

Medical Image Segmentation Of Wbc Using Improved Dual Threshold Method

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Abstract: segmentation of medical images is a critical method for the proper identification and diagnosis of diseases. Because of the distinction between them, the segmentation of the WBCs is an important issue. The automatic diagnosis of multiple white blood cell or leukocyte disorders plays a significant role. The suggested work is an Improved Dual-Threshold approach based on a variation of white blood cell (WBC) segmentation of different color spaces. The improved dual-threshold segmentation method consists of three stages: the pre-processing stage, the segmentation step of the threshold, and the post-processing phase. For additional handling, two images are obtained: one is a contrast-stretched grey image and the other is an H part image from the altered colour space of YCbCr in the pre-processing step. The three main steps comprising the threshold segmentation are context separation, red blood cell extraction, and the finest threshold selection. The single-threshold method in RGB colour space is involved in the process of separation of Red Blood Cells (RBC), the H channel image is used in the step of background extraction. The Golden Section search method is used for the best threshold selection item. Finally, to eliminate the noise and the unfinished

WBCs, median filtering and arithmetical morphology are used in the post-processing stage. The image data collection for Acute Lymphoblastic Leukaemia (ALL) is used to test and segment irregular cells from test data using an overall accuracy. Compared to the current segmentation outcome, the implemented segmentation approach shows better precision performance.

Keywords: Contrast-Stretched grey image, H part image, Dual-Threshold

1. Introduction

This chapter introduces the medical image segmentation which becomes vital process for its proper detection and diagnosis of diseases. Due to the distinction between them, the segmentation of the WBCs is an important problem. Automatic diagnosis of multiple white blood cell or leukocyte disorders plays an important role. For haematologists, extracting information on diseases is valuable. Image processing methods have helped to evaluate the cells that have been led in recent years to more fine, normal and distant disease finding systems. Compared to white blood cells, red blood cells have a smaller scale. In several additional tasks, the shape of the WBC nucleus is significant, such as classification for differential including purposes, path-cost significance is used which takes appropriate image characteristics into account. This frame work consists of various methods for nucleus segmentation and cytoplasm removal. The general segmentation techniques are edge and border detection, region growing, mathematical morphology filtering and watershed clustering. In order to eradicate a fake clustering or scattering due to a blurred pixel similarity to minimize those errors. The main five types of white blood cells or leukocytes are presented in human blood. Neutrophils, basophils, eosinophil's, lymphocytes and monocytes are the types of leukocytes.

Diagnosis and screening the haematologist requires two types of blood count. They are Complete Blood Count (CBC), and Differential Blood Count (DBC) [1]. By its existence, the classification system may affect the design of treatment regimens and may even prejudice leukemogenesis investigations. Paediatricleukaemia therapy is the tremendous achievement of modern cancer treatment. White blood cells in bone marrow are classified according to their maturation stages. The size and shape of the nucleus, and many other characteristics changes when a white blood cell becomes older.

2. Related Work

Morphological components such as nucleus and cytoplasm are typically obtained from each segmentation of the WBC and the entire WBC is extracted from a daunting context and is the vital WBC segmentation ambition. The RGB color space-based threshold methods are prominently used due to their high efficiency and accuracy. In addition, the nucleus and cytoplasm are correspondingly segmented with various techniques in different other segmentation techniques away from single threshold segmentation techniques [2]. To segment a transformed color space such as HSV [3], HSI [4], a few researchers have showed their interest to simplify the cytoplasm segmentation via threshold-based approaches and also the WBC is segmented from its background by means of hue channel of the single-threshold method of HSV color space.

Segmentation implies deterioration of picture in various parts for different applications. The division calculation is critical on the grounds that the exactness of the subsequent element extraction and order depend on the precise division of white platelets. Due to the confused structure of the cells and confusion in the infinitesimal picture, it is also an intertwined and severe technique. Cseke used the technique of programmed thresholding. At all times, threshold approaches do not obtain prominent results as spatial information is not used in the division limit determination [5].

The practices of mathematical morphology are coupled with it. The system was 92 percent accurate and an accurate method of division for the white platelets developed by [6]. It is a simple thresholding technique to give important marks to pixels in the platelet images. In view of previously mentioned data about blood spread pictures are the algorithm used and then the labels based on large regional context information to generate significant results using shape detection method. Only if the state of each white platelet limit is near a circle is this strategy rational. The edge recognition system can be broad for division in the same way, but it is important precisely when there is a large difference between frontal area and foundation and is supported by [7]. Based on Gram Schmidt orthogonalization process for enhancing the preferred color vectors was developed by [8] based on Gram Schmidt orthogonalization process for the segmentation of white blood cell nucleus.

A hybrid white blood cell segmentation technique by combining two methods, watershed clustering and scale space filtering [9]. In this technique, extraction of two WBC segments such as nucleus and cytoplasm, are extracted correspondingly from different techniques.

