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Diagnosis of Cervical cancer using CLAHE and SGLDM on RGB Pap smear Images through ANN

S. Jaya, M. Latha

Abstract - Cervical cancer is one of the most preventable Cancers in the present day. PAP and HPV tests are followed for early diagnosis for screening procedure. In medical field, it is difficult to detect Pap smear images through microscope. Image processing is a vital role to take right decision by using various technique and algorithms. In this paper, the proposed technique is used to enhance the Pap smear images by comparing Histogram Equalization in Contrast Stretching algorithm, Power Law Transformation for Gamma Correction, Shading Correction, Contrast Limited Adaptive Histogram Equalization (CLAHE). The Quality measurement MSE, PSNR, SC and NAC value has been calculated to find performance analysis of enhanced Pap smear images. Then proposed four different feature extraction algorithms SGLDM- Spatial Gray Level Difference Method, RDM- Run Difference Method, LBP- Local Binary Pattern and HOG-Histogram of Oriented Gradients are used to extract features of Pap images. Experimental results are obtained for a data set of 215 Pap images taken from the Management and Decision Engineering Laboratory (MDE-LAB) database. MATLAB R2016a used as a programming tool. ANN Classification is used for each feature extraction algorithm to evaluate the accuracy level. Thus, CLAHE achieved the good result for enhancement and SGLDM feature extraction algorithm reached 93% accuracy using ANN.

Keywords* : *Cervical cancer, Pap smear image, Enhancement, Feature Extraction.

I. INTRODUCTION

Cervical cancer is the fourth to the highest degree type of cancer for women worldwide, it is also one of the most preventable sort of cancer.Cervical cancer effectuate to take place during midlife. It is most frequently diagnosed for women under the ages of 35 and 44. It rarely affects the women category under the age of 20. Most cervical cancers start in the cells at the place of transformation zone where the connection between the uterus and vagina. The long-standing test for early detection has been recommended to take Pap test to diagnosis the cancer is present or not. Human Papilloma Virus (HPV) tests can find if any of the high-risk types of cancer found in cervix.

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***** Correspondence Author
S. Jaya*, Ph.D Research Scholar in Computer Science, Sri Sarada College for Women (Autonomous), Salem - 16, India.
Dr. M. Latha, Associate Professor of Computer Science, Sri Sarada College for Women (Autonomous), Salem - 16, India.

A Pap test can be recommended to check every three years. An HPV test is recommend for every five years. A Pap smear is a microscopic examination of cells taken from the uterine cervix. Those microscopic images very small in size and it will not appear as much clear one. In such a case, Image Processing is a part to solving those problem in medical field using lot of methods and technologies.

In first phase, the Pap smear images taken for Pre-processing to enhance the contrast level of the microscopic image. The proposed paper compared and analyzed topmost three Enhancement algorithm for the purpose of which enhancement algorithm is works well on Pap smear images. So that the pathologist can easily find the state of the cancer based on the microscopic images. Used Power Law Transformation for Gamma Correction, Histogram Equalization in Contrast Stretching and Contrast Limited Adaptive Histogram Equalization (CLAHE). Thus, CLAHE achieved the best result in the performance evaluation test than other two algorithm.

In Second phase, the features extraction is done for further classification result to diagnosis the Cervical cancer. Feature extraction algorithms are SGLDM- Spatial Gray Level Difference Method helps to extract the Gray Level Co-occurrence Matrix- GLCM features such as Contrast, Correlation, Energy and Homogeneity. LBP- Local Binary Pattern is an efficient texture operator which labels the pixels of an image by threshold the neighborhood of each pixel and the result considered as a binary number. It is a statistical and structural model of texture analysis for various applications especially it is useful for medical application. RDM- Run Difference Method extracts texture feature that describe the size and prominence of texture property in the image. RDM texture descriptors are (DGD) Distribution of Gray level Differences, DOD Distribution Of average Difference, (DAD) Distribution of Average Distance. HOG-Histogram of Oriented Gradients is edge oriented histogram used for the purpose of object detection. The luminance gradient is calculated at each pixel. Extracted HOG features with different cell size of 2x2, 4x4, 8x8, 16x16, 32x32. In this paper has been used four different feature extraction algorithm to compare which algorithm is best for Cervical cancer classification and tested with 165 Pap smear images.

II. II. RELATED WORKS

The author referred on neuro-expert system was developed using advanced neuro-fuzzy inference system, which helps to diagnosis the cervical cancer for women earlier[1].

