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Feature Enhancement Of Pap Smear Images Based On Noise Reduction And Segmentation

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ABSTRACT

Objective - This paper proposed feature enhancement of Pap smear images and present an automated method for noise reduction and segmentation techniques for detection of cells nuclei in pap stained cervical smear images.

Methods - In the first study, smears was filtered from unwanted noise preserving edges of nucleus and cytoplasm. In the second study, filtered images were segmented nuclei boundaries with threshold and RGB techniques.

Results - Filtering techniques involves mean, median, Gaussian, and Weiner filters. Compare to other filters, the median and Weiner filters gives better clarity of images for screening the nucleus and cytoplasm. For segmentation, the threshold (Otsu method) was used to separate the object of interest. RGB segmentation gives separate distinct region in an image and coloring the segments for getting more accurate results.

Conclusion - The combination of filtering and segmentation techniques provides important insights of individual nucleus and cytoplasm shows with accurate images for further screening and detection of cervical cancer with high accuracy.

KEYWORDS: *Cervical cancer; filtering techniques; Threshold; Otsu's method; Segmentation.*

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INTRODUCTION

Cervical cancer is affected in the part of cervix (lower part of the uterus) called uterine cervix. Cervical cancer is the second most common cancer affecting women worldwide and it is reduced through early detection and treatment[1,2]. The main reason of cervical cancer is caused by Human Papilloma Virus (HPV). Pap screening is the most popular method for preventing and diagnosing the cervical cancer, but this method is fully dependent by humans. Figure shows the normal and abnormal Pap smear images (Fig. 1). To avoiding the human error and false diagnosis rate, we implement the automated methods for detecting cervical cancer through Pap smear images.

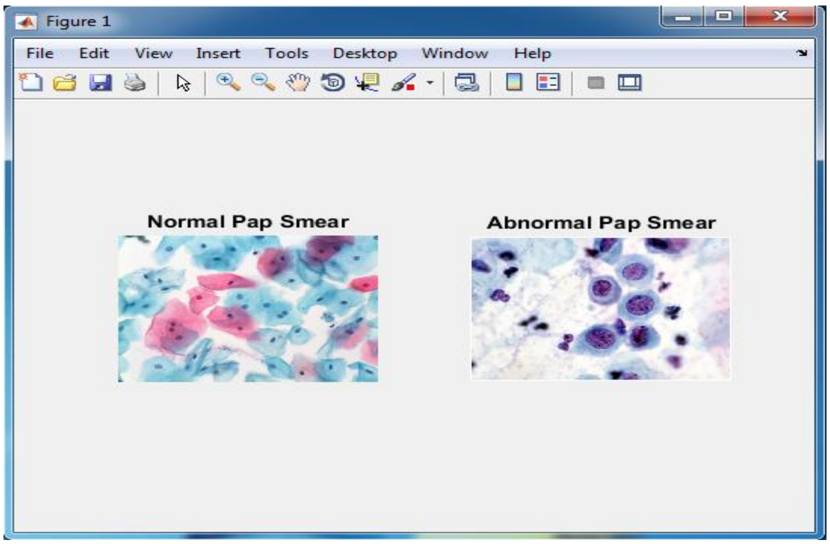

Fig.1 Normal and Abnormal Pap smear

Feature enhancement techniques are used to removing unwanted noise and enhancing the quality of images with brightness and contrast. In our work, we propose a two-stage automated method for determination of nucleus in Pap smear images, which contain single cell or cluster of cells[3]. In first step, the filtering techniques are used to reducing the unwanted noises in Pap smear images. In this work, the filtering techniques are: mean, median, Gaussian, Weiner filtering methods were examined. In second step, the filtering images are used to implement in the segmentation process. The segmentation process of nuclei from Pap smear images is to extract the features of nucleus and cytoplasm of images[4].

METHODOLOGIES

The proposed methodology involves two image enhancement techniques, which are filtering and segmentation. In figure (2) shows the information of processing the inputs and applying feature enhancement methods. In table (1) shows details of implementation of feature enhancement of pap smear images[5].

