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DETECTION OF MASSES IN MAMMOGRAM IMAGES USING ANT COLONY OPTIMIZATION

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ABSTRACT
This paper proposes the advances in edge detection techniques, which is used for the mammogram images for cancer diagnosis. It compares the evaluation of edge detection with the proposed method ant colony optimization. The study shows that the edge detection technique is applied on the mammogram images because it will clearly identify the masses in mammogram images. This will help to identify the type of cancer at the early stage. ACO edge detector is best in detecting the edges when compared to the other edge detectors. The quality of various edge detectors is calculated based on the parameters such as Peak signal to noise ratio (PSNR) and Mean square error (MSE).
***Keywords* –** Ant colony optimization, cancer, diagnosis, edge detection, mammogram.

I. INTRODUCTION

Cancer is most dangerous disease which is caused by some factors like hormones, immune conditions etc [1]. According to the World Health Organization, breast cancer is one of the most deadly in women [2]. A group of rapidly dividing cells may form a mass of extra tissue in breast which is called tumors. Tumors can either be cancerous called as malignant or non-cancerous called as benign. Malignant tumors usually penetrate and destroy healthy body tissues [14].

A major class of problem that always can be seen in medical science is that the diagnosis of disease, based upon various tests performed upon the patient. Even after performing the several tests, the ultimate diagnosis may be difficult to obtain, even for a medical expert. This has given rise, over the past few decades, to use the computerized diagnostic tools for doctors [7]. Mammography screening associated with clinical breast examination is the only viable and effective method at present for mass screening to detect breast cancer [15].

The edge detection can be used to detect the masses in mammogram images because image edge detection detects outlines of an object and boundaries between objects and the background in the image [10]. This will help the detection of breast cancer at the early stage.

This paper shows three basic edge detection operators such as Sobel, Prewitt, and Canny were selected and a comparison is done to check the quality of the edge detectors with the proposed method Ant colony optimization (ACO). The study shows that the ACO edge detector is best in detecting the edges when compared to other edge detectors. Two parameters are used for the comparison evaluation of various edge detection techniques such as peak signal to noise ratio and mean square error.

II. LITERATURE SURVEY

The literature survey shows that many of researchers have found number of solution for detection of breast cancer with better accuracy [4]. In [6] author uses neural pattern recognition model which is the combination of two methodologies fuzzy systems and evolutionary algorithms, from which they got the success of 97%. Another method by using the hybrid system for diagnoses of the breast cancer based on FCOSVM represented in [3] improves the accuracy up to 97.34%. In [5] authors suggested other technique using segmentation with fuzzy models and classification by crisp k-nearest neighbor (k-nn) for breast cancer. In [7] authors shows the comparison of various methods using neural network for diagnosis of breast cancer in which the authors found that by using Jordan and Elman Network has achieved more accuracy up to 98.03%. Amin Einipour in [8] combines two methods fuzzy systems and ACO algorithm which automatically produce systems for breast cancer diagnosis which gives the results with accuracy 98.21%.

The Previous work on image edge detection performed by various researchers has found the good results for edge detection. In [16] authors show the comparison of sobel and canny edge detection in which they found that the canny proves to be better and fulfills the noise rejection requirement by a user.

The paper [17] shows the evaluation of all edge detection techniques out of which sobel edge detection method is found as the best in detecting the edges in a noisy IR images.

In [10] authors compare the all edge detection methods with the new technique ACO based on the parameters PSNR and MSE. ACO-based image edge detection takes advantage of the improvements in the edge detection. The results they found that the possibility of the approach in identifying edges in an image and mean square error of proposed algorithm is 6% to 19% lower in comparison to that of sobel and canny algorithm which leads to 2 to 5% increase in Peak signal to noise ratio of proposed algorithm in comparison to that of sobel and canny algorithm.

III. IMAGE EDGE DETECTION

The image Edge detection is an important element in image processing, since edges contain a major function of image information [19]. The function of edge detection is to identify the boundaries of homogeneous regions in an image based on properties such as intensity and texture between the background and object present in that image.

