

Cervix Segmentation in Ultrasound Data Based on Numerical Technique

C. Pahl, A. Jeffree, Y. Myint, and E. Supriyanto

Abstract—Cervical cancer is the second-most common cause of death among women worldwide. Since ultrasound is the fastest and cheapest method for imaging internal organs, the usage of this modality increases significantly. Here, a numerical technique based the level-set method is shown to overcome the obstacle of extracting the human cervix in ultrasound images. The active contour based algorithm will be explained and discussed subsequently. Results show that a cervix extraction can be performed semiautomatically.

Keywords—Cervix, ultrasound, segmentation, level-set.

I. INTRODUCTION

CERVICAL cancer is one of the most common forms of cancer in women worldwide, and it occurs in 80% of the women in developing world, where very few resources exist for management. Most of the women do not know whether they have cervical cancer or not. So it becomes most deadly cancer in women. But its symptoms can be seen only in advanced stages of the disease. In order to overcome this situation, it is required to detect symptoms of cervical cancer at early stages of the disease. Therefore, an automatic ultrasound scanning system will be developed to identify the early stages of cervical cancer. It will give comfort to the patient while scanning the cervix.

The cervix is the lower third portion of the uterus, which forms the neck of the uterus and opens into the vagina which is also called the endocervical canal. The narrow opening of the cervix is called the os. Fig. 1 illustrates the anatomy of cervix. The cervical os allows menstrual blood to flow out from the vagina during menstruation. During pregnancy the cervical os closes to help keep the fetus in the uterus until birth. Another important function of the cervix occurs during labor when the cervix dilates, or widens, to allow the passage of the fetus from the uterus to the vagina.

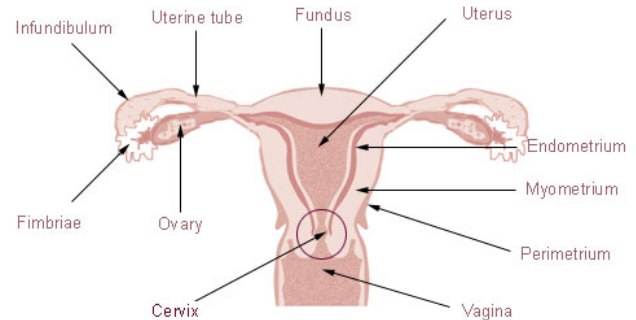


Fig. 1. Anatomy of female reproductive system [18]

Human papillomavirus is considered to be a major etiological factor for the development of cervical cancer. HPV type 16 is the most prevalent HPV accounting for more than 70% of cervical cancer cases in India, followed by HPV type 18 and other high-risk types. However, an infection with HPV is essential but it is not sufficient for the development of cervical cancer, which implies the involvement of host genetic factors [6]. Squamous cell carcinoma of the uterine cervix is the second cause of cancer-related deaths in women, the higher incidence being observed in developing countries [7]. Additional information such as HPV genotype and HPV viral load is thought to improve the predictive ability of which women will develop cervical cancer [8]. Please submit your manuscript electronically for review as e-mail attachments.

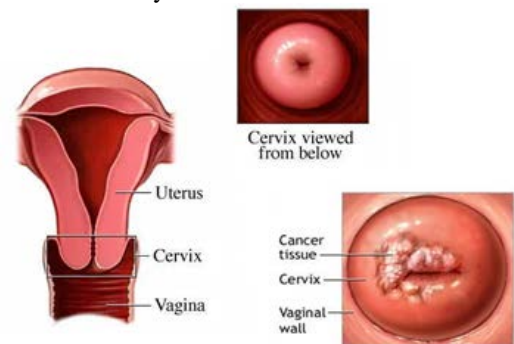


Fig. 2. Cervix position and normal and cancerous cervix image [19,20]

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A. Cervical Cancer and symptoms

Cervical cancer is one of the most common forms of cancer in women worldwide. Most cases of cervical cancer can be prevented through screening programs aimed at the detection of earlier stages of cervical cancer. The world-wide occurrence of the cervix cancer cases show that only 20% of these cases

occur in developed nations while 80% of the cases are found in the developing countries that include India. In India, the cancer of the uterine cervix is the most frequent malignancy observed in females, as according to the reports of the different cancer registries published in the Indian Council of Medical Research (ICMR) biennial report. Cervical cancer goes undetected in developing countries because of the cost of the tests and the lack of trained personnel and resources to screen and diagnose.

