Angiographic Image Segmentation Using Gradient Descent Method

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***Abstract*--Image processing is the process of converting an image into digital form and perform certain operations on it. These operations are performed so that enhanced image can be obtained from the original image or we can extract some useful information from the original image. Image segmentation is used to partition an image into non overlapping regions based on intensity or textual information using GA approach. The active contour/snake model is one of the most successful variation models in image segmentation. It consist of evolving a contour in image toward the boundaries of objects and if user is not satisfied, selects a new set of population. Its success is based on strong mathematical properties and efficient numerical schemes based on the level set method. In this research work some techniques have been introduced that helps in the further research.**

Keywords– Active Contour, Gradient Descent Method, Image Segmentation, Level Set Method, Genetic Algorithm.

I. INTRODUCTION

Image segmentation is a process of dividing images into regions (group of connected pixels with same properties) and properties (gray level, colors, texture, motion ……..). In image processing and computer vision, image segmentation is a important part. Region segmentation and edge segmentation are the two approaches of image segmentation. An image have number of objects and each object may contain number of regions describing different parts of images. Images can be subdivided into its constituent regions or objects in image segmentation. Dividing an image into several constitute parts are called segments. Discontinuity and homogeneity are the two basic properties of the image segmentation. In image homogeneity (similarity) is used to partition an image into regions. In the intensity of images homogeneity is present which is hard to process. In image discontinuity, images can be partition which depend on the sharp changes in the images. In image segmentation portioning an image into segments region is the problem. An important part of the image segmentation is to segment the image into "face" and "background". Compact description of an Image is the important part of image segmentation. In image segmentation following two approaches could be used: a) Contour Segmentation (edge detection and contour tracing), b) Region Segmentation (Grouping of connected pixels in to regions of uniform properties).

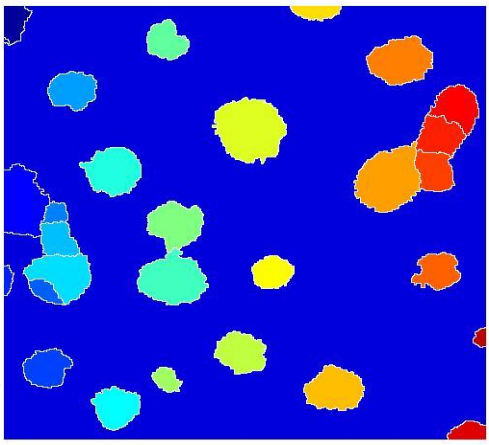

Figure: Image Segmentation

In active contour, image segmentation and machine vision algorithm are used to extract the two dimensional objects which are surrounding by the minimum area of contour. To shrink/expand the objects outer contour in any iteration is the main idea of the algorithm. Parametric active contour and Geometric active contour are the two different classes of active contour. An active contour is an energy minimizing spline that detects specified features within an image. It is a flexible curve/surface which can be dynamically adapted to required edges/objects in the image, it can be used to automatic objects segmentation. It consists of a set of control points connected by straight lines. In active contour theory, contour is represented in two dimensional space by a set of connected points. The contour points may be expressed as a function of one variable between zero and one:

$$C(s) = [x(s), y(s)], s\_ [0, 1]$$

Osher and Sethain implement the level set method whose theory is depend on the curve and surfaces. The level Set Method is a numerical technique for tracking interfaces and shapes has been increasingly applied to image segmentation. Time dependent level set formulation and Stationary level set formulation are the two formulation of the level set method. The main advantage of Level Set Method is that one can perform numerical computations involving curves and surfaces on a fixed Cartesian grid without having to

parameterize these objects. The level set method amounts to representing a closed curve using auxiliary function called level set function which is represented as the zero level set. The level set method defines problem in one higher dimension. The zero level set at one point in time as a slice of the level set surface. The formulation of level set implies that the level set value of a point on the contour with motion must always be zero. Number of segmentation problem is solved by level set method. Signed distance function is used to define the level set method. Any pixel in the image is taken by the signed distance function and returns as its output the Euclidean distance between the pixel and the closest point on the interface. The level set method is a geometric active contour model, can be used to isolate and build a description of a particular shape by coherent mathematical.