The techniques such as, canny, prewitt, and sobel etc. are conventional methods, which are more expensive because, each set of operations is conducted for each pixel [10]. This technique doesn't give the direct detection of cancer tumor from mammogram image. ACO based edge detection has an improvement in detection of tumor.

IV. ANT COLONY OPTIMIZATION

ACO is nature inspired algorithm to find the shortest path between nest and food source [12]. When all ants in their colony act as a community they are able to solve complex problems [13]. The communication between the members in that colony is through pheromone substance. The ants deposit pheromone in the journey between nest and food. This will increase the probability of pheromone so that the other members of the colony will follow the same path [9]. This will become the guidance for other ants to choose the shortest path [12]. In this paper, ACO method is used for the edge detection to extract the information from mammogram images.

Artificial ants are distributed over the image for shortest route construction. Edge detection of an image is the identifying the pixels that are correspond to the edges. A 2-dimensional image is used with the pixel value as its elements. The ACO algorithm for edge detection is given below-

4.1 Initialization Process

K numbers of ants are placed in random for each pixel value with an image of size M1 × M2. In this M1 is the length of an image and M2 is the width of an image. The parameters α and β are initialized and heuristic information is set. The initial value of each component of the pheromone matrix is set to be a constant τ (init).

4.2 Construction Process

In Construction process K number of ant is randomly moving for L construction steps on image from node i to node j. The movement of ants is in accordance with the 8 connectivity by using transition probability rule according to equation (1)

$$p_{i,j}^{(n)} = \frac{(T_{i,j}^{(n-1)})^{\alpha}(\eta_{i,j})^{\beta}}{\sum_{j \varepsilon \Omega i}((T_{i,j}^{(n-1)})^{\alpha}(\eta_{i,j})^{\beta}} \quad , \text{if } j \,\square\, \Omega i \qquad (1)$$

Where,
τ(i,j) is the pheromone information value on edge i,j, α is a parameter to control the influence of τ(i,j), η(i,j) represents the heuristic information of edge i,j, β is a parameter to control the influence of η(i,j), Ωi is the neighboring nodes of (i,j).

There are two fundamental concerns in the construction process. The main concern is with the determination of heuristic information η (i,j) which can be determined by the pixel location (i,j) as,

$$(i\,,j) = \quad I(i, j)\,/Z \qquad (2)$$

Where, Z is the normalization factor and is defined as,

$$\sum i\text{=1:M1} \sum j\text{=1:M2 Vc I (i,j)} \qquad (3)$$

Where, Ii,j represents the intensity value of the pixel (i, j) of image I. The value of function Vc (Ii,) depends on changes in pixel intensity values which is defined as,

$$\begin{aligned} Vc\,(i, j) = f|(\, I(i-1, j) - I(i+1, j)| + \\ |(i-1, j-1) - I(i-1, \quad j+1)| + \\ |(i-1, j-1) - I(i+1, j+1)| + \\ |(i, j-1) - I(i, j+1)| \qquad (4) \end{aligned}$$

The shape function in equation (4) is modified mathematically using four functions (Flat, Quadratic, Sine and Wave) for computing the heuristic function.

$$f(x) = \lambda x, \quad \text{for } x \geq 0,$$

$$f(x) = \lambda x^2, \quad \text{for } x \geq 0,$$

$$f(x) = \begin{cases} \sin(\pi x / 2\lambda) & 0 \leq x \leq \lambda; \\ 0 & \text{else.} \end{cases}$$

$$f(x) = \begin{cases} (\pi x \sin((\pi x/\lambda))/\lambda & 0 \leq x \leq \lambda; \\ 0 & \text{else} \end{cases} \quad (5)$$

The parameter λ in above functions adjusts the respective shape.

4.3 Update Process

The update is performed after the movement of each ant and second update is performed after the movement of all ants.

