Hardware Implementation of Genetic Algorithm for Ovarian Cancer Image Segmentation

Devesh D. Nawgaje, Rajendra D. Kanphade

Abstract— Imaging plays an important role in the diagnosis and treatment of ovarian cancer. An accurate segmentation is critical, especially when the ovarian tumor morphological changes remain subtle, irregular and difficult to assess by clinical examination. Traditionally, segmentation is performed manually in clinical environment that is operator dependent and very tedious and time consuming labor intensive work. In this paper genetic algorithm for selecting the optimal threshold in image segmentation is proposed. In the computational process, the GA adjusts crossover probability and mutation probability automatically according to the variance between the target and background. Moreover, the complete algorithm is implemented using Digital Signal Processor TMS320C6713 which decreases the run time greatly.

Index Terms— Genetic algorithm, Ovarian Cancer, Digital Signal Processor, Segmentation.

I. INTRODUCTION

Ovarian cancer is cancer that begins in the ovaries. Ovaries are reproductive glands found only in women. The ovaries produce eggs (ova) for reproduction. The eggs travel through the fallopian tubes into the uterus where the fertilized egg implants and develops into a fetus. The ovaries are also the main source of the female hormones estrogen and progesterone. One ovary is located on each side of the uterus in the pelvis.

Many types of tumors can start growing in the ovaries. Most of these are benign (noncancerous) and never spread beyond the ovary. Benign tumors can be treated successfully by removing either the ovary or the part of the ovary that contains the tumor. Ovarian tumors that are not benign are malignant (cancerous) and can spread (metastasize) to other parts of the body.

Ovarian tumors are named according to the kind of cells the tumor started from and whether the tumor is benign or cancerous. There are 3 main types of ovarian tumors:

- Epithelial tumors start from the cells that cover the outer surface of the ovary. Most ovarian tumors are epithelial cell tumors.
- Germ cell tumors start from the cells that produce the eggs (ova).
- Stromal tumors start from structural tissue cells that hold the ovary together and produce the female hormones estrogen and progesterone.

The American Cancer Society most recent estimates for ovarian cancer in the United States are for 2011:

- About 21,990 women will receive a new diagnosis of ovarian cancer
- About 15,460 women will die from ovarian cancer

Ovarian cancer is the ninth most common cancer among women. It ranks fifth in cancer deaths among women [1]. This high death rate is due to the fact that almost 70% of women with ovarian cancer remained undiagnosed until the disease has advanced to Stage III or IV. To alleviate the situation, greater effort has to be focused on the early detection of ovarian cancer since the survival rate is significantly higher if the disease is diagnosed at an early stage [2].

Segmentation is important steps in many systems. Segmented images are now used routinely in a multitude of different applications, such as, diagnosis, treatment planning, localization of pathology, study of anatomical structure, computer-integrated surgery, among others. However, image segmentation remains a difficult task due to both the variability of object shapes and the variation in image quality. Particularly, medical images are often corrupted by noise and sampling artifacts, which can cause considerable difficulties when applying rigid methods.

Many segmentation methods have been proposed for medical-image data [3-8]. Unfortunately, segmentation using traditional low-level image processing techniques, such as thresholding, histogram, region growing and other classical operations requires a considerable amount of interactive guidance in order to attain satisfactory results. Automating these model-free approaches is difficult because of complexity, shadows, and variability within and across individual objects. Furthermore, noise and other image artifacts can cause incorrect regions or boundary discontinuities in objects recovered from these methods.

II. IMAGE SEGMENTATION

This paper adopts OSTU Principle as the image segmentation standard. In this method, we can directly calculate the threshold without pretreatment to histogram. This algorithm is simple and is a remarkable method for selecting the threshold. Here's the fundamental principle. The gray value of a grey-scale map is 0~255.The total number of pixels is defined as N, ni is the number of pixels which's gray value is i .By normalizing the histogram, the following equations could be obtained.

$$\sum_{i=0}^{255} n_i = N \qquad (1)$$

$$p_i = \frac{n_i}{N} \qquad (2)$$

pi is the probability of the pixels which's gray value is i. The threshold of the image segmentation is defined as m, then the probability θ_0 and mean value μ_0 of the background can be obtained through the following equations:

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$$\theta_0 = \sum_{i=0}^{m} p_i \qquad \mu_0 = \frac{\sum_{i=0}^{m} ip_i}{\theta_0} \quad (3)$$

The probability and typical value of the target also can be obtained:

$$\theta_1 = \sum_{i=m+1}^{255} p_i \qquad \mu_1 = \frac{\sum_{i=m+1}^{255} ip_i}{\theta_1} \quad (4)$$

The variance between the background and target is defined as σ2B

$$\sigma_B^2 = \theta_0(\mu_0 - \mu_T)^2 + \theta_1(\mu_1 - \mu_T)^2 \quad (5)$$

$$\mu_T = \sum_{i=0}^{255} ip_i \quad (6)$$

By computing the equation (3),(4),(5)and(6),the following equation (7) could be obtained.

$$\sigma_B^2 = \theta_0\theta_1(\mu_0 - \mu_1)^2 \quad (7)$$

Variance is a metric of the uniformity of distribution, the greater the variance yields, the greater the difference between the target and the background. Therefore, the threshold which makes the variance yields maximal is the optimal threshold.

