

A STUDY OF REGION BASED SEGMENTATION METHODS FOR MAMMOGRAMS

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Abstract

Breast Cancer is one of the most common diseases that are found in women. The number of women getting affected by cancer is increasing year by year. Detecting cancer in the late stages, leads to very complicated surgeries and the chance of death is very high. Early detection of Breast Cancer helps in less complicated procedures and early recovery. Many tests have been found so as to detect cancer. Some of these tests are mammography; ultrasound etc. Mammography is a method that helps in early detection of Breast cancer. But finding the mass and its spread from a mammographic image is very difficult. Expert radiologists are needed for accurate reading of a mammogram. Researchers have been working for years for algorithms that help for easy detection and segmentation of breast masses. Feature extraction and classification have also been done extensively so that the studied cases can be compared to diagnose the new cases. Segmentation of cancerous mass regions from the breast tissues is a difficult process. Many algorithms have been proposed for this. Some of these algorithms are region growing, watershed segmentation, clustering etc. Region Growing Method is based on two major factors which is the seed point selection and then the stopping criteria. Watershed Segmentation on the other hand is based on the basic geographical concept of watersheds and catchment basins, and uses a technique called as flooding. A study of these two major region based methods such as Region Growing and Watershed Segmentation are compared and detailed in this paper.

Keywords: Mammography, Mass Detection, Segmentation, Region growing, and Watershed Segmentation.

1. INTRODUCTION

Cancer is one of the most dreaded diseases and it has been studied for years. The major cause of cancer has not been found yet. Among the various types of cancers Breast Cancer is a common type and is mostly found in women. A new cancer is diagnosed every 2 minutes [1]. Late detection of breast cancer causes the cancer cells to spread to other body parts and organs. This will result in complicated surgeries and also increase the chance of death. Because of these reasons women after the age of 50 are advised by doctors to conduct tests to detect cancer at its early stage. Mammography is one such test that helps to detect cancer at its early stage.

Many CAD systems are available for the detection of the breast cancer [2]. Digital Mammography helps for easy diagnosis and several studies have been done in this area to make the diagnosis of cancer by the expert radiologists easier. Many algorithms have been proposed and some of them are Region Based methods, Watershed approach, clustering, thresholding etc

This study is performed of Region growing and Watershed Approaches. These methods are studied based on the performance measures used, steps followed and the number of images the method was tested on.

2. REGION BASED METHODS

Region based methods works on a concept that the cancerous mammogram region has some feature that is common. The algorithms that are region based usually starts with one or many seed points and then they are expanded. For clarity, Region based methods can be easily classified as region growing and split-merge method. Watershed method can be called as a type of region growing method.

Q. Abbas et. al, 2012 [3] introduced a 4 stage automatic mass segmentation method. In the first stage of this method a dynamic improvement of contrast in the ROI was done. CLAHE was a method that was used in contrast enhancement. In the second stage noise was reduced. Template matching to determine the noise pixels and the gradient magnitude of these pixels were calculated. Then these noise pixels were replaced. This was followed by the third stage where a multiscale decomposition was done on the image using steerable-pyramid transform. Then the multiscale feature fusion of each sub image was found. Then the candidate points were detected from the prior and posterior probabilities based on the multiscale feature fusion. In the fourth stage the lesion area was characterized using maximum a-posteriori and then a smooth mass boundary was drawn using Bezier spline curve. This method showed effective segmentation result for circumscribed, spiculated, ill-defined, microlobulated, obscured and mixed masses.

2.1 Region Growing Method

Region growing is a major type of Region Based segmentation method. Region Growing has been illustrated in the Fig. 1.

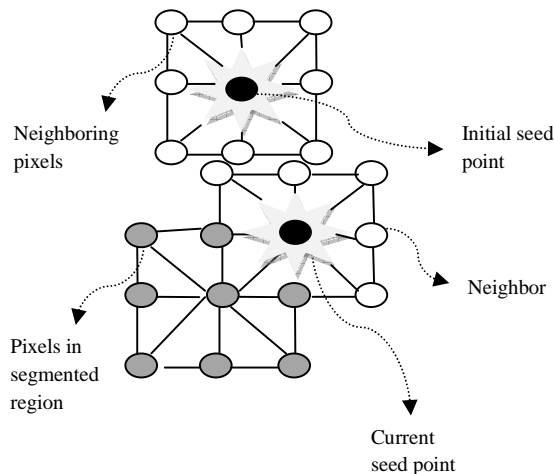


Fig- 1: Region Growing Illustrated

The starred circle represents the initial seed points. The immediate eight neighbors are illustrated using white circles. Each of these pixels is added into the segmenting region if they satisfy the thresholding condition. The grey circles show the pixels that have satisfied the criteria. The best of these pixels are then selected as the next seed point.