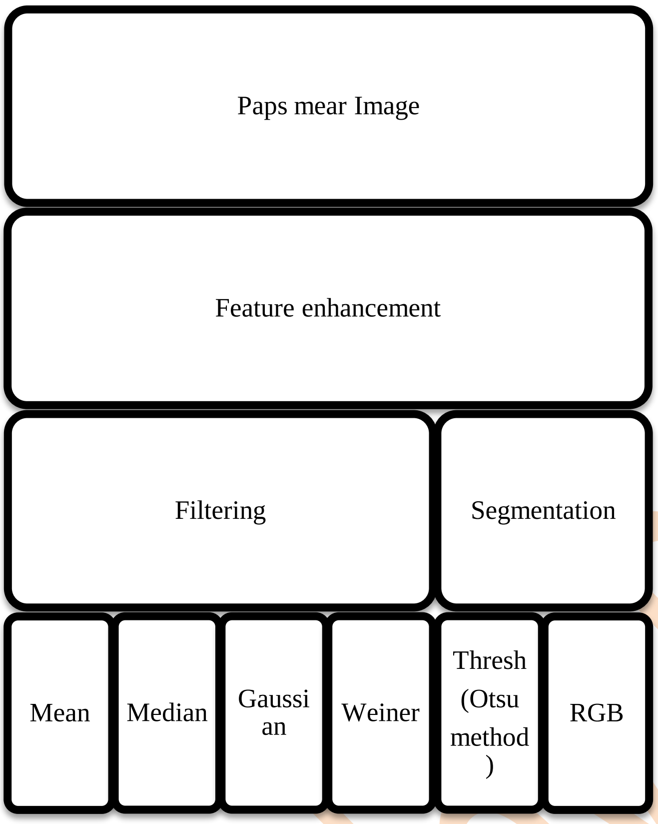

Fig.2: Process f Feature Enhancement

Table.1 Information of implementation details

Software	MATLAB R2015a
Data sets	Pap Smear
Feature Enhancement Techniques	Filtering: Mean, Median, Gaussian, Weiner Segmentation: Threshold(Otsu method), RGB segmentation
Operating System	Windows 7
Data set File Format	Image (jpeg format)
Purpose	Feature Enhancement

Filtering:

It is a technique for modifying or enhancing an image. Filtering means smoothing, sharpening, removing noise, and enhancing the edges of images[6]. The function of filtering is determining the value of the pixels in the neighborhood of the input pixel. It defines the neighborhood of pixels and their locations of relative to that pixel. The process of applying filter to an image called convolution may be either spatial or frequency domain.

Mean Filter (Box Filter):

In this work, we used the mean filtering for smoothing and reducing the noise of the Pap smear images[7]. It reduces the amount of intensity variation between one pixel to another. Mean filtering is used to replace the each pixel value with the mean (average) value of its neighbors in images. To calculate the mean value of images, we need to know the shape and size of the neighborhood pixels. It replaces each pixel by the average of pixel values in a square centered at that pixel.

$$g_{ij} = \sum_{k=-m}^{m} \sum_{l=-m}^{m} \omega_{kl} f_{i+k,j+l} \qquad (1)$$

Where i, j= (m+1)… (n-m).Where g_{ij} denotes output from the filter with pixel values. A linear filter of size (2m+1) * (2m+1), with specified weights ω_{kl} for k, l=-m… m. the weights (ω) can depend on i and j, resulting in a filter which varies across the image.

Median Filter

In this work, median filter can suppress the neighborhood averaging of noise images. The median filter replaces a pixel by the median, instead of the average, of all pixels in a neighborhoodω.

$$y[m,n] = median\{x[j,j],(i,j) \in \omega\} \qquad (2)$$

Where ω represents a neighborhood, and [m, n] is the centered around location in the image. It is calculating the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel with the middle pixel value[8].

Gaussian Filter

It is a 2D convolution operator that is used to 'blur' the images and remove the detail and noise[9]. It calculates the amounts to estimate at each position of a local average of intensities and corresponds to low-pass filtering. Convolution by a positive kernel is the basic operation in linear image formatting.

$$G_B[I]_p = \sum_{q \in s} G_\sigma (\|p-q\|) I_q \qquad (3)$$

$G_\sigma(x)$ denotes two-dimensional Gaussian kernel.

$$G_\sigma(x) = \frac{1}{2\pi\sigma^2} exp\left(\frac{-x^2}{2\sigma^2}\right) \qquad (4)$$

In this filtering, the weighted average of the intensity of the adjacent positions with a weight decreasing with the spatial distance to the center position P. This distance measured by $G_\sigma(\|p-q\|)I_q$, where σ a parameter is defining the extension of the neighborhood.

