Automatic Detection And Classification Of Malignant Tumor In Mammograms Image Using Image Feature Fractal Dimension

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Abstract: Breast cancer is a second largest disease in worldwide and even in India as per the statistics of world health organization after the lung cancer. The conventional approach to identify the breast cancer is biopsy, it takes on an average of more than week together time and most of the hospitals do not have this facility to perform the biopsy. This approach also demands expertise in the domain of analysis of tumor tissues to identify the cancerous cell. Hence to overcome the drawbacks of the conventional diagnosis system. In this paper a novel approach has been presented to diagnose the breast cancer by analyzing X-ray mammograms by a technique called rotational contour based fractal dimension with an interval of 60 degree. In this paper, the work is categorized into four phases,(1).Enhancing the mammogram images using Gabor filter and also estimated PSNR before and after the enhancement of the mammogram images that leads to accurate segmentation of tumor from the mammogram. (2).The automatic segmentation of region of the tumor through watershed and morphological operations and also obtained the contour of the tumor. (3). The contour analysis has been performed using a new approach called contour based fractal dimension approach that gives excellent classification result for the benign and malignant tumor. The Fractal Dimension for benign tumor ranges from 1.462 to 1.71 where as for malignant tumor the FD ranges from 1.78 to 3.78. And the Standard Deviation for benign tumor 0.06 and for malignant is 0.58. (4).In classification phase the automatically identifying and segregating the cancer disease. In this work, consider huge set of images from publicly available popular databases such as Digital Datagram Screening Mammogram, MIAS and also considered for the images available in the SDM hospital, Ujire and Dharwad etc. This approach gives almost 100 percent accuracy. Hence this technique can be considered as diagnostic parameter for the identification and classification of disease which serves the oncologist to take better decision.

Index term: cancer, mammogram, fractal dimension, perimeter fractal dimension, biopsy

1. INTRODUCTION

Breast cancer is the most common type of cancer that appeared in women worldwide. Around 25% of newer cancer cases are related to breast. Also, it is the leading cause for mortality among middle-aged woman across the world. The only way to keep a check on the mortality rate due to breast cancer is detecting it at an early stage. The best way to detect the cancer tumor is through analysis of mammograms. As on today three major techniques to diagnose the cancer tumor were reported so far. 1. Inspection of the masses, 2.Speculated lesions, and 3.microcalcifications. Circumscribed masses are compact and roughly elliptical. Benign masses are usually radioluent lesions. The boundary of a malignant mass is very much irregular and is of radiopaque in nature. Most speculated lesions are malignant. They have a central tumor mass which has a pattern of linear speckles radiating from it. The calcium deposits from cell secretions and necrotic cellular debris appear as bright spots in a mammogram. Such a cluster formation appearance is called microcalcification. Benign microcalcification is usually smooth which have uniform density, whereas malignant microcalcification have irregular shape and are distributed in a very non-uniform manner. Figure 1.a. describes the smooth, uniform and circular tumor region, 1.b. describes the malignant tumor denoted by highly irregular contour.