In the US, resources are wasted on the evaluation and treatment of lesions not likely to progress to cancer. Both the screening and detection of cervical cancer could be vastly improved by optical technologies that improve, automate, and decrease the cost of screening and detection. Due to the lack of resources and infrastructure, many women die because of cervical cancer. From other research journal, an alternative method of cervical cancer screening, termed cervicography, uses visual testing based on color change of cervix tissues when exposed to acetic acid. This inexpensive method helps to detect abnormal cells that turn white (“acetowhite”) following the application of acetic acid. As before, there was no development of robot to scan the cervix. To detect the cervix, commonly use the ultrasound machine rather than robotic related with software and hardware implementation. Cervical cancer can be detected from symptoms like abdominal bleeding, unusual heavy discharge, pelvic pain, pain during urination and bleeding between regular menstrual periods, after sexual intercourse, douching or pelvic exam. Cervical cancer is multi-factorial disease comprising both genetic and environmental components. Current applications included automated Pap smear screening for detection of cervical cancer and diagnosis of Alzheimer’s disease. Most cases of cervical cancer can be prevented through screening programs aimed at detection earlier stage abnormalities in cervical images. Cervical cancer can be detected from symptoms like abdominal bleeding, unusual heavy discharge, pelvic pain, pain during urination and bleeding between regular menstrual periods, after sexual intercourse, douching or pelvic exam. Cervical cancer is multi-factorial disease comprising both genetic and environmental components. Current applications included automated Pap smear screening for detection of cervical cancer.

Relatively low cost, quick and convenient ultrasound examinations are non-invasive as they do not require the body to be opened up, or anything to be inserted into the body. There is no harmful effects have been detected at the intensity levels used for examinations and imaging. This contrasts with methods based on X-rays or on radioactive isotopes, which have known risks associated with them, and ultrasound methods are preferred whenever possible. This is particularly relevant to examination of pregnancy development. The major disadvantage of ultrasound is that the resolution of images is often limited. This is being overcome as time passes, but there are still many situations where X-rays produce a much higher resolution. Therefore, cervical imaging software is needed to

develop to help doctors to analyze abnormalities in the cervix.

B. Ultrasound machine

When Ultrasonography [25] is a medical imaging technique that uses high frequency sound waves and their echoes. The technique is similar to the echolocation used by bats, whales and dolphins, as well as SONAR used by submarines. In ultrasound, the following events happen. The ultrasound machine transmits high-frequency (1 to 5 megahertz) sound pulses into your body using a probe. The sound waves travel into your body and hit a boundary between tissues (e.g. between fluid and soft tissue, soft tissue and bone). Some of the sound waves get reflected back to the probe, while some travel on further until they reach another boundary and get reflected. The reflected waves are picked up by the probe and relayed to the machine. The machine calculates the distance from the probe to the tissue or organ (boundaries) using the speed of sound in tissue (5,005 ft/s or 1,540 m/s) and the time of the each echo’s return (usually on the order of millionths of a second). The machine displays the distances and intensities of the echoes on the screen, forming a two dimensional image. In a typical ultrasound, millions of pulses and echoes are sent and received each second. The probe can be moved along the surface of the body and angled to obtain various views.

II. METHODOLOGY

A. Cervix Ultrasound Image

To accomplish this thesis, more than hundreds of cervical ultrasound images from women of age between 20 and 45 were collected in Diagnostic Lab in UTM. All images are from the healthy women without any history of cancer diseases. Toshiba ultrasound machine and 3.5MHz convex probe are used with the presence of a layer of the electrolyte gel during scanning acting as a transmission medium.

