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A Detailed Analysis Of Different Enhancement Methods On Low Resolution Cervical Images

BN Bobi Nath[1]*, and S Vimala[2]

[1]Research Scholar, Department of Computer Science, Mother Teresa Women's University, Kodaikanal, Tamil Nadu 624101, India
[2]Associate Professor, Department of Computer Science, Mother Teresa Women's University, Kodaikanal, Tamil Nadu 624101, India

ABSTRACT

The cancer region in high resolution Cervical Image can be easily detected and segmented due to the higher intensity over the entire region of the cervical image. It is very difficult to detect the cancer region in low resolution cervical image due to its low intensity of pixels. Hence, an image enhancement is required for the low resolution cervical image as a preprocessing step in cervical cancer screening method. In this paper, different enhancement techniques are applied over the low resolution cervical images to enhance the internal regions for further cervical cancer screening and its diagnosis. The performance of the proposed enhancement techniques are analyzed in terms of Peak Signal to Noise Ratio (PSNR), Minimum Mean Square Error (MSE), Mean Absolute Error (MAE), Absolute Mean Brightness Error (AMB) and Contrast-to-Noise Ratio (CNR).

Keywords: Cervical, Cancer, Enhancement, Screening, Intensity;

Corresponding author

INTRODUCTION

The second most live threatening cancer in women around the world is cervical cancer as stated by World Health Organization (WHO). The formation of abnormal tissue in the neck of the cervix area of the women patient leads to cervical cancer. The death of the cervical cancer patient will be prevented if it is initially detected through the modern techniques in medical field. The detection process of the cervical cancer is categorized into image and tissue based approaches. Cervicography is the technique to screen the cervical region and Pap smear test is the technique to screen the tissues in cervical region. In both cervicography and Pap smear test approaches, the morphological features such as solidity, area, width and height of the abnormal pattern are observed from the affected areas of the cervical region. Microscopy equipment is used to detect the Pap smear cells in the cervical region and its nucleus is segmented for further morphological process diagnosis. In case of cervicography, a small digital camera is inserted into the cervix region of the women patient and images are captured for further process of cervical cancer diagnosis. The present methods focused the analysis of morphological properties for Pap smear cells which are obtained from the cervical region and intensity variations of the cervical region is used in case of cervicography. Figure 1(a) shows the normal cervical image which doesn't contain any abnormal tissues in the cervical region and Figure 1(b) shows the abnormal cervical image which contains abnormal tissues in cervical region. Both normal and abnormal cervical images are low resolution images.

(a) (b)

Figure 1: Cervical images (a) Normal image (b) Abnormal image.

In this paper, cervicography technique is used for cervical cancer detection process. Most of the cervical images which are captured by digital camera are low resolution images. The accurate detection of the cancer region in cervical image is difficult due to low intensity variations for both normal and abnormal regions in cervical image. Hence, this paper proposes a method to enhance the intensity of the cervical image which helps the radiologist to screen the cancer region in cervical image. This paper is organized into 5 sections. Section 2 illustrates the conventional methodologies for cervical image enhancement and Section 3 proposes the cervical cancer enhancement method. Section 4 discusses the results and Section 5 depicts the conclusion of this paper.

Literature Survey

Sanparith Marukatat [1] used distribution equalization technique to enhance the images. The authors applied intensity distribution over the image region to enhance the edges to achieve higher performance analysis parameters. Ravindra Pal Singh et al. [2] proposed histogram equalization technique to enhance the image. The authors achieved intensity saturation by applying this enhancement algorithm over the image. This method separated the whole image into two regions using intensity threshold and then enhancement was applied. Dezhao Song et al. [3] developed a framework for screening and diagnosing the cervical cancer from the cervical images of the patients using comprehensive algorithmic framework based on Multimodal Entity Coreference. The authors achieved 83.21% sensitivity and 94.79% specificity for the segmentation of cervical cancer region with respect to ground truth image.