Fig.1. Mammograms (a) Benign (b) Malignant

2. RELATED WORK:

This section describes the work carried out so far in order to diagnose the breast cancer by various authors that revealed image enhancement technique, fractal geometry and segmentation of the tumor region. The structure of breast tissues has statistical roughness and self-similarity at different scales. A general framework for the study of such irregular sets can be obtained from fractal geometry. Fractal Dimension provides an accurate measure of roughness of a texture surface. Along with fractal Dimension value, the lacunarity was combined [1] for the effectiveness to classify benign and malignant cases. An image processing technique applied on mammograms can assist the radiologist to detect breast cancer with higher accuracy and in less span of time. A hybrid approach comprising of frequency domain homomorphism filtering and spatial domain morphology [2] were adopted to enhance mammograms. Image segmentation had been done using K-means clustering algorithms and fuzzy C- means clustering algorithm with morphological operators [4]. These
algorithms lead to intensity-based segmentation. H.C. Nagaraj et al. reveals the study on early diagnosis of breast cancer detection through first order statistical parameters [9]. The breast cancer is the second most leading cause [3][14] of the cancer deaths in women. The author investigated and showed that high mean and low variance as the sign of tumor existence in the breast, high mean and high variance as the possibility of the medium tumor rate. Finally, the low mean, either low or high variance will have no chances of tumor. However, the author didn’t attempt on classification of benign and malignant tumor and accuracy of statistical parameter method is 70% only which is not acceptable in the medical field. The work didn’t considered large datasets [9]. Bhagwati Charan Patel and Dr. G R Sinha [14] presented an identification of breast cancer by self-similar fractal method. In this work, the mammogram image was enhanced using fractal derivatives. The tumor region had been segmented with self similar properties. But author didn’t attempt to find fractal dimension feature of the extracted region of the tumor for the classification of the disease. Sura Ramji Shareef [12] had described breast cancer detection using watershed transformation. The author considered in this work the x-ray and US images and tumor is extracted using morphological Watershed transformation. The author identified tumor region but didn’t classify whether it is benign or malignant. Moh’d Rasoul et al. [8] proposed a technique on breast cancer classification using Artificial Neural Networks(ANN) and medical image processing for mammography images. The author has successfully merged many techniques in order to obtain successful result. This technique includes elimination of tiny objects, scaling of image, smoothening, feature extraction, Region of Intrest (ROI) segmentation, etc. Along with these techniques author has adopted ANN in order to achieve high degree of classification accuracy. Spandana Paramkushan et al. [2] investigated on breast mass contour detection and analyzed using fractal feature spectral technique. The study reveals breast lesion and its contour as most important factor to detect cancer for radiologist. The study also reveals that contour of benign tumors are smooth as compared to contour of malignant tumor. The author has employed several images processing technique for breast lesion contour extraction. These techniques include homomorphism filtering and adaptive histogram equalization for removing noise in image, k-means clustering for mass segmentation, contour extraction using morphological operations. The contour of the tumor had been analyzed using power spectra fractal technique. Finally, tumor contour fractal dimension feature classification of tumor is having accuracy with 82%. Deepa Shankar and Tessamma Thomas conducted an experiment on breast cancer for detecting microcalcification using entropy based fractal modeling for mammograms [4]. In this work developed fast fractal method to model breast background regions based on entropy for the separation of benign tumor from malignant tumor. Model image was separated from original mammogram for the enhancement of microcalcification. The author experimented mammogram images from the MIAS database and achieved accuracy for tumor detection rate about 85%. However, in this study the author didn’t attempt on classification of the tumor either benign or malignant. Dr. K. Sathya Prasad and S. Saheb developed a system to identify breast cancer mass in x-ray images through morphological operators and Fuzzy c-means clustering technique [10]. The author [11] reveals on enhancement technique for mammogram images for the enhancement of required region i.e. tumor. For the enhancement stage the author has adopted four parts to extract the required region and eliminating the unrequired and non influence part of the system in order to obtain the tumor. The tumor portion is extracted from the mammogram images using hard threshold strategy. In addition, the author considered color mammographic image and converted into grey scale image then preprocessed through image enhancement techniques for the elimination of the label, noise, fractal muscles and focused on the region of interest for the segmentation. The contour of tumor is extracted using morphological techniques such as hole-filling, delusion, erosion, etc. In this work, the contour of normal and cancerous tumor was obtained and concluded smoother boundary for the normal tumor and irregular boundary for cancerous tumor. However, the author didn’t attempt to measure the dimension of the irregularity. Through the above literature survey we are able to implement contour based fractal dimension for the classification of benign and malignant tumor. In the work done by the various authors presented in this section, there were certain drawbacks such as consideration of only biopsy, the use of conventional methods, noisy images, dimension concepts, etc. The Couple of these drawbacks were considered in our research work & a new algorithm contour based fractal dimension (CBFD) is developed which has been verified and validated through effective results presented in the results & discussion section.

