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DETECTING LEOPARD SKIN IN THE CERVIX BY IMAGE PROCESSING METHOD

Nguyen Ngoc Quynh[1,*], Dam Trung Thanh[2], Nguyen Minh Hung[2], Phan Ngoc Khuong Cat[3], Tran Van Tien[3], Ly Anh Tu[3]

[1]*Department of Biomedical Engineering, Faculty of Medicine, Nguyen Tat Thanh University, Viet Nam. e-mail: nnquynh@ntt.edu.vn*

[2*] *Department of Biomedical Engineering, Faculty of Applied Science, Ho Chi Minh City University of Technology, Viet Nam.*

[3]*Department of Applied Physics, Ho Chi Minh City University of Technology, VNU-HCM, Viet Nam.*

Abstract

Leopard skin appeared on the surface of the cervix in vaginitis is associated with trichomoniasis infection. Trichomoniasis is the most common sexually transmitted infections (STIs) worldwide with more than 250 new cases each year and about 70% of cases without any signs or symptoms. The appearance of leopard skin in the cervix is the origin of cervicitis and some other dangerous gynecological diseases. Without early detection and prompt treatment, the disease can become one of the causes of infertility and cervical cancer. In clinical, colposcopy combined with the use of Lugol's iodine is a common method for detecting the presence of leopard skin. This method is considered to be of low accuracy, the diagnosis result depends on the quality of Lugol, the smear technique, and the experience of the doctor reading result. In this study, based on the distribution characteristics of blood and glycogen, we developed an automated method of detecting the presence of leopard skin from images obtained by digital colposcopes. Results of image segmentation are compared and evaluated with the traditional method.

Key words: leopard skin, trichomoniasis, cervix, digital colposcopes.

1. Introduction

Trichomoniasis is one of the sexually transmitted infections (STIs), it occurs in both men and women with more than 250 million new cases each year and a prevalence of more than 180 million people infected [1]. In women, cervicitis caused by trichomoniasis is gradually becoming popular all over the world. The incidence of this disease is different in different groups of countries, it depends on many factors such as differences in science and technology, and cultural differences. In 2016, WHO estimated that the number of trichomoniasis cases occurring globally each year was higher than that of chlamydia, gonorrhea, and syphilis combined. The number of sexually related diseases is on the rise, and the number of trichomoniasis cases has increased by half after nearly a decade [1-2]. In Vietnam, the rate of cervicitis caused by trichomoniasis is gradually becoming popular. However, statistical studies on specific data are still lacking and not really interested.

Cervicitis caused by trichomoniasis is divided into two main stages: the leopard skin stage - the first stage of the disease when there are no specific symptoms; the strawberry stage - when the disease has turned to a severe stage and has a clear manifestation. Accordingly, the disease in the leopard skin stage needs to be detected earlier to increase the effectiveness of treatment. At this stage, the cervical surface is still smooth, does not show inflammatory spots, and has no special symptoms. Today, the method of supporting the diagnosis of cervicitis caused by trichomoniasis in clinical is divided into two groups: cytology and histology. The typical method based on cytology is the cervical smear (Pap test). For histology, the typical method is colposcopy combined with a smear of Lugol's iodine solution on the surface, also known as visual inspection with Lugol's iodine (VILI). Each method has its advantages and disadvantages. Specifically, the Pap test method is highly accurate, but time-consuming as well as the cost is still an issue. The VILI method is cost-effective and gives quick results, but the sensitivity and specificity are not high. In clinical practice, the VILI method is the most commonly used method and is considered the gold standard in diagnosing the disease. However, the results of this approach depend on the quality of Lugol's iodine and the specialist's experience in reading diagnostic results. Therefore, there are still subjective factors and differences in disease diagnosis among various evaluators.

