Image Segmentation of Mammographic Images Using Kekre'S Proportionate Error Technique on Probability Images

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Abstract—**Mammography is well known method for detection of breast tumors. Early detection and removal of the primary tumor is an essential and effective method to enhance survival rate and reduce mortality. In this paper, proposed algorithm uses probability of mammographic image as input for vector quantization .For region forming Kekre's Proportionate Error (KPE) algorithm is used and codebook of size 128 is formed .Further this 128 clusters were used for region merging using KPE algorithm for reclustering .To separate tumor ,post processing is done by morphological operations. For this tumor sectional area is calculated and center point is compared with LBG algorithm for segmentation of mammographic images.**

Index Terms— **Mammographic images, segmentation, vector quantization**

I. Introduction

Of all diagnostic methods currently available, mammography is the most reliable method for early detection [1], [2]. Of the breast cancers that are visible in retrospective studies, however, 10% to 30% are missed during mammographic interpretation [3]-[5], and 40% of the missed cancers appear as masses on the mammograms. In an attempt to lower the cost and increase effectiveness, investigators are developing alternative techniques to improve mammographic imaging [6]. Computer-aided diagnostic (CAD) methods have been proposed as one low cost tool to aid radiologists in film interpretation [7], [8]. CAD can be used to alert radiologists to locations of suspicious lesions and provides a second reading which has been found to reduce misdiagnosis. However, a well-trained computer program (which can screen a large volume of mammograms accurately and reproducibly) is needed in order for CAD to become practical in clinical settings. Such a program has yet to be developed.

The fundamental step in many CAD methods is the segmentation of possible target signals in the input image. Detection of a subtle mass on a mammogram is a difficult task because mammograms contain edges of low signal-to-noise ratio and complicated structured background. A number of image processing methods have been proposed to perform this task. S. M. Lai et al [9] and W. Qian et al [10] have proposed using modified and weighted median filtering, respectively, to enhance the digitized image prior to object identification. D. Brzakovic et al [11] used thresholding and fuzzy pyramid linking for mass localization and classification. Other investigators have proposed using the asymmetry between the right and left breast images to determine possible mass locations. Yin ***et al.*** uses both linear and nonlinear bilateral subtraction [12] while the method by Lau ***et al.*** [13] relies on "structural asymmetry" between the two breast images. Recently Kegelmeyer [14] has reported promising results for detecting speculated lesions based on local edge characteristics and Laws texture features [15,16].The above methods produced a true positive detection rate of approximately 90%.The work we have done till now is to propose a segmentation process which identifies on a mammogram the opaque areas, suspect or not, present in the image using vector quantization[17-26].

Vector Quantization (VQ) [27-35] is an efficient technique for data compression and has been successfully used in various applications such as index compression [36, 37]. VQ has been very popular in a variety of research fields such as speech recognition and face detection [38, 39]. VQ is also used in real time applications such as real time video-based event detection [40] and anomaly intrusion detection systems [41], image segmentation [42-45], speech data compression [46], content based image retrieval CBIR [47] and face recognition [48].Hence in propose method vector quantization is used for region forming and region merging.

The rest of the paper is organized as follows. Section II describes proposed algorithm used for image segmentation of mammographic images. Followed by the experimental results for mammographic images are in section III and section IV concludes the work.

II. Proposed Algorithm

In this proposed algorithm probability of original image is used for grouping pixels into regions and then the image of probability is formed. For image segmentation Equalized probability image is used as an input image for further segmentation.

The proposed technique has three steps to follow:
1. Region forming using vector quantization technique
2. Region merging using reclustering.

Manuscript received April 1, 2010 .
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3. Post Processing.

A. Probability

For complete image probability of particular i th gray level which is given by:

$$\text{Probability } P(i) = \frac{X_i}{MXN} \qquad (2.1)$$

Where *X*i is number of pixels for i th gray levels, M and N are no. of rows and columns of the image.

After calculating this the image is formed which contains probability values for that particular gray level instead of gray level in the image and it is displayed as probability image as shown in Figure 2(b) for original image in Figure 2(a) and Figure 2(c) is histogram equalized probability image.

