DOI: 10.21917/ijivp.2017.0208

SEGMENTATION AND CLASSIFICATION OF CERVICAL CYTOLOGY IMAGES USING MORPHOLOGICAL AND STATISTICAL OPERATIONS

S. Anantha Sivaprakasam[1] and E.R. Naganathan[2]
Centre for Information Technology and Engineering, Manonmaniam Sundaranar University, India
Department of Computer Science and Engineering, Hindustan University, India

Abstract
Cervical cancer that is a disease, in which malignant (cancer) cells form in the tissues of the cervix, is one of the fourth leading causes of cancer death in female community worldwide. The cervical cancer can be prevented and/or cured if it is diagnosed in the pre-cancerous lesion stage or earlier. A common physical examination technique widely used in the screening is called Papanicolaou test or Pap test which is used to detect the abnormality of the cell. Due to intricacy of the cell nature, automating of this procedure is still a herculean task for the pathologist. This paper addresses solution for the challenges in terms of a simple and novel method to segment and classify the cervical cell automatically. The primary step of this procedure is pre-processing in which de-nosing, de-correlation operation and segregation of colour components are carried out, Then, two new techniques called Morphological and Statistical Edge based segmentation and Morphological and Statistical Region Based segmentation Techniques-put forward in this paper, and that are applied on the each component of image to segment the nuclei from cervical image. Finally, all segmented colour components are combined together to make a final segmentation result. After extracting the nuclei, the morphological features are extracted from the nuclei. The performance of two techniques mentioned above outperformed than standard segmentation techniques. Besides, Morphological and Statistical Edge based segmentation is outperformed than Morphological and Statistical Region based Segmentation. Finally, the nuclei are classified based on the morphological value. The segmentation accuracy is echoed in classification accuracy. The overall segmentation accuracy is 97%.

Keywords:
Cervical Cancer Cell, Pap Smear Test, Segmentation, Classification, Morphological and Statistical Edge Based Segmentation, Morphological and Statistical Region Based Segmentation

1. INTRODUCTION

Cervical cancer is the second leading cause of cancer among women. According to World Health Organization, every year there are around 530000 new cases of cervical cancer registered worldwide and 27500 of them trimmings up with death [1]. Incidence of cervical cancer [2] in India is that about 122,844 new cervical cancer cases are reported and diagnosed annually that is ranked as the 2nd cause of female cancer in India and also is most common female cancer in women aged between 15 to 44 years. However, noteworthy improvement has taken place in the last few decades to reduce these deaths because of the accurate early screening test. The popular screening test called Papnicolaou test involves microscopic examination of exfoliated cells from the transformation zone of the cervix. Still, the screening tests need to be simplified and prevalent to prevent the cervical cancer deaths especially in the developing countries. In the developing countries [3], around 80% of all cervical cancer deaths happen. So, the medical image processing approach towards automatic detection of presence and level of the cancer in test samples is the need of the hour. A novel method for cervical cytology image segmentation based on colour features with K-Means clustering algorithm is proposed by Dr. E.R. Naganathan [4]. In this method, first enhancement of colour separation of the image using de-correlation stretching concept and grouping of the regions into a set of classes are carried using K-Means algorithms. K-means algorithm depends on the initial cluster centroid position and there is no guarantee that it will converge to the optimal solution. The cervical image segmentation using unsupervised methods in L*U*V color transformation is proposed by S. Anantha Sivaprakasam [5]. Here, image is segmented using fast K-Means with weighted and careful seeding method and Fuzzy-C-means clustering method. The noise and over-segmentation happened in this method degrades the image segmentation accuracy. S. Anantha Sivaprakasam [6] put forward a novel method to segment the nucleus and cytoplasm from cytology image using arithmetic and automatic thresholding concept. In this, first cell nuclei are localized using automatic contrast stretching, histogram equalization and image arithmetic operation. Then, the localized image is segmented using global thresholding method. Finally, the intensity value of the nuclei is increased using minimum filter. Over-segmentation of the nuclei and cytoplasm dwindle the segmentation accuracy. Susanta Mukhopadhyay [7] proposed a method of segmenting gray scale images using multi-scale morphology. At each scale, the algorithm perceives valid segments using three criteria namely, growing, merging and saturation. At the final stage, all extracted valid segments at various scale are combined together to make the final result, This method is a time consuming one and also it needs more space for storing the result at each level.

Thanatip Chankong et al. [8] proposed the automatic cervical cell segmentation and classification in Pap Smears. But in this, single cervical cell image was segmented into nuclei, cytoplasm and background using FCM techniques and classified using 4 classifier such as, KNN, SVN, LDA, ANN. This method is not suitable for the image with multiple cells. Asli Genctav et al. [9] proposed Unsupervised Segmentation and Classification of cervical cell images. In this paper, the morphological operations and automatic thresholding concepts were applied for isolating the cell regions from the background. Then the hierarchical segmentation algorithm was used for partitioning these cells and binary classifier was used to segregate the nuclei from cytoplasm within the cell regions. Finally, the cells were ranked based on their features characteristics calculated from the nuclei and cytoplasm regions. The overlapping of the cell was not segregated properly in this method. Karthigai Lakshmi [10] presented novel method to extract the cytoplasm and nuclei from the image using fuzzy thresholding and active contour method. In this method, individual cell was not segregated for analysing the stage of the cervical cancer. The entire cell was considered as a group. Rahmadwati et al. [20] put forward a method which investigates cervical cancer diagnosis based on the morphological characteristics of cervical cells. This method include pre-processing, image segmentation, nuclei and cytoplasm detection, features calculations and classification. The images are classified into CIN1, CIN2 and CIN3 based on the abnormality degree of the cell. But, K-means algorithm does not guarantee that the optimal solution is achieved. Besides the accuracy of the K-means algorithm depends on the initial centroid value. The accuracy of the segmentation reflected in the classification process. N.B Byju [11] put forward an edge based approach using customized Laplacian of Gaussian (LoG) filter to segment free lying cell nuclei in bright-field microscope images of Pap smear. This method performs well for stain varied images containing the focussed nuclei. Mohideen Fatima [12] put forward a new method on bi-group enhancement followed by edge detection and foreground segmentation of nucleus and cytoplasm. This method was not applicable for multiple cells and overlapping cells. An efficient and simple techniques for automatic segmentation of nuclei of Leukocytes using Otsu method was proposed by Naveed Abbas [13]. Segmentation accuracy differs from image to image because of over-segmentation. Marina E. Plissiti [14] put forward an automated method for the detection and boundary determination of cell nuclei in Pap stained cervical smear images. Morphological reconstruction process is applied to detect the candidate nuclei areas and watershed transform is used to segment the boundaries of the nuclei. Only boundaries of the nuclei are extracted that is not suitable. In this paper, a new and novel techniques based on morphological and statistical operations are wished-for to segment nuclei from cytoplasm in cervical image. In this, both edge based segmentation technique and region based techniques are utilized to segment the nuclei in cervical image. This paper is organized in the following way.