The gradient descent method is used to solve the optimization problem in level set method. Gradient descent method is also known as steepest descent. Gradient descent of the energy deforms the initial contour. Convergence to local optima and slow convergence in general leads by the gradient descent method. The gradient descent method always moves in the negative direction of the gradient which minimizes the cost function. Solving the steps of gradient descent method is easy since they only involve the first order derivatives of the cost function. Gradient descent exhibits slow convergence and is sensitive to local optima. The convergence rate and the robustness against local optima for gradient descent method has been improved by avoiding the complexity of more sophisticated optimization algorithms like gradient descent with Momentum and Rprop. The resilient back-propagation algorithm (Rprop) was proposed by Riedmiller and Braun (1993). This technique uses adaptive steps based on the behavior of the cost function. A simple and intuitive approach is to extend traditional gradient descent by adding momentum. This idea was initially proposed in Rumelhart et al. (1986), where the training of an artificial neural network is formulated as an optimization problem. The basic idea is to add a fraction of the previous search direction to the current step, which adds a physical "inertia" to the motion in the search space. The practical benefits of this strategy are that local optima can be overstepped while the search accelerates in favorable directions, there by increasing the rate of convergence.

In image processing problems, many Genetic algorithms have applied, such as edge detection, image segmentation, image compression and feature extraction from remotely sensed and medical images. The genetic algorithm, processes with a population of random pipelines, evaluates the fitness of pipelines in the population, choose the fitness to create the next generation. The genetic algorithm framework brings considerable flexibility into the segmentation procedure by incorporating both shape and texture information. Genetic algorithm is used to find the state position for the contour points of each iteration of the active contour, which involves primarily a parametric method usually with Snakes.

Medical imaging allows scientists and physicians to understand potentially lifesaving. Information without doing anything harmful to the patient. It has become a tool for surgical planning and simulation and for tracking the progress of diseases With medical imaging playing an increasingly prominent role in the diagnosis and treatment of disease, the challenging problem of extracting clinically useful information about anatomical structures imaged through CT, MR, PET1 and other modalities has become important [95]. Although modern imaging devices provide exceptional views of internal anatomy, the use of computers to quantify and analyses the embedded structures with accuracy and efficiency has been limited.

Angiography is the imaging of vessels, and the resulting pictures are angiograms.
Angiography of the retina of the eye requires the injection of a small
Amount of dye into a vein in the patient's arm. The dye travels through the blood
Stream and is photographed using special cameras and colored light as it travels
Through the vessels of retina.

II. RELATED WORK

In paper [1], five experiments has been done. In first it uses the 2D synthetic image Spiral with noise. In this there is a middle vertical line in the local dip in magnitude and from top to bottom magnitude gradient has also been added. In second it uses three retinal images from the drive database. In this images have cropped to the vicinity of the macula lutea. In third it uses 3D synthetic volume with a shell disturbed by noise. In forth it test volume in the 3D "Head MRT and Angiography" and the dataset is displayed in a volume. In fifth and final experiment it uses 100 different 3D volumes generated by VascuSynth.
In paper [2], the level set function has been initialized to constants in which it have different signs are inside and outside the contour. In this Gaussian filter has been utilized to smooth the level set function. In this inhomogeneous gray intensity is often occur in medical images. In the image, vessel boundaries pats are quite weak and it is difficult to segment the task of the vessel for the back-ground.
In paper [3], in this two experiment has been done. In first, it employed two different areas for cell planning. In this radius of the cell was fixed. In second, tried to evaluate the algorithm for the realistic case. In this resulting of the radius was not fixed. In this on the basis of active contour theory cell planning has been evaluated.
In paper [4], in this by applying the level set method on the whole image of the cyst border. It indicated that we do not need to find a new set of parameters on the whole image. In this it measure the airway of the inner diameter of CT images. In this one of the problem was during the lung CT image processing was voxel size.
In paper [5], images has been taken from a database of 2700 pelvic CT scans on testing has been done. 15-20 slices of

2D and 3D CT scan of the patient has been stacked together. The prostate has been delineated three times on the same set of images by the radiologist which provides a database for intra-operator variability.

III. PROBLEM STATEMENT

After studying literature, we find that there can be a method which can optimize the boundary result within less iterations with faster convergence and escaping local minima. So this is how we decided to make a modification in the existing Stochastic Gradient Descent (SGD) method to make it the most suitable optimization method. In this paper we focus on the image segmentation using the level set method and optimization is performed over it by our proposed method.

Need and significance of proposed research work:

- Since there have been devised a series of methods to optimize the image segmentation but the still there is need to do refinements in the images. What if the image given to the system is noisy itself? One needs to apply noise removal technique over it and then proceed with the system.
- We are changing the level set function which causes the parameters to be changed.
- And hence the evaluation function is to be altered in such a way so as to properly judge the functioning of the new level set method.