Trichomoniasis region has a mechanism of glycogen loss compared with normal regions. So, when smeared on the cervical surface a quantity of Lugol solution (strong iodine solution), the amount of glycogen present in the normal area will react with the amount of iodine in Lugol's solution to make dark brown on the cervical surface. In contrast, inflammatory sites with little or no glycogen will appear light brown due to the inability to color with Lugol. From there, through the staining of Lugol with glycogen, the doctor can easily show the infected trichomoniasis area to conduct further tests. However, the above method only makes conclusions about the location of the infected trichomoniasis area through visual observation with the naked eye and the results depend on the experience of the specialist. In addition, the spread of a chemical like Lugol on the sensitive parts is uncomfortable, and psychological reluctance to actively take part in regular health visits of patients [3-5].

Nowadays, with the development of computers, the use of image processing techniques to improve the efficiency of the use of metrological equipment is an increasing concern and growing in biomedical engineering. In recent years, many algorithms to automatically detect and segment anomalies in biomedical images have received more research and application interest. Many authors have proposed different methods to segment the cervical area from the original cervical image. In 2016, A. M. Grajales et al., performed a study on cervical image segmentation using active contours via acetowhite (AW) samples. In this study, a method for segmenting an image of the cervix based on temporal changes in AW reactions was presented [6]. The results show that a study method is a promising tool to aid colposcopy in the early detection of cervical cancer and to reduce mortality of this disease. More recently, in 2017, the J. Liu team did a study of segmentation of the AW region from cervical images using ratio combined images [7]. Another study by the B. Bai group about automatically classifying pathological regions in cervical images using the K-mean algorithm was conducted in 2018 [8]. The study has demonstrated that segmentation of the pathological area from HSV color space-based colposcopy images using the K-means algorithm has high clinical efficiency and helps experts in the early diagnosis of cervical cancer.

In this study, we build a method of image processing to automatically detect trichomoniasis on the cervix at the stage of leopard skin based on the properties of the disease. Specifically, it is the distribution of blood and glycogen in normal cervical tissue and in cervical tissue with leopard skin. The proposed method helps to overcome the limitations of traditional methods. Images of the leopard skin cervix before and after smear Lugol's iodine was captured by colposcopy using polarized light. This image is processed and compared and evaluated with the results with traditional methods. A standard diagnostic system with clear execution and computational workflow is essential. It is consistent with the goal of minimizing subjectivity to the lowest level and improving the accuracy of diagnostic results.

2. Methods

2.1. Data collection method

In this study, the cervical images before and after Lugol smearing of leopard skin were collected by the model of colposcopy using a polarized led source. This model was approved by the Research Ethics Committee of the National University of Ho Chi Minh City. Accordingly, the cross-polarization technique used in the device helps to eliminate the mirrors of reflections from water, mucus on the surface of the cervix. The captured image is a Full HD image, it has a size of 1920 1080 pixels and good support for optimal image processing. In addition, polarized images also contain important information to support image processing to increase the contrast between normal and diseased tissues.

The method of acquiring colposcopy images is performed by an obstetrician and is safe for the patient. The data collection process consists of 5 steps, as follows:

-Step 1: Patient is in position for gynecological examination.

- Step 2: The doctor uses a speculum forceps to enlarge the patient's vagina and expose the cervical.

- Step 3: The doctor uses a colposcope to look at the cervical and look for abnormal cells. Take and save the original colposcopy image.

- Step 4: Doctor smears 3% - 5% Lugol solution on the surface of the cervical. Then do the same step 3. Take and save the image after Lugol smearing.

- Step 5: The doctor gives the diagnosis and returns it to the patient.

