SEGMENTATION TECHNIQUES ON MAMMOGRAMS TO DETECT BREAST ABNORMALITY: A SURVEY
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Abstract

All over the world, breast cancer is the second most prevailing threat related to cancer among the female community. Researchers are striving hard to detect breast cancer at an early stage and provide appropriate remedial measures to extend the lifespan of cancer patients. Image segmentation is an important aspect of medical imaging. Medical images are frequently corrupted by high levels of noise and signal dropouts and thus, it results in poor contrast along boundaries. This paper surveys the segmentation methods used in processing mammographic medical images. Segmentation of these images helps in detecting the abnormalities like benign and malignant tumors and microcalcifications at early stages. The radiologist uses the CAD system for better classification of benign and malignant abnormalities from the mammograms. This survey is conducted on the various segmentation methods used in the mammograms to detect the abnormalities and explores the methods useful for better classification which will reduce false positives.

Keywords: Mammographic images, segmentation, benign, malignant, micro-calcification, CAD system, false positive.

1. Introduction

In recent times, many research and development activities are being focused on early breast cancer detection since the mortality rate is more compared to other types of cancer. In India, breast cancer stands as the second most prevailing disease affecting women. In the U.S., 1 in 8 women are afflicted with breast cancer throughout the course of her lifetime. The best way to screen for breast cancer is by means of mammograms. A mammogram is the result of the breast being exposed to a small dose of ionizing radiation, resulting in an image of the breast tissue. There are some views that may be taken for a diagnostic mammogram. Namely, Medio-lateral view will be taken only during routine
mammogram. This will show the granular as well as the fatty tissue, Cranio-Caudal view (CC) will be taken during both types of tests namely diagnostic mammogram and normal/routine mammogram. In this view, we can see as much as possible of the glandular tissue, the surrounding fatty tissue and the outermost edge of the chest wall muscle. Medio-lateral view covers large area when compared to the CC view. The pictorial representations for some of these views are given in fig 1.

![Mammogram Views](image1)

**Fig 1: Mammogram Views**

The appearance of the lesion at an early stage is very subtle and unstable. Image processing techniques provide a sufficient assessment to categorize the abnormalities such as (a) Microcalcification, (b) Circumscribed Masses, (c) Spiculated Masses (d) Architectural Distortion, as shown in Fig. 2 to make a clear diagnosis of the images. Therefore, physicians and radiologists have chances of missing the abnormality if they tend to diagnose and assume by their own experiences. The key task in designing such an image processing and computer vision application is the accurate segmentation of medical images. Image segmentation is the process of portioning different regions of the image based on different criteria [7]. Image segmentation in mammogram is the most difficult and critical task in breast cancer but it is the most significant task. Mammography imaging is the most structured imaging technique. Mammography is highly accurate but like most medical tests, it also fails to identify abnormalities during the screening because of factors like age and breast density, etc.[8]. On an average, mammography will correctly detect around 80% - 90% of occurrences of breast cancer in women. There are many types of segmentation computer aided techniques available for mammographic image processing. In this paper, various image processing techniques are being listed and suggestions have been put forward for selecting a particular technique.

![Mammogram Classification](image2)

**Fig 2: Mammogram Classification.**
The figure 2 gives a sufficient assessment to various types of abnormalities such as (a) microcalcification, (b) circumscribed masses, (c) spiculated masses, (d) architectural distortion as shown in Fig 1 to make a clear diagnosis of the images.

2. Image Segmentation

Image segmentation is a process by which the image is classified or partitioned into several regions for the purpose of examines the region of interest to classify all its feature based on result to be obtained. Segmentation is a way to divide the image into simple regions with an identical form. There are many number of segmentation techniques available and each has its own advantages and disadvantages. In this paper, we are going to discuss about certain segmentation techniques and give a superior method for the segmentation of images.

2.1 Fuzzy c-means:

Clustering of data is an important step to be carried out in image segmentation which divides the data into homogeneous classes for further analysis. The major need for clustering is to find groupings of data in natural form from a large dataset to make a brief representation of its system's behavior. [Fuzzy c means is a soft clustering which is one of the data clustering]. It involves datasets grouped into n clusters with each of its data points in the dataset attached to every cluster to a certain degree. [In fuzzy c means cluster the data don’t belong to a single cluster each data belongs to one or more cluster and each of its element are being bound to membership levels]. Initially this method starts with an assessment of the cluster centers, which are suspected to be the mean location of each cluster but that guess is likely to be incorrect. Then by assigning of each data point a membership grade for each cluster. By continuously updating of the membership grades and the cluster centers for every data point, they iteratively traverse the cluster centers to the location that resides to right in a data set. This iteration is carried by minimizing a function's objective which shows the distance from the point to cluster centers is being weighted by its data point's membership grade.

![Fig 3: Sample Result of FCM.](image)

Fig 3 represents 3 different density regions of the cancer using FCM. As the number of clusters increases, excess information is obtained about the tissue which is impossible to be identified by the pathologist.
Pre-Conditions:

J - Squared error clustering m -real number greater than 1, and the degree of membership in cluster ‘j’ $U_{ij}$-Updated membership $C_j$-Clustered center $J_m$-local minimum or saddle point

The fuzzy c means algorithm written in following steps [11].

