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Digital Image Processing: Gizmo in CIN Diagnosis

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***Abstract*—Cervical intra-epithelial neoplasia (CIN) is a disorder that indicates the possibility of a developing cervical cancer, and it is therefore important to diagnose and treat it as early as possible. Image Processing Techniques such as image acquisition, segmentation, compression and registration are used in medical field for the diagnosis of CIN. This work focuses on image analysis technique that can fetch comparative results based on Image Texture Analysis & help early detection of CIN in order to prevent cancer**

I. INTRODUCTION

Cervical cancer is the second most common cancer in females worldwide, with nearly a half-a-million new cases and over 270,000 deaths annually. Image analysis of cervical imagery can be used in cervical cancer screening and diagnosis with the potential of having a direct impact on the improvement of women's health care and associated cost reduction [3].
Lesion characteristics such as margin, contour, color, opacity, blood vessel caliber, inter-capillary spacing, and capillary distribution help in clinical diagnosis.
Early detection of CIN aids in prevention and treatment of cervical cancer [2].

As invasive diseases are preceded by pre-malignant cervical intraepithelial neoplasia (CIN), if it is detected early and treated adequately, cervical cancer can be universally prevented[2][3].

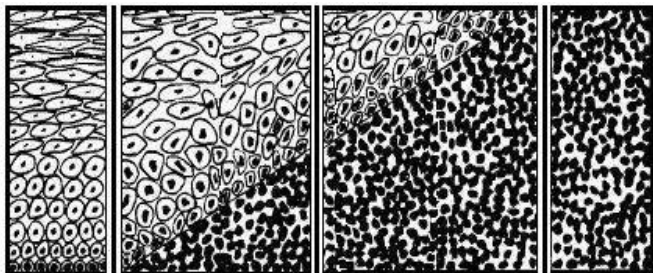

Fig.1. Structural model (histological)of cervical epithelium in normal and CIN conditions[8]

CIN is categorized histologically as grades 1, 2, and 3, depending on the severity of the lesions [3]. The diagnosis of cervical cancer or CIN is based on the interpretation of visually assessed features of cervical histological slides. Diagnostic decisions are generally made by an individual pathologist with a broad range of experience. This process is extremely subjective in nature, resulting in inter- and intra-observer variation and poor reproducibility in the grading of cervical lesion. Image processing tools can aid in clinical diagnosis. Quantitative measurement and analysis of images captured during colposcopy or any other digital imagery system can provide a diagnostic and prognostic tool for gynecologists. It also reduces the need of biopsies [7][8].
Diagnostic digital image processing is a gizmo in the field of medicine.
These technologies have greatly increased the knowledge of normal and diseased anatomy for medical research and are a critical component in diagnosis and planning of treatments [8].
This paper discusses a complete system with digital image processing tools that can aid in the diagnosis of CIN. The significance and confidence of each individual tool used in yielding adequate diagnostic clue is elucidated.

II. DIGITAL IMAGE PROCESSING SYSTEM

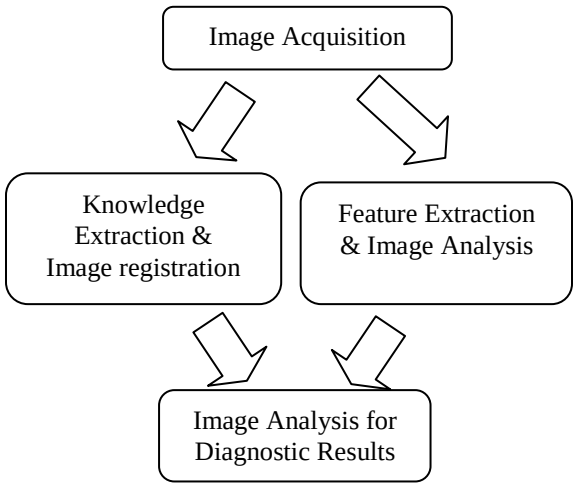

Fig.2. Model of the Digital Image Processing System

A system using Digital Image Processing tools is represented in this block diagram that can help in the diagnosis of CIN.

A. Image Acquisition

Colposcopy is a well established diagnostic method to detect cancerous and pre-cancerous tissues.
The method involves application of acetic acid (3-5%) on the cervix inducing color and textural changes in abnormal and

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metaplastic epithelium. Maximum contrast is achieved in 60 seconds after which cervix regains its originality in three to five minutes. The color changes are observed through a low magnification microscope (colposcope). The Colposcopic findings are confirmed by biopsy studies [1][4].

Generally, 60 images are captured in the first minute of image acquisition stage (640x480) as a base line reference (1 frame/s).Each image is then saved independently [4].

Other imaging techniques such as virtual microscopy that creates image files through scanning of histo-pathological slides are also used and are within the scope of digital pathology. Magnetic Resonance Imaging (MRI), computed tomography (CT), digital mammography and other imaging modalities can provide an effective means for non-invasively mapping the anatomical abnormality of any subject [8].

Compared to traditional techniques, major advantages of digital image acquiring systems are - images can be viewed , archived and retrieved easily and most importantly analyzed using image processing tools rather than by manual analysis .