The actual region of the complete cell is obtained and is not explicitly revealed in the whole cell cropping method [10]. Theera-Umpon uses a fuzzy C-Mean clustering to separate single cell images of white platelets in the bone marrow into two regions, i.e., nucleus and non-nucleus. The processing time increases if the clusters number is more than two [11]. Mad loom performed some image arithmetic operations and some threshold operations to find out the white blood cell nuclei [12]. A system to segment white blood cells from the image. They applied some threshold techniques and then after they applied contour identification [13]. They have assumed that all cells are circular to make the algorithm works efficiently. Due to the assumption of the circular shaped cells, this system is not suitable for the lymphoblast cells which are irregular in shape. A system in which he proposed "two-stage blood image segmentation algorithm" [14]. They are using binary filtering and some automatic threshold techniques. This system performs well for extracting the nucleus, cytoplasm and nucleolus from the lymphocyte images. The two stage segmentation processes have been applied here and because of this the computation time is higher. The images are taken under different lightening condition which makes difficult to choose the optimum threshold for segmentation.

A scheme which segments the leucocytes automatically [15]. He used the EM algorithm and Gaussian mixture modelling. In this method, parameter tuning is not required. This is an unsupervised approach. This scheme does not work for all stains.

A technique for the white blood cell nucleus segmentation [16]. He applied fuzzy clustering. This technique works well for the nucleus segmentation but the cytoplasm extraction is also as important as the nucleus segmentation which is not taken care in this technique.

A scheme for the nucleus extraction [17]. The watershed transform has been used in this scheme which is based on the image forest transform. He has extracted cytoplasm by using the size distribution information. This scheme is not working well if the cytoplasm is not round.

An algorithm for the segmentation of cell [18]. The algorithm uses $L*U*V$ color space and divides the image into clusters. This technique works well for the nucleus segmentation but the cytoplasm extraction is also as important as the nucleus segmentation which is not taken care in this technique.

A model to segment leucocytes using GVF [19]. He has used $L*U*V$ color space in the model. The L2E estimation technique and color gradient have been used in the GVF model. The proposed new GVF model performs well than the standard GVF model but the textures and weak edges are not distinguished properly. Therefore, the lymphocytes cannot be segmented properly.

A neural network trained by PSO to segment the white blood cells from the image [20]. The uniform sampling and mean shift are used to reduce the time and size of the training data set. This scheme does not work well for the cytoplasm nucleus detection.

A technique to find out accurate threshold for the segmentation of the leucocytes [21]. He used fuzzy divergence in that technique. He has used various functions like Gaussian, Gamma, Cauchy, etc. in that technique. This technique works well for segmenting the nucleus but the extraction of cytoplasm has not been taken care which is also as important as the nucleus extraction in cancer detection.

3. Proposted Method

The improved technique of dual-threshold segmentation consists of the following three phases: pre-processing phase, segmentation phase of the threshold, and post-processing phase. An outline of the proposed approach is shown in Fig.3.1.

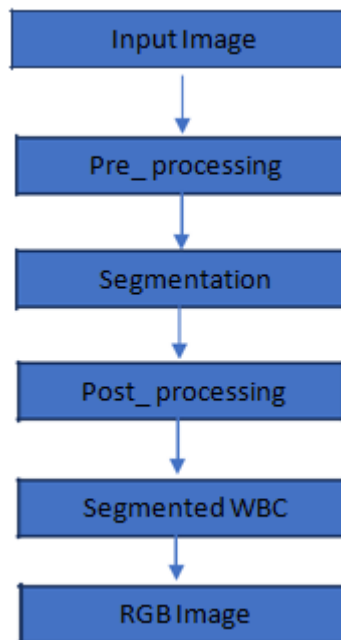


Fig.3.1 Block diagram of the enhanced dual-threshold segmentation

For additional handling, two images are obtained: one is a contrast-stretched grey image and the other is an H part image from the altered colour space of YCbCr in the pre-processing step. The background separation, red blood cell extraction, and the finest threshold collection are the three key steps comprised by the threshold segmentation. The single-threshold method in color space of RGB is engaged in red blood cell separation step, H channel image is used in the background extraction step. For the finest threshold collection part, golden section search technique is used. Finally, to eliminate the noise and the unfinished WBCs, median filtering and arithmetical morphology are used in the post-processing stage. The brief summary of the complete procedures is as the following five steps. The following subsections are the information of each step.

Step 1: Read input microscopic blood cells image which is a RGB image.

Step 2: Convert it to a 250x250 resized grayscale image with RGB image and convert YCbCr colour space to obtain H part image.

Step 3: After converting the RGB to grayscale image, pre-processing the image by using Median filter.

Step 4: Enhanced Dual threshold Segmentation.

Step 5: After applying dual threshold segmentation, post processing.

Step 6: Finally, segmented White Blood Cell (WBC) image.

Step 7: From the Segmented WBC image, the RGB color image is extracted.