2.2 Image processing method

The cervical mucosa is composed of many epithelial layers such as (figure 1) and contains large amounts of glycogen. When there is trichomoniasis on the cervix, the amount of glycogen in the epithelial layers will gradually disappear as they are used to restore the damage and accumulate for the growth of the inflammatory area. Therefore, the area of trichomoniasis will have a distribution of blood vessels closer to the tissue surface than the normal area. Trichomoniasis in the leopard skin stage usually does not show clearly, the blood distribution begins to change very small so it is difficult to identify through visual observation. In the strawberry stage, the disease is more obvious, some inflammatory sites will gradually develop into convergence points forming a strawberry network on the surface of the cervix. Therefore, in this study, a number of related image processing methods investigating the distribution of blood were developed in order to clearly identify the locations of the hematoma on the cervical surface. Thereby supporting the detection of cervicitis in the leopard skin stage [5].

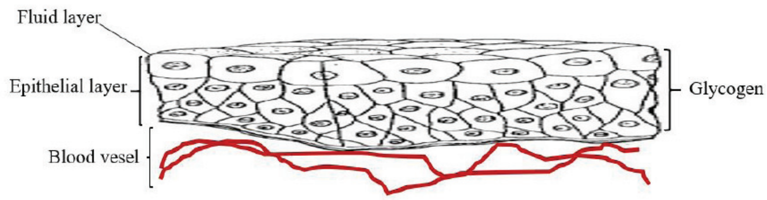


Figure 1: Distribution of blood and glycogen in cervical tissue.

Image processing is a technique that enhances image quality, image processing is seen as the input image manipulation process to produce the desired results. The output of image processing can be a “better” image or a ”conclusion”. In this study, from the white picture of the cervix is diagnosed leopard skin, we performed filter noise, increase the contrast of the inflammatory area and finally segment the inflammatory spots. Inflammatory score segmentation results will be evaluated and compared with the Lugol smear method. The cervical inflammation points are the convergence points, concentrating many blood vessels. The blood vessel shape is quite thin and has a color similar to the cervical background color creating obstacles. In this proposed method, inflammatory spots are determined by examining the properties of the image. The main steps of the process are shown in the diagram in figure 2.

Many studies have shown that hemoglobin absorbs blue and green light very strongly in the RGB color space. So, when separating the white cervical images into blue (B) and green (G) channels, the convergence points on the cervix will appear as dark spots on a light cervical background [9-10]. On the other hand, bright red blood will have high color saturation, when separating the white image of the cervical to a saturated color channel in the HSV color space, the convergence points will appear as bright blobs on a darker cervical background. Based on these absorption properties, combining images at different wavelengths such as blue or green in the RGB color channel with the saturation channel in the HSV color channel becomes significant in increasing the contrast of the trichomoniasis area.

To contrast enhancement for the purpose of analyzing cervical morphology with trichomoniasis, the hematoma sites have been identified by splitting the primary colposcope image into three channels: the blue and the green (RGB color space); and channel saturation (HSV color space). However, when combining color channels, it is necessary to balance the image because the image of the cervix with trichomoniasis after passing the blue or green channel and after passing through the saturated color channel is completely opposite. By creating an inverted image of the blue or green channel after passing the Gaussian refinement filter and aggregating it with the image from the saturation

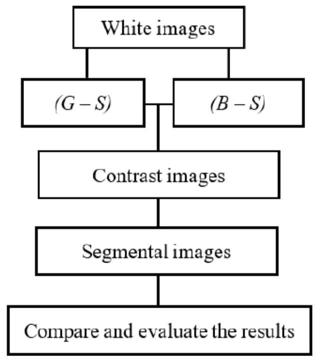


Figure 2: Algorithm diagram.

channel increases the contrast of the convergence sites on the surface.

The image after increasing the contrast will get the Gaussian filter to eliminate the noise. The image will then be sharpened to clarify the convergence points. After the sharpening process, the Wiener filter is used to remove the noise again. The Otsu threshold method is next applied to remove gray. Image after being filtered for noise continues to use the morphological expanding algorithm. A segmented image of the trichomoniasis region is shown. Finally, we compared and evaluated the results of image segmentation with the image after applying Lugol.