3. IMPLEMENTATION

In this section, the mathematical background of proposed method Contour Rotational Based Fractal Dimension technique has been derived and discussed in 3.1 and 3.2 respectively. Also in subsections 3.3, 3.4 and 3.5 the segmentation, Data flow diagram and the algorithm have been discussed respectively.

3.1 Fractal Dimension

As per Benoit Mandelbrot [X] fractal dimension has been defined with scaling factor, s=1/4. By observations, the relationship between the number of subparts ,n and the scaling factor  is can be generalized as ns = 1[17]. In general, with Euclidean objects such as line, square, and cubes etc. The fractal dimension FD for similar objects can be obtained from the equation,

\[ nS^{FD} = 1 \]  

...equation(1)

By applying logarithm on both sides for equation (1), then we obtain

\[ \ln(n) + FD \ln(s) = \ln(1) \]  

...equation(2)

By solving equation (2) for FD, then we obtain

\[ FD = -\frac{\ln(n)}{\ln(s)} \]  

......equation(3)

By applying logarithmic properties on both sides, we have

\[ FD = \frac{\ln(n)}{\ln\left(\frac{1}{s}\right)} \]  

......equation(4)
3.2. Rotational Contour Based Fractal Dimension

This approach is employed to compute the fractal dimension of the malignant and benign breast tumor of the contour. The graph is drawn against the variables $L$ & $\lambda$ as $\log(L)$ against $\log(\lambda)$ as shown in the Fig. 4.

![Fig. 2: Generalized graph perimeter method](image)

Proposed Rotational Contour based fractal dimension technique estimates fractal dimension of the contour of the breast tumor. To calculate the length of the contour, the product of $N$ (number of the rulers needed to cover the contour) & ruler length $\lambda$ (scale factor) is obtained. Finally, the complete length is estimated as $L=Na$.... equation(5).

$L(\lambda) = N(\lambda)\lambda$ ....equation(6)

The measured length of the contour, $L(\lambda)$, as a function of the step length, $\lambda$, and relationship is with number of step to $N(\lambda)$.

$N(\delta) = 1/\deltaD$ ........equation (7)

Linear scales techniques, $\lambda$ and $\delta$, are proportional to each other

$\lambda = \delta$ ........equation(8)

Hence

$N(\lambda) = N(\delta)$ ........equation(9)

Combining the above equation we obtain

$(1/\deltaD)\lambda = L(\lambda)$ ........equation(10)

The above equation can be simplified to

$\lambda1-D = L(\lambda)$ ........equation (11)

Taking log on both side then we have

$\log(L(\lambda)) = 1 - D \log(\lambda)$ ......equation(12)

Solving above equation then we get

$D=1- \log(L(\lambda))/\log(\lambda)$ ......equation(13)

Equation can be written as follow

$D=1- \text{slope}$ ....equation(14)

Where slope is $\log(L(\lambda))/\log(\lambda)$ and $D$ is the fractal dimension of the contour of breast tumor.

3.3 Segmentation

Morphological operation is used to segment the region of tumor from the mammogram. Then traced boundary pixel co-ordinates (ROI) are used to determine the contour of the tumor [14]. To determine the fractal dimension of the contour of the tumor the log ($L$) versus log ($\lambda$) were plotted; the slope is computed and subtracted from 1 as shown in the equation 14. The slope is shown in the generalized graph fig.2.

3.4 Data flow diagram (DFD)

The DFD describes the workflow of the proposed method in various stages as follows,

Stage 1: original mammogram images captured by the medical instruments are input to the algorithms as shown in stage 1.

