One of the applications that have been widely developed is microscopic image processing, which includes processing and analyzing leukocytes based on image processing. According to this condition, currently a lot of research about leukocyte in the world. Nizam [1] researched intending to evaluate the efflux of leukocytes and platelets fibrin (L-PRF) and combining with bovine bone mineral in the treatment of maxillary sinus. Moshavash [2] researched texture-based leukocyte segmentation for leukemia identification. Li [3] developed a holographic imaging system to determine the differences in three



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parts of leukocytes. Wang [4] used the use of machine learning in classifying leukocytes, in particular, the use of the Single Shot Multibox Detector method. The results obtained have a pretty good precision of around 90%. Choi [5] researched the automatic counting system of leukocytes cells from the bone marrow using a two-stage artificial neural network. After that, classify myeloid and erythroid. Reta [6] researched identifying leukocyte morphology by using the contextual analysis method in acute leukemia. Blood cell data came from the bone marrow. From this analysis, he can produce an automatic leukemia detection system with an accuracy of around 90%. Hegde [7] researched leukocyte image processing to detect cell nuclei and leukocyte classification based on cell core features using the TissueQuant method. The primary variable used in the identification and classification of this research is color. Abdulhay [8] researched leukocyte segmentation by focusing on identifying the region of interest (ROI) accurately. The input image used is a static microscopic image. Kelley [9] In his research, he uses a protocol used to explain multichannel in confocal images in living cells. The method he uses includes all stages of research, such as preparation, image synchronization, image acquisition, and quantitative analysis of leukocyte images. Loddo [10] reviewed a variety of research into the operation of blood cell morphology in the classification of various diseases that have relevance to blood cells. Our research also discusses the application of digital image processing in the health sector. The long-term goal of our research is the development of computer-aided diagnosis (CAD) in early detection of leukemia. Based on the fact that in developing countries like Indonesia, the number of specialist doctors is minimal. So that the presence of CAD can help improve the quality of health, especially optimal health services in the community. We have conducted several experiments in the context of developing CAD [11] [12][13][14][15][16][17]. In this paper, we focus on calculating the diameter and number of leukocytes using the K-means clustering method. The main objective is to obtain one of the leukocyte morphology variables precisely and accurately as apart of our CAD leukemia identification.

2. Methods

2.1. Input images

This experiment uses a digital image of blood cells taken from the Acute lymphoblastic Leukemia Image Database for Image Processing (ALL-IDB) of the University of Degli Studi in Milano, Italy, and is available at <http://crema.di.unimi.it/~fscotti/all/>. Image data available on ALL-IDB was taken with a laboratory optical microscope plus a Canon PowerShot G5 camera with different microscope magnifications ranging from 300 to 500. All images are in JPG format with 24-bit color depth and a resolution of 2592 x 1944. Figure 1 shows examples of input images which is used in this experiment. In this paper, we will analyze the results of the segmentation of white blood cell objects from the image of blood cells of Acute Lymphoblastic Leukemia (ALL) patients, which then count the number and diameter. There are two types of leukocytes cells in the image data, namely ordinary leukocyte cell objects that are dark blue in solid and round shape. Furthermore, abnormal leukocyte cell objects are purplish in blue and have a non-solid and round shape. Normal leukocyte cell objects to be segmented and counted in number and diameter.

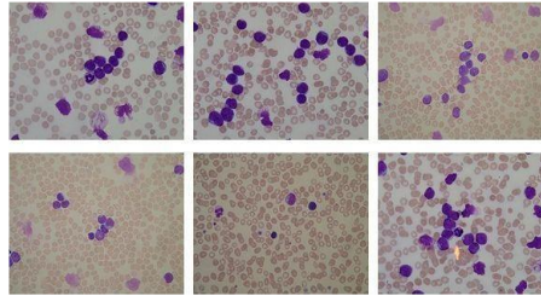


Figure 1. Examples of input images

2.2. Pre-Processing Image

At the stage of image pre-processing, we performed contrast stretching operations and the conversion of RGB color space to HSV color space. Contrast stretching techniques have a function to improve image contrast so that the values of the image pixels are distributed evenly. It refers to the input image, as shown in Figure 1, each component of the image of a blood cell has low contrast; that is, the image pixels grouped in a particular area. The initial image is in the form of an RGB image that has been stretched out before contrast and then transformed into the HSV color space. Figure 2 shows an example of an input image that has been converted into the HSV color space and is ready for use in this research, especially for the image in the H component.

