C7_15_Citacee_2013

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Submission date: 06-Jan-2018 05:12PM (UTC+0700)
Submission ID: 900576392
File name: C7_15_Citacee_2013.pdf (256.57K)
Word count: 1647
Character count: 9191

Distance Regularized Level Set Evolution for Medical Image Segmentation

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Abstract—**Medical image is an important tool because it can be used for surgical planning and simulation, radiotherapy planning, and tracking the progress of disease. To analyze the medical image, it must partitioned into different segment using image segmentation methods. Many methods are introduced to perform that segmentation, one of them is DRLSE. DRLSE are the development of level set method and maintained by forward-and-backward (FAB) diffusion derived from distance regularization term. Because of that DRLSE eliminates the need for re-initialization and avoid the undesirable side effect. This research use DRLSE for medical image segmentation. DRLSE can be used in medical image segmentation.**

Keywords-segmentation; medical image; DRLSE

I. INTRODUCTION

Medical image is important tool because it can be used for surgical planning and simulation, radiotherapy planning, and tracking the progress of disease [1]. Medical image is analyzed depending by experience of doctor and takes a long time [2]. The solution to the problem is by using computer to segment the medical image with image segmentation methods.

Many method are introduced to perform image segmentation, such as distance regularized level set (DRLSE) [3], [4], [5], level set approach [6], [7], [8], [9], region-based [10], particle swarm optimization (PSO) [11], a pyramidal segmentation algorithm [12], edge detection [13], wavelet-based [14], and others method. This research will used DRLSE method for image segmentation.

DRLSE use level set method approach. DRLSE is proposed because level set function (LSF) in level set method typically develops irregularities during its evolution, which cause numerical errors and destroy stability of level set evolution. To solve these problem, re-initialization method was introduced to restore the regularity of level set function and maintain stable of level set evolution. But it has some theoretical and practical problem in practice of re-initialization [3]. DRLSE method proposed different approach to solve these problem. Consistent of level set function in DRLSE is maintained by a forward-and-backward (FAB) diffusion derived from the distance regularization term. DRLSE eliminates the need for initialization and avoids the undesirable side effect. DRLSE formulation also significantly reduce iteration number and computation time, while maintaining sufficient numerical accuracy in both full domain and narrowband implementation.

In this research, DRLSE method be used to perform medical image segmentation. This research hoped it can be useful in medical image segmentation. It will be easier to perform medical image segmentation.

II. MEDICAL IMAGE

Image is picture that represent something. Image can be picture of people, animals, scene of the outside, microphotograph of electronic device or result of medical image [15]. Medical image is an image which created with different technologies in order to diagnose, monitor and analyze medical condition. Each technology can give different information about body part witch will be studied or treated, related to the diseases, accidents, or to track the development of medical treatment.

One of the tools which can be used for medical image are Magnetic Resonance Imaging (MRI). MRI makes temporary magnetic field around the patient's body. Radio waves transmitted and received to transmitter or receiver in the machine, then the signal will create a digital image of the desired area. Figure 1 shows an example of MRI scan image on knee.

Figure 1. MRI Scan Image on Knee

III. SEGMENTATION

Segmentation is process to dividing the digital image into multiple segments. The purpose are to make the image more meaningful and easier to analyze. There are many methods to do image segmentation, which are intensity thresholding, region growing and region splitting, edge detection, interest operators, watershed segmentation, and markov random models [16].

Region growing approach by making grouping of pixels into large region based on common criteria. Region splitting making the image into one region and divided into smaller region then found the desired results. Level set method used this approach for image segmentation. Distance regularized level set evolution was one of many level set method evolution which is used for image segmentation.

IV. DISTANCE REGULARIZED LEVEL SET EVOLUTION (DRLSE) METHOD

Distance Regularized Level Set Evolution is a development of level set method. It is developed because level set function develops irregularities that cause numerical errors and destroy the stability of level set evolution. To overcome the problem, distance regularization term is added into PDE, then it becomes a DRLSE formulation

$$\frac{\partial \phi}{\partial t} = \mu\, div(dp(|\nabla\phi|)\nabla\phi + F|\nabla\phi| + A.\nabla\phi \quad \ldots(1)$$

With distance regularization term, numerical scheme is stable without the need for re-initialization. DRL. DRLSE can be used for image segmentation including region-based or edge-based image formation to define the external energy. Li in his paper [3] introduced the DRLSE application to an active contour model using edge-based information.
This algorithm first filter the image using Gaussian Kernel Filter to smooth the image to reduce the noise.