Weiner Filter

It is an important technique for removal of blur in images due to linear motion or unfocussed optics. It produces an estimate of a desired process by linear time-invariant filtering of noisy process[10]. It minimizes the mean square error between the estimated random process and desired process. The main goal of this filter is to computer the statistical estimate of an unknown signal using a related signal as an input and filtering to produce the output. It executes an optimal tradeoff between inverse filtering and noise smoothing. This filter is used to estimate the linear information of the original image.

Weiner filter estimates the local mean and variance around each pixel.

$$\mu = \frac{1}{nm}\sum_{n_1,n_2\in n} a(n_1,n_2) \tag{5}$$

And

$$\sigma^2 = \frac{1}{nm}\sum_{n_1,n_2\in n} a^2(n_1,n_2) - \mu^2 \tag{6}$$

Where n is the N-by-M logical neighborhood of each pixel in the image. Weiner filter creates a pixel wise filter using these estimates,

$$b(n_1,n_2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(a(n_1,n_2) - \mu) \tag{7}$$

Where v^2 is the noise variance. If the noise variance is not given, Weiner filter uses the average of all the local estimated variances.

Segmentation:

It is a process of partitioning a digital image into multiple segments called as super pixels or sets of pixels. It is used to locate objects and boundaries in images. The goal of segmentation is to change the representation of the image[11]. It partitions an image into distinct regions of each pixels with similar attributes. It is used to identify objects or the information of images. It involves separating an image into regions and contours of corresponding objects. It is used to segment the regions with common properties or to segment the differences in contours between edges[12,13].

Threshold

This method is used to extract those pixels from the Pap smear images. The binary information of the pixels represents a range of intensities. In the binarization process, mask the pixels belong the foreground regions with a single intensity and the background regions with different intensities. Threshold process is to separate the light and dark region of images. It creates binary images from grey-level ones by turning all pixels below threshold to zero and all pixels about the threshold to one[14,15].

Threshold with Otsu's method

This method is used to measure the regions with high homogeneity and will have low variances[15]. It selects the threshold by minimizing the within –class variance of the two groups of pixels and minimizes the combined spread[16].

Within-class variance

$$\sigma^2 \; within \; (T) = n_B(T)\sigma_B^2(T) + n_o(T)\sigma_o^2(T) \qquad (8)$$

Where

$$n_B(T) = \sum_{i=0}^{T-1} p(i)$$

$$n_o(T) = \sum_{i=T}^{N-1} p(i)$$

$\sigma_B^2(T)$= the variance of the pixels in the background

$\sigma_o^2(T)$= the variance of the pixels in the foreground and $[o, N-1]$is the range if intensifying levels[17].

Between –class variance

$$\sigma_{between}^2(T) = \sigma^2 - \sigma_{within}^2 = n_B(T)[\mu_B(T) - \mu]^2 + n_o(T)[\mu_o(T) - \mu]^2 \qquad (9)$$

$\sigma^2 = combined\ variance, \sigma^2 = combined\ mean$

T we

(i) Separate the pixels into two clusters according to the threshold.

(ii) Find the mean of each cluster.

(iii) Square the difference between the means.

(iv) Multiply by the number of pixels in one cluster times the number in the other.

RGB segmentation

Color segmentation may be more accurate because of more information at the pixel level comparing to grayscale images[18,19]. RGB representation has interrelated color components and has been designed in order to redundancy, determine actual object, background colors of illumination and obtain stable segmentation[20,21]. It involves a partitioning of the color space of RGB. This approach is based on reference or dominant color $(R_0,\ B_0, G_0)$ and thresholding of Cartesian distances from every pixel color[22, 23].

$$f(x,y) = \big(R(x,y), G(x,y), B(x,y)\big): \quad (10)$$

$$g(x,y) = \begin{cases} 1\ if\ d(x,y) \le d_{max} \\ 0\ if\ d(x,y) > d_{max} \end{cases};$$

$$d(x,y) = \sqrt{(R(x,y) - R_0)^2 + (G(x,y) - G_0)^2 + (B(x,y) - B_0)^2} \quad (11)$$

Where $g(x,y)$ is the binary region after threshold[24].

RESULTS AND DISCUSSION

The feature enhancements techniques have been successfully implemented in pap smear images and getting better result of images. From this comparison we conclude that median and Weiner filter methods gives better noise reduction images than other filter methods. The threshold method gives the information about the pixel intensities and separates the light and dark regions. The Otsu's method minimizes the class variance of the pixels. Our goal with this paper was to describe a method that was entirely focused on the problem of noise removal of the Pap smear image. In RGB segmentation method to segment the image with color representation is obtained accurate results. The effectiveness of a particular image segmentation algorithm is determined with respect to a particular class of images. The method has been tested in terms of the accurate segmentation of the cytoplasm borders in images from Pap smear slides, and as it was verified by the results it presents a high performance. The resulting images are used to further analysis of feature extraction and detection of cervical cancer. The first step in this proposed method of segmentation is removing of noise then segmenting cell from background by using Otsu's method which gives the best results by splitting the cells into three regions background, cytoplasm and nucleus in chinch boundary can be easily seen.

