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Segmentation of Chondroblastoma based on Active Contour and Level Set Method

P. Y. Muhammed Anshad[1]* and S. S. Kumar[2]

[1]Department of Electronics and Communication, Noorul Islam University, Tamil Nadu – 629180, India; anshadpy@gmail.com
[2]Department of Electronics and Instrumentation, Noorul Islam University, Tamil Nadu – 629180, India; kumar_s_s@hotmail.com

Abstract

Chondroblastoma is a type of benign bone tumor originates from chondroblasts. The rate of misdiagnose is much higher among benign bone tumors. The treatment method is different in both cases. Computer Aided Diagnosis (CAD) system helps more for reducing the rate of misdiagnosis. Segmentation is used for the selection of area of interest from medical images. The possible ways of diagnosis is X-Ray, CT, MRI and Biopsy. Active contour modeling is tested using region based approach. Various levels set and Gaussian distribution function is used for segmentation process. The proposed system separates similar intensity values of mean and different intensity values of variance. This system segments similar intensity regions as suspected area. At the end of this work, the system can extract the exact position and shape of the condroblastoma affected region in bone.

Keywords: Chondroblastoma, Computer Aided Diagnosis, Gaussian Distribution Function, Level Set, MR Images Segmentation

1. Introduction

Chondroblastoma is a type of rare benign bone tumour which starts from chondroblasts. Segmentation of Chondroblastoma is a challenging job that can reduce misdiagnosis. Segmentation is one of the basic tasks for computer oriented diagnosis methods. But due to varying parameters, this segmentation becomes difficult to get higher accuracy. In case of chondroblastoma, the intensity variations may cause diversions from the original Regions of Interest (ROI).

There are different methods of segmentation available as a result of researches in this field. One widely selected new method is active contour method. Here actually gives pixel by pixel and sub pixel accuracy than other methods. This active contour method can apply in two different classes. One Edge based method and another one is region based.

Region based modelling refers to homogeneity to in homogeneity transitions. This groups similar intensity regions as group. But these intensity variations can occur in different ways. All the ways except the lesion occurred area should remove from the selection of region of interest. Another one change of intensity variation is due to change of machines. Different machine gives different intensity values due to strength of RF coils. Noise is one of the major problems facing issue in this field. These factors always affect a successful segmentation and the challenge can overcome up to a limit using this method of segmentation.

Edge based model is the other one model. This is more susceptible to noise. This modelling can separate ROI with neighbouring pixels. If the segmentation area is straight or curved, which can segment part based segmentation.
Intensity homogeneity is the basic step in segmentation. This can acquire with the usage of different modalities.

*Author for correspondence

In chondroblastoma, X-ray images and MRI images were considered for initial CAD based diagnosis systems. Variation of intensity in an image from normality is due to different reasons. Noise interaction and abnormalities are the main reasons for this change. These two things are the platform of this paper.

In this paper Active contour model can perform segmentation more accurately and reliably. Some local fitting energy method is used for the detection of object boundary and used its mean and variance for the interpretation of some functions. Gaussian distribution method is used for the calculation of intensity values with the calculated mean and variance. To make a cluster, the similar values are needed to categorize with its neighbouring points. Curves can evaluate using some associated functions. The local intensity functions can help to segment various regions using this various intensity values.

2. Background

In the area of medicine, diagnosis is one of the most important to start treatment. There is a well-developed system already available with lots of machineries like X-Ray, CT, and MRI etc. These machineries only provide the corresponding images of the affected area. The decision is still manual in most of the cases. This may cause the highest possibility of misdiagnosis. Here comes the importance of CAD system. Now a day's a large number of researches going on in the field of Computer Aided Diagnosis. Segmentation is one of the major areas in CAD systems. There are different types of segmentation methods available now. This is possible to use manual, semiautomatic or automatic segmentation schemes which depend on the area of segmentation.