4. Input Datasets

In processing blood smear microscopic images for computer-aided diagnosis, however, there are many difficulties and one of them concerns the ability to perform on various image databases. Thus, the robustness of the proposed approach in three separate public databases should be achieved and assessed: ALL-IDB2, SegBlood and Leukocytes. The ALL-IDB2 [22] is a group of cropped regions of interest of ordinary and blast cells. ALL-IDB2 have 260 pictures in the JPG format with 24-bit color depth, and a native resolution equal to 2592×1944, captured with a Power Shot G5 camera.

A typical peripheral blood sample of 368 was taken and stained using the standard Gismo-Right technique in the SegBlood image database. Using a 100x objective lens, the standard light microscope was used to obtain

digital images from the blood slide [23]. An analogue CCD color camera is connected to the microscope and the video output is fed to video grabber card to capture color images with 640×480 pixels resolution.

There are photos of four groups of leukocytes delimited with red edges in the Leukocytes database. To standardize the tests, these images were resized to 198×189. There was a total of 149 photos on the base, but only 107 were available.

The input image taken is of six types. They are (1) band cells (2) Metamyelocytes (3) Myeloblast (4) Myelocyte (5) Promyelocyte (6) Neutrophil cells.

(1) Band cells

A cell that undergoes granulopoiesis is called a cell of the band. This is derived from a metamyelocyte and a mature granulocyte is the main one. The nucleus, which is curved but not lobar, is represented by band cells. Band neutrophils are considered an intermediate stage before the complete maturation of segmented neutrophils. The signalling of the bone marrow is indicated by the rise in band neutrophils and the increase in WBC production.

(2) Metamyelocyte

A cell undergoing granulopoiesis, derived from a myelocyte and leading to a band cell is called a metamyelocyte. Appearance of a bent nucleus, cytoplasmic granules, and the absence of visible nucleoli is characterized. The intermediate between the mature myelocyte and the two lobed granular leukocyte is the transitional shape is the myelocyte with nuclear construction. A cell intermediate in development between a promyelocyte and the mature is a precursor in the granulocytic series. In the segmented granular leukocyte, the U-shape nucleus is the nucleus of the kidney bean and the cell are identical in form, but significantly smaller than myelocytes.

(3) Myeloblast

The myeloblast is called a unipotent stem cell, which will differentiate into one of the granulocyte series effectors. Stimulation causes maturation, cell survival, differentiation and proliferation through G-CSF and other cytokines. Myeloblasts are found in the bone marrow. Myeloblasts are tiny cells and an oval nucleus occupies the major part. The characteristics are the presence of more prominent nucleoli, cytoplasmic granules, and nuclear chromatin.

(4) Myelocyte

A young cell is called a myelocyte in the granulocytic series. It usually occurs in the marrow of the bone. Myelocyte maturation is caused by promyelocytes and gives rise to metamyelocytes. Myelocytes are smaller cells, and the more advanced types of myelocytes present multiple cytoplasmic granules. A precursor of the mature granulocyte of the blood and the bone marrow cell is large.

(5) Promyelocyte

A precursor of a granulocyte is called a promyelocyte and grows from the myeloblast and into the myelocyte. In the granulocytic sequence between the myeloblast and myelocyte, it is a precursor. A few undifferentiated cytoplasmic granules are found in this sequence. A cell containing a few granules grows from a myeloblast and develops into a myelocyte during the differentiation of a granulocyte. In the cytoplasm, it is a popular principal granule.

(6) Neutrophil cells

Neutrophils cells are the most abundant type of granulocytes and the most abundant type of white blood cells. An essential component is the innate immune system that they form. The

segmented nuclei surrounded by erythrocytes and platelets are Neutrophils. They are formed in the bone marrow from stem cells. The neutrophil sub-divisions are segmented neutrophils and banded neutrophils. In the blood stream, neutrophils are normally found.

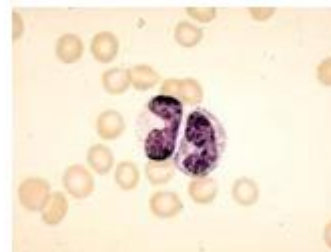
5. Image Pre-Processing

In pre-processing, for further image segmentation processing, two processed images are obtained. The color input image should first be transformed into a grayscale image (Figure 3.2(b)). The intensity of each pixel is determined by each element of the matrix. Most advanced digital files use integer numbers between 0 (to designate black, the minimum intensity color) and 255 (to designate white, maximum intensity) for ease, resulting in 256 distinct grey levels. To work with medical images, this number of grey levels is enough.

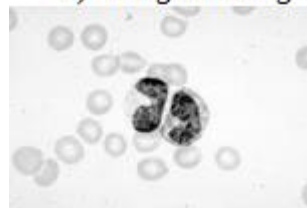
All grayscale algorithms fundamentally use 3 steps.

- 1) Find pixel values of red, green and blue.
- 2) Use averaging algorithm to convert these RGB values into Grey values Grey= (R*0.3 + G*0.59 + B*0.11)
- 3) Then grey values replace the original RGB values.

