EARLY STAGE DETECTION OF TUMORS IN MAMMOGRAMS

PAWAR B. V. AND PATIL SUSHAMA

Electronics Dept., W.C.E. Sangli – 416415(Maharashtra), India.

Abstract:

This paper presents a method for detecting tumors in breast. The tumors detected are circular in shape. The method used for detecting tumor is pixel-based mass detection. It uses template-matching procedure. These templates are defined according to the shape, and brightness of the tumor masses. Prior to template matching, median filtering enhances the mammogram images. High pass filtering enhances the edges and then edge detection is used to detect the shape of the tumor. Only circular shaped tumors are detected, which are also the early stage tumors, in case, the tumor is malignant. In the template matching, the threshold is set for the calculated values of the cross-correlation. Then the percentile method is used to set a global threshold for each film. It is shown that,this method of template matching for detecting early stage tumors gives substantially better detection results. A large number of digitized mammogram images were used for evaluation of this method. The results obtained by applying these techniques to a set of test images are described further.

Images Courtesy: **Siddhivinayak Cancer Hosp. Miraj, Maharashtra.**

I. INTRODUCTION

Breast cancer is one of the cancers occurring among women, and day by day its incidence is rising. It generally occurs in women over 45 years of age due to following reasons –

1) Prior history of breast cancer in the family. It may be seen in mother or sister. 2) Nuliparity i.e. women having no child or first child after 35 years of age. Oral contraceptive use, alcohol and tobacco use, radiation exposure, obesity, and stress. etc..

The early signs of breast cancer show breast asymmetry and nipple retraction while the pain occurring in the breast shows the late sign. Primary prevention is not possible since the cause of this disease is not understood. However, current methods of treatment are very effective when the breast cancer is detected in its early phase. There are large number of diagnostic methods currently available, among which mammography is the most reliable method, for detecting early breast cancer [1]-[2].

The analysis of mammograms by computer is roughly divided into three steps:

1) Enhancement of pre-selected features.
2) 2) Localization of suspicious areas and
3) Classification of these areas into benign or malignant tumors[5].

The analysis is difficult due to several reasons. It involves the analysis of small features of low contrast superimposed onto non-uniform backgrounds. The mammogram images are first to be scanned and then digitized for further processing. The images were obtained from the hospital, which were taken by mammography machine. The filming and digitization further reduces the difference between the background and the tumor. In addition, the presence of noise and anatomical structures, such as ducts, and glands, increase the background variations of tumor areas. The boundaries of tumor areas are fuzzy, and in some cases only partially available. Also the early stage tumors are very small in size.

A large number of images processing techniques are available for image enhancement, object localization and pattern classification.

However, the aim of this paper is to just locate the tumor and no classification between benign and malignant tumor is attempted.

In order to design a method for detecting by circumscribed masses, the radiologist description] of tumor symptoms must first be translated into computational procedures. Based on these descriptions, we define a suspicious area as area, brighter than its surrounding tissue, uniform density inside the area, an approximately circular shape of varying size and area having a fuzzy edge . Two examples of mammogram images are shown in fig.1a and fig.1b

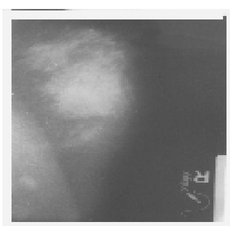

Fig. 1a

Fig. 1b

Then the image enhancement by median filtering and edge enhancement by high-pass filtering and edge detection is discussed. Then the next section discusses the template matching technique for detecting suspicious areas. The last section discusses the results of the template matching process and the conclusions.

II. FILTERING & EDGE DETECTION

Median Filtering: -

Median filtering has been found to be very powerful in removing noise from two-dimensional signals without blurring edges. This makes it particularly suitable for enhancing images].

The median filtering output is

$$\mathbf{X^{\wedge}_{ij} = median\{ x_{r,s} : (r,s) \in N(i,j)\},(i,j) \in z^2}$$

Where N(i,j) is the area in the image covered by the window W(i,j). The window W(i,j) is centered at image co-ordinates (i,j) of

a picture$\{ x_{ij} : (i,j) \in z^2\}$

Figs. 2.1a) and 2.1b) shows median filtered images of figs.1a) and 1b) respectively.

