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Research paper

Automatic segmentation of chondroblastoma from X-ray images using active contour and levelset method

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Abstract

Chondroblastoma is a benign but locally aggressive bone tumor found usually in the age below 25 years. Chondroblastoma is a destructive type of lesion with a thin radio dense border which is normally seen in the epiphysis of long bones. The benign tumors have similarities in pathology and could be related with histogenic similarity. This tumor reduces the strength of affected bone and may leads to death if not treated early. Chondroblastoma can be diagnosed from X-ray/CT/MRI images and the treatment is its removal by surgical methods. Diagnosis of Chondroblastoma is difficult due to the similarities with other benign tumors like chondromyxoid fibroma. To reduce diagnostic errors, computer aided methods can adopt. This work focuses on automatic segmentation of Chondroblastoma using active contour and level set method which gives better segmentation results and a mild stone to CAD design.

Keywords: *Chondroblastoma, computer aided methods, segmentation, active contour, levelset method, CAD,*

1. Introduction

Chondroblastoma is a benign bone tumor most frequently arise in the epiphyses of long bones, with 75% occurring in the humerus area. They tumor size commonly seen is 3-4 cm. Figure 1 shows the anatomy of normal knee and Chondroblastoma affected knee. It clearly shows some lesion around the cartilage area. Chondroblastoma is diagnosed from X-ray/CT images and the tumor can be removed by surgical method. In the proposed method, the system can identify tumor area using automatic seed point selection method, can identify the region of interest (ROI) using segmentation method and can calculate the volume of ROI which assists the doctors for the successful removal of tumor.

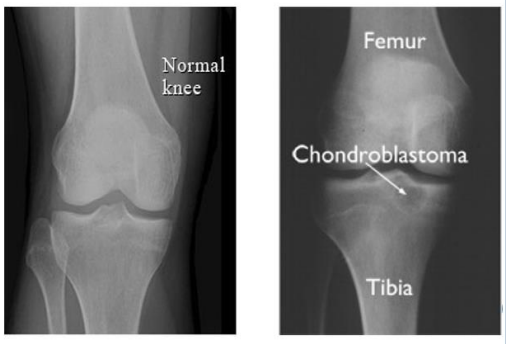

Figure 1: a). Normal knee anatomy b). Chondroblastoma affected knee

In most of theimage based diagnostic operations need individual objects to be divided into different from the image. Image segmentation is a fundamental task which is responsible for the separation of different parts using homogeneity. The job of segmentation is to divide an image into its basic and disjoint sub-regions that are identical based on their properties like color, quality, intensity etc. Segmentation algorithms are commonly based on either discontinuity or similarity with sub regions. The purpose of segmentation is to divide an image into different sub-regions. The role of classification is to identify the divided sub-regions. Thus, segmentation and classification are general functions as individual and sequential process. Active contours work on the basis of relaxation [1] methods, and this valid to different image segmentation issues. Active contours also can be used for image segmentation and boundary tracking in snakes by Kass et al. [2]. The basic idea is to start with initial boundary shapes which is represented in a type of enclosed curves. The contours are iteratively change them by applying expansion or shrink operations based on the constraints of images. These are called contour evolution and made by the minimization of some energy function like fixed region based segmentation methods [3].

2. Background

In the area of medicine, diagnosis is one of the biggest and fundamental task to start treatment. There is a well-developed system already available in the field of diagnosis like X-Ray, MRI, CT etc. These machineries only provide the images of the affected area for diagnosis. The decision is still manual in most of the cases. This may increase the possibility of misdiagnosis. Here comes the importance of CAD system. Now a day's more researches going on in the field of CAD. Segmentation is one of the difficult and important area in CAD systems. There is a variety of segmentation methods available. This is possible to use semiautomatic or fully automatic segmentation methods which depend on the area or method of segmentation. Bone tumor images varies in size, shapes, position and its appearance. It's based on reducing an object function by updating membership function to cluster centers. The object function used here is the weighted sum of distances from cluster centers. The weighted mean of data is the cluster center anditeration is continued till the operation between iterations exceeds a threshold value. This method is more time consuming and to overcome this problem. Atkins proposed such a model for brain tumor segmentation. Here

thresholding and active contour method can produce a good segmentation algorithm. Thresholding is used to find the edges in the image [6]. Finally two contours are merged together and form a common segmented image. The major disadvantage of this level set function is that when it approaches zero level set, then this may change sharp edge, breaks in the image, shape information etc [7]. Droske proposed a system using velocity functions and this increases the speed of segmentation [8].