Yung-Fu Chen et al. [4] proposed a semi automatic method for segmentation of nuclei region from the Pap smear cells of cervical cancer patients. The authors used Support Vector Machine (SVM) classifier to classify the test Pap smear cell into either normal or abnormal. The authors achieved an average accuracy of 96.12% for segmentation of nuclei region. The main limitation of this work is that the cervical cancer detection system is based on Pap smear cell and not based on cervigram images. Hence, the sensitivity and classification rate was low and this method is not suitable for low resolution cervical and Pap smear images. The detection of squamous cell carcinoma in cervical images based on Discrete Wavelet Transform (DWT) and K-Nearest Neighbor (KNN) classifier was described by Ramapraba et al. [5].

Proposed Method

The screening and diagnosis process of the cervical cancer system consists of preprocessing, feature extraction and classification steps. The preprocessing step is used to enhance the internal features and intensities of the cervical images which are obtained from low resolution cameras. In this paper, we concentrate different enhancement techniques for low resolution cervical images and analysis the suitability of the enhancement method for low resolution cervical images.

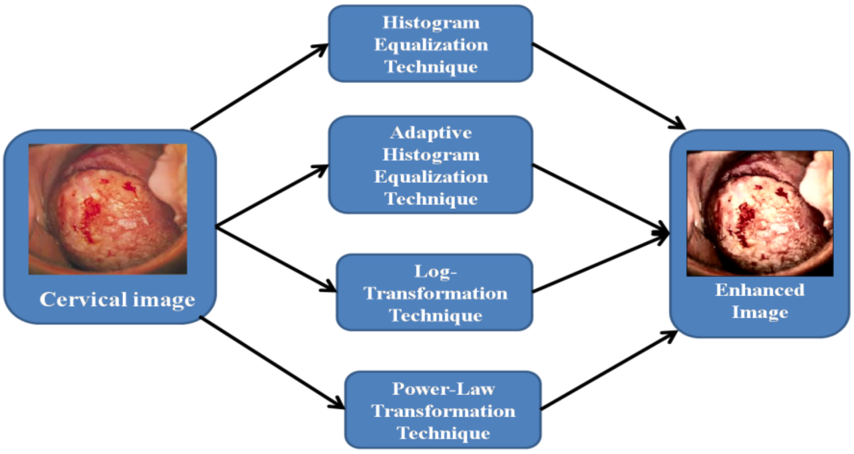

Figure 2: Enhancement methods for Cervical Images

Figure 2 shows the enhancement methodologies for cervical images. In this paper, we use four different enhancement methods for cervical image enhancement as stated below.

- Histogram Equalization
- Adaptive Histogram Equalization
- Log Transformation Technique.
- Power-Law Transformation Technique

Histogram Equalization

It is a method in image processing of contrast adjustment using the image's histogram. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values.

$$h(v) = round\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L-1)\right) \quad (1)$$

where cdf_{min} is the minimum non-zero value of the cumulative distribution function (in this case 1), M × N gives the image's number of pixels (for the example above 64, where M is width and N the height) and L is the number of grey levels used (in most cases, like this one, 256).

Adaptive Histogram Equalization

It differs from ordinary histogram equalization in the respect that the adaptive method computes several histograms, each corresponding to a distinct section of the image, and uses them to redistribute the lightness values of the image. It is therefore suitable for improving the local contrast and enhancing the definitions of edges in each region of an image.

Log Transformation Technique.

The log transformation for cervical image enhancement can be expressed as,

$$S=\log(1+I) \quad (2)$$

Where as, I represents the image to be enhanced

This kind of enhancement technique particularly finds and enhances the dark region pixels in the cervical image region.

Power-Law Transformation Technique

The evaluating expression for power law transformation is given as,

$$s = c * r^{\gamma} \quad (3)$$

This transformation is entirely based on the function 'Gamma' and various enhancement of the cervical image is achieved by varying the gamma function. The difference between the log-transformation function and the power-law functions is that using the power-law function a family of possible transformation curves can be obtained just by varying the λ.

(a) (b) (c) (d)

Figure 3: Normal cervical image enhancement: (a) Histogram Equalization, (b) Adaptive Histogram Equalization, (c) Log Transformation Technique, (d) Power-Law Transformation Technique.