B. Image Registration

Registration is the preliminary stage in image processing carried out to analyze the sequence of acquired images, i.e. to compare and evaluate corresponding subjects in the images that are brought into the same position by removing the differences. For example, from series of colposcope images (taken at different time intervals) only some images are used for analysis with respect to normal reference image used as a standard.

Defining regions of interest (ROI) within the larger image is an important task .This is done by segmentation. For the segmentation of ROIs, there are two common approaches: edge-based and region-based. Edge-based techniques, such as edge detection, are based on pixel discontinuity within a neighborhood, and are a common approach for detecting meaningful discontinuities in intensity values. Edges define the boundaries of regions and can thus be used for segmentation. An alternative way is to use region-based techniques, such as texture classification, which are based on the similarity of a pixel to its neighborhood.

A spatial transformation (also known as a geometric operation) modifies the spatial relationship between pixels in an image, mapping pixel locations in an input image to new locations in an output image These include resizing, rotating, cropping,2-D and 3-D or N-D transformations that can be applied to the image. Transformations can be applied point wise, linear or piecewise–linear.

In system suggested, a point transformation is applied with image resizing .The control point pairs (ROIs) are manually selected and placed to check the epithelial lining feature .The resultant Colposcopic image of normal cell after pre-processing is illustrated in the figure.

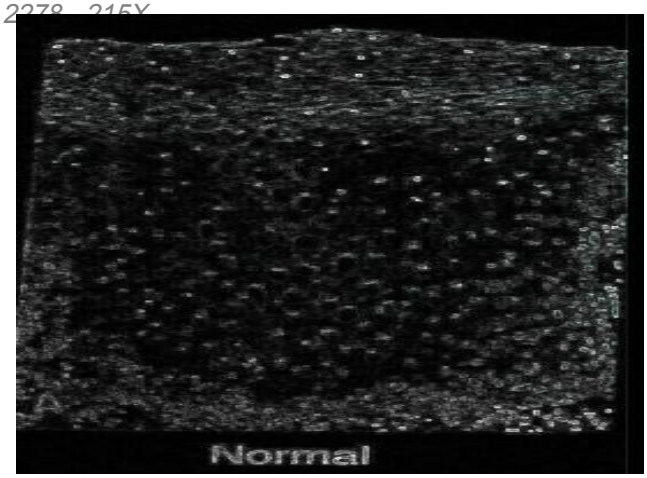


Fig 3-Normal cell image after point transformations

C. Feature Extraction & Image Analysis

After registration process, the signal to noise ratio is increased using a spatial low pass filter implemented using a kernel window (3x3). The intensity value of each pixel over time is used to construct a time series. For this analysis the important parameter i.e. the rate of change can be estimated [3].

The segmentation methods based on regional approaches suitable for CIN analysis include- thresholding , Region growing, Classifiers, Clustering ,Markov random field models, Artificial neural networks, Deformable models, Atlas-guided approaches etc. [5].

Cervical histological scenes are complex in nature, with the presence of large numbers of edges. There are major structural edges, such as the boundaries between squamous epithelium and stroma, and between squamous epithelium and background. But there are also lesser edges – for instance, edges caused by folds, nuclei boundaries and cellular structures inside squamous epithelium and inside the stroma. Therefore, edge information alone is not sufficient to identify the boundaries between squamous epithelium /stroma/ backgrounds but along with it a detail texture analysis has to be done to yield necessary data [8].

In case of CIN diagnosis, important features are inter-capillary distance, coarseness of vessels and regularity of patterns. These are considered as regions of interest and are analyzed to generate the diagnostic data.

Diagnostically significant results after pixel intensity and edge detection based image analysis of CIN include –

- The inter-capillary distance- the distance between vessels or space encompassed by the vessels. In normal epithelium, the maximum inter-capillary distance of the hairpin and network capillaries varies, but it ranges from approximately 50 to 200 µm with an average of about 100 µm.

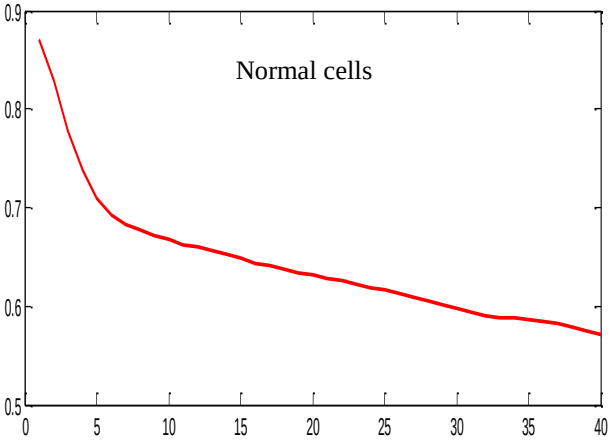
  On the other hand, the maximum inter capillary distance increases as the lesion becomes more severe, i.e. in CIN 1 the average inter-capillary distance may

be 200 µm, whereas in CIN 3 the greatest inter-capillary distance is often 450 to 500 µm [2]