B. Vector Quantization

Vector Quantization (VQ) techniques employ the process of clustering. VQ is a technique in which a codebook is generated for each image. A codebook is a representation of the entire image containing a definite pixel pattern which is computed according to a specific VQ algorithm. The image is divided into fixed sized blocks that form the training vector. The generation of the training vector is the first step to cluster formation on these training vectors clustering methods is applied and codebook is generated.

B.1.Linde-Buzo-Gray (LBG) Algorithm

The method most commonly used to generate codebook is the Linde-Buzo-Gray (LBG) algorithm which is also called as Generalized Lloyd Algorithm (GLA). For the purpose of explaining this algorithm, we are considering two dimensional vector space as shown in Figure 1. In this algorithm centroid is computed as the first codevector C_1 for the training set. In Figure 1 two vectors v_1 & v_2 are generated by adding constant error to the codevector C_1. Euclidean distances of all the training vectors are computed with vectors v_1 & v_2 and two clusters are formed based on nearest of v_1 or v_2. Procedure is repeated for these two cluster to generate four new clusters. This procedure is repeated for every new cluster until the required size of codebook is reached or specified MSE is reached.

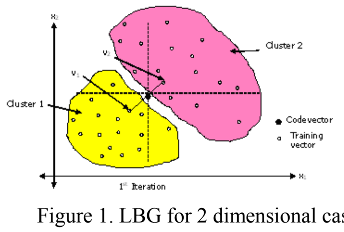


Figure 1. LBG for 2 dimensional case

The drawback of this algorithm is that the cluster elongation is $+135^0$ to horizontal axis in two dimensional cases. This results in inefficient clustering.

B.2. Kekre's Proportionate Error (KPE) algorithm

In this codebook generation algorithm, proportionate error is added to the centroid to generate two vectors v1 & v2. Magnitude of members of the centroid decides the error ratio. Hereafter the procedure is same as that of LBG. While adding proportionate error a safe guard is also introduced so that neither v1 nor v2 go beyond the training vector space. This removes the disadvantage of the LBG.

The size of codebook is set to 128. Training vectors are reassigned to encoding regions in every iteration. Once the code book size reaches 128 the process is stopped. In the original image pixel value is replaced by the encoding region number to which the pixel is assigned.

Region merging:

For region merging codebook of size 128 is used as an input to KPE algorithm where we are merging these clusters to form new codebook of size 8.Further image for each codevector is formed by considering minimum value of each codevector as a reference and by adding two more levels on the top of the first codevectors which is greatest gray level value i.e. 255 and at the bottom of the last codevectors which is lowest gray level i.e. 0. Total nine images were generated for one equalized probability image.

Post Processing:

If some unwanted regions are present in the segmented image then post processing is required to achieve only tumor in the final image. For that morphological operations are used .For proper boundary detection, canny edge detector is used .Then by using actual physical size of mammograms area of the tumor is calculated.

III. Results

Mammography images from mini-mias database were used in this paper for implementation of LBG algorithm and proposed algorithm using equalized probability image for tumor demarcation. Fig.2(a) shows original image with tumor. It has fatty tissues as background. Class of abnormality present is CIRC which means well-defined/ circumscribed mass. This image has malignant abnormality. Location of the center of abnormality is (338,314) for x,y image co-ordinates. Approximate radius is 56(in pixels) of a circle enclosing the tumor. Proposed algorithm is tasted on thirty mammographic images which consist of micro calcification with specific tumors.