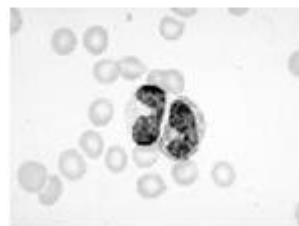
YCbCr color space image obtained from the RGB color space image conversion input is also concurrent, and then H channel image H2 is extracted from the YCbCr color image. It is shown in Fig.3.2 that the contrast between the grayscale of the background and foreground pixels is generally not sufficient to precisely sort the pixels.



a) Original Image



b) Gray Scale Image



c) Stretching Image

Fig.3.2 Contrast stretching image

The ICS is performed by sliding a window (called the KERNEL) over the picture and modifying the inside component utilizing the accompanying equation (1)

$$I_p = 1 + \frac{I_o - m_i}{m_m - m_i} \quad (1)$$

where I_p is the organize of the picture pixel; I_o is the yield shading level for the pixel from the differentiation extending process; I_o is the information shading level for the pixel ; m_i and m_m are the base and greatest shading level an incentive in the info picture.

It is seen that the contrast throughout the image is equalized and it has been easier to see the image details in the regions that are originally difficult to understand, after applying ICS (Fig.3.2(c)).

6. Color Spaces

Any additive color image space depends on the RGB color is called RGB color image space. In computer graphics red, green and blue color space is widely used. The RGB color space is the most common choice for computer graphics because the red, green and blue colors are used to generate the desired color. The RGB is not very efficient when dealing with real world images. HSL and HSV are the two most common cylindrical co-

ordinate representations of points in an RGB color model. HSV, CMYK and YCbCr are the color pickers that are used.

a) HSV

HSV means Hue, Saturation and Meaning, respectively. The angle in the central vertical axis area is the hue, and the distance from the axis is the saturation, and the magnitude is the distance along the axis. In image analysis for feature identification, HSV and the associated models are used. The instruments' applications include object detection for medical image processing. The features can be recognized in the color dimensions used.

b) CMYK

CMYK is a subtractive color space and is used for output printing and hard copying. The black component is used to improve the density range and the available color gamut. This is easy to implement, but it is difficult to transfer from RGB to CMYK properly. With visual perception, the CMYK color space is device dependent and non-linear and reasonably unintuitive.

c) YCbCr color space

In YCbCr color space luminance data is represented by a single segment Y and color data is stored as two color difference parts Cb and Cr. Y segment is the luminance. Cb is the difference between the blue portion and reference esteem. Cr is the difference between a reference value and the red segment. This color space is used extensively in the HSV color space of digital video. The color space of the HSV is formulated by looking at the RGB color cube along its grey axis, resulting in a color palette hexagonally spaced.

7. Threshold Segmentation

The image thresholding applications for image segmentation have a central position. Thresholding is the simplest method of image segmentation and is used for a specific image. A method used to create binary images from a grey scale image is thresholding. If the image intensity is lower than some fixed constant, each pixel in an image with a black pixel is called the simplest thresholding method. If the intensity of the image is greater than that of a constant, it is a white pixel. The peaks of the valley and the curvatures of his histogram are analysed by methods based on histogram shape. Two distinct modes are in the histogram and a threshold T that separates them is easy to select. The computer automatically selects the threshold and then the threshold is fully automated.

The intensity histogram compares to an image $f(x,y)$ – an image composed of light objects on a dark background. Objects and background pixels have intensity levels assembled into two modes. To extract the objects from the background to select a threshold T that isolates these modes. An object point is any image point (x,y) with $f(x,y) > T$, otherwise the point is background point. The threshold image $g(x,y)$ is defined, equation (2),

$$g(x,y) = \begin{cases} 1 & \text{if } f(x,y) > T \\ 0 & \text{if } f(x,y) \leq T \end{cases} \quad (2)$$

The objects are labelled pixel A1 and the background is labelled pixel B1. $A=1$ means white through conversion and $b=0$ means black. An entire image T is considered as an applicable constant, then the global threshold is considered to be the equation. Variable thresholding implies changes in the value of T over an image.

a) Dual Thresholding

Dual thresholding is a combination of two image features. This approach is to divide the image based on the equalisation of the histogram. This is validated by the high compactness of the clusters or objects and the high gradients of their boundaries. One is the one-dimensional brightness histogram $H = H(B)$ for the purpose of adding two spaces, while the second is the two-dimensional dual. Dispersed with the brightness of the image by computing insignificant clustering k_{min} in the first space to measure how minimized.

For defining binary image the threshold T brightness corresponding to k_{min} is defined. Image bitmap $B = \Phi(x,y)$ where $\Phi(x,y) = 0$, if $b(x,y) < T$.

The segmented image is given by, equation (3)

$$G(x,y) = \begin{cases} A & \text{if } f(x,y) > T_2 \\ B & \text{if } T_1 < f(x,y) \leq T_2 \\ C & \text{if } f(x,y) \leq T_1 \end{cases} \quad (3)$$

$$B \text{ if } T_1 < f(x,y) \leq T_2$$

$$\{C \text{ if } f(x,y) \leq T_1\}$$

The three distinct intensity values are A, B, C and the key factors affecting the properties are the separation between peaks, the noise content in the image, the relative sizes of objects and background, the uniformity of the illumination sources and the uniformity of the reflectance properties of the image.