**Step-1:** Initialize $U=[U_{ij}]$ matrix, $U^0$

**Step-2:** At k-step calculate the center vectors $C^{(k)}=[C_j]$ With $U^{(k)}$.

Update $U^{(k)}$ , $U^{(k+1)}$

$$u_{ij} = \frac{1}{\sum_{k=1}^{K} \frac{[(x_i-c_j)^{m-1}]}{[(x_i-c_k)^{m-1}]}}$$

$$\|u_{ij}^{k+1} - u_{ij}^{k}\| < \epsilon$$

**Step-3:** If then STOP, otherwise return to step 2.

**Advantage of this method is** the improved result that is obtained by overlapping the data set which is comparatively better than k-means algorithm. In contrast to the k-means where the data point should exclusively exist in one cluster center in this data point are assigned to membership to each of its cluster center as a result data point may exist in more than one cluster center.

**Disadvantage could be** Apriori specification of number of clusters. In lower values, we can get the better result but at the excess values, we get more number of iterations. Excess sensitive to good initialization.

2.2 K-Means clustering method

Clustering is a pattern recognition technique which involves the process of partitioning a group of pattern vectors into its subsets which are called as clusters. Clustering is a form of data compression where the large number of data sets is being converted into small homogeneous datasets. K-means is an iterative process and a portioning method which aims to partition a mammogram image into k clusters. K-means clustering focus to achieve n observations in k clusters.

The k-means algorithm is defined to cluster n number of objects based on attributes to k number of partitions, where $k<n$. It is close to the algorithm of expectation-maximization for mixtures of Gaussians where they both attempt to search the centers of natural clusters in data. It imagines that the object attributes pattern of vector space. K-means uses iterative algorithm thus minimizes the sum of distance between each object and the centroid.
Fig 4: Examples of K-Means.

Fig 5: Results of K-Means.

Fig 5 represents 3 different density regions of the cancer using k-means. As the number of cluster increases, excess information is obtained about the tissue which is impossible to be identified by the pathologist.

The K-means algorithm composed of following steps:

**Pre-conditions:**

Calculate the objective function $j$,

$$ J = \sum_{j=1}^{k} \sum_{i=1}^{n} ||x_i^{(j)} - C_j||^2 $$

Where,

- $J$ = objective function
- $K$ = number of clusters
- $N$ = number of cases
- $X$ = A set of $N$ data vectors.
- $C$ = centroid for clusters

**Algorithm**

Step: 1

KMEANS($X$, $C_i$)

Step: 2

Repeat
C_{\text{previous}} \leftarrow C_j

Step: 3
For all I \in [1, N] Do

P (i) \leftarrow \arg \min d (x_i, C_j);

i \leq j \leq k

Step: 4
For all J \in [1, K] Do

C_j \leftarrow \text{Average of } X_j, \text{ whose } p (i) = j;

Step: 5
Until C = C_{\text{previous}}

**Advantage of K-Means** are faster most of the times computationally than hierarchical clustering when variables are large, if we keep k smalls. Tighter clusters are produced by k-means than hierarchical clustering, especially when the clusters are globular.

**Disadvantage of K-Means** is that the Prediction of K-Value is difficult and decreased performance with global clusters.

Difference in partition initially can result on difference of final clusters.

Clusters of variable size and variable density do not work well.

**2.3 Edge-Based Segmentation**

An Edge is defined as the group of interconnected pixels that lie as the boundary between two regions and is the break or a change in the intensity level of the image. Edge based segmentation detects and link the edge pixels to generate contours.

Edges play an vital features to separate regions in the image. Discontinuity in the intensity of the image will be present either at the Step edge, where there will be an abrupt change in the value of intensity in one side of the discontinuity to a distinct value in its opposite side or its Line Edges, where the intensity value of the image changes abruptly but then restore to the initial value within short distance.

Edge based segmentation follow two steps: Initially the detection of edge where the edge pixels are identified. Secondly linking of edge where the edges are linked with its adjacent edges.
Algorithm:

The algorithm for edge based segmentation are[13]

Step-1: Given an image f ,

Step-2: Compute an edgeness image \( \nabla f \) from f. Any preferred gradient operator can be used for this.

Step-3: Threshold \( \nabla f \) to an image \((\nabla f)_t\) , so we have a binary image showing edge pixels.

Step-4: Compute a Laplacian image \( \Delta f \) from f. Any favoured discrete or continuous Laplacian operator is used.

Step-5: Compute the image \( g = (\nabla f)_t \cdot \text{sign}(\Delta f) \).

Advantages of edge based segmentation is mostly less complex, The excess of prior information used in the process of segmentation, gives a better result. Images with good contrast between the background and the object produce a good result.

Disadvantage of edge based segmentation are the identification of edge on a region is often said to be hard to find because of its noise, Disappearance of edge where a real border exists does not work well on images with low contrast and smooth transitions. It is sensitive to noise.