Stage 2: in this stage breast images were processed to convert 3D to 2D because color images (3D) are 24 bits hence complex to handle, so converted to gray scale (using MATLAB rgb2gray function) images which are 8 bit without losing features of the breast.

Stage 3: in this stage breast image is enhanced for the clear identification of the tumor and then segmented using morphological operation. In order to detect cancer, the contour analysis is essential and hence, contour has been input to the proposed method.

Stage 4: the tumor contour has been rotated at the intervals of 60 degree to enhance the accuracy of computation of fractal dimension.

Stage 5: the classification has been done as benign or malignant with certain threshold value of fractal dimension.

![Fig. 3: Data flow diagram of the proposed method](image)

3.5 Algo_cont_fd($L;\lambda$)

do 
Begin:
Rotate the object by 60 degree,(six times)
do
Begin:
Set the ruler length $\lambda=2, 4, 6, 8, \ldots \leq L / 2$
Fix the initial point at the top most position of the curve
Mark an arc taking initial point as center that crosses the curve
Repeat above two steps until the end of the curve is reached
Mark the point $\log (L)$ versus $\log (\lambda)$
End; loop3
Repeat loop1 for next step length, each time plotting logarithmic graph $L$ versus $\lambda$
Fractal dimension, compute $FD$ using equ.(10).
End ;loop2
Repeat until reaches six rotation
End; loop1