The threshold can also be set for color pictures. Designate a separate RGB variable threshold and use the AND operation to merge them. Often used are the HSL and HSV color models. Hue is a circular quantity, so circular thresholds are necessary. There is also the possibility of a CMYK color model. There are two parameters in the improved algorithm,

Threshold1 and Threshold2. Corresponding projects of the white platelet division are used for image foundation extraction and red platelet expulsion. Arbitrarily selected limits on

actual calculation acknowledgment, notwithstanding when they are in the sensible extension, no optimality can be guaranteed. Limit choice can be created as an optimization difficulty with two variables (Threshold1 and Threshold2) and are likely to use a suitable method to find the most favourable solution.

To invent an appropriate objective function, to initiate Dice Similarity Coefficient (DSC) first, this is frequently used to evaluate segmentation effect quantitatively. It is defined as equation (4),

$$DSC(A, B) = \frac{2 * |A \cap B|}{|A| + |B|} \quad (4)$$

$$(1+1)$$

Where A1 is the territory of the objective locale of ground truth picture acted by the physically portioned pictures; B1 is the zone of the objective district of the aftereffect of a consequently divided picture. DSC differs somewhere in the range of 0 and 1. As per this reality, the target work is given by equation (5),

$$DSC(A, B) = \frac{2 * |A \cap B|}{|A| + |B|} \quad (5)$$

In this method, the trouble of advancement is depicted beneath: influence DSC to be as extensive as conceivable by choosing proper Threshold1 and Threshold2. The primary objective of the improved dual threshold algorithm is the elimination of background and red blood cells from the grayscale image and the H part image. The extraction of the context and separation of red blood cells are the next two steps, both based on this process. The histogram of the contrast stretched gray image presents a triple-modal, correspondingly, instead of WBC nucleus, RBC (cytoplasm), and background.



Fig.3.3 Binary image after background extraction

After ICS, foundation directly has a particular appear differently in relation to different portions in the picture, so it is adequate to evacuate it through single-edge (set apart as T1 in Fig.3.1) strategy. Regardless, as it has been acknowledged, that it is yet difficult to part the whole white platelet (both core and cytoplasm included) from the picture in that cytoplasm has a practically identical dark power with red platelets. Along these lines, the primary phase of the technique is to separate the picture foundation as appeared in dark in Fig.3.3 and it gives the resultant picture for first limit.



Fig.3.4 Binary image after removing Red blood Cells

Following the first threshold, the second threshold divides the red blood cells. The second threshold is the product of a valuable method shown in Fig.3.4 to remove red blood cells in the picture. Thus, by subtracting the foundation and red platelets from the first info image, WBC can be essentially portioned. Because of double limit strategy, the point in this progression is to isolate the red platelets from the picture is done effectively and is appeared in fig.3.5.

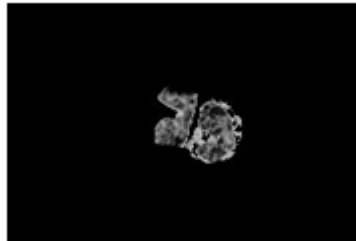


Fig.3.5 Grayscale image after WBC Segmentation

8. Post Processing

After edge division, it is possible to section white platelets around (S in Fig.3.5). In the meantime, it is still a grayscale image with a few clamours, so binarization is used to change this resulting image to a paired image at first in this progression. At that point, morphological disintegration is utilized combined with middle separating and maximum connected region (MCR) extraction activities to fill little openings, interface restricted holes, and expel little dabs and also the inadequate WBCs in the picture. Finally, the parallel picture is changed over into RGB shading picture, however this is anything but an absolute necessity.

a) Binarization

Binary images often emerge in digital image processing as masks or as the consequence of definite operations such as segmentation, thresholding, and dithering. Binary images are pictures that have been quantized to two values, usually denoted 0 and 1, however regularly with pixel values 0 and 255, instead of black and white.

Binary images are used in many applications since they are the simplest to process, but they are such an impoverished representation of the image information that their use is not always possible. Though, they are helpful where all the information required can be given by the object summarize and when it can obtain the silhouette of that object effortlessly.

Steps for grayscale image to binary image conversion:

1. Read the input image.
2. The pixel will be fixed as a 255 or 1 pixel when the pixel value is greater than the threshold value.
3. The pixel will be fixed as a 0 or black when the pixel value is less than the threshold value.