3. Proposed method

The proposed work consists of preprocessing of input images, automatic selection of seed point, segmentation of Chondroblastoma, calculation of volume and ROI parameters etc. This work compares different existing methods for bone tumor segmentation and shows how this work exhibits higher results. Figure 2 shows the block diagram of proposed work which includes preprocessing, seed selection, segmentation and volume calculation using different algorithms.

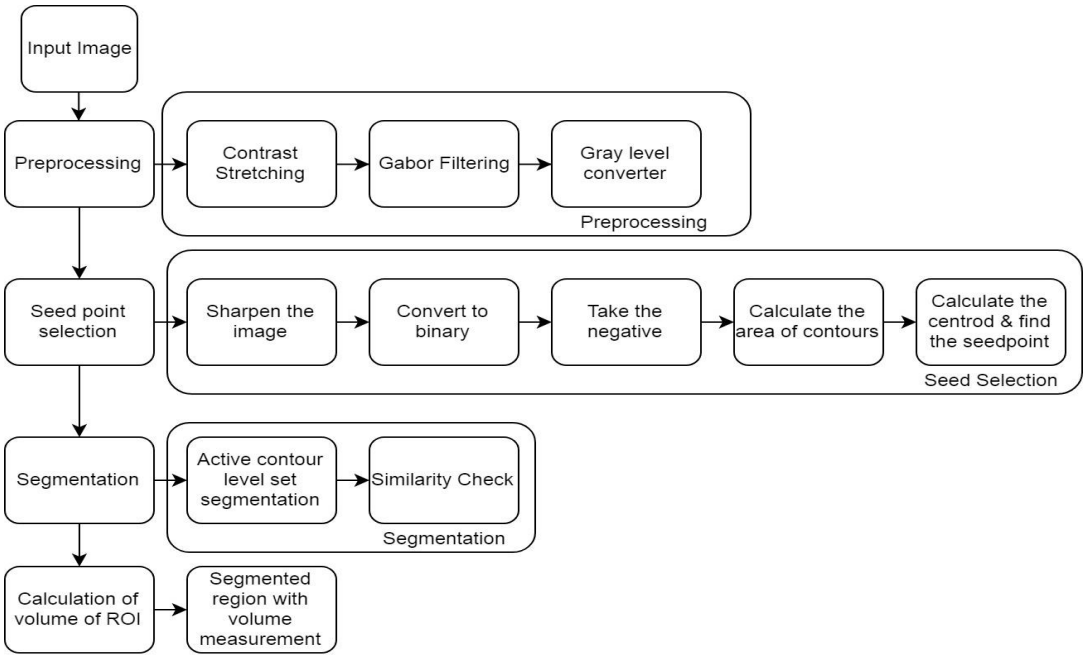

Figure 2: Proposed Segmentation of Chondroblastoma

3.1. Pre-processing

It is a fundamental step to improve the quality of input image. The image pre-processing started contrast stretching technique to improve the quality of input image. In the pre-processing, the main importance is given for background separation so as to get the region of interest. The main pre-processing steps are contrast stretching and morphological operation to remove noise and small objects from the background. Figure3 shows the result after pre-processing.

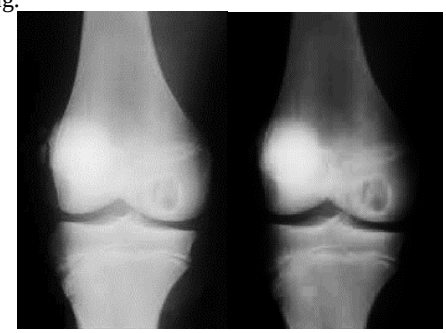

Figure 3: a. Original Image b. Pre-processed Image

3.2. Segmentation

Segmentation is the process of partitioning a digital image into different segments based on similarity in intensity values. From the proposed method chondroblastoma is segmented using active contour & level set function. Region growing is the most common segmentation algorithm normally used for lesion segmentation. It is a simple region based segmentation method which partition an image into different regions based on intensity. This groups pixels of similar intensities as one group. However the seed point and threshold values are selected manually which leads to human errors.