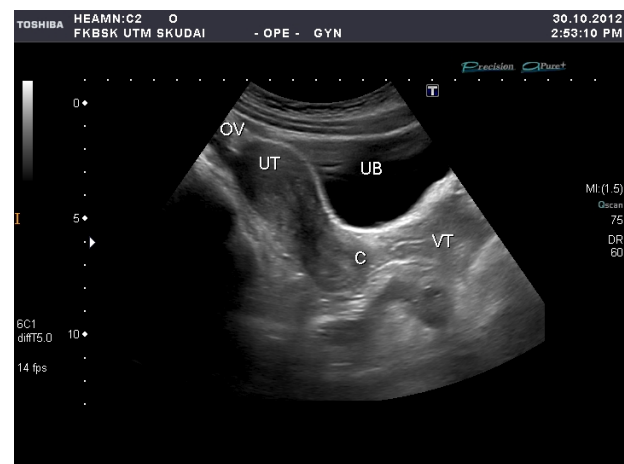


Fig. 3. Cervix ultrasound image

Fig. 3 displays one of the images in our database. In Fig. 3, cervix is marked as C. As shown in this figure, the cervical tissue cannot be clearly isolated from its surrounding tissue.

B. MATLAB

MATLAB is a high-level language and interactive environment that enables to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and FORTRAN. MATLAB can be used in a wide range of applications, including signal and image processing, communications, control design, test and measurement, financial modeling and analysis, and computational biology. Add-on toolboxes (collections of special-purpose MATLAB functions, available separately) extend the MATLAB environment to solve particular classes of problems in these application areas. MATLAB also provides a number of features for documenting and sharing work. Moreover, MATLAB code can be integrated with other languages and applications.

Image Processing Toolbox provides a comprehensive suite of reference-standard algorithms and graphical tools for image analysis tasks such as statistical analysis, feature extraction, and property measurement. This toolbox allows the user to restore noisy or degraded images, enhance images for improved intelligibility, extract features, analyze shapes and textures, and register two images. Most toolbox functions are written in the open MATLAB language, giving the users the ability to inspect the algorithms, modify the source code, and create their own custom functions. Image processing used to analyze the cervical image, modify pictures to improve them (enhancement, restoration), extract information (analysis, recognition), and change their structure (composition, image editing). Removing blurring and noise, increasing contrast, and revealing details are examples of enhancement operations.

C. Active Contour Algorithm

One type of segmentation used in this study was active contour algorithm [21]. An active contour is an energy minimizing spline that detects specified features within an image. It is a flexible curve (or surface), which can be dynamically adapted to required edges or objects in the image (it can be used to automatic objects segmentation). In this study, there are three methods used for active contour algorithm segmentation [22], which are localizing initial point using freehand tool, defining initial point with region growth and freehand tool with region growth. About thirty cervix images were collected from women age 23 years old. Images are all in healthy condition without any history of cancer diseases. In this thesis writing, some cervical image was selected randomly from thirty images to see the different results from each method. All the methods can extract the cervix region. Toshiba ultrasound machine and 3.5MHz convex probe are used with the presence of a layer of the electrolyte gel during scanning acting as a transmission medium. There are three image-processing flow charts used in these methods using MATLAB software.

The segmentation strategy addressed in this paper is active contour algorithm. This is an energy minimizing spline that detects specified features within an image. It is a flexible curve (or surface), which can dynamically adapt to required edges or objects in the image (it can be used to automatic

objects segmentation). This study tested active contour algorithm segmentation with three methods of initial point defining. In Method I, the initial point is localized using freehand tool. In Method II, initial point is pre-programmed and region growth model is applied. In Method III, initial point is defined by freehand tool but region growth is used.