Fig.3.6 Binary image after WBC Segmentation

Suppose the intensity of an object is denoted by $f(x,y)$ and the histogram is as shown in Fig.3.6. In this image, it can be seen that the image intensity can be group into two no overlapping classes based on the value of threshold T in the histogram. In the segmented binary image, background pixels have value of zero while object pixels have value 1. That is given by equation (6),

1, , >

(,)= (6) 0, ,<

b) Morphological Operation

Morphological operations assume a key part in advanced digital image processing with specific application in the field of machine vision and automatic object recognition. The morphological activities incorporate expansion, disintegration, opening, closing and skeletonization and so on. Dilation is a procedure that thickens protests in a parallel picture. The degree of this thickening is controlled by the Structuring Element (SE) which is spoken to by a grid of 0s and 1s. Mathematically, dilation operation can be given in the form of set notation as below in equation (7),

$$A \oplus As = \{z | (A's)z \cap A \neq \Phi\} \quad (7)$$

Where Φ is an empty component and as is the organizing component. The enlargement of A by As is the set including all organizing component beginning areas where the reflected and transmitted As spreads at any rate a couple of portions of A. Dilation activity is commutative and acquainted.

Erosion contracts or reduces the items in a double picture by the use of organizing component. The numerical representation of erosion is as exhibited as below in equation (8),

$$A \ominus As = \{z | (As) z \cap Ac \neq \Phi\} \quad (8)$$

Erosion is performed in MATLAB using the command imerode (Image Name, SE). In image processing, erosion and dilation are used often and in various blends. The gathering of these two standards prompts morphological picture opening and morphological picture shutting. Morphological opening can be depicted as a disintegration task taken after by an expansion activity. Morphological opening of picture X by Y is indicated by $X \circ Y$, which is erosion of X by Y followed by dilation of the result obtain by Y closing and opening are shown in equation (9) (10),

$$X \circ Y = X \ominus Y \oplus Y \quad (9)$$

$$X \bullet Y = X \oplus Y \ominus Y \quad (10)$$

Morphological closing can likewise be portrayed as dilation task taken after by erosion activity. Morphological Closing of Image X by Y is shown by $X \bullet Y$, which is dilation of X by Y taken after by erosion of the result gained by Y.

The handling of morphological images is a social matter of non-straight tasks linked to the form or morphology of a picture's highlights. Morphological practises rely only on the relative demand for pixel values, not on their numerical characteristics, and are therefore especially suitable for the use of duplicate images.

Morphological behaviours will correspondingly be correlated with grayscale images with the ultimate objective of dark light exchange capabilities and no or slight intrigue in their aggregate pixel estimates. A picture with a small shape or format called an organising feature is investigated by morphological strategies. In the picture, the organising portion is arranged in all potential territories and it is contrasted with the resulting pixel neighbourhood. A few operations measure whether the part "fits" within the region, while others test whether it "hits" or meets the region: A morphological activity on a double picture makes another parallel picture in which the pixel has non-zero esteem just if the test is productive at that region in the information picture shown in fig.3.7.

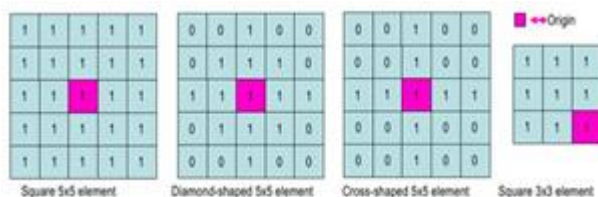


Fig.3.7 Simple Structuring Elements

A little paired picture is the organizing component, i.e. pixels with a little network, each with an estimation of zero or one: The network measurements indicate the size of the organising component. The organising component's state is defined by the example of zeros.

Generally, one of the pixels is a starting point for the organising component, even though the beginning would usually be outside the organising component. An ordinary practise is to have odd organisational grid estimates and

the cause is defined as the network's focal point. Organizing components play in a morphological image that prepares indistinguishable part in a straight picture separating from convolution parts.

The comparative pixel of the region under the organising component is connected with each of its pixels in a parallel image when an organising component is precisely positioned, and it appears in Fig.3.7. If the comparative image pixel is additionally set to 1 for each of its pixels, the organising part is said to match the image 1. So also, an organizing component is said to hit, or converge, a picture if, at any rate for one of its pixels set to 1 the looking at picture pixel is likewise 1.

The structuring element of zero-valued pixels is slighted, i.e. specify points where the relating image value is insignificant.

The opening of an image f by a structuring component s (represented by $f \circ s$) is erosion followed by dilation is shown in equation (11),

$$f \circ s = (f \ominus s) \oplus s \quad (11)$$



Figure 3.8 Morphological Opening Operations

Opening is believed because a hole can be opened between objects connected by a thin scaffold of pixels. Through the expansion, all areas that have survived the disintegration are restored to their specific size and it appears in figure 3.8. An idempotent task is called Opening: resulting openings with the same organizing component have no further effect on that picture when once a picture has been opened is shown in equation (12),

$$f \circ s = (f \circ s) \circ s \quad (12)$$

The closing of an image f by a structuring element s (denoted by $f \bullet s$) is a dilation taken after by an erosion is shown in equation (13),

$$f \bullet s = (f \oplus s) \ominus s \quad (13)$$

For this situation, the widening and disintegration ought to be performed with a revolution by 180 organizing component. Ordinarily, the latter is symmetrical, so that the rotated and beginning types of it don't contrast. Closing is so called because it can fill holes in the regions while keeping the initial region sizes is shown in fig.3.9.



