

Segmentation based Specular Reflection Detection in uterine cervix images

D. B. Patil¹, Dr. S. B. Patil², B. T. Salokhe², R. T. Patil²

¹ (Electronics Engg. Department, TKIET Warananagar, Shivaji University, India)

² (Electronics Engg. Department, JIMCOE Jaysingpur, Shivaji University, India)

² (Electronics Engg. Department, TKIET Warananagar, Shivaji University, India)

² (Electronics Engg. Department, TKIET Warananagar, Shivaji University, India)

ABSTRACT : Cervicography is one of the methods for cervical cancer screening that uses visual testing based on the color change of cervix tissues when exposed to acetic acid. Cervicography is a technique for visual screening of cervical cancer. In this approach, during a gynecological exam, the uterine cervix is washed with 5% acetic acid for one minute, the process is known as visual inspection after the application of acetic acid (VIA), which causes whitening of potentially malignant regions of the epithelium; these regions are called acetowhite lesions (AW). A cervicographic image is a photograph of the uterine cervix after acetic acid treatment obtained with a specialized 35-mm camera outfitted with a ring flash. Image preprocessing is required prior to invoking AW detection algorithms on cervicographic images for two reasons: (1) to remove Specular Reflections (SR) caused by camera flash, and (2) to isolate the cervix region-of-interest (ROI) from image regions that are irrelevant to the analysis. Another technique is colposcopy in which the images of uterine cervix are obtained with a specialized camera outfitted with a ring flash. In this paper the simulation of segmentation based detection of specular reflection is carried out using simulink toolbox of MATLAB prior to this image processing toolbox (IPT) is used for preprocessing and the results obtained are the detected SR regions in an uterine cervix images. The automatically finding and isolating cervix region of interest is very helpful when compared with manually finding and isolating cervix region of interest for diagnostics in cervical cancer.

Keywords - Acetowhite [AW], Cervicography, cervix region-of-interest [ROI], inspection after the application of acetic acid (VIA), Specular Reflection [SR].

I. INTRODUCTION

1.1 Cervical cancer: The cervix (Fig.1) is the lower part of the uterus (womb). It is sometimes called the *uterine cervix*. The body of the uterus (the upper part) is where a baby grows. The cervix connects the body of the uterus to the vagina (birth canal). The part of the cervix closest to the body of the uterus is called the *endocervix*. The part next to the vagina is the *exocervix* (or *ectocervix*). The 2 main types of cells covering the cervix are *squamous* cells (on the exocervix) and *glandular* cells (on the endocervix). The place where these 2 cell types meet is called the *transformation zone*. Most cervical cancers start in the transformation zone. Most cervical cancers begin in the cells lining the cervix. These cells do not suddenly change into cancer. Instead, the normal cells of the cervix first gradually develop pre-cancerous changes that turn into cancer. Doctors use several terms to describe these pre-cancerous changes, including cervical intraepithelial neoplasia (CIN), squamous intraepithelial lesion (SIL), and dysplasia. These changes can be detected by visual inspection after acetic acid application (VIA) on uterine cervix and treated to prevent the development of cancer. Cervical cancers and cervical pre-cancers are classified by how they look under a microscope. There are 2 main types of cervical cancers: *squamous cell carcinoma* and *adenocarcinoma*. About 80% to 90% of cervical cancers are squamous cell carcinomas. These cancers are from the squamous cells that cover the surface of the exocervix. Under the microscope, this type of cancer is made up of cells that are like squamous cells. Squamous cell carcinomas most often begin where the exocervix joins the endocervix. Computer-aided analysis of these images would assist in automated lesion detection and post-screening research and training. Researchers at various cancer institutes are developing automated lesion detection and tissue classification algorithms.