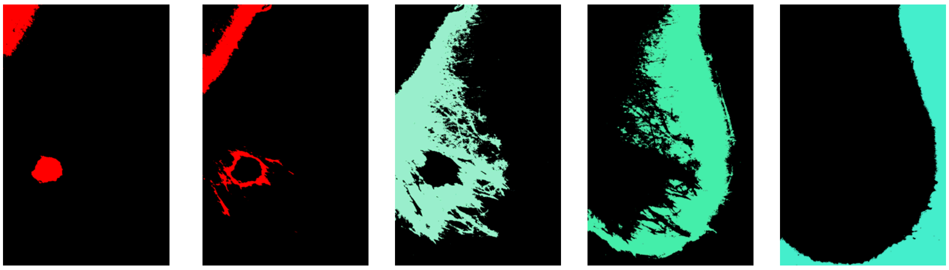
First probability of image is achieved as shown in Figure 2(b) for original image. Since the values are very low further processed with histogram equalization for probability, where it is possible to differentiate between normal and abnormal masses displayed in Figure 2(c). In third step vector quantization is used for region forming. For vector quantization KPE is used instead of LBG. The segmentation thus obtained is comparatively better than LBG as shown in Figure 3(a)-(e) .The validation of the work has been done by visual inspection of the segmented image by an expert radiologist.

For extraction of only tumor ,morphological operations were performed on Figure 3(a).Figure 4 (a) indicates binary gradient image by using Sobel operator where as Figure 4(b) shows dilated gradient image for Figure 4(a)processing it further finally segmented image is obtained in Figure 4(e).

Figure 5 (b) indicates superimposed segmented image on original image .To differentiate tumor it is indicated in green color.

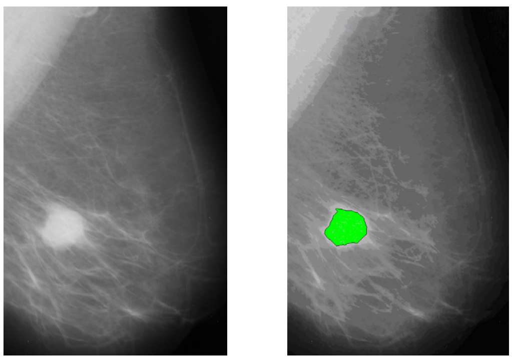
Results for sectional area calculation for Proposed Algorithm [For Figure 4(e)]
Total no. of pixel in the image = 4802409
No. of pixels with gray level 0 = 473322
No. of pixels with gray level 255 = 6918
Enter Length of actual image/object in cm = 18
Enter Breadth of actual image/object in cm = 24
Total image/object area = 432sq.cm
Area of image with gray level 0 = 425.7769 sq. cm
Area of image with gray level 255 = 6.2231 sq. cm

(a) (b) (c)
Figure 2 : (a)Original Image,(b) Probability Image,(c)Equalized probability image



(a) (b) (c) (d) (e)
Figure 3 : (a) Image for 2nd codevector, (b)Image for 3rd codevector, (c)Image for 4th codevector, (d) Image for 5th codevector, (e)Image for 6th codevector

(a) (b) (c) (d) (e)
Figure 4: (a) Binary gradient image for Figure 3(a), (b) Dilated gradient mask,(c)Binary image with filled , (d)Cleared border image, (e) Final segmented image



(a) (b)
Figure 5 : (a)Original Image , (b)Superimposed image

Co-ordinates	**Name of the algorithm**	
	LBG	**Proposed Algorithm using KPE**
Xmax	361	386
Xmin	322	281
Ymax	348	366
Ymin	293	273
Xc	341	334

Yc	320	319

TABLE 1: CO-ORDINATES OF BOUNDARY AND CENTER POINT

for calculation of sectional area, final image consists of only tumor thus it becomes very easy to find out it.Required input from user is physical length and breadth of the mammogram. Even center point for Tumor using x, y co-ordinates system can be compared with LBG segmentation for proposed algorithm as shown in Table 1.

IV. CONCLUSION

From results specifically by observing Figure 5(b) which clearly indicates the segmented tumor. Table 1 gives comparison of co-ordinates of boundary and center point for LBG and proposed algorithm using KPE .This shows that center point by proposed algorithm is closer to the center point (338,314) which is mentioned in the mini-mias database for the specific image .For this tumor sectional area is 6.22sq.cm by considering length x breadth is 18cm x 24 cm. This proposed algorithm does not lead to over segmentation or under segmentation.

ACKNOWLEDGEMENT

The authors would like to record their appreciation to Dr. Manisha Munde for her help in validating the results.

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