Cervical Segmentation in Ultrasound Image Using Level-set Algorithm

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Abstract: - Cervical cancer threatens women life around the world and cervical cancer symptoms are not obvious during early stages. To overcome this fighting on women life, a solution for detecting cervical cancer at early stages becomes essential. Three dimensional (3D) imaging will be helpful for doctors to analyze the cervix. In taking the first few steps towards this analysis, the theme of this work is to extract the cervix from ultrasound image. But this extraction can pose a challenging because, in ultrasound, the isolation between the cervix, the lower uterine segment and the surrounding vaginal tissue is not clear. This paper discusses segmentation of cervical by using active contour based level set method. By this attempt, the cervix can be extracted positively but the method is semiautomatic.

Key-Words: - cervical segmentation, level set, active contour, region growth, ultrasound image, cervical cancer.

1 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. Since cervical cancer symptoms can be seen only in advanced stage of the disease, it becomes most deadly cancer in women. So, A solution is needed to overcome the deadly cause of women by cervical cancer by detecting it at the early stages.

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.

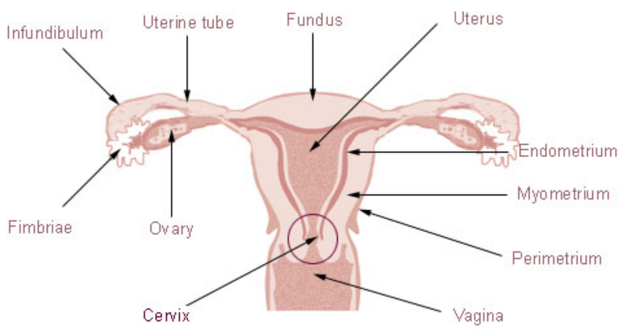


Fig. 1. Anatomy of cervix [18]

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].

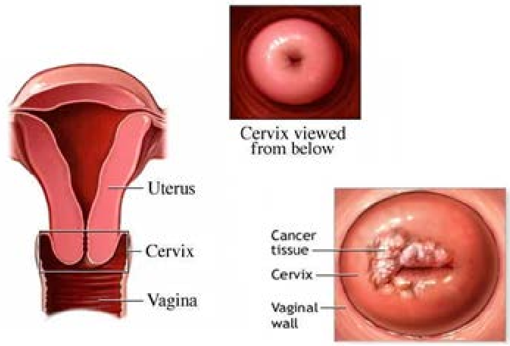


Fig. 2. Cervix position and normal and cancerous cervix image[19,20]

Most case of cervical cancer can be prevented through screening programs aimed at detection earlier stage abnormalities in cervix image [1], [2]. An alternative method of cervical cancer screening termed cervicography, uses visual testing based on colour 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 [3]. 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 [4] [5].

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 analyse abnormalities in the cervix.

2 Methdology

2.1 Cervical ultrasound image

Ultrasound or ultrasonography is a medical imaging technique that uses high frequency sound waves and their echoes. 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.

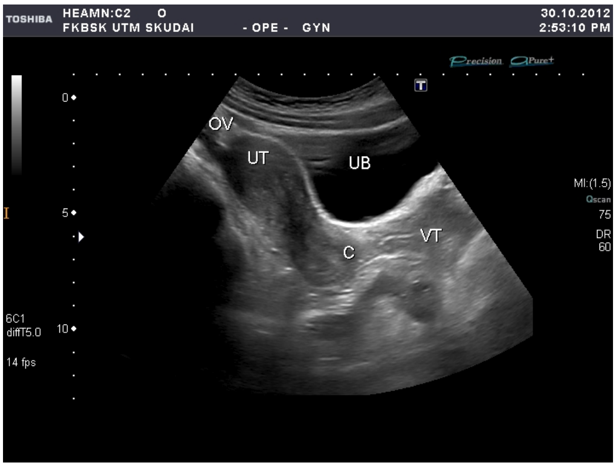


Fig. 3. Cervix Ultrasound Image

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.