Section 2 thrashes out the Mathematical morphology definition and its properties in order to satisfy various requirements of scale space representation. Besides, it talks about the statistical operations which play a vital role in this paper. Section 3 presented proposed method. The theoretical formulation of the proposed method and its implementation details are presented in this section Experimental results and performance analysis are discussed in section 4. Finally, concluding remarks including future enhancement to be carried out in future are also discussed in section 5.

2. MATHEMATICAL MORPHOLOGY

Mathematical Morphology [15,16,17,18] is a powerful technique for solving the various problems in the field of Image processing and Computer Vision. Morphological operations, such as, erosion, dilation, opening, closing, top-hat transformation, bottom-hat transformation etc play a vital role in extracting, modifying, manipulating the features present in the image based on their size and shapes. The shape and size of Structuring element (SE) that plays a crucial role in such kind of operations, is defined according to the need and purpose of the associated application.

The primary mathematical morphology operations are dilation and erosion based on Minkowski alegebra. These operations are defined as,

Dilation

$$D(A,B) = A \oplus B = \bigcup_{\beta+B} (A+\beta) \tag{1}$$

Erosion

$$E(A,B) = A\Theta(-B) = \bigcup_{\beta+B} (A-\beta) \tag{2}$$

In general, Dilation means objects to dilate or grow in size and erosion means the objects to shrink. The choice of the structuring element determines how much amount and way of the object to be grown and shrunk. Dilation or erosion operation without the structuring element makes no sense that likes applying the low pass filter without specifying the filler.

The morphological filtering [7] techniques can also be extended to gray scale images. Here, the structuring element that comprises a finite number of pixels is convex and bounded. However, the structuring element has gray values associated with every coordinate position as does the image.

Dilation of the Grayscale image by a two dimensional point set B is defined as,

$$(g \oplus B)(r,c) = \max\left\{ g(r-k, c-l) \middle| (k,l) \in B \right\} \tag{3}$$

Similarly, erosion of the gray scale image by a two dimensional point set B is defined as,

$$(g\Theta B)(r,c) = \min\left\{ g(r+k, c+l) \middle| (k,l) \in B \right\} \tag{4}$$

where, g is the gray scale image, B is a structuring element B and (r,c) is the pixel of the image g, (k, l) is the size of the element B. The gray scale image is operated by structuring element. Here, the structuring element is summed with a shifted version of the image and maximum value of all shifts within the $k\times l$ domain of the B is used as the results. After morphological operation, image shape features, such as, edges, filters, holes, corners, wedges and cracks can be extracted. Mathematical morphology can also be extended to colour images without the loss of information of traditional binary technique [19].

2.1 STATISTICAL OPERATION

In this paper, three statistical operations are used along with the morphological operations. These three operations play a vital role and one of the factors to determine the segmentation accuracy. They are Mean, Median and Standard Deviation.

2.1.1 Mean:

Mean means to find out the average or mean of the given array. It is also possible to find out the mean of the each column of the matrix and each row of the matrix.

A = [5 6 6 6 4 8 1 5 4]

The mean value of each column is 4.00 5.00 6.00

The mean value of each row is 5.66 6.00 3.33

The mean value of entire matrix is 5.

2.1.2 Median:

It is used to find out the median value of the array. It is also used to find out the median value of each column of the matrix and each row of the matrix.

A = [5 6 6 6 4 8 1 5 4]

For each column, the median value is the mean of the middle two numbers in sorted order.

The median value of each column is 5 5 6

For each row, the median value is the middle number in sorted order

The Median value of each row is 6 6 4

The median value of entire array is 5

2.1.3 Standard Deviation:

There are two common definitions for the standard deviation *s* of a data vector *X*.

$$s=\left(\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2\right)^{1/2} \quad (5)$$

$$s=\left(\frac{1}{n}\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2\right)^{1/2} \quad (6)$$

where,

$$\bar{x}=\left(\frac{1}{n}\sum_{i=1}^{n}x_i\right)$$

and *n* is the number of elements in the sample. The two forms of the equation differ only in the *n*-1 divisor. The standard deviation of Matrix A is 1.9365.

3. SEGMENTATION AND CLASSIFICATION OF CERVICAL CYTOLOGY IMAGE USING MORPHOLOGICAL AND STATISTICAL OPERATIONS

Though many researches is going on in the area of the morphology for segmenting the image based on the orientation and type of the Structuring Element (SE), the present paper put forward a new, simple and novel method to segment the cervical image based on the combination of mathematical morphology and primitive statistical operations along with coefficient. In general, a gray scale image consists of both bright and dark object features with respect to size or scale. The primary objective of the present segmentation technique is to sketch out the most optimal shape of these bright and dark features (nuclei only). For this, the present paper put forward two new techniques called Morphological and Statistical Edge based Segmentation and Morphological and Statistical Region based Segmentation. These techniques are derived in the form of model. In this paper, the results of the segmentation bank on the combinational coefficients of α, β and γ. This dependency is controlled by means of keeping the condition $\alpha > \beta > \gamma$.

The proposed method extracts the nuclei from cytoplasm based on morphological and statistical operations with co-efficient. This method consists of following stages.