Fig.3.9 Morphological Closing Operations c) Median Filtering

The median filter is a nonlinear filter that is capable of eliminating impulsive distortions in an image without distorting the edges of an image too much. An effective technique is the removal of discrete noise without blurring sharp edges.

The median of all small sliding window pixels in the neighbourhood is replaced by a pixel using the Median filtering operation. In cases where noise is impulsive in nature, it provides better results than the neighbourhood average. The benefit of a median filter is that it is stable and has the potential to filter outliers only and is therefore an excellent option for eliminating salt and pepper noise and horizontal scanning artefacts in particular. In MATLAB, the median filter is realised by the medfilt2 function. Any central symmetric shape, a round disc, a

square, a rectangle, or a cross is the window of a 2D median filter. The median of all pixel values inside the window is replaced by the pixel at the center. Image filtering is used to:

- Remove noise
- Sharpen contrast
- Highlight contours
- Detect edges

Image filters can be classified as linear or nonlinear. Convolution filters are also known as Linear filters as they can be represented using a matrix multiplication. Thresholding and image equalization are examples of nonlinear operations, as is the median filter.

A nonlinear technique used to eliminate noise from images is median filtering. Even as a commonly used protection of edges, it is a valuable way of eliminating noise. For the elimination of 'salt and pepper' style noise, the median filter is mainly useful. It operates by replacing each value with the median value of neighboring pixels, moving through the image pixel by pixel and is shown in fig.3.10. The pattern of neighbors is called the "window", which slides, pixel by pixel over the entire image pixel, over the entire image. The median is calculated by first sorting all the pixel values from the window into numerical order, and then replacing the pixel being considered with the middle (median) pixel value.

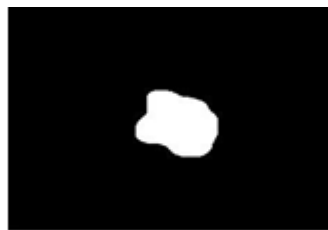


Fig.3.10 Median filtered image

Without blurring the sharp edges, which is an effective technique, the median filter can eliminate isolated noise. Specifically, using the median filter, the median of all the pixels in the neighbourhood is replaced by a pixel. Any central symmetrical form, a rectangle, a cross, a round disc, or a cube, may be the 2D median filter window.

d) MCR Extraction

A connected component is a set of pixels in an image which are all connected to each other pixels. Connected component labelling is finding all connected components in an image and marking each of them with a distinctive label and is applied in fig.3.11.

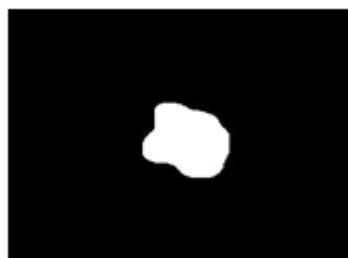


Fig.3.11 MCR Extraction image

It identifies the connected components in an image and assigning each one, a unique label, creating a Label Matrix Connected components labelling scans an image and groups its pixels into components based on pixel connectivity. In medical image processing, the connected component labelling is a fundamental module; it improves the turnaround time of various medical procedures and diagnoses.



Fig.3.12 Segmented WBC RGB color image

Thus the post processing of Segmentation of WBC is done simultaneously after threshold segmentation. Then, to fill little openings, associate limited holes, and evacuate little dabs and additionally the flawed WBCs in the image the morphological erosion, median filtering, and maximum connected region (MCR) extraction activities are used. At last, the binary image is transformed into RGB color image shown in fig.3.12.

9. Experimental Results

The proposed methodology is experimented with the dataset for the robustness of the proposed method on three different public databases: ALL-IDB2, SegBlood and Leukocytes. These datasets are open and free accessible dataset given by Department of Information Technology. It was recorded using PowerShot G5 camera. The proposed methodology implemented by

Mat lab. Table-9.1 shows the Characteristics of Publicly available Datasets of microscopic images and its comparison is shown in Table 9.2.

Table 9.1 Characteristics of Publicly available Datasets of microscopic images

DATASET	PIXEL SIZE	NUMBER OF IMAGES
ALL-IDB2	2592×1944	260
SegBlood	640×480	368
Leukocytes	198×189	149

a) Performance Measure

The performance of the proposed feature extraction by enhanced dual threshold segmentation (EDTS) and classification technique by I-ANFIS was evaluated by the metrics Sensitivity, Specificity, Classification and Accuracy is shown in Table 9.3 and its comparison is shown in Fig.9.3. The results of proposed work help to analyse the efficiency of the process with the aid of microscopic blood cell datasets.