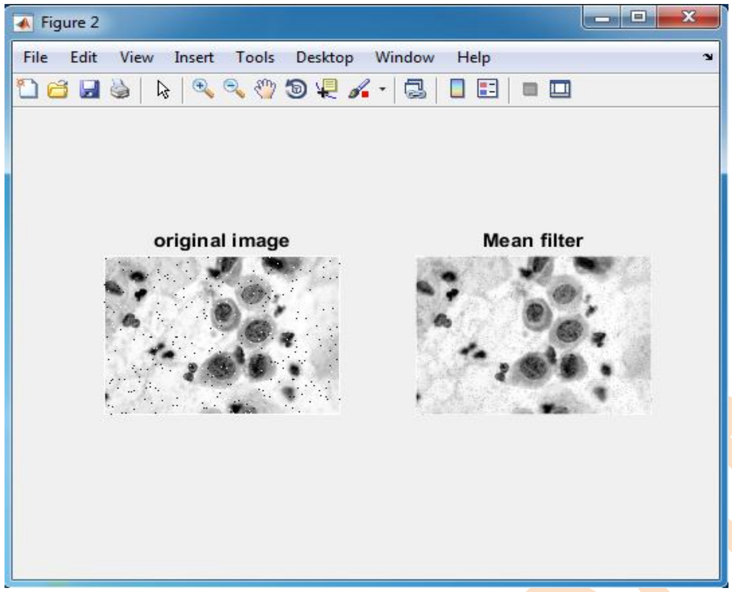

Fig.3 Output of Mean filter

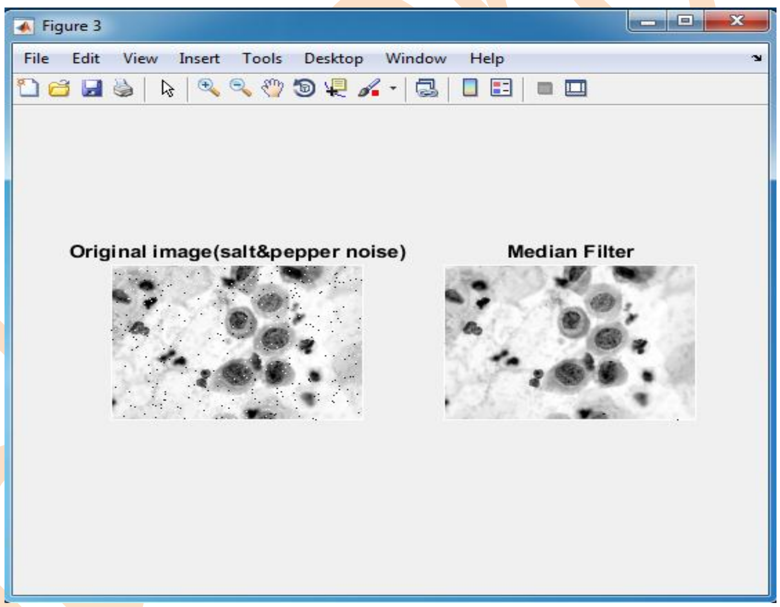

Fig.4 Output of Median filter

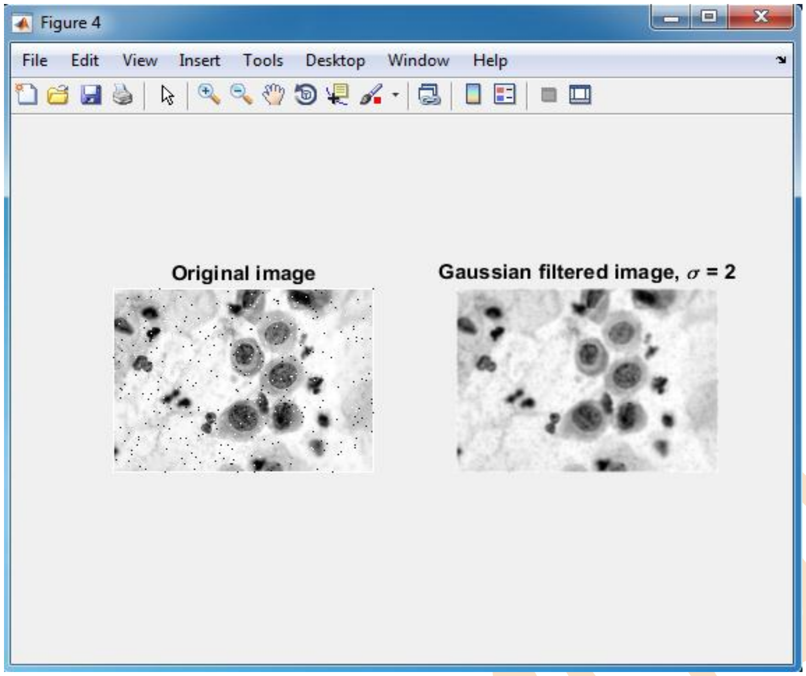

Fig.5 Output of Gaussian filter

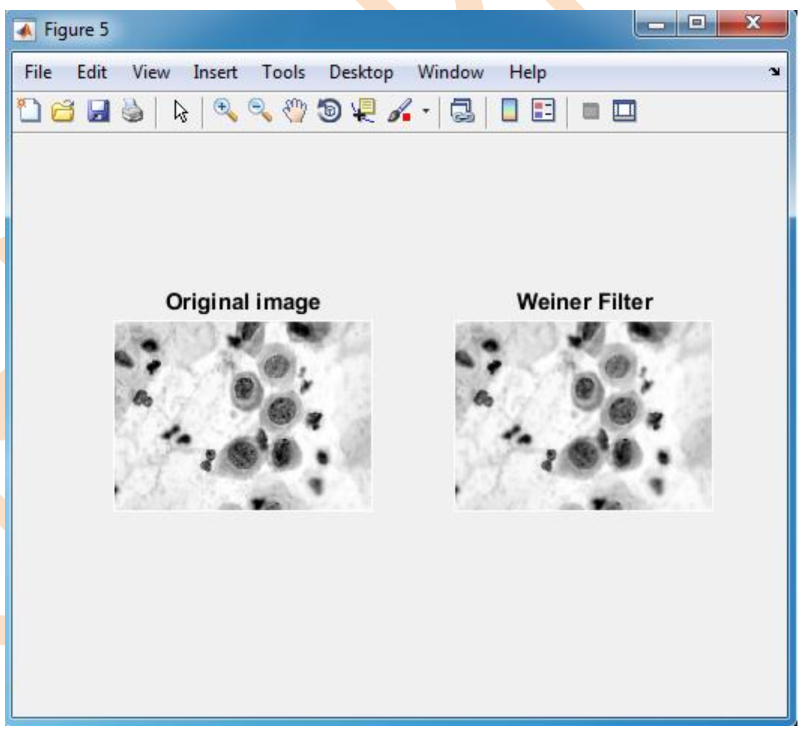

Fig.6 Output of Weiner filter

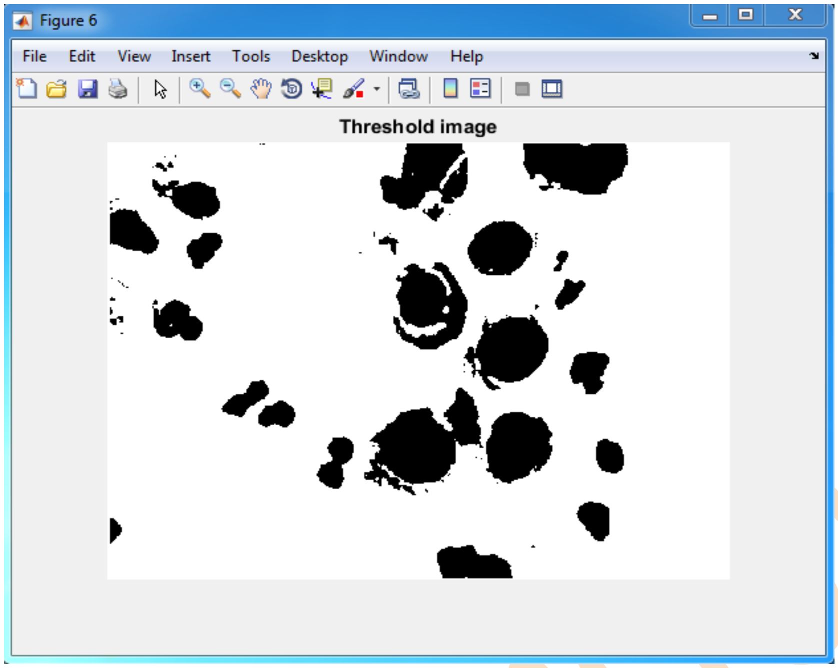

Fig.7 Output of Threshold image

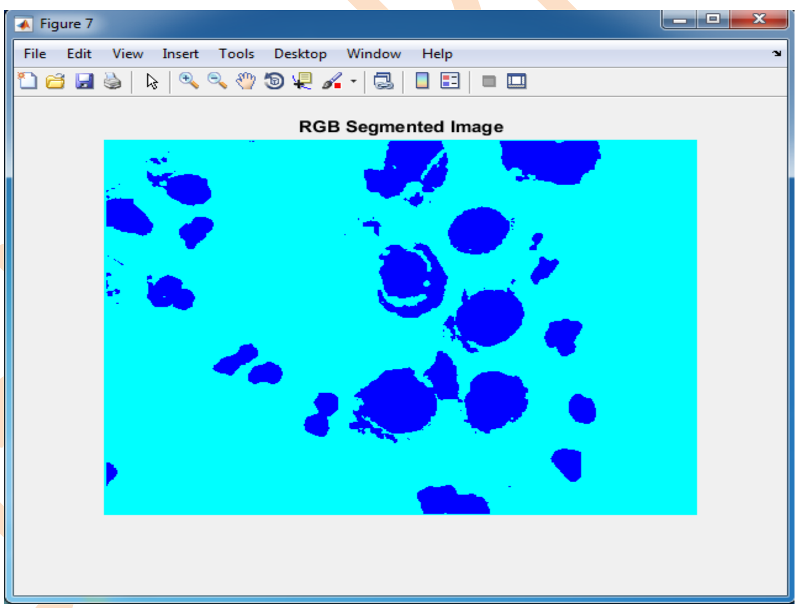

Fig.8 Output of RGB Segmentation of image

Table.2 Regional information of Threshold Pap smear image

Field	Area	Major Axis Length	Minor Axis Length	Eccentricity	Orientation	Euler Number	Equiv Diameter	Perimeter
1	199543	688.26	483.04	0.71	0.62	-70	504.05	1930.24
2	31	7.12	5.95	0.55	-4.07	1	6.28	17.79
3	4	3.44	1.69	0.87	31.72	1	2.26	4.41

4	1	1.15	1.15	0.00	0.00	1	1.13	0.00
5	6	3.33	2.58	0.63	45.00	1	2.76	5.91
6	6	4.16	2.00	0.88	-71.57	1	2.76	6.37
7	4	2.31	2.31	0.00	0.00	1	2.26	3.56