1. Pre-processing
2. Segregate colour image into 3 channels/components
3. Morphological and Statistical Edge Based Segmentation on each channel
4. Morphological and Statistical Region based Segmentation on each channel
5. Integration of 3 channels
6. Feature Extraction
7. Classification
8. Result and Performance analysis

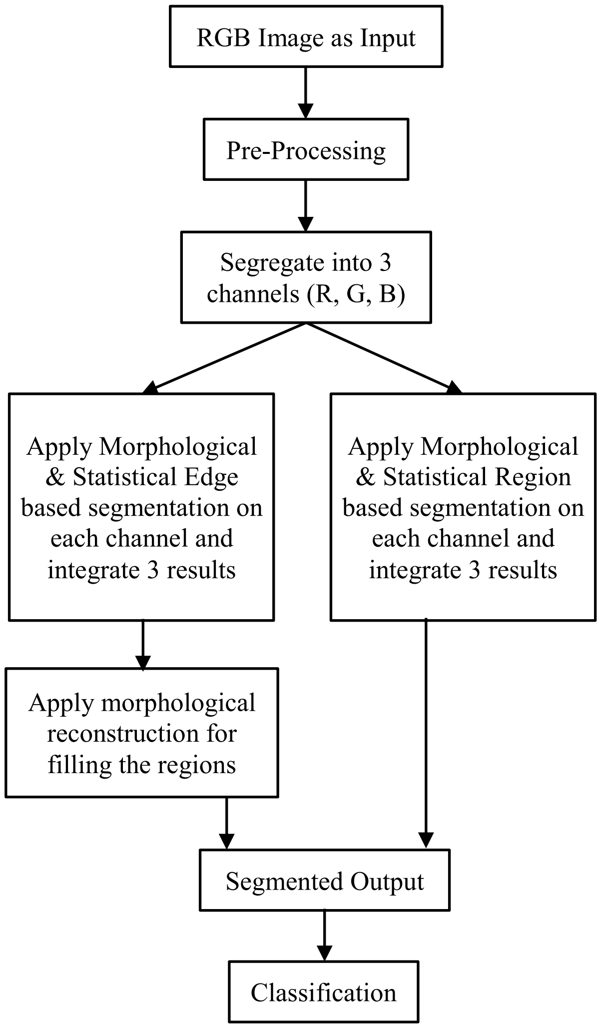


Fig.1. Scheme of the proposed method

3.1 PRE-PROCESSING

The image is corrupted by noise due to various factors, such image capturing, image transformation, staining process and etc. So, it is indispensable to perform the de-noising process. In this paper, for de-nosing process, Gaussian filter is applied to remove the noise from the image.

3.1.1 Gaussian Filter:

The Gaussian filter [10] is a non-uniform low pass filter that is used to blur image and remove noise and details. This filter is used in both one dimension and two dimension data. The two dimension Gaussian function is used for the image. This is nothing but a product of two 1D Gaussian functions and is given by,

$$G\left(X,Y\right)=\frac{1}{2\pi\sigma^2}e\frac{x^2+y^2}{2\sigma^2} \quad (7)$$

where, σ = standard deviation of distribution. The distribution is assumed to have a mean value of 0.

The application of Gaussian filter has a smoothening effect on the image. Noise ratio is very minimal because of staining method. The Gaussian filter removes all type of noises except salt and pepper noise. Even if cervical image contains the noise after applying the Gaussian filter, erosion will eliminate that kind of noise.

3.1.2 De-Correlation Stretching:

De-correlation algorithm [21] is a linear or non-linear algorithm. De-correlation stretching enhances the colour separation of an image with significant band-to-band correlation. The embroidered colours improve visual interpretation and make feature discrimination easier. In this proposed method, the feature discrimination plays a vital role in segmentation and classification process.

In this method, the original colour values of the images are mapped to a new set of colour values with a wider range. The colour intensities of each pixel are transformed into the colour eigenspace of the NBANDS-by-NBANDS covariance or correlation matrix, stretched to equalize the band variance and then transformed back to the original color bands. Here, the entire original image is used to define the bandwise statistics with subset option or any selected subset of it.

3.2 SEGREGATION OF COLOUR IMAGE CHANNELS

In this proposed method, only the morphological operations can be applied on binary image or gray scale image. The reason behind the segregation of colour image into three channels is to get full features of each colour. Here, the segmentation techniques are applied on each channel separately and finally all segmented channel's outputs are combined together to get a full-fledged segmentation result.

3.3 CO-EFFICIENT VALUE (*α*, *β*, *γ*)

The co-efficient values play a vital role in segmentation process. Segmentation accuracy depends upon the value of alpha, beta and gamma. So, it is a mandatory to select exact values of the co-efficient to obtain the accurate segmentation result. The value α, β, and γ of is subject to the condition that $\alpha > \beta > \gamma$. So, the ideal value for these co-efficient that provide the promising result for both segmentation techniques are alpha = 4 beta = 3 or 2 gamma = 1.

3.4 MORPHOLOGICAL AND STATISTICAL EDGE BASED SEGMENTATION

The goal of this module is to extract the nuclei from cytoplasm. For extracting the nuclei from cytoplasm, combination of morphological and statistical operation along with coefficients - alpha, beta, gamma - are used. Morphological operations used in this method are dilation, erosion. Statistical operations used in this proposed method are mean, median and standard deviation. This technique is represented in the form of models and applied on the cervical image.