The proposed work of this paper is to detecting the cervical cancer by following pre-processing. Segmentation, texture feature extraction and geometric feature extraction done with SVM[2]. The paper, intends to explore various support vector based classifiers, such as (SVM), twin support vector machine (TWSVM),
and twin-hypersphere support vector machine (THSVM), and test their performance on cervical cancer cell classification in 2-class and 4-class scenarios. The cell LCH data set used from Lampang Cancer Hospital in Thailand. The experimental results show that TWSVM is preferable to SVM and THSVM in the cervical cancer cell classification [3]. The author focused on analysis of cervical cancer using smear Analysis Tool (PAT) tool for fuzzy-c means and feature selection and classified normal and abnormal cell [4]. the author only focused on types of feature selection for cervical cancer.Feature selection is achieved using Mutual Information(MI), Sequential Forward Search (SFS), Sequential Floating Forward Search (SFFS) and Random Subset Feature Selection(RSFS) methods[5]. The author Akshitha Shetty and Vrushika Shah take a survey on cancer prediction using machine learning compared with existing techniques [6]. Ayubu Hassan Mbaga, Pei ZhiJun, analysed SVM classifier, SVM Gaussian and Polynomial Kernel function used to performance evaluation. Thus the found Polynomial kernel function achieved the good accuracy than other two [7]. M.K. Soumya, K. Snehaand, C.Arunvinodh, the paper proposes a classification technique using Magnetic Resonance Images(MRI) to obtain the staging of cervical cancer patients [8]. The paper of this eight co-authors taken a importance of Cervical cancer with the process of screening, diagnosis and staging level [9]. R. Marshall Austin, Agnieszka Onisko, and Chengquan Zhao, developed CxCa and HPV diagnosis for screening procedure evaluated with CxCa obtained a better result[10]. J. Bethanney Janney, G. Umashankar, Sindu Divakaran, Shelcy Mary Jo and S. Nancy Basilica focused on cervical cancer detection on multiclass-SVM[11]. Rajesh Kumar, Rajeev Srivastava, and Subodh Srivastava proposed diagnosis of cervical cancer by pre-processing, segmentation, feature extraction and classifier used with microscopic cancer images[12]. The author focused on NeuroalPap system for cervical cancer classification with the result of various feature extraction algorithm [13]. Ms.M.S.Priya, G.M.Kadhar Nawaz, developed four types of feature extraction algorithm using gray scale image. Classification done by KNN classifier[14].

III. III.PROPOSED METHODOLOGY

A. Enhancement Techniques

A color image always contains a large amount of information. Human eyes fail to analyze hidden information like intensity, color, texture etc. So, need an efficient color image Enhancement technique to remove the redundant pixels and improve the quality of the Pap smear microscopic image to detect Cervical Cancer. The result of feature extraction and classification is totally depends on the quality of the image.

A.1 Power Law Transformation for Gamma Correction

In medical image analysis contrast enhancement is essential factor for visual assessment of microscopic images to diagnosis the cervical cancer. The color image enhancement technique gives the proper result and it produce a good clearance of pixel value than gray scale image. The power law transformation for Gamma correction has general function of $\mathbf{s = c*r^{\gamma}}$. 'S' refers the value of output pixel. 'R' refers the value of input pixel. The symbol ɣ is called Gamma Transformation. 'C' is called scaling constants. For Pap smear images gamma value is used as ɣ = 2.0. The Constant value is c =255. If ɣ>1 the image will be darker else it is ɣ<1brighter. The performance evaluation has been calculated for pap smear images using power law transformation for gamma correction. To evaluate the quality of the color image had been measured Mean Square Error (MSE), Peak Signal to Noise Ratio (PSNR), Normalized Cross-Correlation (NCC), Average Difference, Structural Content, Maximum Difference and Normalized Absolute Error (NAC) for each color pap smear image.

A.2. Histogram Equalization in Contrast Stretching

The main purpose of Histogram equalization is used for adjusting the intensities to enhance the contrast level.This paper will provide an overview and analysis of different techniques commonly used for image enhancement of cervical cancer which is used in medical application. For color image enhancement need to convert the RGB image into Hue Saturation Value (HSV) to perform Histogram Equalization based on Intensity Component. In contrast stretching, the RGB color image will fix the lower and upper limits of intensity value [low in, high in][low out, high out]. Based on the adjustment of intensity components of the color image it will obtain the contrast level of the Pap smear images.