III. GENETIC ALGORITHM

Genetic algorithm which imitates the principles of biological evolution is a method for global search and optimization. GA begins at a random initial group and then adopts selection, crossover and mutation, and some other genetic operations based on the principle of survival of the fittest to obtain a preferable group. The algorithm keeps iterating until meets the terminal condition.

In GA, the crossover probability Pc and mutation probability Pm which are the key parameters affecting the performance of the GA should be determined using equation (8) and (9)

$$p_c = \begin{cases} p_{c1} - \dfrac{(p_{c1} - p_{c2})(f' - f_{avg})}{f_{max} - f_{avg}} & f' \geq f_{avg} \\ p_{c1} & f' < f_{avg} \end{cases} \quad (8)$$

$$p_m = \begin{cases} p_{m1} - \dfrac{(p_{m1} - p_{m2})(f_{max} - f)}{f_{max} - f_{avg}} & f \geq f_{avg} \\ p_{m1} & f < f_{avg} \end{cases} \quad (9)$$

f_{max} the maximum fitness; f_{avg} the average of the fitness; f' the larger fitness of the two individual which will take the cross-operation. f the fitness of the individual.

IV. IMPLEMENTATION USING TMS320C6713 DSP

The Texas Instruments TMS320C6000 DSP platform of high-performance digital signal processors (DSPs) now includes the TMS320C6713. The C6713 brings the highest level of performance in the C6000 DSP platform of floating-point DSPs. At the initial clock rate of 225 MHz, the C6713 can process information at a rate of 1.35 giga-floating-point operations per second.[11]

Code composer studio (CCS) includes tools for code generation, such as a C compiler, an assembler, and a linker. It has graphical capabilities and supports real time debugging. It provides an easy-to-use software tool to build and debug programs. In this paper program for segmentation using genetic algorithm is written using C. The C compiler compiles a C source program with extension .c to produce an assembly source file with extension .asm. The assembler assembles an.asm source file to produce a machine language object file with extension.obj. The linker combines object files and object libraries as input to produce an executable file with extension .out. This executable file represents a linked common object file format (COFF), popular in Unix-based systems and adopted by several makers of digital signal processors. This executable file can be loaded and run directly on the C6713 processor.

Steps of the Genetic Algorithm

Step 1: Coding Scheme

This paper takes the 8-bit binary code. As the gray value of a grey-scale map is 0~255, any threshold can be coded with a 8-bit binary code.

Step 2: Initial group

The initial group is random, the number of which's individuals is 20 and the maximal generation is 50.

Step 3: Fitness function

Fitness indicates the quality of the individual. This paper takes the equation (7) as the fitness function.

Step 4: Selection

The purpose of the selection is selecting the excellent individuals, so that they have the opportunity to breed the next generation as parents.

Step 5: Crossover

We can obtain new individuals which combined the characteristics of parents through crossover. This paper takes the single-point Crossover operator. The crossover probability is defined as the equation (8).

Step 6: Mutation

Mutation gives birth to the individuals which have some other characteristics, keeping diversity of the group. The mutation probability is defined as the equation (9).

Step 7: Re-insertion

The ratio of the new group's size to the old group's size is called gap. The gap in this paper is 0.9. In order to keep the group size, some new individuals should be inserted to the old group. The method in this paper is replacing the individuals which's fitness are less.

Step 8: Terminal condition

The algorithm ends when the genetic algebra is 50.

V. EXPERIMENTAL RESULT

Figure 1 shows the ultrasonic image of ovarian cancer on which various segmentation techniques are applied for detecting tumor. Figure 2 shows the segmented image using canny operator, but the canny operator fails to segment the required region from the complete image. Also the figure 3 which shows the result for ostu is unable to segment require region of interest. Figure 4 shows the segmented image using genetic algorithm.