3.4.1 Edge Based Segmentation:

This process includes two steps:

1. Edge detection (to identify "edges" - edge pixels)
2. Edge linking - linking adjacent "edgels" into edges

3.4.1.1 Edge Detection Method:

A large group of methods are used for edge detection. Some of the Edge detection methods are Gradient, Laplacian, LoG, Canny filtering, sobel etc. These operators are used to detect the edges. The main drawbacks of these operators are,

1. For all kind of images, a single operator cannot be fitted.
2. Computational complexity increases the size of the operator
3. Non-continuous edges are occurred many times

In order to rectify the above problems, the morphological and statistical edge based segmentation is proposed in this paper. In this method, this technique is derived in the form of models which detect the edge of the nuclei only. The models are given below,

Model 1:

$$S[I,J] = \alpha * D[i,j] - (\beta * E[i,j] + |\gamma * (D[i,j] - E[i,j])/2|)$$

Model 2:

$$S[I,J] = \alpha * D[i,j] - (\beta * E[i,j] + \gamma * (D[i,j] + E[i,j])/2|)$$

Model 3:

$$S[I,J] = |\alpha * D[i,j]| - (\beta * E[i,j] + \gamma * \text{Avg})$$

Model 4:

$$S[I,J] = \alpha * (I[i,j] - E[i,j]) - (\beta * D[i,j] - I[i,j])$$

Model 5:

$$S[I,J] = \alpha * (I[i,j] - E[i,j]) + (\gamma * D[i,j] - I[i,j])$$

where, $I[i,j]$ = grayscale image, $D[i,j]$ – Dilation, $E[i,j]$ – Erosion.

Here 3×3 disk based structuring element are used. α, β, γ - coefficient. Avg = average of the whole i/p image.

3.4.1.2 Edge Linking:

Post processing steps must follow to combine edges into edge chains to represent the region border. For performing the post processing, Local edge linking, Hough transform etc. are used. But in this proposed method, morphological reconstruction concept is applied to fill the region.

Morphological Reconstructions [22]: Reconstruction is a morphological transformation involving two images and a structuring element. One image, called Marker, is the starting point for the transformation and another image, called mask, constraints the transformation. The structuring element used here defines connectivity. By default, eight connectivity is used.

3.4.1.3 Filling Holes:

Morphological operation has a wide spectrum of practical applications, each characterised by the selection of the marker and mask images. For example, let I denotes a binary image and suppose the marker image F to be 0 everywhere except border, where it is set to be 1-I

$$F(x,y) = \begin{cases} 1 - I(x,y) & \text{if } (x,y) \text{ is on the border of } I \\ 0 & \text{otherwise} \end{cases}$$

Then, $H = \left[R_I^c(F)\right]^2$ is a binary image equal to I with all holes filed.

3.5 MORPHOLOGICAL AND STATISTICAL REGION BASED SEGMENTATION ON EACH CHANNEL

The aim of this module is to extract the nuclei from cytoplasm. For extracting the nuclei, combination of morphological based operations statistical operations along with coefficients are used. This method is implemented in the form of models and that are applied on the cervical image to extract the nuclei. They are,

Model 1:

$$S[I,J] = |\alpha * D[i,j] + \gamma * \text{Med} - \beta * E[i,j]|;$$

Model 2:

$$S[I,J] = |\alpha * D[i,j] - \beta * \text{Avg}|;$$

Model 3:

$$S[I,J] = |\alpha * \text{std} - \beta * E[i,j]|;$$

Model 4:

$$S[I,J] = |\alpha * \text{Med} - \beta * D[I,J]|;$$

Model 5:

$$S[I,J] = |\alpha * \text{Med} - \beta * E[i,j]|;$$

where, Med = Median of the whole i/p image and Std = standard deviation of the image.

3.6 INTEGRATION OF THREE CHANNELS

After all three channels are segmented individually using these techniques, it is the need of the hour to integrate all three channel's output to get the full-fledged segmentation result.

3.7 FEATURE EXTRACTION

After applying the automatic segmentation based on Morphological and Statistical operations, a set of morphological features [23] is hauled out from the nucleus in each image. There are six features extracted from nucleus alone. The features are selected based on the nucleus and entire cell during the cell division process.

After segmentation process, it is essential to extract the morphological features of the each nucleus for classification purpose. In this proposed method, six morphological features, such as, Area, Mean intensity, Eccentricity, perimeter, diameter and compactness [24] of the each nucleus are extracted and analysed for classification purpose.

Feature 1: Area of Nucleus:

Area means total number of pixels in the each nucleus region. When nuclei are affected by the cancer, its size is increased gradually.

Feature 2: Perimeter:

Perimeter is a scalar value that specifies the distance around the boundary of the region. It can be calculated by means of calculating the distance between each adjoining pair of pixels around the border of the region. In case if the image contains the non-contiguous regions, perimeter may contain the undefined value.

Feature 3: Diameter:

It is a scalar value that specifies the diameter of a circle with the same area as the region.

Feature 4: Mean Intensity:

It specifies the mean of all intensity values in the region. Normally, the colour intensity value of the normal cell is high. If the cell is affected by the cancer, the colour intensity value is decreased based on the degree of the cancer.

Feature 5: Compactness:

It is a dimensionless shape feature which measure compactness. A normal nucleus has a well-formed and a compact shape in normal condition. Cells with abnormality gradually deform and the compactness increases. The normal cells have lower value of compactness than that of the abnormal nuclei.

Feature 6: Eccentricity:

The cell nuclei are round in shape in normal condition. The roundness is not perfect and the shape can be considered as ellipse. The normal nuclei have a minimal proportion between the width and height and thus have greater roundness. Uncontrolled growth of the nuclei does not keep this uniform proportion and as a result their eccentricity deviated farther away from zero (0). The Eccentricity value of normal cell is zero.

4. EXPERIMENTAL RESULTS AND PERFORMANCE ANALYSIS

4.1 EXPERIMENTAL RESULTS

The proposed method has been executed on a set of cervical cytology images and has implemented in Matlab ver 14.0. The size of the image taken here is 1127 x 736. Here, this method is applied on more than 30 images and result of these images are analysed. Some images are taken from Hacettepe Data and others are obtained from Mithra Hospital Madurai, H, Madurai, books and Net.