A.3. Shading Correction for RGB images

Shading Correction Technique is used for enhancing the illumination of contrast level of the image. The microscopic Pap smear images are recommended for Classification purpose to take decision by the pathologist. The Pap image is go for smoothing purpose to remove light illumination after filtering used. Shading Correction is not produce good result for microscopic images.

A.4. Contrast Limited Adaptive Histogram Equalization (CLAHE)

In the proposed work, there are three kind of contrast enhancement techniques has been compared and analyzed to classify a cervical cancer through Pap smear images. The purpose of this paper is to recognize which is the best suitable enhancement algorithm to detect Cervical cancer due to the pap image looks small in size.CLAHE is one of the most widely and entrenched method for the successful enhancement of low-contrast images. CLAHE is used to prevent the over amplification of noise and increase the contrast level in color image.It consider a small regions in the image, is known as tiles and clip limit used for histogram to overcome the problem of noise amplification. Clip limit is mainly control the quality of the color image by increasing the clip limit value the image brightness will also be increased. The original color pap smear image will be converted into L*a*b color space. Scale the value to range from 0 to 1 and clip limit is 0.002 for sample image AIS11005.jpg. Thus the result shows the proposed algorithm CLAHE is very suitable enhancement techniques for microscopic Pap smear images when compared to other algorithms.

B. Feature Extraction

B.1 Spatial Gray Level Difference Method – SGLDM

SGLDM is texture analysis of object recognition and classification in various applications. It is a statistical method constructs spatial distribution of gray level in the (ROI) Region of Interest. SGLDM used to measures second order texture characteristics which play an important role in human vision and to achieve the classification performance. The properties are extracted from SGLDM algorithm are contrast, correlation, homogeneity, energy, entropy, mean, RMS, Skewness, Kurtosis, mean, standard deviation, median, variance.

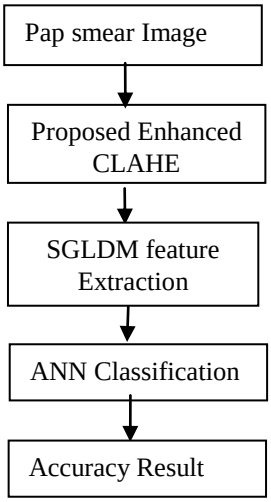

Figure 1: Work Flow of SGLDM

B.2 Local Binary Pattern – LBP

Color-based LBP operator referred to as the color LBP feature which exploits both color and texture discriminate features in Pap Smear images. This is can be divide an RGB channel separately and fix the threshold value by comparing with other 8 neighborhood pixel in a image. The Results of these works indicate that color information can play an important role in a texture analysis and classification for detecting cervical cancer on microscopic images. The steps are followed for LBP,

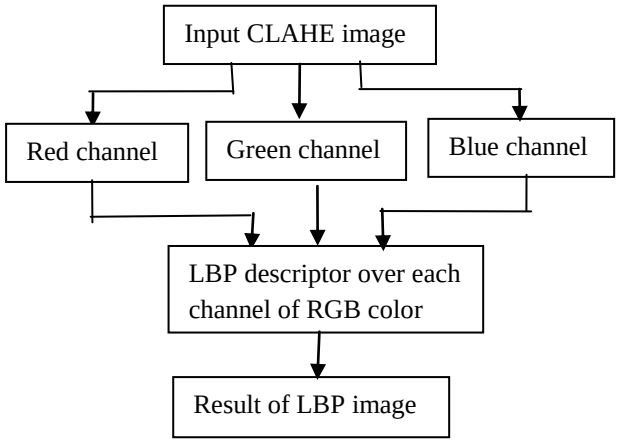

Figure 2: Diagram of LBP operator

Here, the original image taken as RGB color Cervical cancer Pap Smear image which has 3x3 pixels. It may contains the intensity of each pixel between (0~255). Then take center value of each matrix that determined threshold value which is 90. This threshold value will be compared with other 8 neighborhood pixel. If the neighbor value is less than the threshold means it will become '0', if it is greater than the threshold value means it is consider as '1'.

B.3 Run Difference Method (RDM)

RDM extracts texture features that describe the size and prominence of texture elements in the Pap Smear images. RDM measures p(r, $gdif|s$). Gdif defined the variation between the two pixels in a image. That is at a distance r away from each other in the direction. RDM works well on Gray scale image than RGB color image. The accuracy has been obtained using ANN 84.60%.