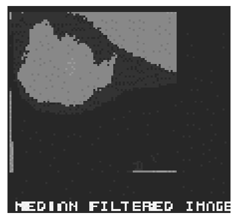

Fig. 2.1a

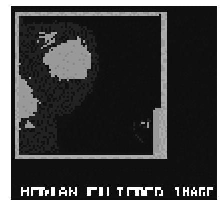

Fig. 2.1b

High-Pass Filtering: -

The boundary information of the enhanced image was extracted for visual evaluation. A high-pass (laplacian) filter was used for this purpose. The high-pass filter output is defined as –

$$g(x,y) = \left| \sum_{i=-1}^{1} \sum_{j=-1}^{1} f(x+i, y+j) - 9f(x,y) \right|$$

Fig. 2.2a) and 2.2b) shows high-pass filtered images of fig.1a) and 1b) respectively.

Fig. 2.2a

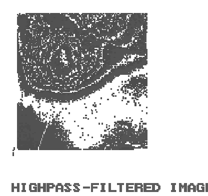

Fig. 2.2b

Edge Detection:

An edge is defined as the boundary between two regions with relationally distinct gray level properties. Since the tumor is circular in shape, one alternative to detect tumors is to extract image edges and then look for ring like structures.

Different operators were used for edge detection such as Kirsch, Prewitt, Sobel, Quick and Frei and Chain. From the observations, it is concluded that Sobel operator gives more sharp and clear edges as compared to other operators.

Fig. 2.3a) and 2.3b) shows the edge detected images of fig. 1a) and 1b) respectively, which are obtained by using Sobel mask.

Fig. 2.3a

Fig. 2.3b

IIITUMOR DETECTION USING TEMPLATE MATCHING

Template matching :

For detecting a tumor, we use its two characteristics that are approximately circular shape and brightness homogeneity of the tumor area.

One way to detect tumor is to find the image edges and then look for ring-like structures. However, in noisy or lightly textured images, a large number of noisy edges are extracted and edge tracking becomes difficult.

Hence, we use template matching which is based both on shape and brightness criteria. These criteria are defined by using the templates. The location of detected suspicious areas can then be obtained from the output of the matching operation, which can be visualized very clearly.

Fig. 3.1a) and 3.1b) shows the output of template matching for fig. 1a) and 1.b) respectively.

Fig. 3.1a)

Fig. 3.1b)

Since the sizes of the tumors certainly differ from each other, templates of different sizes need to be used to obtain the exact size of the tumor. To detect early stage tumors, template size upto 7 pixel in diameter can be generally used.

Similarity Measure :

Now, there is a need to measure the similarity between a true suspicious area and the template. For this purpose, we require a similarity measure. Hence, the normalized cross-correlation measure is used.

Suppose that 'S' is an image of size L* L array of pixels, each taking one of k gray level, and W be the M*M template with M<<L. Each M*M sub image of S can be uniquely referenced by its upper left corner co-ordinates (i,j).

The normalized cross- correlation measure is defined by,

$$R(i,j) = \frac{\sum^{M}\sum^{M} \{(W(k,m)-\mu_w)^2 \ (S(i+k-1)-\mu_s(i,j))^2\}}{\sqrt{\sum_{k=1}^{M}\sum_{m=1}^{M} (W(k,m)-\mu_w)^2 \sum^{M}\sum^{M} (S(i+k-1)-\mu_s(i,j))^2}}$$

Where, μ_w is the mean of the template, and μ_s is the mean of the subimage centered at image point (i,j).

The template matching operation gives the output in which, each pixel value is the result of cross correlating the template and the sub-image centered at that point. These values should be interpreted such that suspicious areas are detected and non-suspicious areas are rejected.