2.1 Active contour algorithm

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 preprogrammed and region growth model is applied. In Method III, initial point is defined by freehand tool but region growth is used.

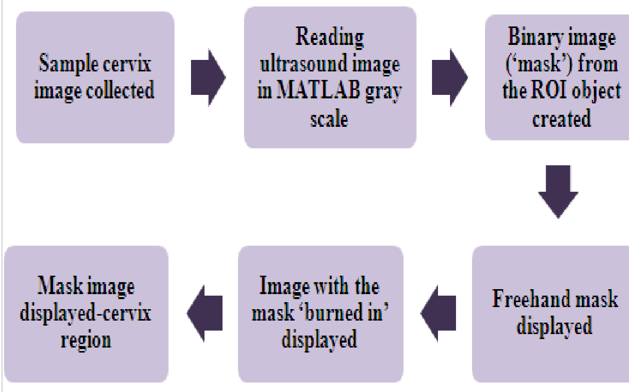


Fig.4. Flow chart of Method I

ISBN: 978-1-61804-190-6

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 is 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 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 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.

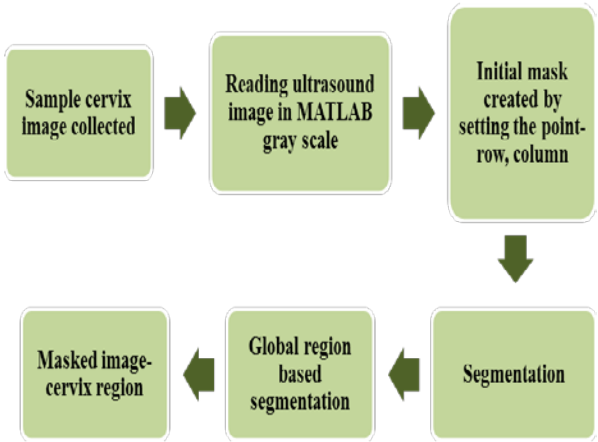


Fig.5. Flow chart of Method II.