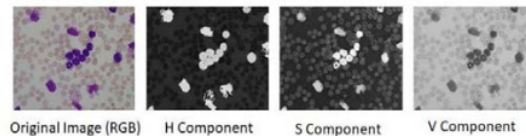


Figure 2. An example of an RGB image conversion to HSV color space

2.3. K-Means Clustering

K-means clustering is one type of clustering algorithm that is commonly used by grouping data according to similar characteristics. This data group is called a cluster. Data in a cluster has similar characteristics and is not similar to data in another cluster. The input received is the data or object and the desired group (cluster). This algorithm will group data or objects into these groups. In each cluster, there is a center point (centroid) that represents the cluster. The process of grouping data into a cluster could be done by calculating the closest distance from a data to a centroid point. The distance of each data to the centroid added, and the smallest total distance obtained. Minkowski distance calculation could use to calculate the distance between 2 pieces of data, as shown in Equation 1.

$$d(X_i, X_j) = (|X_{i1} - X_{j1}|^g + |X_{i2} - X_{j2}|^g + \dots + |X_{ip} - X_{jp}|^g)^{1/g} \quad (1)$$

which is:

$g = 1$, to calculate Manhattan distance

$g = 2$, to calculate Euclidian distance

$g = \infty$, to calculate Chebychev distance

x_i, x_j are the two data to be calculated the distance

p = dimension of a data

If the total distance of each data is already obtained, then the centroid will be updated to the midpoint of the data in the cluster. The renewal of a centroid can be done by Equation 2.

$$-\sum \quad (2)$$

Which is μ_k is centroid point of the K-cluster, N_k is the amount of data in the K cluster, and x_q is q data in the K-cluster.

2.4. Number of Objects Calculation

Calculation of leukocyte objects number by tracing the edge of pixels of each object or hole in the object. The results of the calculation would be stored in the matrix M x 2, where the length M is the number of detected leukocyte cell objects.

2.5. Object Diameter Calculation

Diameter is the longest distance between two points of a shape. In digital image processing can use the maximum distance between each pair of points that form an object. The calculation is quickly done by testing the points on the edges of the object, ie, the distance between each pair of edge points. This experiment will calculate the diameter of each object one by one —the result obtained by calculating the distance of the one-pixel pair and counting the other pixel pairs. Then the most significant distance between pixels is obtained and taken as the diameter of the object.

3. Results and Discussions

As already explained in Subsection 2, the image to be analyzed in this experiment is the image in the HSV color space, precisely the image of the H component only. In the hue component, leukocyte cell objects have a high intensity value used to segment leukocyte cell objects using the K-Means method. The hue component which is the matrix M x N will be changed to 2 x (M * N). This experiment has two clusters, cluster 1 for high-value data, and cluster 2 for low-value data. The system makes two centroids that represent each cluster. Data of each pixel that has been grouped is then labeled based on the cluster and stored for later in comparison with the original image so that the K-Means clustering segmentation image can be displayed. Figure 3 shows some examples of the clustering result.

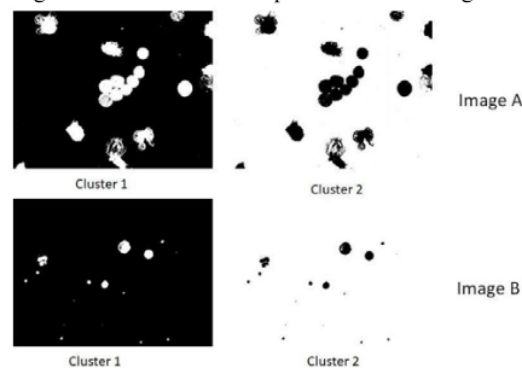


Figure 3. Examples of clustering

However, image segmentation results not only produce leukocyte cell images, but there is also much noise. If not removed, noise can interfere with subsequent processes. Our algorithm will delete

objects with a value of fewer than 500 pixels. After the noise is removed, the image of leukocytes will be obtained. Figure 4 shows an example of noise removal in image B.