Effective criteria for selection of suspicious areas must be able to solve the following problems-

1) Most suspicious areas should have the maximum cross-correlation value when being matched with different templates.
2) We do not have prior knowledge of the size and number of tumors in a mammogram film.

3) Some mammograms have a rich image texture due to presence of glands and fatty tissues leading to high cross-correlation values in the template matching stage. Some of these values may be even larger than those for some suspicious areas in other images.

Percentile Method

We use a percentile method and classify a fixed percentage of locations as suspicious. The fixed percentage should be chosen so as to have no misses and a reasonably small number of false alarms.

The template matching process only considers local information; therefore, it cannot adjust to global image texture of each image. The percentile method improves the template-matching step by taking into account global image information. In general, if many locations in an image produce large cross-correlation values, a large threshold will be selected to minimize the number of false alarms. In the case of image with smooth texture a smaller threshold is used to ensure the detection of suspicious areas. Now the X–Y co-ordinates of these cross-correlation values, represent the location of suspicious areas. These are calculated to obtain the tumor location.

IV. RESULTS

The software is developed in C/C++. The results of the computer and radiologist are shown for few cases in Table 1. The co-ordinates of the points in suspicious areas diagnosed by radiologists and by using this software are very close to each other and are satisfactory .

Table 1: Comparison of the computer and radiologist's interpretation.

Case No.	Co-ordinates of the points in suspicious areas				No. of Areas detected
	Radiologist		Computer		
	X	Y	X	Y	
1	50	70	59	68	1
2	36	50	42	51	2
3	75	80	80	80	2
4	50	65	51	63	
	65	80	66	75	5
5	30	50	30	45	2
6	-	-	-	-	-
7	44	40	44	44	2
8	20	59	21	59	1
9	45	80	43	82	-
	35	65	38	60	3
10	35	50	38	50	1

V. CONCLUSION

This paper presents a method for early stage breast tumor detection in mammograms. The first step towards tumor detection is image enhancement. The median filtering was found effective in removing noise.

The second step is edge enhancement. For this purpose, high pass filtering is used which enhances the edges and makes them sharp. Also edge detection was used for tracking the edges. Several algorithms were used for edge detection. But Sobel mask was found more effective in obtaining clear and sharp edges.

The next step is concerned with tumor detection. Our method is based on template matching and is capable of detecting suspicious areas independent of their orientation and position.

To have a global approach, we use percentile method, which decreases the number of false alarms and also the non-suspicious areas to be considered as suspicious areas.

The results obtained with our method are quite encouraging. By combining the three criteria, namely, the contrast, the uniform density, and the circular shape of tumor areas, the detection algorithm is capable of detecting all tumor locations. The results for detecting tumors and locating its co-ordinates match with the radiologists results.

BIBLOGRAPHY

1. Guido M. te Brake and Nico Karssemeijer, "Single and multiscale detection of masses in digital mammograms", *IEEE Transactions on Medical Imaging*, vol. 18, No. 7, July 1999, pp. 628-638
2. J. E. Harvey, L. L. Fajardo, & G. A. Inis, "Previous mammograms in patients with impalpable breast carcinoma : Rctrospective vs. blinded interpretation," *AJR*, vol. 161, PP. 1167-1172, 1993
3. I.W. Hult, S. M. Astley, & C.R.M. Boggis," Prompting as an aid to diagnosis in mammography; in Digital Mammography," A. G. Gala, S. M. Astley, D. R. Dance, & A. Y. Cairns, Eds. Amsterdam. *The Netherlands : Elsevier*, 1994, pp. 389-398.
4. S. Astley, I. Hutt, S. Adamson, P. Rose, P. Miller, C. Bogg, C. Taylor, T. Valentine, & J. Davis, " Automation in mammography : Computer vision & human perception," *SPIE* 1905, pp 716 – 70, 1993.
5. Naga R. Mudigonda, Rangaraj M Rangayyan and J. E. Leo Desautel, "Gradient & Texture analysis for the classification of Mammographic Masses," *IEEE trans. on MI*, vol. 19, no. 10, Oct. 2000 pp. 1032 – 1042.