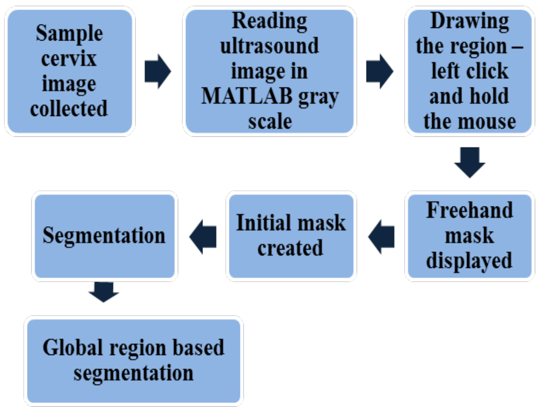


Fig. 6. Flow chart of Method **III**

3 Results and Discussions

Method I

Fig. 7. Original cervical image

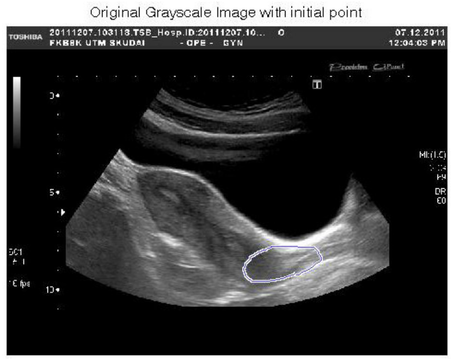


Fig. 8. Original grayscale image with initial region localized by handfree tool

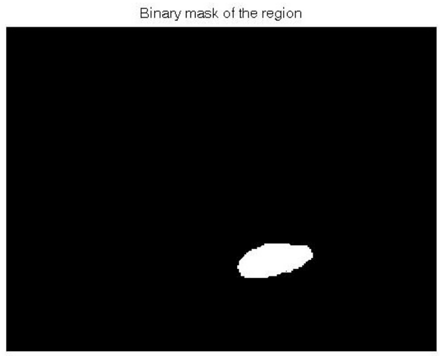


Fig. 9. Binary mask of the region

Fig. 10. New image with mask burned

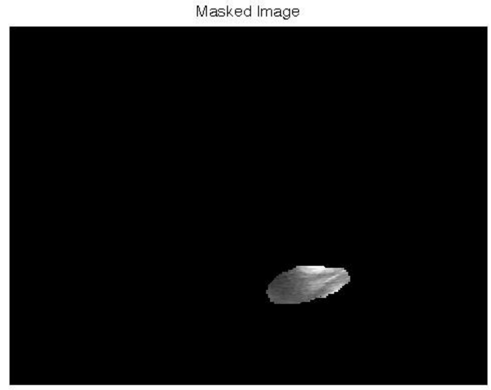
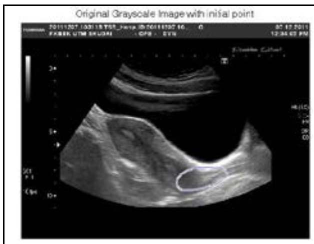
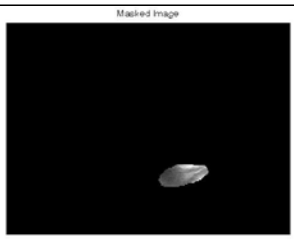
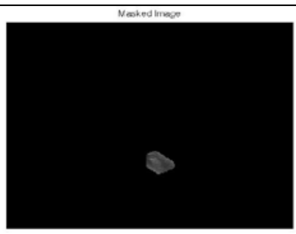


Fig. 11. Final extracted region

Fig. 7 shows the original image and Fig.8 through 11 describe the image obtained in each step. This method extracts only the initial region localized by the operator. So, this method wholly depends on the operator's proficient. 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.

Table 1. Extracted results with different initial region

 Original image with initial point around cervix	 Extracted region of cervix area
 Original image with initial point in uterus	 Extracted region in uterus

Method II.