The update process, which updates the pheromone matrix after each ant is moved given by,

$\mathcal{T}_{i,j}^{n-1} = (1-\rho).\mathcal{T}_{i,j}^{n-1} + \rho.\Delta_{i,j}^{(k)}$ if (i,j) is visited by the kth ant otherwise

$$= \mathcal{T}_{i,j}^{n-1} \quad (6)$$

Where, ρ is evaporation constant, Δi,j(k) is determined by the heuristic matrix,

$$\Delta_{i,j}(k) = \eta(i,j) \quad (7)$$

The pheromone matrix is again updated after all the ants move in each construction step. This is done according to equation (8)

$$\tau(n) = (1 - \psi) \cdot \tau(n-1) + \psi \cdot \tau(0) \quad (8)$$

ψ being a decay constant.

4.4 Decision Process

A binary decision is made in this process at each pixel location to determine whether it is an edge or not, by applying threshold T on final pheromone matrix □ (N).

V. PEAK SIGNAL TO NOISE RATIO

The mostly common use of peak signal to noise ratio is a measure of quality of reconstruction of lossy compression codecs (e.g., for image compression). It is an expression for the ratio between the maximum possible power of a signal and the power of corrupting noise that affects the fidelity of its representation. When comparing compression codecs it is used as an approximation to human perception of reconstruction quality, therefore in some cases one reconstruction may appear to be closer to the original than another, even though it has a lower PSNR.

It is most easily defined via the mean squared error (MSE) for two m×n monochrome images I and K where one of the images is considered a noisy approximation of the other and is defined as:

$$\text{MSE} = \frac{1}{mn}\sum_{i=0}^{m-1}\sum_{j=0}^{n-1}[I(i,j) - K(i,j)]^2 \quad (9)$$

The PSNR is defined as:

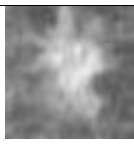
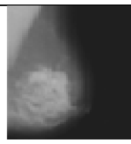
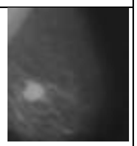
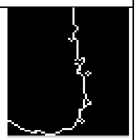
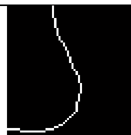
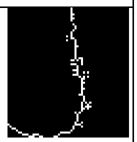
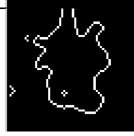
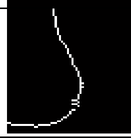
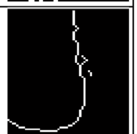
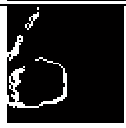
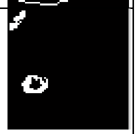
$$\text{PSNR} = 10\ log10(\frac{MAX\ I^2}{MSE})$$
$$= 20 \log10\ (\frac{MAX\ I}{\sqrt{MSE}}) \quad (10)$$

Here, MAX I is the maximum possible pixel value of the image. PSNR is always expressed in terms of the logarithmic decibel scale.

VI. RESULT

The results of different mammogram images using ACO and other edge detection techniques shows that ACO gives better results than other methods.

Table No. 1

	Fig.1	Fig.2	Fig.3
Original mammogram images			
Sobel			
Prewitt			
Canny			
ACO			

From the results it shows that the method ant colony optimization gives better results than other edge detection techniques. It gives direct detection of cancer tumor present in the mammogram image. The performance evaluation is also calculated by calculating the peak signal to noise ratio and mean square error. The calculated values of PSNR and MSE are shown in the table below.

Table No. 2

Fig. No.	Edge Detection methods							
	Sobel		**Prewitt**		**Canny**		**ACO**	
	MSE	PSNR	MSE	PSNR	MSE	PSNR	MSE	PSNR
1	20186.70	5.11	20188.00	5.11	20188.56	5.11	0.87	48.75
2	8479.14	8.88	8479.05	8.88	8479.25	8.88	0.79	49.21
3	4773.07	11.38	4772.66	11.38	4773.62	11.38	0.31	53.32

VII. CONCLUSION

ACO based edge detection has an advantage over conventional edge detection techniques. Experimental results show the possibility of the approach in identifying edges in mammogram image and mean square error of proposed algorithm is lower in comparison to that of sobel, prewitt and canny algorithm which leads to increase in Peak signal to noise ratio of proposed algorithm in comparison to that of other edge detection methods.

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