To choose either method of combining blue and saturated (B - S) or green and saturated (G - S) images as the optimal method for contrast enhancement of positions trichomoniasis, figure 3 depicts the contrast assessment for these two images matching methods. This process is performed on images of trichomoniasis in the strawberry stage. Because the image of the strawberry cervix shows a clear difference between the normal and the pathological area. From the white picture of the two strawberry-stage trichomoniasis cases, the trichomoniasis and the normal region were selected and marked as (TV) and (NA) respectively, as shown in figure 3. After 25 TV-NA pairs have been selected, graphs depicting the contrast ratio (solid line) and the average contrast ratio (dashed line) of the 25 zone pairs are given. Accordingly, the (B - S) image composite method is represented by the blue line and the (G - S) image composite method is represented by the green line.

According to the graph comparing the contrast coefficient of the two methods (B - S) and (G - S) (figure 3), the average contrast coefficient of the two methods has a big difference. This means that the combination of images by the two methods is not the same as what the naked eye sees and perceives. Specifically, the case of strawberries in the figure shows that the average con-

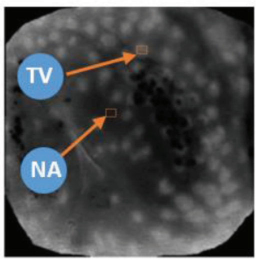
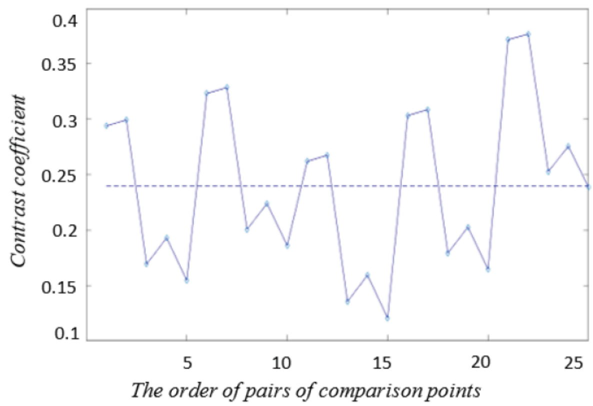
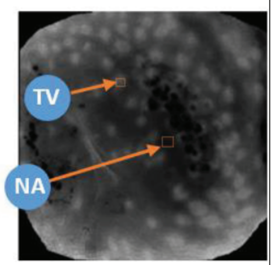
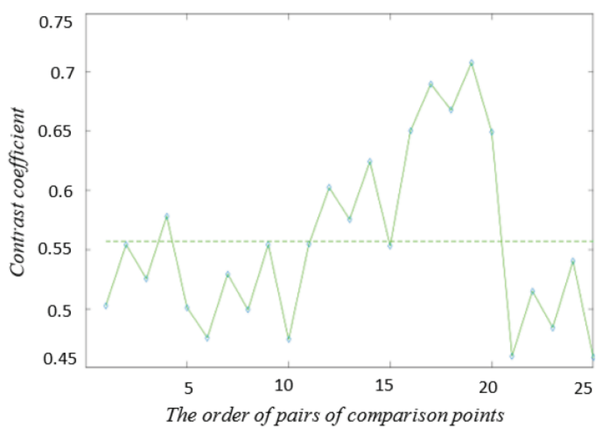
Image after increasing contrast	Graph comparing the contrast coefficient of two methods B - S and G - S
Trichomoniasis area: TV *Normal area:* NA	*The solid line: Contrast coefficient of 25 selected area pairs* *The dashed line: Average Contrast Ratio (M_{TB})*
 *(B – S) combination method*	 **M_{TB} = 0.2397**
 *(G – S) combination method*	 **M_{TB} = 0.5571**