Original Image

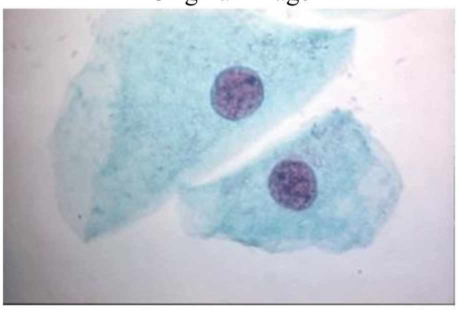


Fig.2. Original RGB Image

After applying the Gaussian filter

Fig.3. De-noised image

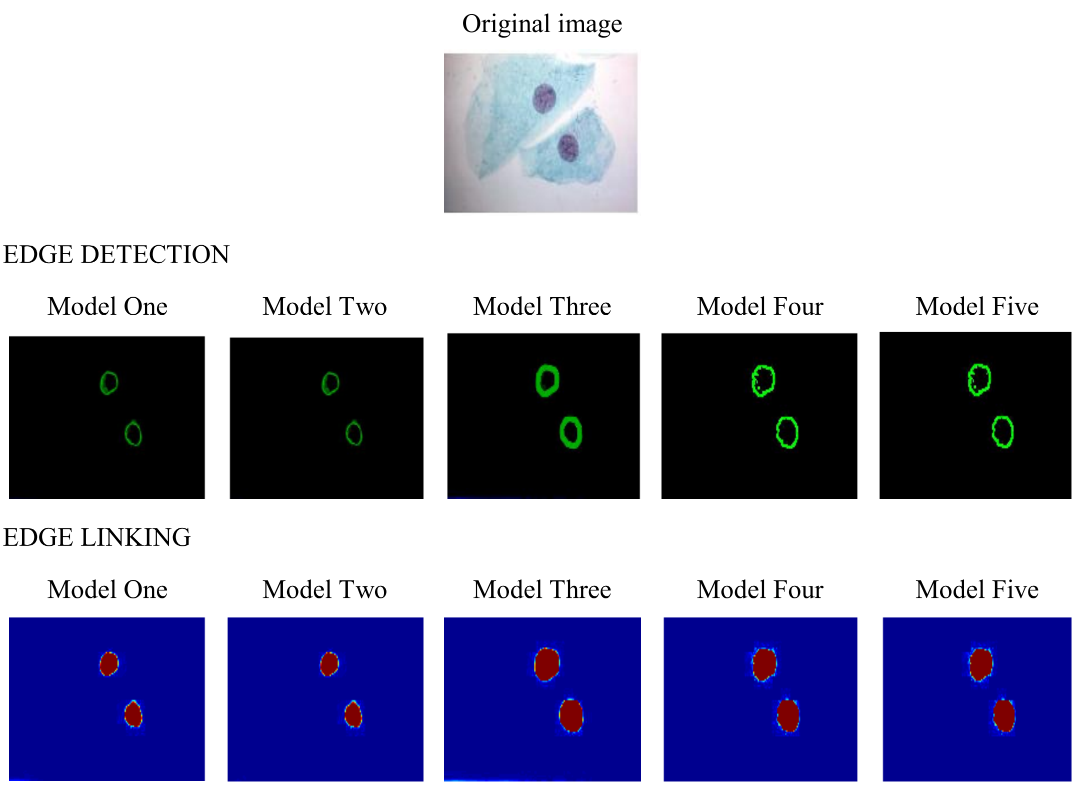


Fig.4. Morphological and statistical Edge based segmentation output

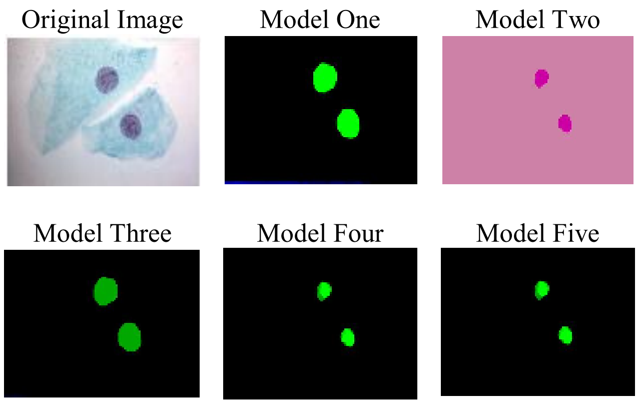


Fig.5. Morphological and Statistical Region based segmentation output

In this Fig.4, first row contains the original RGB image, second row contains the result of edge detection using the proposed method and third row contains the result of edge linking using morphological reconstruction.

In this Fig.5, first row first column contains the original image, followed by the output of model one and model two and second row contains the output of Model three, four and five.

4.2 CLASSIFICATION OF NUCLEI

Once the features of the nuclei are extracted, the classification process starts its journey based on the morphological features. In this proposed method, the cervical cell is classified into 4 types. They are,

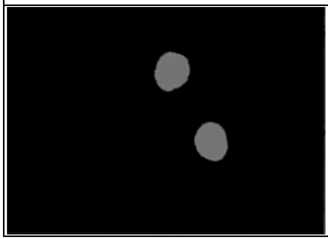
1. CIN 0 - Normal Dysplasia
2. CIN 1 - Mild Dysplasia
3. CIN 2 - Moderate Dysplasia
4. CIN 3 - Severe Dysplasia

The classification is carried out based on the following criteria specified in Table.1.

Table.1. Classification Criteria of morphological features

S. No.	Area	Mean Intensity	Perimeter	Eccentricity	Diameter	Compactness	Stages of the cancer
1	<150	>=100	<16	0	<=13.5	<5.00	CIN0
2	<=400	>=80	<=25	<0.89-0.75	<=18.5	<=5.70	CIN1
3	<600	>=50	<=30	>=.65	<=19.5	<=6.12	CIN2
4	>800	<50	>30	<.65	<=20.5	>6.12	CIN3

Table.2. A sample Classification result of Cervical cell

Image	cell No.	Area	Mean Intensity	Perimeter	Eccentricity	Equivalent Diameter	Compactness	Stages of the cancer
	1	1132	86.34	51.351	0.68331	17.23	6.0	CIN2
	2	1072	94.40	52.35	0.64134	17.44	6.01	CIN2

4.3 PERFORMANCE ANALYSIS

For quantitative analysis, Tanimoto, Jaccard Index, Dice co-efficient, and NPR (Normalized Probability Random) Index methods are used here to measure the segmentation performance. Here, the proposed method is compared with the standard segmentation algorithms.

