Asian Journal of Information Technology 13 (4): 252-259, 2014
ISSN: 1682-3915

Removal of Pectoral Muscle Region in Mammogram Image by Metaheuristic Algorithm-Monkey Search Optimization (MSO)

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Abstract: In this study, a different approach based on Metaheuristic algorithm is presented for removing pectoral muscle region in mammogram image is carried out using image segmentation process. The foraging behavior of monkey is optimized as Monkey Search Optimization (MSO) which is the subset of metaheuristic algorithm. To solve complex problems by cooperation the behaviors of nature is considered. Several algorithms based on population-based metaheuristic algorithms were introduced in the literature to solve different problems like optimization problems; it is proven by result that the proposed approach has the potential to be an appropriate algorithm for image segmentation. Results are presented based on simulation made with the implementation in MATLAB which is tested on the images of MIAS database.

Key words: MSO, climb, watch and jump, cooperation, somersault, stochastic perturbation mechanism, termination

INTRODUCTION

Breast cancer is where cancerous (Malignant) cells are found in the breast tissue. Radiograph of the breast tissue is called mammogram. Getting a mammogram is an effective way to detect breast cancer in its early stages. Breast cancer is the second leading cancer next to cervical cancer.

X-rays are used for diagnosing breast cancer through mammographic screening. Breast cancer is most common in women than men worldwide. According to estimates of lifetime risk will be the US National Cancer Institute, about 13.2% of women in the US will develop breast cancer which is the same as saying one in eight people.

In 2009, about 562,340 Americans died of cancer, >1500 people a day. About 1,479,350 new cancer cases were diagnosed in 2009. In the United Sates, cancer is the second most common cause of death and accounts for nearly one of every four deaths. The chance of developing invasive breast cancer at some time in a woman's life is about one in eight (12%).

X-ray mammography is the most common investigation technique used by radiologists in the screening and diagnosis of breast cancer they could help the radiologists in the interpretation of the mammograms and could be useful for an accurate diagnosis. To perform a semi-automated tracking of the breast cancer, it is necessary to detect the presence or absence of lesions from the mammograms.

Literature review: The preprocessing technique is also known as background suppression. Before getting into the presence or absence of lesions preprocessing is done to remove the pectoral region as it is not in need of the whole image (Ramirez-Villegas *et al*., 2009). In most conditions any of the filters is used as by Thangavel *et al*. (2005) and Kumar *et al*. (2010).

Overview of Metaheuristic algorithms: This study explains a new algorithm called Monkey Search Optimization for removing the pectoral muscle region in the mammogram image. This MSO is a Nature-Inspired Evolutionary algorithm.

OVERVIEW OF THE PROBLEM

In this study, researchers focus on the removal of the pectoral muscle region also known as preprocessing in the mammogram images. The region which contains some chest portion of the patient is the pectoral muscle region. It is the region which mostly covers front upper chest (Boss *et al*., 2013). Preprocessing technique involves background removal, noise removal and enhancing the image.

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Comparison is made based on the behaviors of three different monkey species such as Howler, Spider and Squirrel monkeys (Amato *et al.*, 2007). The behaviors of monkeys differ with one another based on the food type, movement, searching for food, resting, watching and doing other activities. Types of food are leaf, fruits and insects. Howler monkey depends on leaves, Spider monkey focuses on leaves and fruits whereas squirrel monkeys have both fruits and insects. Mammogram image is considered as forest. Forest will have both edible and non-edible foods. This study presumes the pectoral region as the better quality food which is the look alike of edible food for monkeys. Hence, the pectoral region is marked and removed.

BASIC OF THE MSO

MSO focuses on the foraging behavior of monkey. Monkeys go in search of foods available in the branches of the trees. Each branch is considered as feasible solution. Selection of the branch is based on the probability mechanism. The process of MSO is organized in three processes such as climb, watch-jump and somersault processes. Climb process is further classified as climb up and climb down along with either long or short step climb process (Mucherino and Seref, 2013; Serra *et al.*, 1997; Wang *et al.*, 2010; Zhao and Tang, 2008).