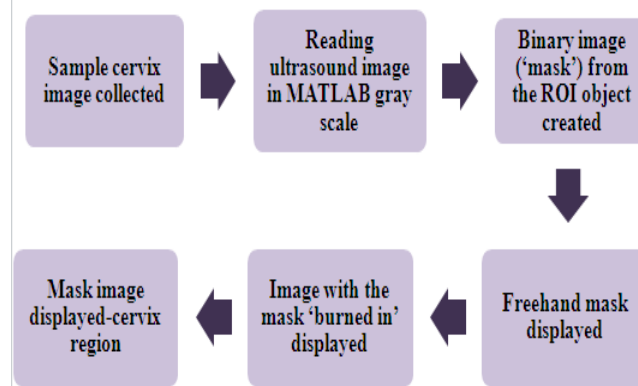


Fig.4. Flow Chart of Method I

Fig. 4 illustrates flow chart of Method I, in which the initial region, ROI, is specified using freehand tool. As a first step, original image is converted to gray scale and then binary 'mask image' from the region of interest object is created. From freehand mask, boundary coordinates of freehand drawn region are obtained. Image is burned line back by setting it to 255 wherever the mask is true. Then, image with the mask burned in is attained. Finally, ROI is extracted from original image.

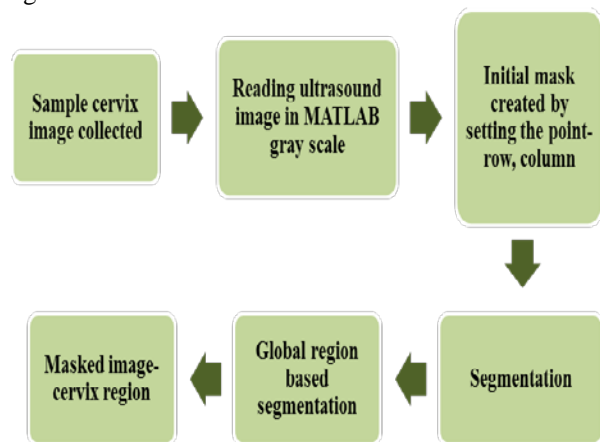


Fig.5. Flow chart of Method II

Fig. 5 depicts the flow chart of second method. In this method, the initial point is preprogrammed. The initial mask is created and the interested region is growing based on global region segmentation.

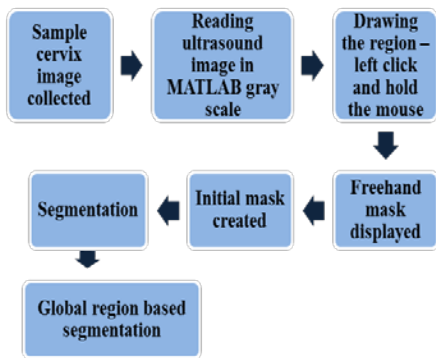


Fig. 6. Flow chart of Method III

Fig. 6 describes the flow chart of Method III, freehand tool with region growth. The region is localizing at any point in the image as the initial point. Then, initial mask is created and then the interest region is segmented by global region based segmentation.

III. RESULTS AND DISCUSSION

This chapter will discuss about the results from image analyzing techniques, which include active algorithm segmentation, edge detection and filtering.

Results showed that all three methods have successfully done to extract the cervix region from ultrasound image. Out of 30 images, the qualified original has been chosen to observe the different natures and performances of these methods. For the first method, the cervix region can be extracted by localize the initial point using freehand tool, but the operator must be an expert person to figure out the region. If the area cannot be identified, possibility the wrong region localized happened. This method can be applied in another image rather than second and third methods. While in the second method, initial point is needed to define by using trial and error method in the cervical part. The location of cervix region determined by set the row and column in the pixel image. If this method wants to be applied to another image, the initial point has to find out according to the pixel of that image.

A. Method I



Fig. 7. Original cervical image

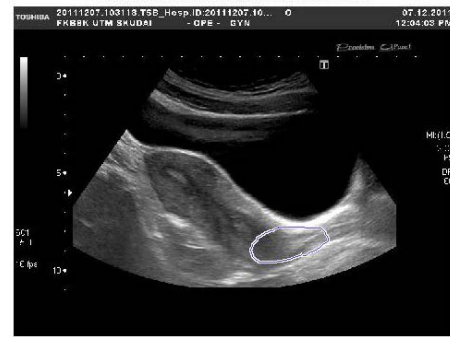


Fig. 8. Original grayscale image with initial region localized by freehand tool



Fig. 9. Binary mask of the region



Fig. 10. New image with mask burned



Fig. 11. Final extracted region

Fig. 7 shows the original image and Fig. 8 until Fig. 11 describes the image obtained in each step. This method extracts only the initial region localized by the operator. So, this method totally depends on the operator's skills. If the operator does not have the capability to define the cervix in

ultrasound, then the result becomes unreliable. We can see this comparison in Table 1.