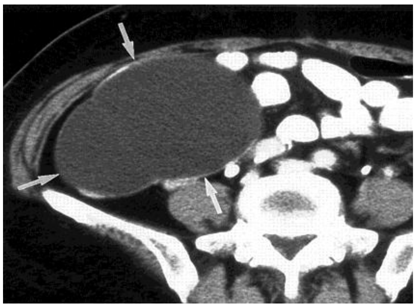

Figure 1 original image of ovarian with tumor

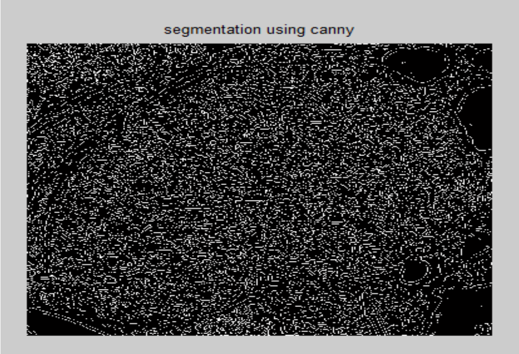

Figure 2 segmentation using canny

Figure 3 segmentation using ostu

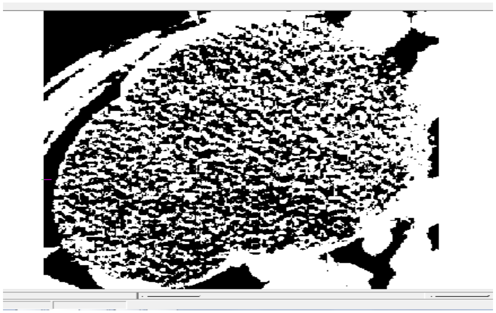

Figure 4 segmentation using GA

From the figure 4 it is clear that the GA gives better result for the segmentation of ovarian cancer image which is helpful for the diagnosis of cancer treatment. Simulation is done on CCS whereas implementation is done on TMS320C6713 digital signal processor on number of images. The average computing time for simulation of GA using Intel core I3, 2.13GHz processor is 14.56 minutes, whereas computing time using TMS320C6713, 225MHz DSP is 29 seconds which shows the implementation using DSP decreases run time greatly.

VI. CONCLUSION

The success of an image analysis system depends on the quality of segmentation. In the analysis of medical images for computer-aided diagnosis and therapy, segmentation is often required as a preliminary processing task. In this paper genetic algorithm is used to select the threshold in ovarian cancer image segmentation. In the computational process, the GA adjusts crossover probability and mutation probability automatically according to the variance between the target and background. Experimental data demonstrate the accuracy of segmentation which helps doctor for diagnosis purpose. Moreover the hardware implementation of this algorithm on DSP TMS320C6713 is achieved successfully.

REFERENCES

1. American Cancer Society. Cancer Facts and Figures 2011. Atlanta, GA: American Cancer Society; 2011.
2. Jermal A, Murray T, Samuels A, Ghafoor A, Ward E, Thun MJ. Cancer statistic 2003. CA: Cancer Journal for Clinician 2003;13:5—26.
3. W. Kenong, D. Gauthier and M. D. Levine: “Live Cell Image Segmentation”, IEEE Transactions on Biomedical Engineering, vol.42, no. 1, Jun. 1995.
4. J. Sijbers, P. Scheunders, M. Verhoye, A. Van der Linden, D. Van Dyck, E. Raman: “Watershed-based segmentation of 3D MR data for volume quatization”, Magnetic Resonance Imaging, vol. 15, no. 6, pp 679-688, 1997.
5. C. Chin-Hsing, J. Lee, J. Wang and C. W. Mao: “Color image segmentation for bladder cancer diagnosis”, Mathl. Comput. Modeling, vol. 27, no. 2, pp. 103-120, 1998.
6. Rodríguez, R., Alarcón, T., Wong, R. and Sanchez, L.: “Color segmentation applied to study of the angiogenesis. Part I”, Journal of Intelligent and Robotic System, Vol. 34, No.1, May 2002.
7. P. Schmid: “Segmentation of digitized dermatoscopic images by two-dimensional color clustering”, IEEE Trans. Med. Imag., vol. 18, no. 2, Feb., 1999.
8. J.E. Koss, F. D. Newman, T. K. Johnson and D. L. Kirch: “Abdominal organ segmentation using texture transforms and a hopfield neural network”, IEEE Trans. Med. Imag., vol. 18, no. 7, July, 1999.
9. Payel Ghosh, M. Mitchess, “ Automatic segmentation of the prostate using a genetic algorithm for prostate cancer treatment planning”, IEEE proceeding of ICMLA 2010.
10. Liu Jianli, Zuo Baoqi, “The segmentation of skin cancer image based on genetic neural network”, IEEE proceeding of CSIE 2008.
11. Texas Instruments, TMS320C6713, Floating-Point Digital Signal Processors, Data Sheet, Dallas, TX, 2002.

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