Adams et al.[1] proposed a homogeneity method which calculates the difference between mean intensity and pixel intensity of regions. Pohele et al.[2] proposed for the usage of adaptive method of region growing algorithm which used a differences in learning process other than weighted sum method. Region growing algorithms are faster and may segment unwanted regions due to noise. The possibility of more number of segmentation is another one problem for the same. Bencher et al.[3] proposed a watershed algorithm. This uses some mathematical morphology for this algorithm. Serra et al.[7] proposed watershed algorithm with some changes. The landscape height represents the pixel intensity. In this system, the water sheds are divided by lines of rain falls on each region. But this method failed to detect or poor detection on thin regions and regions with low signal to noise ratio. Grau et al.[4] proposed a system to reduce over segmentation and achieving this some prior information should give to the system.

Kass et al.[5] proposed a system using active contour model. This method contains two kinds of segmentation. These are based on internal features and external features. External features extract the image features and can find the edges and lines. This model configures with minimum energy and takes the best contour of presented image. Atkins et al.[6] proposed this model for brain segmentation. Thresholding and active contour method in cooperatively can produce a good segmentation algorithm. Thresholding is used to find the edge. Sethian et al.[16] proposed a system using level set functions in corporation with contour method can solve lots of problems and higher definition surface can set using this function. Finally two contours are merged together to form a common segmented image. The major disadvantage of level set function is that when it reaches zero level set, then this may change sharp edge, breaks in image, shape information etc. Droske et al.[8] proposed a system using velocity functions and this increases the speed of segmentation.

3. Proposed Method

Chondroblastoma is a type of benign bone tumor originates from chondroblasts. The rate of misdiagnose is much higher among benign bone tumors. The treatment method is different in both cases. Computer Aided Diagnosis (CAD) system helps more for reducing the rate of misdiagnosis. Segmentation is used for the selection of area of interest from medical images. In this system proposes a method for the segmentation of chondroblastoma using active contour and level set method. The main sections are Image selection, Preprocessing[11], Level set evaluation with Gaussian distribution energy and Active contour method etc.

3.1 Image Selection and Preprocessing

Selection of Images is very important for the improvement of accuracy in diagnosis. In this work the database consists of X- Ray images of different patients of different types of lesions affected and these are specifically collected for study. The radiologist made the seed point for setting them into automatic way of calculations[9].

Image Preprocessing is the fundamental step for the development and interface of these types of Computer Aided Diagnosis (CAD) system (Figure 1). This method will reduce the noise affection and can improve the reliability of this system. This also improves visual clarity and intensity homogeneity is possible with each clusters. RGB to gray converting makes the image in a weighted sum of R, G and B as 0.29, 0.59, and 0.11 respectively. Then the intensity values should saturate as low intensity values and high intensity values. This sets a cluster of low intensity values into a single intensity and high intensity to other one intensity values[10].

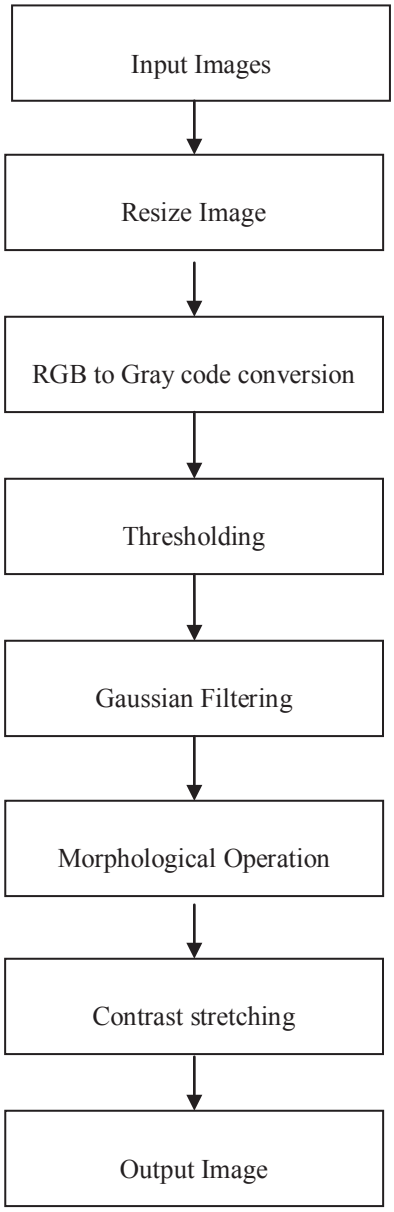

Figure 1. Preprocessing flowchart.