1.2 Automatic Detection of Specular Reflections:

Specular reflections frequently appear in photographic images and interfere with numerous computer vision tasks, such as segmentation, object recognition, shape from shading and binocular stereo. Sometimes they provide useful information about the shape of the objects within the image. In all cases there is the need for identification and special treatment of these potentially problematic regions. Segmentation methodologies are being developed for the identification of three main tissue types: the squamous epithelium (SE), which is smooth and pink, the columnar epithelium (CE) that appears red and irregular (textured) and the acetowhite (AW) region which is a transient, white-appearing epithelium following the application of acetic acid (Fig.2) G. Zimmerman-Moreno and H. Greenspan[4]

Correct (highly sensitive and specific) identification of AW lesions is of clinical importance, since they are a major visual indicator in diagnostic tests for cervical cancer. Initial investigation into cervigram segmentation revealed the significance of specular reflections elimination. Specular reflections (SR), or highlights, are generated in every cervigram as a consequence of the image acquisition process. They obstruct the tissues of interest thus hindering various stages of automatic segmentation. The bright white regions of SR may be mistaken for Acetowhite lesions which are usually relatively light. Furthermore, the high gradients created by SR amplify the local contrast causing erroneous results during extraction of texture features. Such missidentification could cause an incorrect labeling of a cervigram.

A small number of works addresses the problem of specularities in cervical images. A semi-automated algorithm is introduced in a work by Hervet and Kardouchi[5]. An image is first segmented into a large number of regions. The user is required to manually identify the segments belonging to specularities. A histogram transform is then applied between the highlight and the normal tissue region thus eliminating the highlights.

In another work, Van Raad[6] models the pixel distribution in an image as a Gaussian Mixture Model in RGB color-space, where one Gaussian represents SR pixels and another one represents the rest of the image. This model is created based on a set of images. A linear distance measure is used to classify pixels in an image to SR and non-SR pixels. The subject of highlight elimination was extensively investigated in the last twenty years. Physics based approaches often utilize the Dichromatic Reflection Model (DRM) that describes a color of dielectric materials as a linear combination of an object color and highlight color. Klinker[7] and Gershon[8] devised automatic algorithms for highlights elimination, based on the DRM.

The focus of this work is on highlight (specularity) detection and its removal in a particular type of medical images, the cervigrams.

II. SPECULAR REFLECTION DETECTION:

2.1 Types of input images: We have taken a set of 10 data samples. Types are Color, Binary and Gray and for our purpose these images can be taken in .jpg, .jpeg or .tif image formats. Within the cervicographic image, only the region containing the cervix is of significance for our purposes. Hence, it is important to isolate this cervix region-of-interest (ROI) from visual features outside this region, which include vaginal walls and other noncervix anatomy, instruments such as the speculum or a swab, and text labeling or other markings that have been superimposed on the film. It is also important to isolate regions where reflections from the camera flash are of such high intensity that they obscure other visual features. For these reasons, digitized Cervicography images need to be preprocessed for cervix region-of-interest (ROI) extraction and specular reflection (SR) detection and removal before automated lesion detection can be performed.

Our work is focused on detection of specular reflections in these images of acetowhite (AW) lesions, which are sometimes correlated with cervical cancer. These lesions are characterized by the whitening of regions along the squamocolumnar junction on the cervix when treated with 5% acetic acid. Image preprocessing is required prior to invoking AW detection algorithms on cervicographic images.

2.2 Edge detection:

For the detection of specular reflection we have used Image Processing Toolbox (for Fig.3) and Simulink Toolbox (for Fig.4) from MATLAB software. While using simulink for method parameter, if we select Sobel, Prewitt, or Roberts, the Edge Detection block finds the edges in an input image by approximating the gradient magnitude of the image.

If we select Canny, the Edge Detection block finds edges by looking for the local maxima of the gradient of the input image. It calculates the gradient using the derivative of the Gaussian filter. The Canny method uses two thresholds to detect strong and weak edges. It includes the weak edges in the output only if they are connected to strong edges. As a result, the method is more robust to noise, and more likely to detect true weak edges.