This work aims at finding an automatic means of seed point and threshold value selection that can be employed in the region growing algorithm. Segmentation of chondroblastoma using active contour & level set function is explained in 3.4

3.3. Automatic seed point selection

In previous work the seed point selection was manual and the system is semi-automatic. This work proposed an automated seed point selection and segmentation using active contour level set method. Here in the case of chondroblastoma both intensity of tumor region & its volume should be considered. Chondroblastoma shows well circumscribed tumor in the epiphysis and the size of lesion is 3-4 cm. This property can be used to find the seed point.

The pre processed image can convert to binary form to distinguish the contours present in the image. The calculation of contour size leads to region of interest (ROI). The seed point can be selected by calculating the centroid value of selected contour

Steps

1. Sharpen &Convert to binary image.
2. Take negative &Find out the contours involved in the image.
3. Find the area of all contours and find which contour satisfies the properties.
4. Find the centroid of the selected contour using equation 1 and update using 2 & 3.
5. Select the seed value from centroid.

Let the seeds be S1, S2… Sk where k is the total number of seed present. The seeds can also be referred as allocated pixel and others called non-allocated pixel.

$$C = \frac{x1+x2+x3}{3}, \frac{y1+y2+y3}{3} \quad (1)$$

Where
C – Centroid value, x1, x2, x3 – x coordinates, y1, y2, y3 – y coordinates

$$eU = \{x \in {}_{i=1}^{n}U\ Si\ |N(x)iS_i^n \neq 0|\}$$

Where N(x) is the non-allocated neighbors
Similarity criterion δ(x)

$$\delta(x) = |g(x) - mean(g(y))|$$

3.4. Active contour level set method

In the level set formulation, the evolution of curve can be computed by evolving the zero level of a function φ.
A(t) = [(x1,y1) | Φ (t,x1,y1) = 0] of function Φ (t,x1,y1)
In general form, the equation becomes

$$\frac{\partial \phi}{\partial t} + S\,|\nabla \phi| = 0$$

Compute the image gradient

$$\nabla I(x) = [\partial I(x)\ \partial x, \partial I(x)\ \partial y]$$

The edge map is a function based on the image gradient

$$V(x) = 1/1 + |\nabla I(x)|$$

Two kinds of segmentation available with level set. These are based on internal features and external features (Fig. 4). 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.

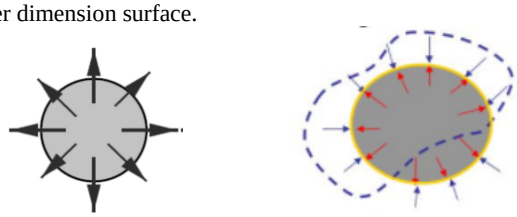

Figure 4: (a) Contour (b) Merged contour

Active contour can detect internal boundaries regardless of the position of its initial contour. The use of this initial contours provides a method of independent segmentation.

4. Simulation results and discussion

This section gives the results of proposed work with the description of database and performance analysis. The input images were acquired from 15 different images from hospitals. The images used for this proposed work is x-ray with a size of 256x512.
The pre-processed image is converted to binary to obtain contours. The area is selected from the obtained contours which satisfy the above condition and calculate the centroid of that contour for seed point selection. Figure 5 shows the different images obtained during processing and the output obtained after active contour and level set method.

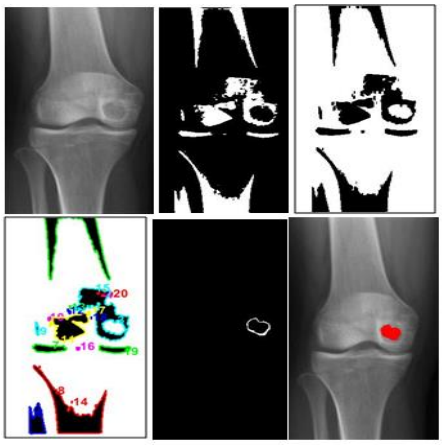

Figure 5: Seed point selection a)Pre-processed input Image, b) Negative of Image c) binary image d) Calculation of area of each contour e) find the seed point by taking centroid f) Segmented region using active contour method