(i) DGD - Distribution of Gray Level Difference

$$DGD_{gdif} = \sum_{r=1}^{[s/2]} p_{rgdif} \tag{1}$$

(ii) DOD - Distribution Of average Difference

$$DOD_r = \sum_{gdif=0}^{G-1} g_{dif}\, p_{rgdif} \tag{2}$$

(iii) DAD - Distribution of Average Distance

$$DAD_{gdif} = \sum_{r=1}^{[s/2]} rp_{rgdif} \tag{3}$$

The properties of RDM Features,

Features are extracted from Enhanced CLAHE Pap smear images with the data set of nearly 165 sample images.

Step 1: Read RGB image from database and converted into gray scale image.

Step 2: Define and declare a variable of offset (8,1) with 8 direction

Step 3: Create run difference matrices and normalize RDM

Step 4: Find mean value of rdm = mean (rdms,3)

Step 5: Now extract feature from rdm of character vectors from gray scale Pap smear images.

Step 6: RDM features are lde, shp, smg, smo, ldel.

(i) Lde – 'Large Difference Emphasis' which defines large difference gray level values.

$$lde = \sum_{gdif=0}^{G=1} DGD(G_{dif}) \ln(2/G_{dif}) \tag{4}$$

(ii) Shp (Sharpness) – defines contrast level of the Enhanced CLAHE image

$$shp = \sum_{gdif=0}^{G-1} DGD(G_{dif})(G_{dif})^3 \tag{5}$$

(iii) Second Moment of DGD (SMG) – it measures the variation of intensity difference in the image.

$$smg = \sum_{gdif=0}^{G-1} (DGD(g_{dif}))^2 \tag{6}$$

(iv) Second Moment of DOD (SMO) – it is used to measures the variation of average gray level differences in the image.

$$smo = \sum_{r=1}^{L/2} (DOD(r)^2 \tag{7}$$

(v) Long Distance Emphasis Level (LDEL) – is measuring the large difference which determines the long distance of each pixel in the matrix.

$$ldel = \sum_{rgdif=0}^{G-1} DAD(G_{dif})(G_{dif})^2 \tag{8}$$

B.4 Histogram of Oriented Gradient (HOG)

The histogram of oriented gradients (HOG) is a feature descriptor used to extract some features for the purpose of Cervical Cancer detection. It occurrences of gradient orientation in localized portions of an image will detection window and region of interest (ROI). It computes centered horizontal and vertical gradients. If it is a color image it takes color channel with highest gradient magnitude for each pixel.

In this paper, it is used to detect the Cervical cancer of Pap smear images tested with pap images using HOG feature detector. The HOG feature extraction process is shown below,

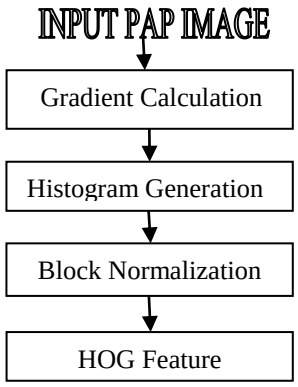

Figure 3:HOG based detection block diagram

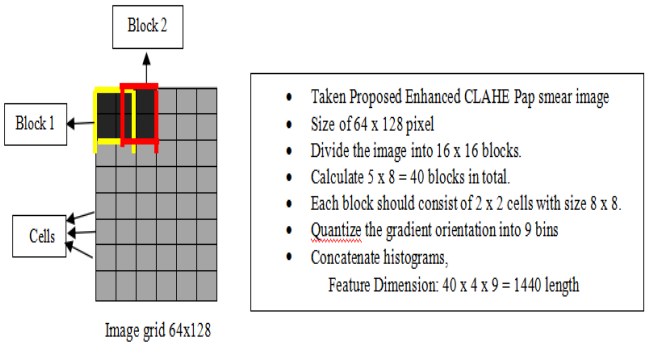

Figure 4: Hog calculation for Sample Pap image

IV.RESULTS AND DISCUSSION

4.1 Enhancement Results

Original image | Power Law Gamma | Contrast Stretch | Shading Correction | CLAHE

Figure 5: Enhancement Result of Pap smear image

Table 1: Performance Evaluation of Enhancement algorithm

Enhancement algorithm	MSE	PSNR	NCC	Avg diff	Structural content
Power Law Gamma Correction	0.0334	18.0469	0.9848	2.6237	1.0134
Contrast Stretching	0.0266	19.9434	1.0018	1.6337	0.9856
Shading Corrections	0.0278	15.6741	0.2456	2.5632	0.9843
(CLAHE)	0.0016	28.9534	1.7653	0.8426	1.7823