The Edge Detection block computes the automatic threshold using the mean of the gradient magnitude squared image. However, you can adjust this threshold using the Threshold scale factor (used to automatically calculate threshold value) parameter. The block multiplies the value you enter with the automatic threshold value to determine a new threshold value.

III. MAGNITUDE OF THE INTENSITY GRADIENT IN CANDIDATE REGIONS:

3.1 Segmentation of SR regions:

In images containing moist tissues, such as cervigrams, reflection regions appear as small bright spots and therefore are associated with high gradients in their vicinity. The candidate regions are obtained by selecting only the pixels in the vicinity of high gradients. Regions of strong gradients were located by applying a threshold on the magnitude of the intensity gradient:

$$|\nabla G| = \sqrt{\left(\frac{\partial I}{\partial x}\right)^2 + \left(\frac{\partial I}{\partial y}\right)^2} > 0.15$$

The resulting regions contain all of the SR pixels, as well as some additional neighboring pixels, approximately in equal proportion. The above set of thresholds was found empirically through a detailed study of a large database of cervigrams. Other types of images may require a different set of thresholds.

4. FIGURES:

The results obtained in our work have been shown to gynecologists and oncologists from Kolhapur Cancer Institute and are as follows:

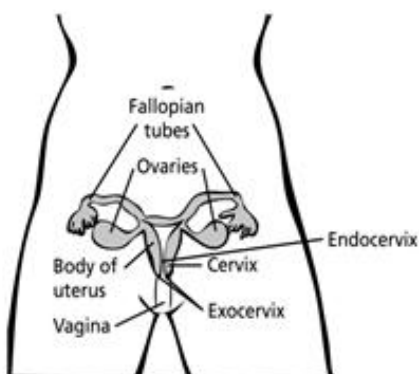


Fig.1: Cervix- the lower part of uterus

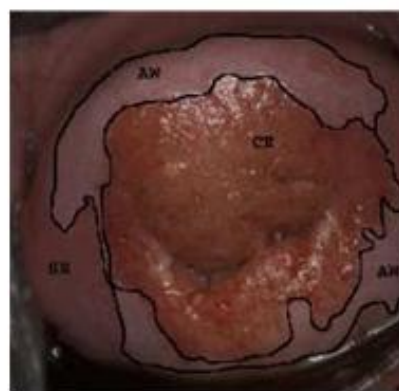


Fig.2: segmentation of three main types of tissue



Fig.3: (4) shows SR detection by Robert's Method using IPT of MATLAB.

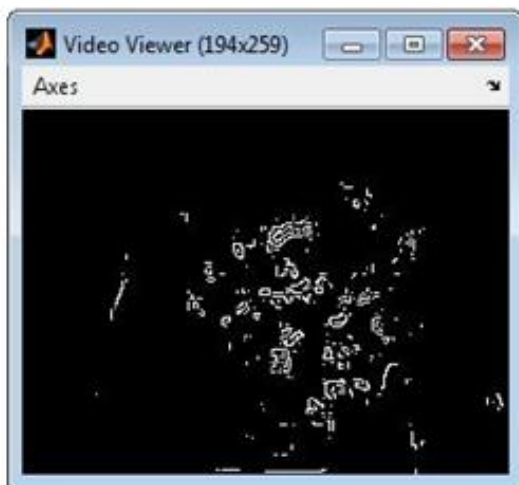


Fig.4: shows SR detection by Robert's Method using simulink toolbox of MATLAB.

5. CONCLUSION

The aim here is to identify the specular reflections in uterine cervix images, thus facilitating further processing of these images while diagnosing the cancer patient. We have obtained the satisfactory results as Color image enhancement and specular reflection detection based on segmentation. We have taken a set of 10 data samples a (Uterine cervix images) The resultant images are useful to gynecologists and oncologists while diagnosing the cancer patient. The work done here is applicable to all kinds of medical images where reflection due to camera flash is present For instance; specular regions are to be discarded when image segmentation is performed so that they are not mistaken for AW lesions. On the other hand, when extracting texture measures, the specular regions have to be not only identified, but completely eliminated

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