S. Meenalosini et.al, 2012 [4] proposed a method that segmented the mass in mammograms using region growing method. In this method pre-processing was done using median filter, morphological operations and thresholding methods. Segmentation was done in four steps. First contrast enhancement was done using histogram utilization. Secondly, alarm pixel generation was done. In this step histogram and accumulated histogram was computed and the location of peaks in the histogram was found out. From this the candidate alarm pixel was calculated and from the selected candidates the alarm pixel was generated based on a specified condition. This alarm pixel was used in the third step which performed region growing. The alarm pixels acted as the initial seed point for region growing. This seed point was expanded until every pixel had been allocated. Finally, in the fourth step Gabor filter was applied on the image. A total of 20 Gabor filtered images were obtained using 20 Gabor filters which was distributed along five frequency bands. This method was designed such that it would detect masses automatically without any human interaction.

K. Yuvaraj et.al, 2013 [5] suggested an automatic technique of the mass segmentation using region growing. The mammographic image was selected and a mask was defined. Statistical features such as mean, dissimilarity, sum average,

sum variance and auto correlation was extracted. These features were compared with the Haralick features that were initially extracted. If the mass features did not match then the mask was shifted and features extracted again. This was followed by the thresholding step where a specific threshold value was selected for all kind of masses. Region growing was finally performed on this image. The initial pixels of the mask were taken as the seed points and this favored the automatic seed selection. At the end of this step a binary segmented image was formed. This image was scanned pixel by pixel and each pixel was assigned with the corresponding pixel value from the preprocessed image when the pixel value was 1. When the pixel value was 0 it was kept 0. The results obtained by this method were compared with the segmentation done by an expert and it was found that the method produces good results.

T. Berber et.al, 2013 [6] has worked on seeded region growing algorithm and has introduced an adaptive thresholding technique. Seeded Region growing is a type of Region growing where the threshold value for every mammographic image was the same such that it caused over or under segmentation. This method had 4 steps. First an ROI was selected which was then made to pass through a series of pre-processing. This was then followed by Otsu segmentation so as to find the split point. This split point was taken as the threshold value. Thus for every mammogram that was considered a different threshold value was generated. The initial seed point selected was the brightest point in the mass. The stopping criterion of this method was that the maximum size of the mass was calculated and the region growing was stopped based on this criterion. This method resulted in very satisfying findings.

P. Görgel et al., 2013 [7] also proposed a region growing based method. In this method first an enhancement of the image was done using homomorphic filtering. Then segmentation was done using Local Seed Region Growing algorithm with some of the rules of Seeded Region Growing algorithm. But the resultant ROI could contain false positives; hence a spherical wavelet transform is applied on the ROI. A 5-level spherical wavelet transform was applied for better performance. Two classifications were done. First classification determined the mass area and the second classification determined the malignancy of the mass.

2.2 Watershed Segmentation

Watershed segmentation can be understood based on the method suggested by L. Vincent et.al. 1991 [8]. Fig -2 shows the basic concepts of watershed, catchment basins and minima as explained in [8].

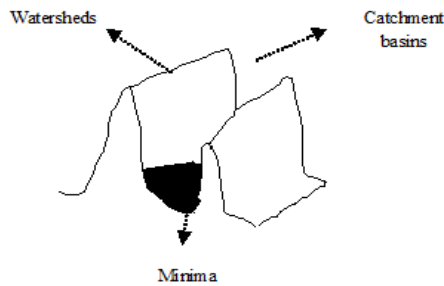


Fig - 2: Basics Of Watershed Segmentation Illustrated

J. Herredsvela et.al, [9] showed a method for detection of breast masses using watershed segmentation algorithm. This method has basically two steps. In the initial step the image was segmented using morphological watersheds. Then these segmented regions were classified using sparse representation of image blocks. Before applying watershed method the image was filtered using alternating open/close sequential filters. The image after watershed method had the suspicious mass region. There may be a lot of false positives in these images. These false positives were reduced using sparse representation using learned dictionaries. Classification of these suspicious segmented masses was done. This was done by creating a training set using a few mammogram images. Using this training set the other images were tested and classified. This was called the testing phase. The error images were filtered using Gaussian low pass filter.

J. Sharma et.al, 2011 [10] proposed a simple segmentation technique using watershed method. In the pre-processing stage of this method Sobel filter mask is applied to perform convolution at 12 different orientations. Each of these convolutions produces Curvilinear Structures (CLS). This is followed by thresholding. The CLS is then suppressed. The image gradient calculation is done using the Canny's Edge Detection. This is based on non-maximal suppression and hysteresis thresholding. Watershed segmentation based on the Vincent-Soille approach is carried out. The image thus obtained was ORed with the minima image obtained as the mask image. This was then imposed on the gradient image. The final step of this method was the segmentation phase

which is based in the catchment basin technique. Flooding is done and flooding ends when the water reaches the highest level. At these points virtual barriers were built which will prevent the merging of water. The image is divided into several regions. Each region corresponds to the region of interest.