5. Performance evaluation and comparison

This proposed system is evaluated using accuracy, specificity and sensitivity. Specificity & accuracy calculations based on FP, FN, TP and TN of its pixels using equation 4 & 5. The ground truth is taken by a group of radiologists and the result labeled by algorithm also tested.
Accuracy (A) = (TN + TP) /(TN + TP + FN + FP) (4)
Sensitivity = NTP/(NTP+NFN) (5)
Specificity δ = TN/ (TN+ FP)

Table 1: Statistical comparison of Accuracy, sensitivity & specificity of obtained results from different images

Images	Accuracy	Sensitivity	Specificity
1	72.904	70.62	78.39
2	71.903	70.33	78.07
3	76.18	74.1	82.25
4	65.104	64.02	71.06
5	80.873	79.22	87.93

Sensitivity and specificity are two statistical measures for finding the performance of processed images in medical field. Sensitivity measures the percentage of actual positives values identified whereas specificity measures the percentage of negative values which are correctly identified. Sensitivity (TPR) is the ratio of tested positive(TP) and actual positive(TP+FN). The statistical values are given in table1 and shown in figure 6. The proposed system shows an average accuracy of 73.4 % which gives a better result in segmentation. This also exhibits an average specificity of 79.54 and a sensitivity of 72%

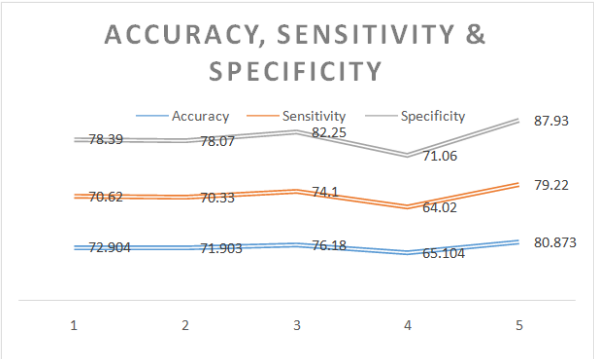

Figure 6: Graphical comparison of accuracy, sensitivity & specificity results.

5.1. Volume measurement

Chondroblastoma is diagnosed from X-ray/CT/MRI images and the tumour can be removed by surgical method. For the successful removal, the exact volume of tumour should be known, which can be identified by segmenting the tumour region from the image. Chondroblastoma can be segmented from X-ray image by manual and computer aided methods.Even once well-trained consultants perform this operation were employed using manual segmentation is susceptible to errors related to inter observer and intra observer variability. To avoid that the volume of tumour can find out using the proposed method. Table 2 shows the comparison chart for the volume measurement and its graphical representation is given in figure 7.

Table 2: A comparative measure of volume by computer aided method and manual method

Comparison of volume measurement		
Images	Ground Truth	Active Contour
1	693	704
2	2675	2850
3	5730	5701
4	5515	5512
5	702	875

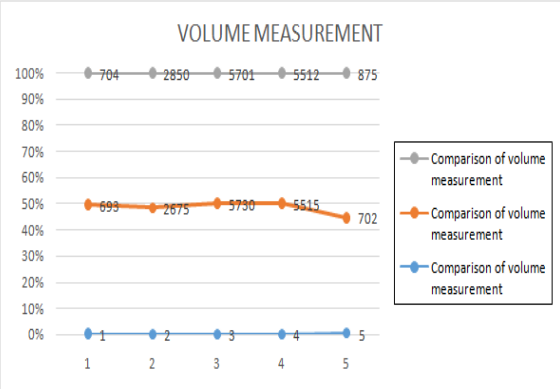

Figure 7: Comparison of volume measurements using different methods

6. Conclusion

This paper describes how segmentation of Chondroblastoma can be made based on active contour level set method with automatic seed selection. This work helps the radiologist and doctor for detecting lesion area and whether the lesion is chondroblastoma or not. This also helps the surgeon for planning surgery based on the evaluation results. This work helps to calculate the volume of lesion affected and the result shows that it is an efficient tool to detect region of chondroblastoma from x-ray images.

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