Morphological and Statistical Edge Based Segmentation technique is compared with canny, sobel edge and prewitt edge algorithm. In the proposed techniques, first, the nucleus edge is detected using the different proposed models and then morphological reconstruction concept is applied for filling the regions. In the standard segmentation method, first, edge is detected using canny, sobel and prewitt operator and then morphological reconstruction concept is applied for filling the regions. The result of the segmentation techniques is given in Fig.6.

In the Fig.6, first row first column contains the original image followed by output of model 1 and 2, second row contains output of model 3, 4 and 5 and third row contains the result of sobel, canny and Prewitt edge based segmentation algorithms. As far as canny edge based segmentation technique is concerned, even the cytoplasm edges are also extracted along with the nuclei. Besides, some nuclei edges are missed.

As far as sobel and prewitt edge based segmentation techniques are concerned discontinuities of the regions are occurred and shape and size of the nuclei are not extracted properly.

But in case of the proposed method, only nuclei are extracted from the image and also the shape and size of the nuclei are preserved. Besides the output produced by the proposed method is much close or similar to the ground truth image. The analysis result portrays that the proposed edge based segmentation technique produces continuous closed contours of the region and over segmentation is heavily reduced by means of morphological operations. Since the shape, size and sub-features are retained in this method, the sub-features are very much useful to detect the abnormalities within the cytology images.

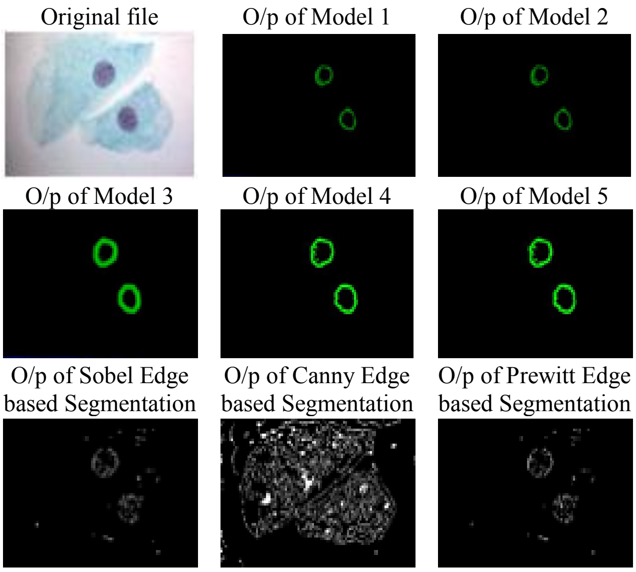


Fig.6. Result of the different edge based segmentation techniques and the proposed techniques

All edge based segmentations are compared with ground truth image using jaccard index, tanimoto, dice, and NPR methods and its segmentation accuracy given in the Table.3, are used.

From the Table.3, it can be understood that the proposed method provides very good segmentation accuracy when compared with other methods. As for as NPR method is concerned, it outperforms than Dice and Tanimoto. Its segmentation accuracy is 98%.

4.4 RESULT ANALYSIS OF MORPHOLOGICAL AND STATISTICAL REGION BASED SEGMENTATION

In this thesis, the morphological and statistical region based segmentation technique result is compared with standard segmentation techniques such as, watershed, K-means and Fuzzy means algorithms. The result of the different segmentation techniques is given in Fig.7.

In the Fig.7, first row first column contains the original image followed by result of model 1 and model 2 of proposed method, second row contains the result of model 3, model 4 and model 5 of the proposed method and third row contains the result of Watershed, K-means and Fuzzy-C means segmentation techniques.

As far as watershed segmentation technique is concerned, nuclei are extracted along with cytoplasm. Besides, over segmentation is also occurred in this technique.

As far as K-means segmentation technique is concerned, nuclei are extracted properly but some background information is also retained. But, the K-Means segmentation technique depends on the initial cluster centriod position and also there is no guarantee that it will converge to the optimal solution.

As far as Fuzzy c-means segmentation technique is concerned, nuclei are extracted properly but some background information is also retained. Fuzzy c –means suffers from the presence of outliers and noise and also it is difficult to identify the initial position. Besides, execution time of this technique is high.

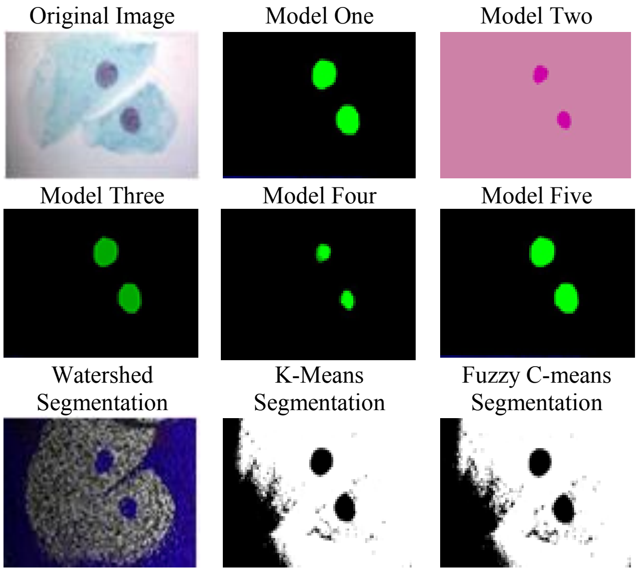


Fig.7. Result of the different region based segmentation algorithms along with the proposed method

While considering the proposed method, it extracts only the nuclei. The output produced by this method is similar to the ground truth image.

Morphological region based segmentation technique accuracy is compared with standard segmentation techniques, such as, watershed, k-means and fuzzy-c-means techniques. Tanimoto, Jaccard index, Dice co-efficient, and NPR method are considered for quantitative and qualitative analysis. The analysis result is given in the Table.4.