Gaussian filter is used[12] for initial filtering the image with an impulse response h(t)

$$h(t) = \frac{exp\left[\frac{-t^2}{2\delta^2}\right]}{\sqrt{2\pi\delta}} \quad (1)$$

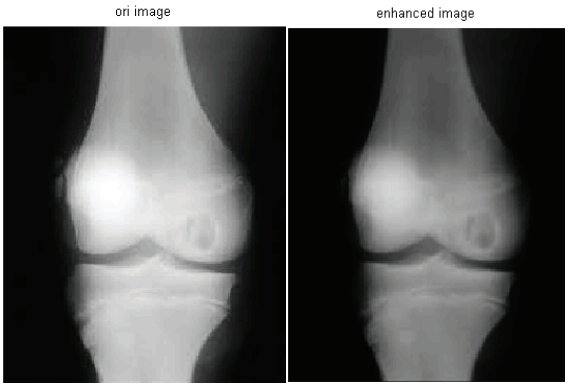

Figure 2. (a) Original Image and (b) Enhanced Image.

The next step is contrast stretching. Here the pixel values below threshold are shown as black and above is white. In between these two is shown as gray as per the intensity variations[14]. Now the lesion will be more visible than original one (Figure 2).

3.2 Level Set Function

Traditional methods of this method include a set of mathematical formalities which is denoted by A. Then the level set equation is[15],

$$A(t) = [(x1,y1) \mid \Phi\ (t,x1,y1) = 0] \text{ of function } \Phi\ (t,x1,y1) \quad (2)$$

In general form, the equation is

$$\frac{\delta^{\Phi}}{\delta t} + S|\nabla\Phi| = 0 \quad (3)$$

Two kinds of segmentation available with level set. These are based on internal features and external features (Figure 3). External features extract the image features and can find the edges and lines. During evaluation, both contours are merged to one in a higher dimension surface[18].

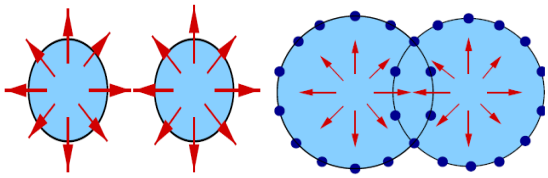

Figure 3. (a) Two contours and (b) Merged contour.

The contour is started by some force and this may depend on many factors like geometric information and global properties of that contour. The iterative algorithm requires updating only the level set section[13]. In this method, the possibility of inaccuracy during zero level set can resolve at edges, corners etc.

4. Variational Level Set Functions

To consider this method of vibrational level set functions some properties need to satisfy (Figure 4). The main function is:

$$|\nabla\Phi| = 1 \tag{4}$$

The proposed integration is:

$$D\Phi = \iint \frac{1}{2}(|\nabla\Phi| - 1)\,dxdy \tag{5}$$

Vibrational level set can propose as:

$$H(\Phi) = \mu D(\Phi) + Em(\Phi) \tag{6}$$

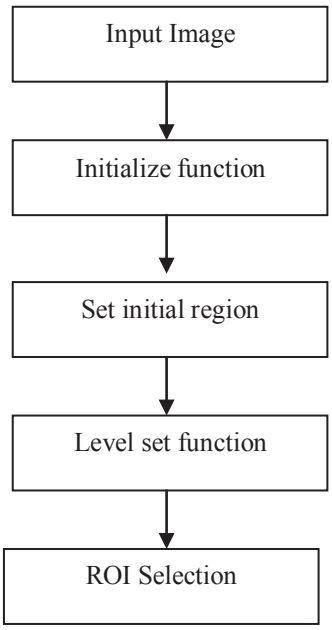

Figure 4. Segmentation using Level set function flow chart.

4.1 Algorithm

- Initialise level set function, Φ.
- Repeat following n times(n is no of iterations).
  - Calculate local means μ1 and μ2 (local to 13x13 neighbourhoods).
  - Calculate local variances σ1 and σ2.
  - Update level set function.
  - The required foreground is the contour of level set function Φ[19].