IV. PROPOSED WORK

Gradient descent method is a very common optimization method which appeal lies in the combination of its generality and simplicity. It can be applied to all cost functions and the intuitive approach of the method makes it easy to implement. The step of gradient descent method are easy to calculate since they only involve the first order derivatives of the cost function. Here, the performances of the proposed methods are quantified in a series of 2D/3D-experiments using real and synthetic data with ground truth. In comparison with standard and stochastic gradient descent, the modifications are shown to reduce the sensitivity for local minima and to increase the convergence rate.

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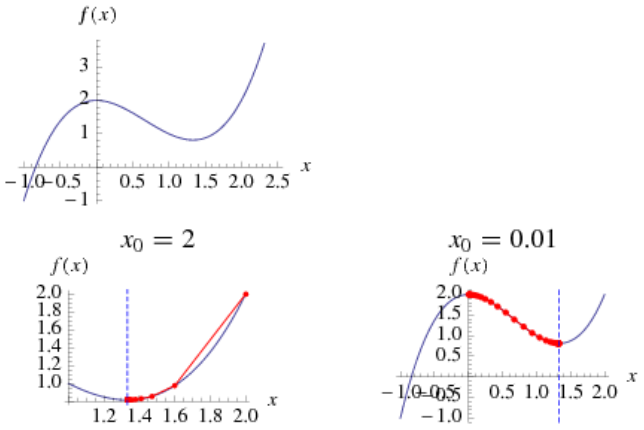
V. METHOD OF GRADIENT DESCENT

An algorithm for finding the nearest local minimum of a function which presupposes that the gradient of the function can be computed. The method of steepest descent, also called the gradient descent method, starts at a point $\mathbf{P}_0$ and, as many times as needed, moves from $\mathbf{P}_i$ to $\mathbf{P}_{i+1}$ by minimizing along the line extending from $\mathbf{P}_i$ in the direction of $-\nabla f(\mathbf{P}_i)$, the local downhill gradient.



When applied to a 1-dimensional function $f(x)$, the method takes the form of iterating

$$x_i = x_{i-1} - \epsilon f'(x_{i-1})$$

from a starting point x_0 for some small $\epsilon > 0$ until a fixed point is reached. The results are illustrated above for the function $f(x) = x^3 - 2x^2 + 2$ with $\epsilon = 0.1$ and starting points $x_0 = 2$ and 0.01, respectively.

VI. PROPOSED ALGORITHM:

- Select an input image from the collected images from dataset.
- If the image is noisy then noise removal techniques will be applied else the image will pass on to be re-mapped.
- The image is converted into gray scale image. Then Bilinear Transformation is applied on image for re-mapping
- Apply Level Set Function by providing level set parameters.
- In order to solve the optimization problem in level set segmentation methods, the stochastic gradient descent method is used.