Table-9.2: Different Segmentation and EDTS Comparison for all Cell types

Cell Types	Input image	DTS	EDTS
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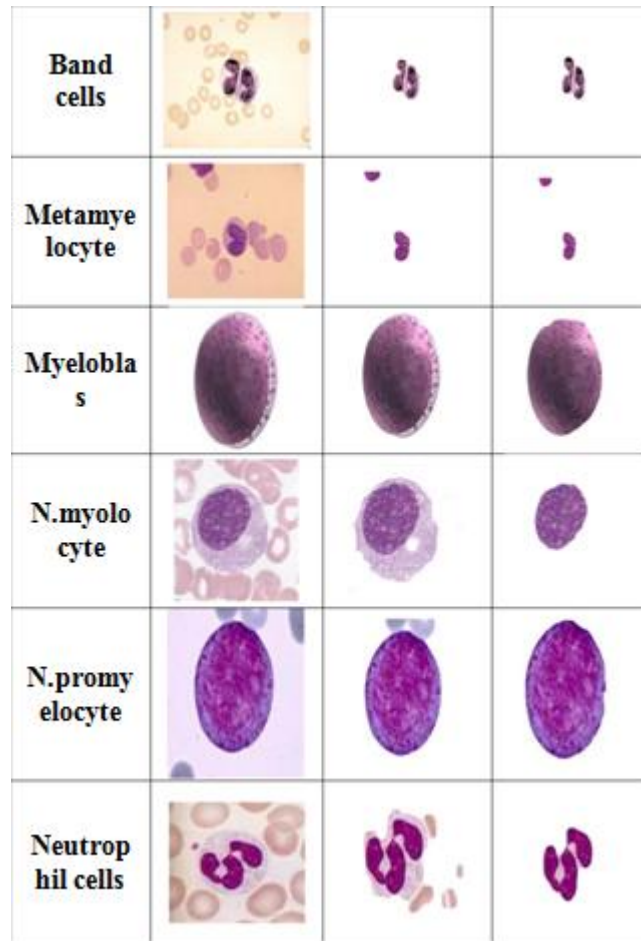


Table 9.3 Different Segmentation and comparison of EDTS Segmentation Performance Measure

Cell Types	DTS Accuracy	EDTS Accuracy	Precision	Recall	F-measure
Band cells	95.7264	96.3456	90.29	99.99	94.89
Metamyelocyte	88.0432	97.2896	98.55	99.45	99.00
Myeloblasts	79.848	89.3216	88.33	99.09	93.40
N.myelocyte	70.9344	92.5936	86.40	99.85	92.64
N.promyelocyte	70.0864	89.7856	87.60	99.96	93.37
Neutrophil cells	67.3392	94.8224	99.86	99.90	99.88

b) Discussion

Experimental results show that enhanced dual threshold segmentation using hybrid discrete wavelet transform.

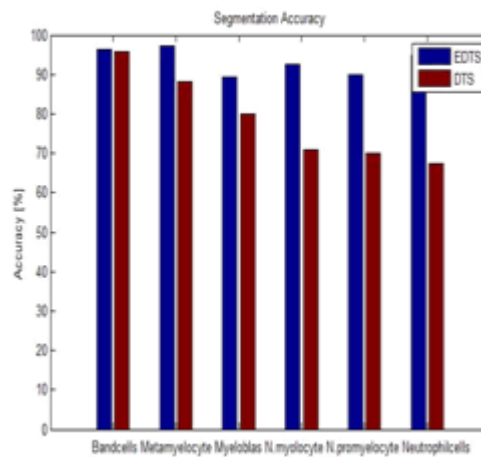


Fig.9.3: Comparison of Accuracy performance for the EDTS

10. Conclusion

For image segmentation, an Enhanced Dual Threshold Segmentation (EDTS) algorithm is used in this chapter. Dual thresholding is a combination of the image's two attributes. The method consists of two thresholding steps implemented simultaneously for context extraction and RBC removal in this suggested segmentation algorithm. Therefore, the segmentation of the threshold gives the resulting image of the intersection. The improved algorithm has two parameters, Threshold1 and Threshold2, which are correspondingly used in the white platelet division's image foundation extraction and red platelet expulsion programmes. Arbitrarily chosen limits in real calculation identification, notwithstanding when they are in the sensible extension, they do not guarantee any kind of optimality. The threshold selection is then generated with two variables (Threshold1 and Threshold2) as an optimization task and is likely to use an acceptable method to find the most favourable solution. After threshold segmentation, white blood cells are approximately segmented. At the same time, it is as yet a grayscale picture with a few commotions, so in this progression, binarization is utilized to change over this resultant picture to paired picture at first.

At that point, the erosion, median filtering and MCR extraction operations are used to fill small gaps, interface slim holes, and eject small dabs and also the inadequate WBCs in the photo. The binary image is eventually transformed into an RGB colour image, but this is nothing but an absolute necessity. The improved dual threshold segmentation is being evaluated on three separate public databases: ALL-IDB2, SegBlood and Leukocytes with the dataset for the robustness of the proposed system. These databases are transparent and publicly available datasets provided by the Information Technology Department. The recording was done using a PowerShot G5 camera. Implementation of the suggested technique by Matlab. For the proposed algorithm, the numerical outcome provides precision, accuracy, and recall and F-measure values. Our improved dual threshold segmentation process achieved greater segmentation precision for all forms of blood microscopic images compared to previously published processes..

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