2.4 Region growing segmentation

Region is a group of connected pixels with similar properties and to interpret images. A region corresponds to the particular object or different parts of an object the goal of segmentation is to simplify the representation of an image into something that is more useful and easier to evaluate image segmentation is used to locate objects and edge in images. Growing of region starts from the seeds and grow regions on to a specified criteria. Region based approaches are grouped together the pixels with same properties, combining the nearness and correlation. Region based path are based on the properties of pixel such as the identity and spatial nearness. After segmentation the regions may need to be refined or reformed. Split operation adds missing edge by divide region that contain part of different object.

Advantages of this method can correctly split the regions that contain the same properties that we define. This method can also give the original images which contain the clear edges with the good segmentation results with respect to noise it performs well.

Disadvantage of Region growing segmentation are that the calculations are consuming, irrespective of time or power. The presence of noise or variation of intensity may lead to holes or over-segmentation. This method may not figure out the shading of the real images.
2.5 Threshold based segmentation

Thresholding is the technique used in day today life for segmentation of image. The thresholding operation is a grey value remapping operation \( g \) defined by:

\[
g(v) = \begin{cases} 
0 & \text{if } v < t \\
1 & \text{if } v \geq t,
\end{cases}
\]

Here the value \( v \) represents a grey value image, and \( t \) is the thresholding value. Thresholding maps a grey-valued image into a binary image. After the thresholding action is carried out, the image is being segmented into two segments, recognized by the pixel values 0 and 1 respectively [16].

![Fig 6: Example of Thresholding](image)

A. Threshold selection

Many methods exist to find a suitable threshold for segmentation. The simplest method is the interactive selection of a threshold by the user –possibly with the aid of the image histogram– a method that is usually accompanied by a graphical tool which lets the user immediately assess the result of a certain choice of threshold. Automatic methods often make use of the image histogram to find a suitable threshold.[16]

![Fig 7: Threshold Selection.](image)

The fig 4 shows the Threshold selection. The range for each threshold is being selected manually.

Advantages of this method are that it is simple to implement and that it is fast (especially if repeating on similar images). Disadvantages include no guarantees of object coherency, may have holes, extraneous pixels, etc.

2.6. Discrete Wavelet Transformation

Discrete wavelet transform (DWT) decompose the image signals into sub bands with minor bandwidths and the lower sample rates explicitly form Low-Low (LL), Low-High (LH), High-Low (HL), and High-High (HH). The four sub-
bands present in the first level of transform - first low-pass sub-band having the common estimate of the foundation image called LL sub band, and three high pass sub bands that develop image details across unusual directions - LH for vertical, HL for horizontal and HH for diagonal details. After decomposition of sub-band high frequency components are obtained and used for detailed analysis of image to yield enhancement. To reconstruct the image from its 2-D DWT subordinate images (LH, HL, HH) the particulars are re-joined with the low pass calculated with up sampling and convolution through the particular synthesis filters.[18]

Advantage of this is that it can avoid blocking artifacts since it has higher compression ratios. It has higher compression ratio-Better description of data is relevant to human perspective (64:1 vs. 500:1) and also high flexibility because the wavelet functions are freely chosen. Disadvantage of this is the use of greater DWT basis functions or wavelet filters produces blurring and ringing noise near edge regions in images or video frames and longer compression time and low quality that JPEG.

2.7 Watershed Segmentation

The watershed is a powerful tool for image segmentation in watershed the image is considered as a topographic surface. The watershed algorithms have been developed and tested on Variaty of mammogram breast cancer images [17].It is said that the result obtained from this helps the radiologist greatly to find the malignancy of the tumor in the lesion of the breast. The watershed algorithm initially starts with the input image. Then the input image is being converted into gravy scale image. Then suitable filters are used to remove the noise from the image. Median filter is the most suggest filter for image processing since in is used majorly to enhance the quality of the image. The final output of the image will be the tumor region. **Advantage of this method is that** the border of each region are continuous. **Disadvantage will be that** the segmentation leads to over-segmentation problem and the algorithm is time-consuming.
Fig 8: Sample Result of Watershed: (a) Initial image, (b) binary image, (c) watershed image with negative distant transform, (d) superimposed-watershed and original image, (e) watershed-gradient, (f) watershed marker controlled, (g) watershed-gradient and marker controlled, (h) extracted tumor image after ROI.

4. Conclusion

Medical image segmentation is so important to detect the presence of abnormalities (tumor, microcalcification, etc.), to diagnose the presence of the breast cancer and to start the appropriate treatment for the patients. Since the medical images take part in diagnosis, training, treatment and therapy, processing these images is very crucial task and the segmentation methods used to extract information and to study the region of interest should be efficient and accurate. It must also be cost and time effective and also be a reliable method.

In this paper a study on various segmentation algorithms is described with its advantage, disadvantage and accuracy using mammograms which is the most demanding and necessary task to be done in image processing for the extraction of features. The methods we discussed in this paper will be useful to analyze the different ways in which segmentation has been carried out over the mammograms to detect the breast cancer and it has been observed that the researcher can try combination of the methods to achieve the efficient and accurate result.

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