Then calculate the energy function:

$$\varepsilon(\phi) = \mu\mathcal{R}_p\phi + \lambda\mathcal{L}_g(\phi) + \alpha A_g(\phi) \quad \ldots(2)$$

Where $\mathcal{R}_p$ is level set regularization, $\lambda > 0$, and $\alpha \in R$ are coefficient of the energy functional $\mathcal{L}_g(\phi)$ and $A_g(\phi)$

$$R_p(\phi) \triangleq \int_\Omega p(|\nabla\phi|)dx \quad \ldots(3)$$

Where P is potential energy

$$\mathcal{L}_g(\phi) \triangleq \int_\Omega g\delta(\phi)(|\nabla\phi|)dx \quad \ldots(4)$$

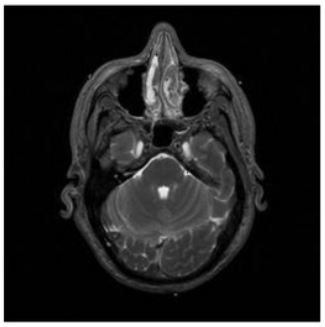
$$A_g(\phi) \triangleq \int_\Omega gH(-\phi)dx \quad \ldots(5)$$

A_g is speed of level set function accelerated. $\mathcal{L}_g$ is minimum when level set function at object boundary.

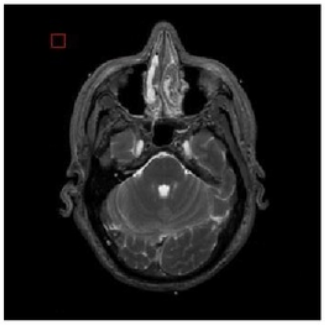
V. RESULT

Distance Regularized Level Set Evolution (DRLSE) method is used in this research for medical image segmentation. Medical image that is used is a MRI Scan of brain and the size of this image is 256x256 pixels. This research shows that DRLSE can be used for image segmentation and the segmentation result is good.

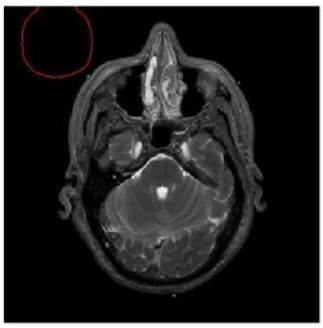
Figure 2 shows the image segmentation result using DRLSE method. First, select the input image. In this research, we using brain scan image (a). After that, initialize the contour of level set function (b). Then the level set function will evolve, moving the zero level set toward the desired object boundary. Curve evolution process of DRLSE model, it is display the zero level contours at iterations 100 (c), 500 (d), 1000 (e) and 1600 (f) which is the segmentation result. The CPU times consumed in this research is 2 minute 20 second. The CPU times were obtained by running the program on HP 431 notebook with Intel Core i3 (2nd Generation) CPU, 2.1 GHz, 2 GB RAM, with Matlab 7.11 on windows 7.



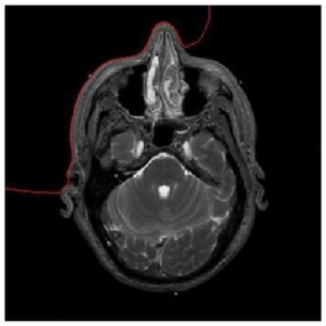
a) Image of Brain Scan



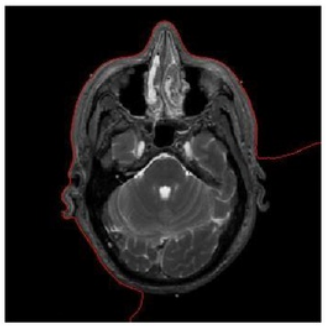
b) Initial Contour of Level Set Function



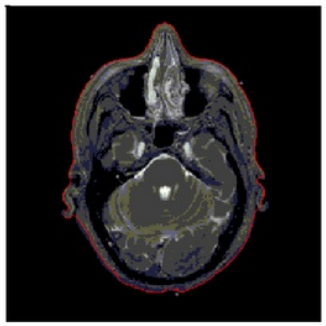
c) Contour at Iteration 100



d) Contour at Iteration 500



e) Contour at Iteration 1000



f) Contour at Iteration 1600, also the image segmentation result

Figure 2. Image Segmentation Result using DRLSE Method

VI. CONCLUSION

DRLSE are one of many method that is used for image segmentation in order to analyze the medical image. DRLSE do not need to re-initialization so the computation time can be faster than level set method. But, if medical image has a big size then time that is need to compute will take longer. To minimize the computational time, maybe in next research, image segmentation with DRLSE method are done in parallel computation. Parallel computation can be done in GPU in order to speed-up the computational time.

ACKNOWLEDGMENT

Thank you Universitas Atma Jaya Yogyakarta for the financial support.

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