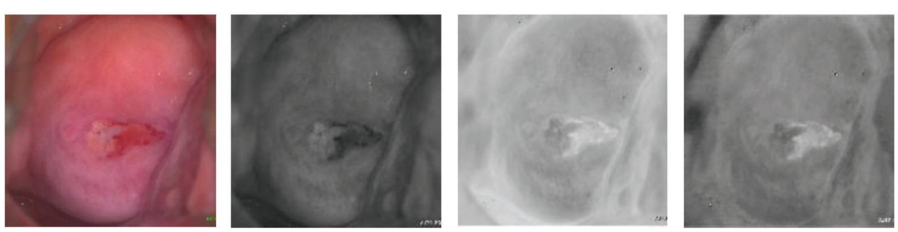
Figure 3: Evaluation of two methods of image combination (B – S) and (G – S).

trast coefficient of the 25 TV-NA region pairs selected in the method (B - S) is 0.2397, much lower than that of the method (G - S), it is 0.5571. Thus, in this study, the image combination method (G - S) will be applied to increase the contrast of trichomoniasis in the leopard skin stage.

3. Results

A white polarized image of leopard skin cervix (figure 4a) is recorded for high quality, clear image, and true color. All leopard skin images obtained are photos with high resolution 1920x1080 pixels, Full HD, capacity about 2.8MB, and saved in * .png format. This is an image that uses data compression without losing the original data. With this format, the image supports 24-bit RGB color, so the resulting image has true-to-life color and helps the doctor better diagnose. In addition, the resulting images contain sufficient information for image processing. In particular, the image does not have surface glare.

For cervical white polarization images at the leopard skin stage, the boundary between the site of trichomoniasis and the normal region is almost indistinguishable. Because the correlations are similar in these two regions, at the same time other signs of the disease are faint. The disease can be detected in this period thanks to the patient actively conducting regular check-ups. The process of increasing contrast in the leopard skin area was conducted by image combination technique (G - S) as described in the method section. To assist in this process the white image of the cervix with leopard skin (figure 4a) was split into a green channel image (figure 4b), a green channel inversion image (figure 4c), and a saturated channel image (figure 4d.). For the green channel image, this is the color channel that the blood absorbs most strongly and peaks. So, the sites of trichomoniasis will appear as dark spots on a light-colored cervical background. In contrast to the saturated image of the HSV color channel, the blood will be highly saturated so trichomoniasis sites will appear as light spots on a dark background of the cervix.



a) *b)* *c)* *d)*

Figure 4: Separate the G and S color channels from the leopard-skin cervical image
a) White image; b) Green channel image (G); c) Green channel inverted image (G); d) Saturation channel image (S)

Image of the cervix after contrast enhancement (figure 5a) will be segmented according to the steps outlined in the method section. Segmentation takes place respectively with figures 5b, c, d, e, f, g, and h. After the image of the cervix is contrasted, there are many noisy signals that need to be eliminated. Gaussian filter is applied within the adaptive threshold. After threshold taking with the Gaussian window, the convergence points in the cervical image lost clarity. Images must be sharpened to clarify the hematoma points. After the sharpening process, blood vessels and noise are indistinguishable. Using advanced algorithms will cause the small hematoma sites to be destroyed and the cervical morphology will be disturbed. The two-way Wiener filter is used to remove the noise again. After the Wiener filter is applied, an unwanted gray color appears. The Otsu threshold method is next applied for gray removal. From there the hematoma sites and the noising sites are separated. The structure and thickness values of the noise were smaller than the hematoma points. Morphological expansion is used. The noise filtered image continues to be passed through the morphological expanding algorithm with two different coefficients. The low coefficient is to separate the infected spots, in which there will be a few glare points alternately. Continue to use a morphological expanding algorithm with high coefficients in order to separate out the glare areas. Finally, the two images with different coefficients are synthesized above by subtracting the high coefficient image from the low coefficient image, the glare points will be eliminated, and only the infected spots.