4. RESULTS AND DISCUSSION

The research was carried out for the efficient detection of malignant tumor in mammogram images using image feature rotational contour based fractal dimension. The mammogram dataset considered for the experiment DDSM, MAIM and also collected from SDM hospitals. The Coding was done for the current work in MATLAB®18. The mammograms from the dataset were given as the input to the programs, the code was executed and simulations were performed & the results were observed. The detailed discussions were put up on the obtained results & finally inferred from their effectiveness. The quantitative & qualitative results shown in this section depicts the effectiveness of the proposed methodologies developed. Rotation contour based fractal dimension code was developed on MATLAB for a series of original breast mammograms as input images (number 500 affected with benign and malignant tumor, in short to say 500 mammogram images were considered with some of them malignant tumor and remaining are benign). The exact number of cancer disease affected not known initially in the 500 mammograms, the exact number of cancer disease affected image to be detected after executing the developed algorithm. The code was implemented and executed; the result observed is a series of figure 4. In 4.a original mammograms taken from the X-ray instruments and noise is removed. The region of interest that is tumor is enhanced and input to the segmentation stage. In this stage morphological based segmentation have been adopted and obtained the contour of the tumor using Canny Edge detection as shown in the 4.b. Due to little error in the segmentation of the region of interest, the multiple contour lines had been observed as shown in fig.4.b. In order to overcome the improper segmentation the area filling algorithm had been adopted as shown in fig.4.c. The Canny edge based detection had been adopted and obtained smooth contour of the tumor as shown in the 4.d. From the fig.4.e to fig.4.i intervals of $60^0$ starting from $0^0$ considered for rotational contour based fractal dimension technique and estimated image feature fractal dimension as $1.545$ .Initial position($0^0$) was considered and FD $1.5465$, Second position($60^0$) was considered, FD $1.5461$, Third position($120^0$) was considered and FD $1.5467$, Fourth position($180^0$) was considered and FD $1.5463$, Fifth position($240^0$) was considered and FD $1.5468$ and Sixth position($300^0$) was considered and FD $1.5462$. Finally geometric mean and arithmetic mean of these intervals of 6 stages FD were considered and result obtained as 1.5412 and 1.5464 respectively. The reason behind to consider the geometric mean over the arithmetic mean is that geometric mean is more consistent than arithmetic mean. To increase the accuracy of result of diagnosis, considered One Dimensional (1-D) signature that is shown in fig. 5.a contour of the tumor have been considered as the input for the method of the One Dimensional signature for fig.5.b. The fig.5.c shows the One Dimensional signature of the benign tumor and also it had been observed that 1D signature is smoother over the malignant tumor as shown in the fig.7.a to 7.c. Similarly, in fig.6.a original mammograms taken from the X-ray instruments and noise is removed. The region of interest that is tumor is enhanced and input to the segmentation stage. In this stage morphological based segmentation have been adopted and obtained the contour of the tumor using Canny Edge detection as shown in the fig.6.b. Due to little error in the segmentation of the region of interest, the multiple contour lines had been observed as shown in fig.6.b. In order to overcome the improper segmentation the area filling algorithm had been adopted as shown in fig.6.c. The Canny edge based detection had been adopted and obtained smooth contour of the tumor as shown in the fig.6.d. intervals of $60^0$ starting from $0^0$ considered for the contour based fractal dimension technique and estimated image feature fractal dimension as 3.1887, Initial position($0^0$) considered and FD $3.1887$, Second position($60^0$) considered, FD $3.1887$, Third position($120^0$) considered and FD $3.1887$, Fourth position($180^0$) considered and FD $3.1887$, Fifth position($240^0$) considered and FD $3.1887$ and Sixth position($300^0$) considered and FD $3.1887$. Finally geometric mean and arithmetic mean of these intervals of 6 stages FD are considered and result obtained is 3.1887 and 3.1921 respectively. Fig.7.a contour of the malignant tumor have been considered for the method of the One Dimensional. Fig 7.b and 7.c shows the One Dimensional (1-D) signature of the malignant tumor. And it had been observed that 1D signature is more complex over 1-D signature benign tumor. It can also be observed from the obtained result that the fractal dimension for the benign tumor is lesser compared to malignant tumor. Lesser FD of the contour of the benign tumor denotes smoother contour over the contour of the malignant tumor. This factor also is supported by physical phenomena of fractal dimension theory higher FD for higher irregularity. The breast that is affected by malignant tumor will growth very rational and aggressive in nature, hence resulting in more irregular contour as shown in the fig.6.a,6.b,6.c and 6.d. The proposed algorithm is applied for a set of 500 images which may or not be affected by cancer and the end result was tabulated as shown in the table 1. It was observed that in the set of 500 images 222 were affected with malignant and 278 was benign, leading to efficient identification and detection of the cancer. In the fig.8, the graph of fractal dimension versus total number of samples was plotted. The graph shows that for malignant tumor samples the FD values were in range of 1.78 to 3.78 in contrast for benign tumor FD ranges from the 1.46
to 1.71. The quantitative result of the 500 images is shown in the table 1(to reduce the length of the paper only 32 samples data have been mentioned). The table 2 describes the first order statistical parameter of the benign and malignant tumor for 500 images considered such as min, max, mean, median, mode, SD and range. From table 2 we can infer that, the mean of benign tumor FD is 1.60 for 222 samples and where as the mean of the malignant tumor is 2.37. The Standard deviation of benign tumor fractal dimension is 0.24 in contrast for malignant tumor is 0.58. This clearly indicates the classification of benign and malignant tumor of the breast. The remaining parameters value can be observed in the table.