Wei-Yen Hsu, 2012, [11] proposed a new automatic approach that segments the breast mass tumor using watershed method and using the prior given information. These images were then stored by compressing the image. Canny's edge detection technique was used because of its localization and thresholding property. The Gaussian scaling parameter of Canny's Edge detector decides the fitness of the edge that was detected. Edges were detected by adjusting to three criteria which are localization, detection and response. An improved watershed transform was performed which was based in the previous information. This was used for tumor edge detection. This method can be applied to various applications based on the amount of information that is available. Vector Quantization and Hopfield neural network idea was also applied. Hopfield neural network is one of the best methods for solving optimization problems.

3. DISCUSSION

3.1 Steps Performed

There are various steps that are followed for segmenting mass from the breast region. Some methods first pre-process the image using various filters such as median, mean, Laplacian, Gaussian, CLAHE etc. This pre-processing may be done before or after the mass detection. Some methods do not perform mass detection and define ROI. In such cases the whole breast image is considered. Segmentation can be done using various methods such as region growing, watershed or clustering. Some methods also go forward to extract features from the mass detected and this will help in the diagnosis of the severity of the cancer mass detected. Compression of the images help is efficient storage of the images, such that memory space is not wasted. Table 1 shows the review of the various steps that are followed in the various methods of this paper.

Table -1: Review of the steps followed in various methods

Method	Pre-processing	Mass Detection	Segmentation	Feature Extraction	Compression
Abbas Q. et. al,2012	✓	✓	✓		
Meenalosini S. et.al,2012	✓		✓		
Yuvaraj K. et.al,2013			✓	✓	
Herredsvela J. et.al,		✓	✓		
Sharma J. et.al, 2011	✓		✓		
Wei-Yen Hsu, 2012			✓		✓
T. Berber et.al, 2013	✓	✓	✓		
P. Gorgel.et.al,2013	✓		✓	✓	

3.2 Database Used

Various databases are available online that provide mammogram images. Some of them are MIAS [12], DDSM [13], DEMS [14] etc. MIAS is Mammography Image Analysis Society which is a database that contains a total of 322 images which are of size 1024x1024. DDSM is Digital Database for Screening Mammography which has about 2620 cases. DEMS is Dokuz Eylul Mammography Set which contains 485 cases. Table-2 shows a review of the databases that is used in the methods discussed and the cases considered for their study. The blank space in the table indicates the lack of specific information.

Table -2: Review of the database used in various methods

Methods	Database Name	Total number of images	Benign	Malignant
Abbas Q. et. al,2012	MIAS/DDSM	480	311	169
Meenalosini S. et.al,2012	MIAS	250	125	125
Yuvaraj K. et.al,2013	MIAS	22	-	-
Herredsvela J. et.al,	MIAS	16	-	-
Sharma J. et.al, 2011	-	-	-	-
Wei-Yen Hsu, 2012	MIAS	-	-	-
T. Berber et.al, 2013	DEMS	260	-	-
P. Gorgel.et.al,2013	MIAS	-	-	-

Table -3: Review of the metrics used in various methods

Method	Visualization	Quantitative Measure
Abbas Q. et. al,2012	✓	Hausdroff distance, Area overlap measure, Combined equal importance
Meenalosini S. et.al,2012	✓	-
Yuvaraj K. et.al,2013	✓	Mean calculation
Herredsvela J. et.al,	✓	True positive and false positive rates
Sharma J. et.al, 2011	✓	-
Wei-Yen Hsu, 2012	✓	Jaccard similarity index, Dice Index
T. Berber et.al, 2013	✓	Haousdroff Distance, Yasnoff Measure etc.
P. Gorgel.et.al,2013	✓	Sensitivity, Specificity, Accuracy

CONCLUSIONS

This paper reviews on Region Growing Method and Watershed segmentation methods. Each of these methods have been discussed based on the steps performed, the number of images they have tested and the method that is used to

3.3 Performance Metrics Used

Every method can be analyzed for their performance based on measurement of their performances. This measurement may or may not be quantitative. The performance measured is the accuracy of the mass detected or the rate of true positives and false positives. Performance of the particular method can also be measured in terms of visualizing the final image and the reference image or manually segmented image. Table-3 shows the review of the various performance measures that are used in the various methods discussed.

calculated and analyze the performance of each of these

measures. For Region Growing method the seed point and the

stopping criteria should be known. But in the case of

Watershed segmentation the pixel intensities should be known

and the concept is wrapped around the geographical watershed

and catchment basins.

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BIOGRAPHIES



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