5. Gaussian Distribution Fitting Energy

In this paper proposes a Gaussian Distribution Fitting Energy (GDFE) with Active Contour Method (ACM) with the distributed intensity values. The initial step is to group the local intensities with respect to neighboring pixels. A group of intensities makes as a cluster and this cluster again divided into 3 groups based on intensity variations. Each sub regions again divided again and again using Bayer's rule. This method differs from other method that is the usage of double integral. Thus the mean and variance will be spatially varying[20].

6. Experimental Evaluation and Results

Segmentation of Chondroblastoma is a difficult task because of intensity in homogeneity in different images. Thus we have selected ACM with GDFE. The main steps include selection of image, preprocessing, Apply ACM and GDFE, Removal of noise, Selection of ROI, Remove other selections of same intensity based on chondroblastomic features. In this section, we have made a semi-automatic segmentation technique to find out the area of chondroblastoma. Manual selection of seed point makes a benefit that the same system can use for both X-Ray (Figure 5) and MRI images (Figure 6). This makes the system more reliable and efficient in this field.

This work was implemented using MATLAB 7.12.0. Extraction of region of interest, the first step is the selection of images as a database. Chondroblastoma is reported as a rare case and so the possibility of fault diagnosis is much higher than other cases. In this system, X-Ray and MRI images can use as input image, but should keep in separate database. Before preprocessing RGB to gray code converter converts the original image into gray scale and applies preprocessing technique. This removes noise affection and improves the quality of image. Level set method and Gaussian distribution function segments the ROI with the help of some specific parameters.

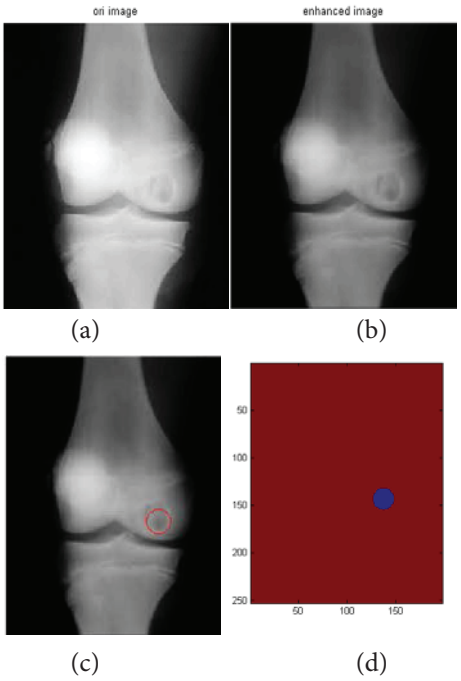

Figure 5. (a) Original Image, (b) Enhanced Image, (c) ROI identification and (d) Shape of ROI.

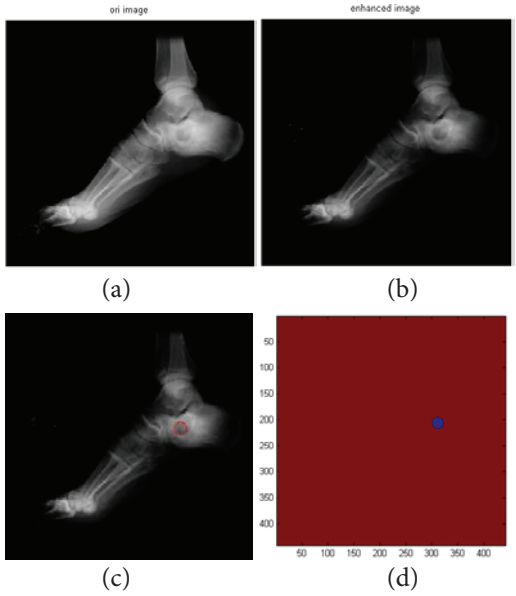

Figure 6. (a) Original Image, (b) Enhanced Image, (c) ROI identification and (d) Shape of ROI.

7. Conclusion

In this paper we proposed a combination of Active contour method with level set function and Gaussian distribution energy for the segmentation of chondroblastoma affected region from medical images like X-Ray or MRI. This method utilized image intensities using Gaussian distribution energy with different mean and variance. The proposed system uses level set function and possible to use for the signed distance function. We demonstrate the system in real images from X-Ray and MRI. In particular this system is applicable in the presents of strong noise and also in weak boundaries.

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