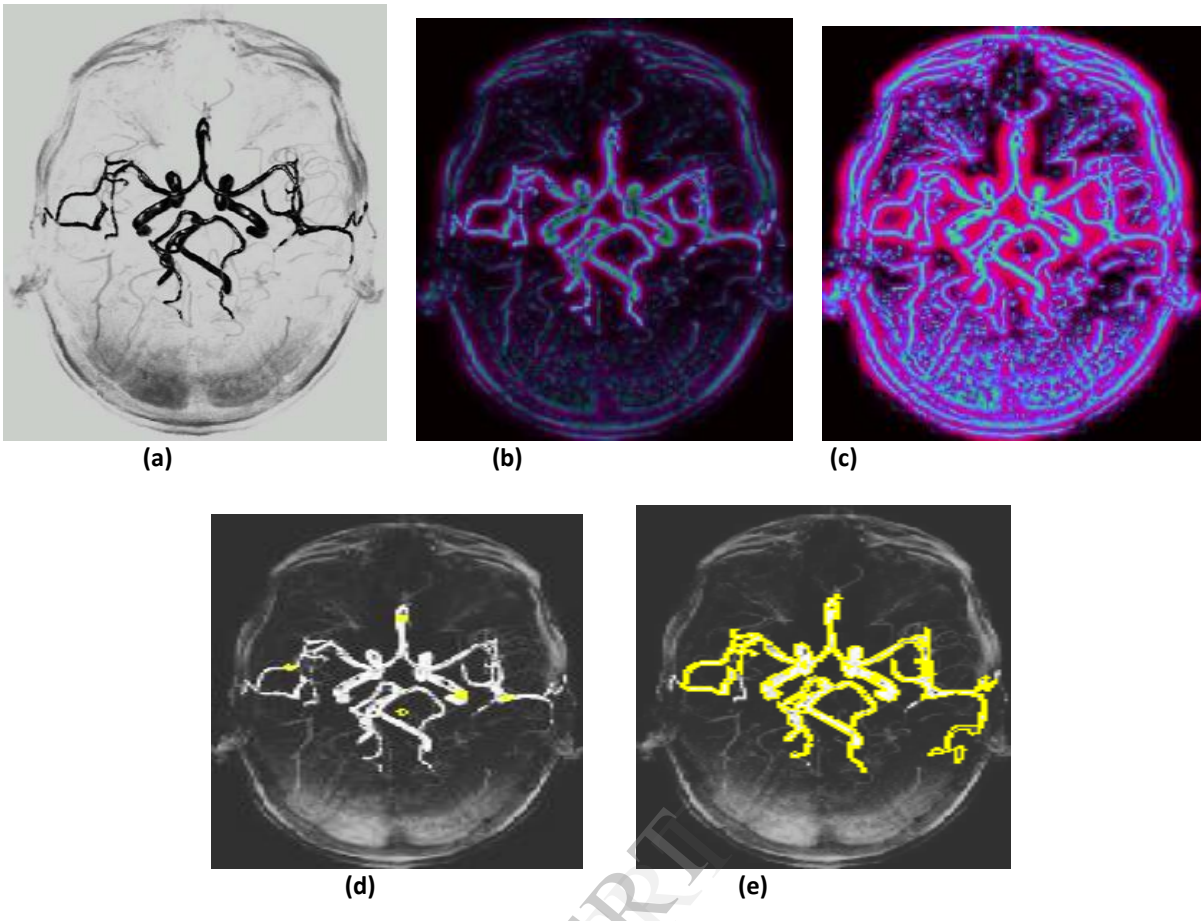


Figure (a): Original Image (b) Refinement of Image (c) Apply Euler M`apping on (d) Initialize level set (e) Final object segmentation using SGD.

Methods(→) Parameters(↓)	GD	SGD	Momentum	R-prop	MSGD
Conv. Ratio	19%	27%	30%	95%	97%
# weighted iter.	400	353	324.5	195	186
Clock time/iter.	0.4	0.4	0.5	0.5	0.42
Youdens Index, Y	0.79	0.8	0.8	0.8	0.86

Figure: Table of Angiographic

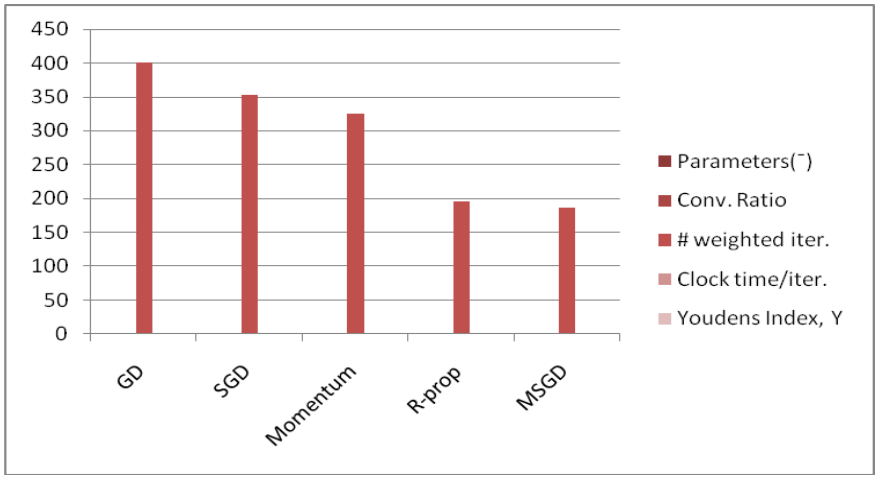


Figure: Graphical representation of Angiographic.

VII. CONCLUSIONS

Image segmentation using level set method involves the optimization in active contour space. This paper proposes an image to obtain the result in as least possible iterations. It accepts all kinds of images. It acquires the results in least possible time. It reduces the complexity of the present method. It accurately locate the edge of an organ in a medical images. The active contour model is image segmentation model which is used in various image processing applications. Its success is based on strong theoretical properties and efficient numerical schemes. Our proposed system correctly assesses geometrical properties of the contour. The segmentation can be optimized effectively using Stochastic Gradient Descent method. The advantages of Stochastic Gradient Descent are Efficiency and Ease of implementation (lots of opportunities for code tuning).

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