4.2. Feature Extraction Results

4.2.1 Result of SGLDM

The aim of this proposed work is to classify a cervical cancer Pap smear images. The Management and Decision Engineering Laboratory (MDE-LAB) database has been used for further experimental tests and results. In the first phase compared three enhancement algorithm of Power law transformation for gamma correction, Contrast stretching and Contrast Limited Adaptive Histogram Equalization (CLAHE) to achieve the quality assessment. Thus, CLAHE will retain the good quality of the image in Pre-processing. There are 13 features have extracted from each feature extraction algorithm using Enhanced CLAHE Pap smear image. SGLDM gives the better feature extraction and obtained accuracy of 93.30% than other algorithm and classification done using Neural Network.

4.2.2 Result of LBP

The LBP operator works with eight neighbors of a pixel, using center pixel value as a threshold. The operation of LBP color image, the RGB Channels are separated individually and fix the threshold value based on middle of the ROI. In this proposed work, have separated Red Channel alone to extract features.If a neighborhood pixel has higher than the center pixel assigned as 1, else it gets a zero. Threshold value is 90 has taken from the proposed CLAHE image.

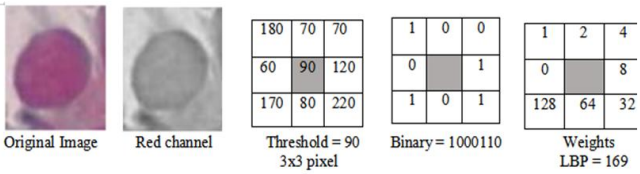

Figure 6: LBP Result of Pap Images

4.2.3 Result of RDM

Using with the set of Enhanced CLAHE Pap smear Images has been extracted and loaded in Neural Network and train the network using scaled conjugate gradient back propagation. The data will be spited into three levels such as Training, Validation and Testing**.** Finally the accuracy has reached 84.60% from extracted features of Pap images.

Table 2: RDM features of three images

Pap smear Images	Properties				
	Ide	shp	smg	smo	Idel
AIS11005	0.0162	0.4519	0.1626	0	6.8617
AIS11006	0.0003	0.1425	0.0387	0	1.7577
AIS11007	0.0001	0.2231	0.0434	0	1.5806

4.2.4 Result of HOG

Histogram of Oriented Gradients is a feature descriptor used for the purpose of object detection. Here, used Cervical Cancer Pap smear images with different cell size.

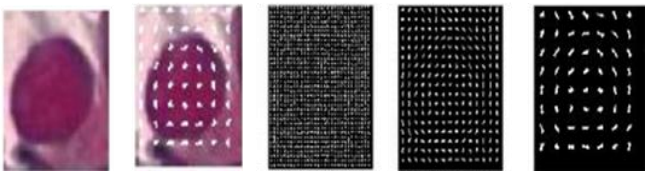

Figure 7: HOG descriptor for different cell size

V.CONCLUSION

The cervical cancer microscopic Pap smear images to determine the real fact of cancer state, which helps the doctor to take right decision and can give proper treatment to the patient earlier. In medical field it is difficult to detect the cervical cancer in pap images due to the nuclei is very small in size. To overcome these problem, Proposed four Enhancement algorithm to improve the resolution of the Pap images. In first phase, used Power Law Transformation for Gamma Correction, Contrast Stretching, Shading Correction and Contrast Limited Adaptive Histogram Equalization (CLAHE). Thus, the CLAHE had achieve the high resolution of the Pap smear images where tested with 165 Pap images. In second phase, used four feature extraction algorithm to extract feature from proposed CLAHE Pap smear images. In SGLDM alone have extracted features for 180 images from MDE-LAB.SGLDM is the best feature extraction for microscopic Pap Images when compared with LBP, RDM, HOG and reached 93.30% accuracy using confusion matrix. ANN is used for classification purpose to achieve the exact results.

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AUTHOR PROFILE

S.Jaya is currently pursuing Ph.D Research Scholar (Full Time) in Department of Computer Scicence at Sri Sarada college for Women (Autonomous), Salem-16. She has published 2 papers. Her area of interest is Digital Image Processing.

M.Latha is currently working as associate professor of computer science in Sri Sarada College for Women (Autonomous), Salem - 16. She has 23 years of teaching experience. Her area of research includes Software Engineering and Digital Image Processing. Her h-index is 5 and i10 index is 4.