**Table 1. Fractal Dimension of benign and malignant tumor with GM and AM**

<table>
<thead>
<tr>
<th>SL No</th>
<th>Benin</th>
<th>FD(Gm)</th>
<th>FD(AM)</th>
<th>Malignant</th>
<th>FD(Gm)</th>
<th>FD(AM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B1</td>
<td>1.6460</td>
<td>1.6490</td>
<td>M1</td>
<td>3.1887</td>
<td>3.1921</td>
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<tr>
<td>2</td>
<td>B2</td>
<td>1.6846</td>
<td>1.6856</td>
<td>M2</td>
<td>3.5355</td>
<td>3.5412</td>
</tr>
<tr>
<td>3</td>
<td>B3</td>
<td>1.7084</td>
<td>1.7109</td>
<td>M3</td>
<td>3.9115</td>
<td>3.9310</td>
</tr>
<tr>
<td>4</td>
<td>B4</td>
<td>1.6451</td>
<td>1.6505</td>
<td>M4</td>
<td>2.1883</td>
<td>2.1999</td>
</tr>
<tr>
<td>5</td>
<td>B5</td>
<td>1.5572</td>
<td>1.5572</td>
<td>M5</td>
<td>3.9069</td>
<td>3.9163</td>
</tr>
<tr>
<td>6</td>
<td>B6</td>
<td>1.4681</td>
<td>1.4701</td>
<td>M6</td>
<td>2.6499</td>
<td>2.6572</td>
</tr>
<tr>
<td>7</td>
<td>B7</td>
<td>1.6096</td>
<td>1.6122</td>
<td>M7</td>
<td>2.2709</td>
<td>2.2774</td>
</tr>
</tbody>
</table>

**Fig. 4** (a) original input mammogram, (b) Extracted RoI benign tumor, (c) Filled area of benign tumor, (d) Obtaining contour of the RoI, (e) Initial position(0 degree) considered and FD 1.5465, (f) Second position(60 degree) considered and FD 1.5465, (g) Third position (120 degree) considered and FD 1.5465, (h) Fourth position (180 degree) considered and FD 1.5465, (i) Fifth position (240 degree) considered and FD 1.5465. (Arithmetic mean =1.5465 and Geometric mean=1.5496)

**Fig. 5** (a) Contour of the benign tumor (b) considered for the 1-D signature (c) 1-D signature

**Fig. 6** (a) original malignant input mammogram, (b) Extracted RoI benign tumor, (c) Filled area of malignant tumor, (d) Obtaining contour of the RoI, (e) Initial position(0 degree) considered and FD 3.1887, (f) Second position(60 degree) considered and FD 3.1887, (g) Third position (120 degree) considered and FD 3.1887, (h) Fourth position (180 degree) considered and FD 3.1887, (i) Fifth position (240 degree) considered and FD 3.1887.

**Fig. 7** (a) Contour of the malignant tumor (b) Considered for the 1-D signature (c) 1-D signature

- Out of 500 samples 222 are benign tumors and 278 are malignant

<table>
<thead>
<tr>
<th>N= 500</th>
<th>Predicted NO</th>
<th>Predicted YES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual NO (Benign)</td>
<td>True Negative 255</td>
<td>False Positive 23</td>
</tr>
<tr>
<td>Actual YES (Malignant)</td>
<td>False Negative 12</td>
<td>True Positive 210</td>
</tr>
<tr>
<td>267</td>
<td>233</td>
<td>500</td>
</tr>
</tbody>
</table>

Accuracy= (TP+TN)/Total=(210+255)/500= 93%  
Misclassification=(FP+FN)/500= (23+12)/500= 7%
The malignant tumor fractal dimension is less than the benign tumor fractal dimension. It can be inferred that the lesser fractal dimension value indicates a benign tumor and the higher fractal dimension value indicates a malignant tumor. The obtained benign contour FD had an average range of 1.46 to 1.71 and for the malignant contour FD ranges from 1.78 to 3.12.

The sensitivity and specificity for the proposed work are 100 and 98 percent respectively. The obtained FD clearly distinguishes the tumor either as benign or malignant. The other statistical parameters had been computed. There is a scope for further work on accurate segmentation of the tumor region, localization, and determining the growth rate of the tumor. The rotation of the contour by certain degrees and the measuring the FD value in different iterations for 500 samples have been done and the range of the FD value clearly distinguishes that the lesser FD value indicating smoother contour in contrast the higher FD indicating higher irregularity of the malignant tumor. The SD value indicated 0.06. The current approach provides a novel technique for the classification of the tumor either as benign or malignant based on the nature of the contour.

### 6 ACKNOWLEDGEMENT

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### 7 REFERENCES


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