8	6	4.00	2.21	0.83	-53.13	1	2.76	6.19
9	33	7.20	6.14	0.52	54.78	1	6.48	17.91
10	43	12.77	4.93	0.92	-68.68	1	7.40	27.52
11	1	1.15	1.15	0.00	0.00	1	1.13	0.00
12	6	4.16	2.00	0.88	18.43	1	2.76	6.37
13	5	3.31	2.13	0.77	71.57	1	2.52	4.96
14	1	1.15	1.15	0.00	0.00	1	1.13	0.00
15	4	2.31	2.31	0.00	0.00	1	2.26	3.56

From the Figure (1) shows the original image of pap smear with unwanted noise and poor contrast. Figure (3) shows after applying the mean filter algorithm in original image. Figure (4) shows after applying the median filter in original image. Figure (5) shows after applying the Gaussian filter in an original image. Figure (6) shows after applying the Weiner filter in an original image. The median and Weiner filter gives us the super clean image compared to the original[25,26]. Figure (7) shows after applying the threshold technique with Otsu's method in the filtered image. Otsu's method gives better result of cells; nucleus and cytoplasm can be easily seen[27,28]. Figure (8) shows after applying the threshold, the threshold image is segment by RGB color segmentation technique and gives better accuracy results[29,30]. The regional information of binary image after threshold, it shows on above table (table.2).

CONCLUSION

This work we have achieved to enhance Pap smear images with filtering and segmentation techniques for further analysis. We have seen several filtering methods to enhancement of cells images. We choose Otsu's method for segmenting the cells images. Then the boundary of cell images is successfully detected with threshold technique and segmenting with RGB. Further work is going on extracting the features of images and detecting the normal and abnormal cells with high accuracy.

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