Figure 4. Image B after noise removal

According to Figure 3, there are several round objects. The first is a single leukocyte cell objects. The second is an irregularly shaped. The others are non-round objects are abnormal leukocyte cell objects, and almost round-shaped objects, which are several leukocyte cell objects which are attached to produce one only object. In order to get the number and diameter of leukocytes cells accurately, these leukocyte cell objects must be separated or cut. Before the object is almost rounded and not rounded, it must be grouped first in order to facilitate the process of cutting the leukocyte cell objects together. Figure 5 shows some examples of the results of measuring the degree of roundness of each object.

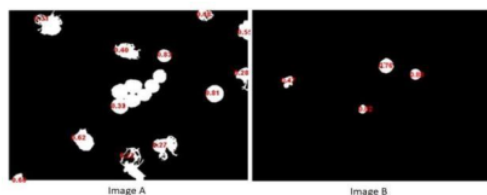


Figure 5. Examples of roundness degree measurement of each Object

Objects that have a degree of roundness approaching value 1 are increasingly rounded the object according to some of the experiments we did. Then the value of the degree of roundness to separate a single object that approaches 1 with a coincident object and unusual object is 0.77. If an object has a degree of roundness less than the boundary value, then the object will be grouped into coinciding and unusual objects, which will then be separated as shown in Figure 6.

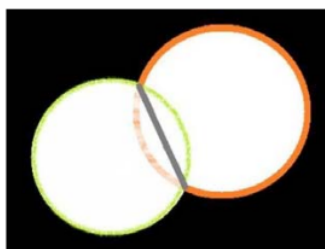


Figure 6. Cutting two Circles Into Each Other

In the object that coincide will be detected several forms of intersecting circles. The area between the two intersecting circle points will then be cut as in Figure 6 so that the adjacent leukocyte cell object can be separated. System accuracy calculation uses sensitivity and specificity methods as we discussed in [17]. In the test using the sensitivity and specificity methods, then there are four variables used, namely True Positive (TP), True Negative (TN), False Positive (FP) and False Negative (FN). Calculation results are shown in Figure 7.

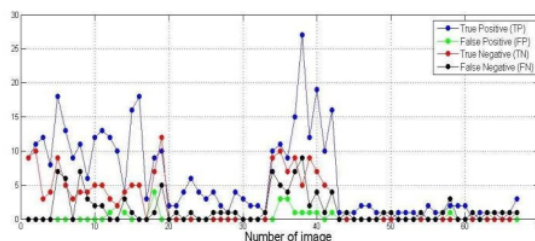


Figure 7. Graph of Calculation Results of Leukocyte Cell Count

Based on the results in Figure 7, the performance results that we obtain in this experiment are as shown in Table 1.

Table 1. Performance of Our System

No.	Performance	%
1.	Sensitivity	84%
2.	Specificity	94%
3.	Accuracy	97%

4. Conclusions

Based on the results we have presented in the previous sub-section, our system can segment 67 cell leukocyte images using the K-Means clustering method. The first step is to improve the input images using contrast stretching operation and the conversion to the HSV color space. There are 2 clusters used, where cluster 1 succeeds in segmenting leukocytes cells, and cluster 2 succeeds in segmenting red blood cells. Although some noise should remove in the input image due to the degree of roundness that is not appropriate, our system can get a sensitivity performance of 84%, a specificity of 94%, and an accuracy of 97%. These results are quite promising for the further development of computer-aided rediagnosis.

Acknowledgements

We want to thank the Ministry of Research and Technology - BRIN for funding support through the Fiscal Year 2020 "Penelitian Terapan" Grant.

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