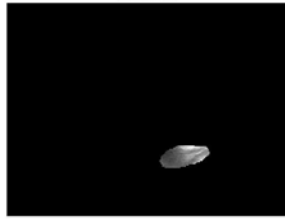

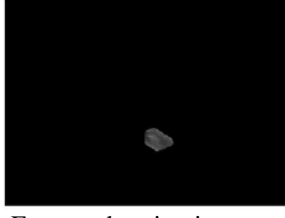
 <p>Original grayscale image with initial point</p>	 <p>Masked Image</p>
<p>Original image with initial point around cervix</p>	<p>Extracted region of cervix area</p>
 <p>Original grayscale image with initial point</p>	 <p>Masked Image</p>
<p>Original image with initial point in uterus</p>	<p>Extracted region in uterus</p>

Table 1. Extracted results with different initial region

B. Method II

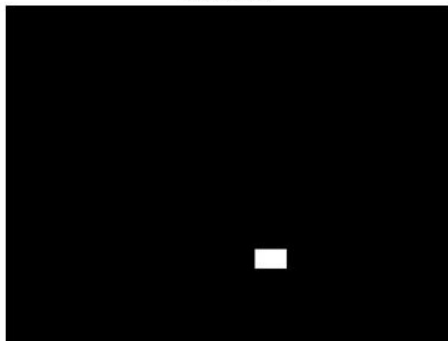


Fig.12. Preprogrammed initial point



Fig. 13. Segmentation of region growth include cervical part



Fig. 14. Global based region segmentation

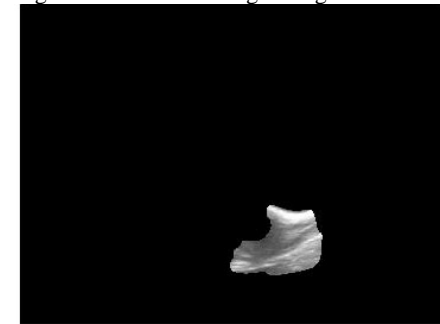


Fig. 15. Masked image with cervix region

The preprogrammed initial point can be seen in Fig. 12 whereas Fig. 13 illustrates the region growing. The final extracted region in Fig. 15 depends on that growth area and that is determined by number of iterations. That evaluation is expressed in Table 2. The resultant region in this method not only depends on number of iterations, but also depends on the coordinates of initial mark. So, in this method, ability of the person is not essential but the initial mask identification in the program should be robust for all images captured by various probe positions.

Table 2. Extracted results depending on iteration numbers

C. Method III

The routines starting from identifying initial mark by freehand tool to final extraction are presented in Fig. 16 through Fig. 18. This method does not fully rely on the operators' capability. At the same time, the problem of robustness faced in Method II is also solved.



Fig. 16. Initial freehand mask on input image

Both second and third methods are using region growth. The initial mark is growing along the contour of same pixel intensity according to the iteration that has been set up. More iteration means that the region will be growing bigger until the pixel with different intensity is detected.