Table.3. Comparison results of various Edge based segmentation algorithms using different techniques

Techniques	**Proposed Method**		**Canny Edge**		**Sobel edge**		**Prewitt**	
	Model	**Accuracy**	**Model**	**Accuracy**	**Model**	**Accuracy**	**Model**	**Accuracy**
Tanimoto/Jaccard co-efficient value	1	.9598	1	0.1105	1	0.2184	1	0.2181
	2	.9561	2	0.1090	2	0.2142	2	0.2141
	3	.9551	3	0.1095	3	0.2162	3	0.2162
	4	.9599	4	0.0898	4	0.1837	4	0.1829
	5	.9599	5	0.0898	5	0.1837	5	0.1829
Dice	1	.9751	1	0.1105	1	0.2184	1	0.2181
	2	.9743	2	0.1090	2	0.2142	2	0.2141
	3	.9616	3	0.1095	3	0.2162	3	0.2162

	4	.9745	4	0.0898	4	0.1837	4	0.1829
	5	.9748	5	0.0898	5	0.1837	5	0.1829
NPR	1	.9958	1	0.1105	1	0.2184	1	0.2181
	2	.9952	2	0.1090	2	0.2142	2	0.2141
	3	.9923	3	0.1095	3	0.2162	3	0.2162
	4	.9666	4	0.0898	4	0.1837	4	0.1829
	5	.9693	5	0.0898	5	0.1837	5	0.1829

Table.4. Comparison results of various Region based segmentation algorithms using different techniques

Techniques	**Proposed method**		**Watershed method**		**K-means**		**Fuzzy-c means**	
	Model	**Accuracy**	**Model**	**Accuracy**	**Model**	**Accuracy**	**Model**	**Accuracy**
Tanimoto/Jaccard co-efficient value	1	.9525	1	.1387	1	.5992	1	.5761
	2	.9314	2	.1387	2	.5992	2	.5761
	3	.9314	3	.1387	3	.5992	3	.5761
	4	.6232	4	.1387	4	.5992	4	.5761
	5	.9525	5	.1387	5	.5992	5	.5761
Dice co-efficient	1	.9827	1	.1387	1	.5992	1	.5761
	2	.9162	2	.1387	2	.5992	2	.5761
	3	.9314	3	.1387	3	.5992	3	.5761
	4	.6230	4	.1387	4	.5992	4	.5761
	5	.9827	5	.1387	5	.5992	5	.5761
NPR	1	.9827	1	.1387	1	.5992	1	.5761
	2	.9164	2	.1387	2	.5992	2	.5761
	3	.9825	3	.1387	3	.5992	3	.5761
	4	.9278	4	.1387	4	.5992	4	.5761
	5	.9827	5	.1387	5	.5992	5	.5761

Table.5. Comparison between Edge Based Segmentation and Region Based Segmentation of the proposed method

Method	Morphological and Statistical Edge Based Segmentation					Morphological and Statistical Region Base Segmentation				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Tanimoto	.9598	.9461	.9451	.9599	.9599	.9525	.9314	.9314	.6232	.9525
Jaccard	.9598	.9461	.9451	.9599	.9599	.9525	.9314	.9314	.6232	.9525
Dice	.9751	.9743	.9616	.9745	.9748	.9827	.9162	.9314	.6230	.9827
NPR	.9958	.9952	.9923	.9666	.9693	.9827	.9164	.9825	.9278	.9827

From the Table.4, it can be identified that region based segmentation technique provides the promising result when compared with standard techniques. In the standard techniques, unwanted region are also extracted along with the nuclei. It is also understood that NPR is outperformed than other techniques specified here. Its average segmentation accuracy is 96%.

From Table.5, it can be understood that Morphological edge based segmentation is outperformed than morphological Region based Segmentation. The overall segmentation accuracy is 97%.

5. CONCLUSION AND FUTURE ENHANCEMENT

5.1 CONCLUSION

The proposed technique is a very simple and novel to extricate the nuclei from cervical image using combination of morphological and statistical operations along with co-efficient value and classify it based on morphological features value. The co-efficient assumes an imperative part in segmentation process and decides the segmentation accuracy. The ideal values of alpha, beta and gamma value for both segmentation techniques are 4, 3, 1 and 4, 3 and 2. The proposed technique implements two new segmentation techniques for extracting the nuclei. First one is Morphological and Statistical Edge based segmentation technique and second one is Morphological and Statistical Region based Segmentation Technique. In the Morphological and Statistical edge based segmentation technique, the techniques are implemented in terms of models and they are applied on cervical image. At that point, this segmentation technique result is compared with canny edge based segmentation, sobel edge based segmentation and prewitt edge based segmentation methods. The result shows that the proposed segmentation method is outperformed than it counterparts in terms of accuracy. Its segmentation accuracy is around 98%.

In the morphological and statistical region based segmentation technique also, five models are framed and they are executed on the cervical image. This segmentation result is compared with standard segmentation techniques. From the result, it can be comprehended that the proposed method is outperformed than its counterparts and also its segmentation accuracy is around 96%.

The emperical results depict that segmentation oupututs are banking on type and number of operations and on coefficceint value. In general, the classification accuracy banks on the segmentation accuracy. The performance analysis is carried out between the proposed segmentation scheme with standard segmentation methods. The result illustrates that overvall segmentation accuracy is 97%. Furthermore, this method operates on the segmentation scheme without intervention of high knowledge and by priori information.

When segmentation is over, it is a mandatory to classify the nuclei to detect the stages of the cancer. For classifying the nuclei, the features of the nuclei are extracted from the segmented nuclei and measured the morphological values of each nucleus. Based on the morphological values of each nucleus, the nuclei are classified into four categories, such as, CIN0, CIN1, CIN2, CIN3. In the proposed technique, six features of the nucleus are taken into consideration for classification purpose. They are area, mean intensity, Perimeter, Eccentricity, compactness and diameter. In some cases, one or two features are not classified the cell correctly due to various factors such as, size, brightness, contrast etc. So, definitely, the classification result never deviates from its original path because this method considers six morphological features for classification. The overall performance of the system is 97%.

5.2 FUTURE ENHANCEMENT

In general, any postulation finding is an undeniable one as a result of dynamic changing of technology, desire of individuals and the mind-set of the people are changed from time to time. So that, enhancement is the need of great important to keep in mind the end goal to redress aforementioned issue. This paper also contains the following constraints that are given below,

1. The proposed method does not bolster the mosaic type of cervical image.
2. Overlapping of nuclei is not detected precisely.