(a) (b) (c) (d)

Figure 4: Abnormal cervical image enhancement: (a) Histogram Equalization, (b) Adaptive Histogram Equalization, (c) Log Transformation Technique, (d) Power-Law Transformation Technique.

RESULTS AND DISCUSSION

In this paper, cervical images are obtained from open access dataset. This dataset contains low and high resolution cervical images. The cancer region in high resolution cervical image can be easily detected and segmented due to the higher intensity over the entire region of the cervical image. It is very difficult to detect the cancer region in low resolution cervical image due to its low intensity of pixels. Hence, an image enhancement is required for the low resolution cervical image as a preprocessing step in cervical cancer screening method. MATLAB R2012 is used in this paper for simulation and this tool effectively enhanced the low resolution cervical image. Table 1 shows the performance analysis of various cervical image enhancement techniques for normal cervical images in open access dataset. Histogram Equalization Technique achieves PSNR about 20.11 dB, Adaptive Histogram Equalization Technique achieves PSNR about 35.80 dB, Log-Transformation Technique achieves PSNR about 17.10 dB and Power-Law Transformation Technique achieves PSNR about 26.07 dB.

Peak Signal to Noise Ratio (PSNR)

$$PSNR = 20\log_{10}\frac{MAX_f}{\sqrt{MSE}} \tag{4}$$

Minimum Mean Square Error (MSE)

$$MSE = \frac{1}{mn}\sum_0^{m-1}\sum_0^{n-1}\|f(i,j) - g(i,j)\|^2 \tag{5}$$

where, 'm' represents width of the fused image and 'n' represents height of the fused image

Mean Absolute Error (MAE).

$$MAE(r,e) = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}|n(i,j)| \tag{6}$$

Absolute Mean Brightness Error (AMB)

$$AMBE(r,e) = |\mu_r - \mu_e| \tag{7}$$

$$CNR(r,e) = \frac{\mu_r - \mu_e}{\sigma_e} \tag{8}$$

Contrast-to-Noise Ratio (CNR)

$$n(i,j) = r(i,j) - e(i,j) \tag{9}$$

$$\mu_r = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} r(i,j) \tag{10}$$

$$\mu_e = \frac{1}{MN}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1} e(i,j) \tag{11}$$

Where, r(i,j) is the original cervical image before enhancement and e(i,j) is the cervical image after enhancement. μ_r and μ_n are the mean of the intensity of the pixels in original and enhanced cervical images, respectively.

Table 1: Analysis of Cervical Image Enhancement Techniques for Normal Images

Enhancement methods	PSNR	MSE	MAE	AMB	CNR
Histogram Equalization Technique	20.11	633.08	48.8	17.88	2845.68
Adaptive Histogram Equalization Technique	35.80	17.07	7.16	3.03	76.16
Log-Transformation Technique	17.10	1265.32	71.74	71.74	1179.43
Power-Law Transformation Technique	26.07	160.41	22.33	22.33	303.10

Table 2 shows the performance analysis of various cervical image enhancement techniques for abnormal cervical images in open access dataset. Histogram Equalization Technique achieves PSNR about 21.22 dB, Adaptive Histogram Equalization Technique achieves PSNR about 32.49 dB, Log-Transformation

Technique achieves PSNR about 16.80 dB and Power-Law Transformation Technique achieves PSNR about 26.50 dB.

Table 2: Analysis of Cervical Image Enhancement Techniques for Abnormal Images

Enhancement methods	PSNR	MSE	MAE	AMB	CNR
Histogram Equalization Technique	21.22	490.27	43.53	14.35	2245.35
Adaptive Histogram Equalization Technique	32.49	36.62	10.17	5.46	153.22
Log-Transformation Technique	16.80	1355.72	73.86	73.86	1322.88
Power-Law Transformation Technique	26.50	145.45	20.65	20.65	300.83

CONCLUSION

In this paper, different enhancement techniques are applied over the low resolution cervical images to enhance the internal regions for further cervical cancer screening and its diagnosis. The adaptive histogram equalization method provides optimum enhancement over the other enhancement techniques. The performance of these different enhancement techniques are analyzed in terms of PSNR, MSE, MAE, AMB and CNR.

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