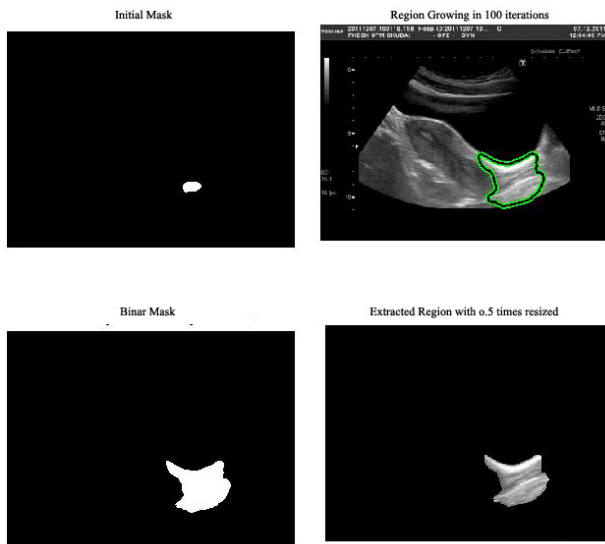


Fig. 17. Initial mask, region growing, binary mask and extracted region

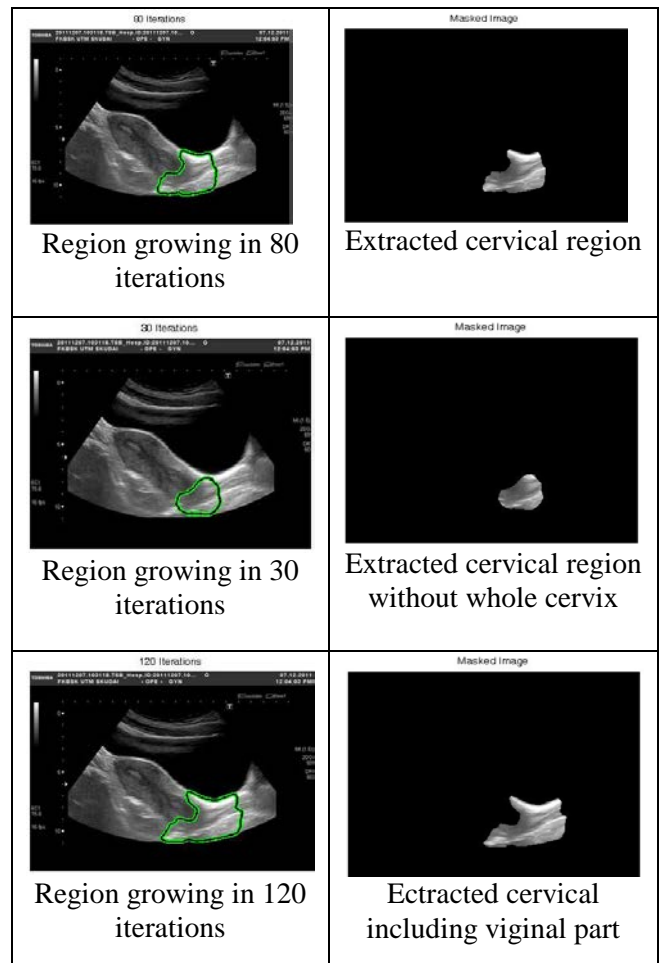


Fig. 18. Segmentation of region growth include cervical part

D. Segmentation

Another method used in segmentation [22] is edge detection. This approach of segmentation [23, 24] is a fundamental tool used in most image processing applications. By obtaining the information from the image, features can be extracted. It is a process of detecting the boundaries between the background and the objects within the image, image brightness changes sharply. There are two categories; Laplacian and Gradient, there are various operators defined i.e. Roberts, Prewitt, Sobel, and Canny. Edge detection is used in this study for analyzing cervical image based on Sobel and Canny.

IV. CONCLUSION

From the image processing technique, it can be seen clearly that the cervix can be extracted definitely in all three methods by using active contour segmentation methods. Image processing has been conducted to extract the cervix region. Enhancement and filtering is needed in order to reduce noise and smoother the image. The results show that all methods can be used to extract the cervix but also has weakness for each method. By using the region growth, it has the weakness due to limitation of different intensity in the image. Furthermore,

images obtained are those of low quality since the images obtained are not as clear compared to those of cervix images obtained from CT and MRI.

For the first method, the expert sonographer is crucial. If the area cannot be identified correctly, the wrong region extraction will happen. While in Method II, initial point is needed to define in program. The location of cervix region determined by set the row and column in the pixel image. It does not need to consider about the expertise in processing time, but it is difficult to identify the initial mark to be appropriate for any image. So, this method needs to set the initial point again and again.

For the third method, freehand tool is used to define the region of cervical. In any part in the region, initial point is localized. So the personal skill becomes not critical and the location of initial point can be set by visualization.

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