Further research can dispose of the above-said limitations and can incorporate the following enhancement:

1. A hybrid segmentation technique will be developed which supports all sort of images including mosaic type images.
2. Co-efficient value will be automatically detected based on the given image.
3. Moreover, cytoplasm features can also be extracted for accurate classification of cell
4. In future, different combination of the proposed scheme can be also developed for accurate segmentation.

REFERENCES

[1] Jemal A, Bray F, Center M.M, Ferlay J, Ward E and Forman D, “Global Cancer Statistics”, *CA: A Cancer Journal for Clinicians*, Vol. 61, No. 2, pp. 69-90, 2011.

[2] Human Papilloma virus and Related Diseases Report India, March 20, 2015. Website: www.HPVcentere.net.

[3] http://www.cervicalcanceraction.org/whynow/about.php

[4] Dr. E.R. Naganathan, S. Anantha Sivaprakasam and V. Saravana Kumar, "Enhanced Colour Image Segmentation on Cervical Cytology Image", *Proceedings of the International Conference on Applied Mathematics and Theoretical Computer Science*, pp. 215-218, 2013.

[5] Anantha Sivaprakasam Sivaprakasam and Naganathan Ealai Rengasari, "Segmentation of Cervical Image Using Unsupervised Clustering Algortihms with L*u*v Color Transformation", *Asian Journal of Information Technology*, Vol. 14, No. 4, pp. 147-153, 2015.

[6] S. Anantha Sivaprakasam and Dr. E.R. Naganathan, "Automatic Cervical Image Segmentation using Arithmetic and Threshold Concept", *Australian Journal of Basic and Applied Sciences*, Vol. 8, No. 18, pp. 283-287, 2014.

[7] Susanta Mukhopadhyay and Bhabatosh Chanda, "Multiscale Morphological Segmentation of Gray-Scale Images", *IEEE Transactions on Image Processing*, Vol. 12, No. 5, pp. 533-549, 2003.

[8] Thanatip Chankong, Nipon Theera-Umpon and Sansanee, Auephanwiriyakul, "Automatic Cervical Cell Segmentation and Classification in Pap Smears", *Computer Methods and Programs in Biomedicine*, Vol. 113, No. 2, pp. 539-556, 2014.

[9] Asli Genctav, Selim Aksoy and Sevgen Onder, "Unsupervised Segmentation and Classification of Cervical Images", *Pattern Recognition*, Vol. 45, No. 12, pp. 4151-4168, 2012.

[10] Karthigai Lakshmi and K Krishnaveni, "Automated Extraction of Cytoplasm and Nuclei from Cervical Cytology Images by Fuzzy Thresholding and Active Contours", *International Journal of Computer Applications*, Vol. 73, No. 15, pp. 26-30, 2013.

[11] N.B. Byju, Vilayil K. Sujathan, Ptrix Malm and R. Rajesh Kumar, "A Fast and Reliable Approach to Cell Nuclei Segmentation in Pap Stained Cervical Smears", *CSI Transactions on ICT*, Vol. 1, No. 4, pp. 309-315, 2013.

[12] M. Mohideen Fatima alias Niraimathi and Dr. V. Seenivasagam, "A Hybrid Image Segmentation of Cervical Cells by Bi-group Enhancement and Scan Line Filling", *International Journal of Computer Science and Information Technology & Security*, Vol. 2, No. 2, pp. 368-375, 2012.

[13] Naveed Abbas and Dzylkifli Mohamad, "Automatic Color Nuclei Segmentation of Leukocytes for Acute Leukemia", *Research Journal of Applied Sciences, Engineering and Technology*, Vol. 7, No. 14, pp. 2987-2993, 2014.

[14] Marina E. Plissiti, Christophoros Nikou and Antonia Charchanti, "Combining Shape, Texture and Intensity Features for Cell Nuclei Extraction in Pap Smear Images", *Pattern Recognition Letters*, Vol. 32, No. 6, pp. 838-853, 2011.

[15] Edward R. Dougherty and Jaakko T. Astola, "*An Introduction to Nonlinear Image Processing*", First Edition, Society of Photo-Optical Instrumentation Engineers, 1994.

[16] Gasteratos, "Mathematical Morphology Operations and Structuring Elements", *In CVonline: On-Line Compendium of Computer Vision*, R. Fisher(ed) Available: http://www.dai.ed.ac.uk/ CVonline/transf.htm, 2001.

[17] Edward R. Dougherty and Jaakko T. Astola, "*An Introduction to Nonlinear Image Processing*", *SPIE Optical Engineering Press*, 1994.

[18] Jean Serra, "*Image Analysis and Mathematical Morphology*", Academic Press Inc., 1983.

[19] F. Ortiz, F. Torres, E. De Juan and N. Cuenca, "Colour Mathematical Morphology for Neural Image Analysis", *Real Time Imaging*, Vol. 8, No. 6, pp. 455-465, 2002.

[20] Rahmadwati, G. Naghdy, M. Ros and C. Todd, "Morphological Characteristics of Cervical Cells for Cervical Cancer Diagnosis", *Proceedings of the 2011 2nd International Congress on Computer Applications and Computational Science*, Vol. 2, pp. 235-243, 2012.

[21] Anil Z. Chitade, Dr. S.K. Katiyar, "Colour Based Image Segmentation Using K-Means Clustering", *International Journal of Engineering Science and Technology*, Vol. 2, No. 10, pp. 5319-5325, 2010.

[22] Rafael C. Gonalez, Richare E. Woods and Steven L. Eddins, "*Morphological Reconstruction*", Digital Image Processing Using MATLAB, MATLAB Digest, Academic Edition, 2002.

[23] E. Martin, "*Pap-Smear Classification*", Master's Thesis, Technical University of Denmark, DTU, 2003.

[24] C. Demir and B. Yener, "Automated Cancer Diagnosis based on Histopathological Images: A Systematic Survey", *Computer Science Technical Reports*, Vol. cs-05-09, 2005.