- Grading of Observed Vascular Patterns- In mosaic and punctuation patterns, the inter-capillary distance increases as the degree of histological abnormality in the epithelium becomes greater. Mosaic and punctuation may be additionally graded on the basis of coarseness of vessels and regularity of their pattern: the more severe underlying lesion, the coarser the vessels are likely to be and the more irregular the pattern [2].
- Regularity of patterns - The distinctive vascular patterns associated with abnormal epithelium are mosaic and punctuation. The punctuation pattern is easily recognized, being characterized by dilated, elongated, often twisted and irregularly terminating vessels of the hairpin type, arranged in a prominent punctuate configuration. Its essential colposcopy appearance is a series of fine red dots in a whitish background [2].

Texture analysis refers to the characterization of regions in an image by their texture content. Texture analysis attempts to quantify intuitive qualities described by terms such as rough, smooth, silky, or bumpy as a function of the spatial variation in pixel intensities. In this sense, the roughness or bumpiness refers to variations in the intensity values, or gray levels. The analysis is done using all the available filters in the mat lab such as range-to find variations in the gray levels, knowing standard deviation in the gray levels and finding the entropy of the gray scale images under various stages of CIN.

The GLCM technique (Gray level Co-Occurrence Matrix) yields results that are shown below. There are 40 coordinate points considered that are listed on X-axis and the gray level analysis is on Y-axis.



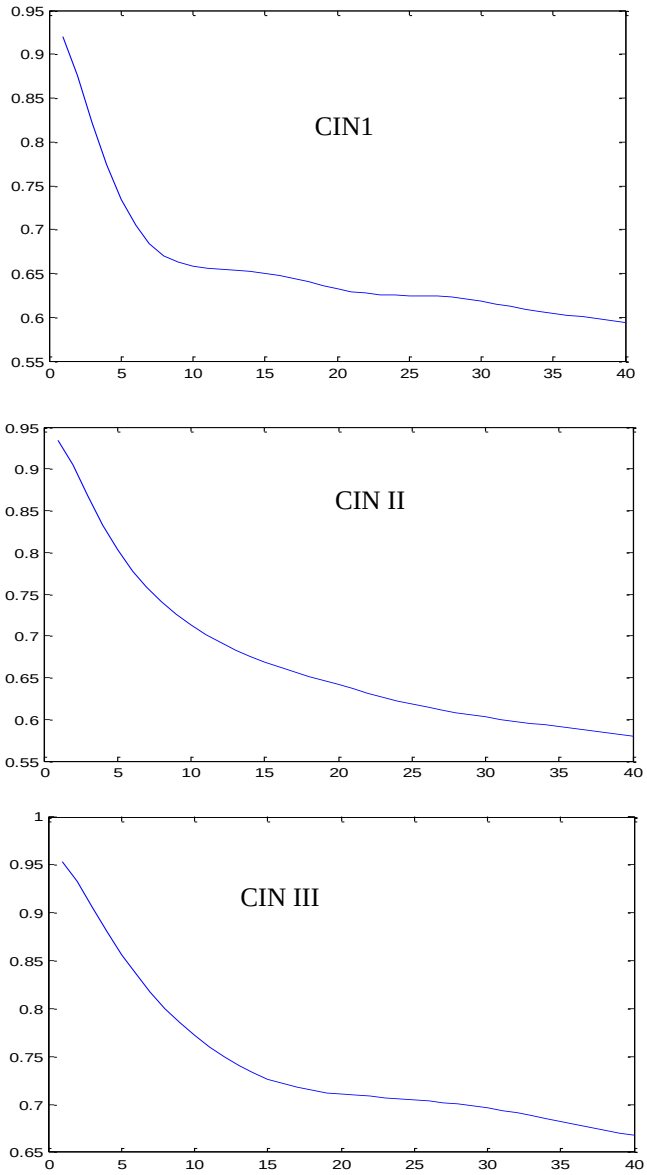


Fig 4 Image Texture Analysis Results

The texture analysis results clearly indicate absolute differences in the three cases of CIN that can help in diagnosis at an early stage

D. Diagnostic Results

The Complete Image Processing system with stored image database which is updated with every new testing sample is suggested.

The images acquired by other imaging techniques can be analyzed using multi-resolution approach to minimize large and complex data practically without compromising segmentation accuracy [8].

Diagnostic clues that are outcome of this system are compared with the standard reference data .The system performance can

be enhanced with comparative analysis to attain more precision in diagnosis.

With incorporation of maximum image processing tools, accuracy in CIN diagnosis can be maximized.

III. CONCLUSION

The Digital Image Processing is a gizmo in CIN diagnosis as traditional way of diagnosing CIN is subjective, resulting in great inter/intra observer variability and poor reproducibility.

First, main challenging task is use of complex histological imagery that requires greater robustness to be able to handle non-typical situations, such as isolated and/or circular regions of squamous epithelium. The other difficulty being computation time: the large nature of imagery data requires data optimization, less computationally intensive algorithms for feature extraction and computation of results.

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