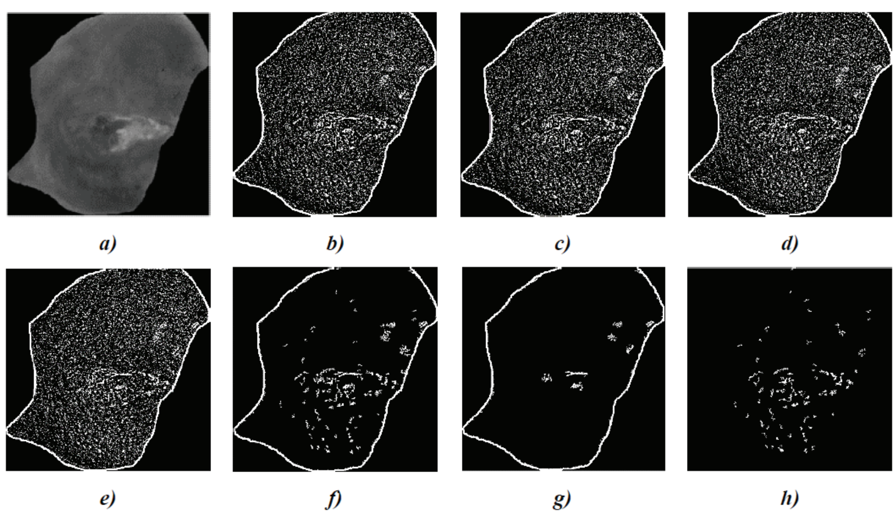
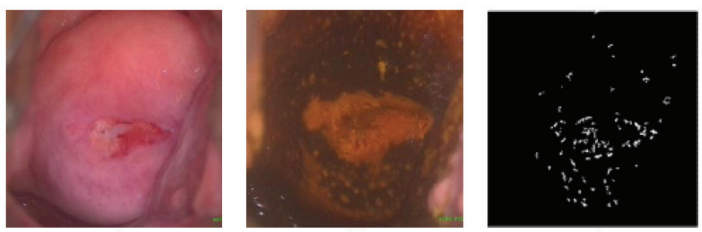


Figure 5: Segmenting image of cervicitis due to trichomoniasis in leopard skin stage.
a) Increasing contrast image; b) Gaussian filter; c) Sharpening; d) Wiener filter; e) Otsu threshold; f) Morphological expanding with low cofficient; g) Morphological expanding with high cofficient; h) Subtracting image

Finally, the segmented images were compared and evaluated with the white image before and after the application of Lugol (figures 6a and 6b) to verify image processing results. Inflammatory spot segmentation image that revealed trichomoniasis spots as white spots on a black base of the cervix (figure 6c). Corresponding white spots are spots with abnormal blood distribution and also sites of glycogen loss. From there it can be seen that colposcopy before the application of Lugol has no clear signs of leopard skin and after using image processing has helped to identify the presence of cervicitis caused by trichomoniasis. However, pictures before and after applying Lugol's solution were taken at different times. These two images have different viewing angles because the patient's posture has shifted. Therefore, the results of inflammatory point segmentation images only rely on the distribution of white spots to identify leopard skin conditions. The white spots have a shape of the distribution corresponding to the shape of the distribution of the inflammatory spots on the image after the application of Lugol's solution.



a) *b)* *c)*

Figure 6: Compare and evaluate the results
a) Image before applying Lugol; b) Image after applying Lugol; c) Infected spot segmented image

4. Discussion and Conclusions

In the present study, based on the distribution of blood and glycogen in normal cervical tissue and leopard-skin cervical tissue, we developed an automatic method of leopard skin detection using a digital colposcopy image. The results of image segmentation were compared and evaluated by the traditional method - cervical image after applying Lugol's solution. Pictures before and after applying Lugol's solution were taken at different times. Therefore, the evaluation results are mainly based on the shape of the inflammation point distribution on the segmental image corresponding to the shape of the distribution of inflammation points on the image after applying Lugol. The research opens a new approach to support doctors in quickly diagnosing diseases, making conclusions about the condition, and appropriate treatment options. At the same time, it solves the limitations of traditional methods. However, further studies need to be done to assess method sensitivity and specificity.

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