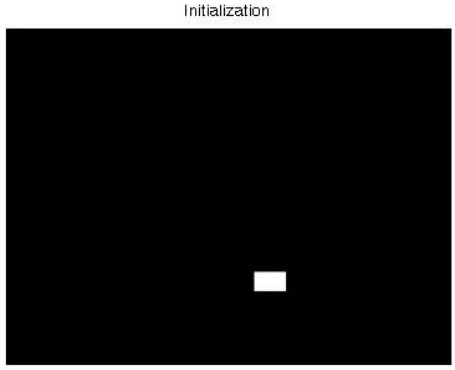


Fig.12. Preprogrammed initial point

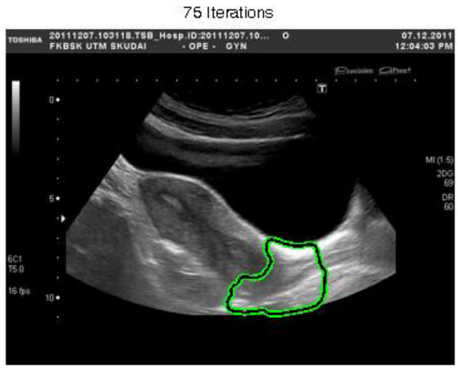


Fig. 13. Segmentation of region growth include cervical part

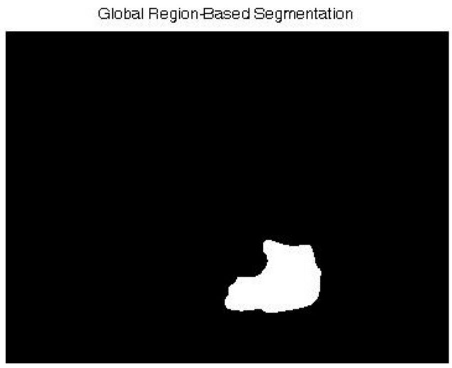


Fig. 14. Global based region segmentation

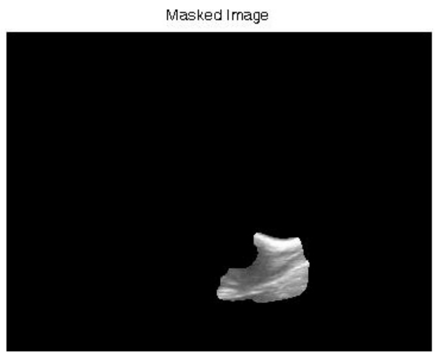


Fig. 15. Masked image with cervix region

The preprogrammed initial point can be seen in Fig. 12. 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.

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's capability. At the same time, the problem of robustness faced in Method II is also solved.

Table 2. Extracted results depending on iteration numbers

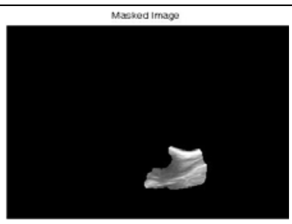
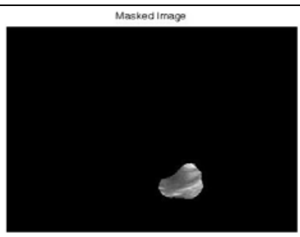
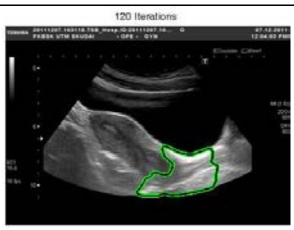
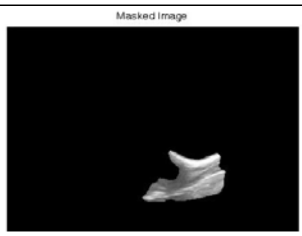
 Region growing in 80 iterations	 Extracted cervical region
 Region growing in 30 iterations	 Extracted cervical region without whole cervix
 Region growing in 120 iterations	 Ectracted cervical including viginal part

Fig. 16. Initial freehand mask on input image

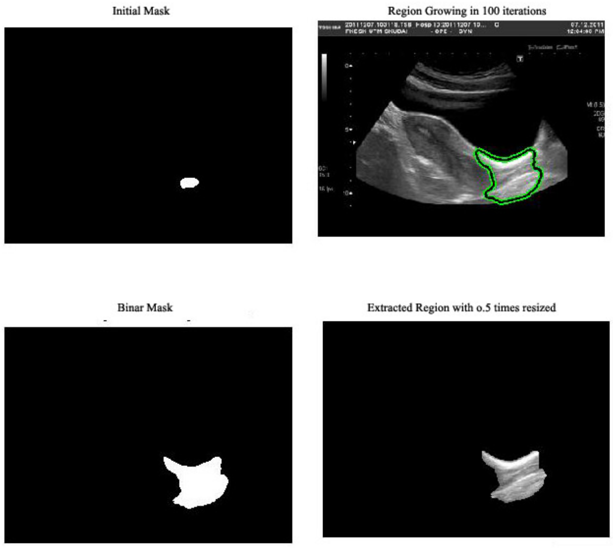


Fig. 17. initial mask, region growing, binary mask and extracted region

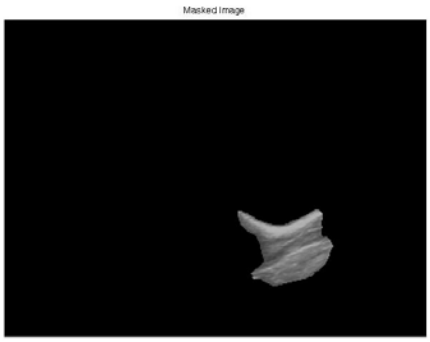


Fig. 18. Segmentation of region growth include cervical part

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.

ISBN: 978-1-61804-190-6

4 Conclusion

Results showed that all three methods have successfully done the cervix region extraction from ultrasound image. Out of the images in database, the qualified original has been chosen to observe the different natures and performances of these methods.

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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