Climb process: Let assume the concept by having the decision variable vector $P_i = (p_1, p_2, p_3, ..., p_n)^T$ and the objective function for minimization as f(P). $\Delta P = (\Delta p_1, \Delta p_2, \Delta p_3, ..., \Delta p_n)^T$ is a randomly generated vector. The pseudo-gradient of function f(P) at the point p can be expressed as: $(f_1'(P), f_2'(P), ..., f_n'(P))^T$ where:

$$f_j'(P) = \frac{f(P+\Delta P)-f(P-\Delta P)}{2\Delta p_j} j \in \{1, 2, ..., n\} \quad (1)$$

As the generations of ΔP are repeated, local optimum is found by the decrease in the objective function f(P) based on the sign caused as a result of slow replacement of P with P+ΔP or P-ΔP.

Watch-jump process: This process is made once the monkey reaches the tip of the tree. Since, the monkey has to move on to find availability of any other feasible solution in the forest. Besides searching for food the monkey has to be aware of the presence of enemies. If there is any feasible solution then it is replaced with the current solution (Mucherino *et al.*, 2013; Serra *et al.*, 1997; Wang *et al.*, 2010; Zhao and Tang, 2008).

Cooperation process: This process focuses on the cooperation among monkeys. Hence, the monkeys at better solution will communicate with monkeys at poor solution and make them to climb to the better of the area (Wang *et al.*, 2010).

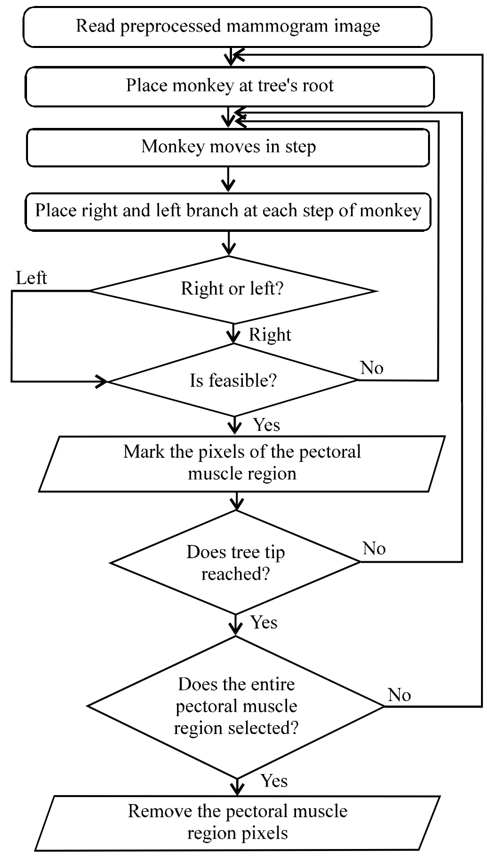

Fig. 1: Flowchart for removing pectoral muscle region using MSO

Somersault process: In this phase, monkeys will move from one position to another position to find the availability of new solution (Wang *et al.*, 2010) in the given forest area. Figure 1 depicts the MSO for removing or segmenting the pectoral muscle region in mammogram image. The algorithm for MSO is given as:

Algorithm for MSO:

```
Set parameters M, P_i, Δp_i
Randomly generate monkey population M
    for i = 1 to M
        initialize monkey's position at tree's root
        P_i = (p_1, p_2, p_3,...p_n)
        if change in position
            then ΔP = (Δp_1, Δp_2, Δp_3,...Δp_n)
        end if
    end for
    for each monkey ido f(P+ΔP)
        generate right and left branches for each step
        using probability mechanism choose either right
       left branche
        if the distance is small
            then choose ΔP_i = (0, ..., 0, Δp_i,j 0,...0)^T
```

```
15              else if distance is large
16                      then choose ΔPi = (Δpi,1, Δpi,2, Δpi,3, ..., Δpi,n)^T
17              end if
18              end if
19              if the branch has the unwanted pixel
20                  mark as feasible solution Pi
21              else
22              move next step (repeat from step 1)
23              end if
24                continue the process from step 10 until the monkey
                reaches the tree tip
25          end for
26          while tree tip is reached by monkey do
27              for each monkey i do f(P-ΔP)
28                  move to next tree
29                  repeat the process from step 4
30                  if local feasible solution is obtained
31                      then cooperate the monkeys, Pi''
32                  end if
33              end for
34          end while
35          while local optimum is obtained
36              move on to new domain uj in search of better solution
37              find Pi'''
38              update with monkeys initial position Pi
39              move all monkeys to Pi'''
40          end while
41          if the entire pectoral region is marked
42              then remove the pixels and terminate the process
43          end if
```

Implementation of MSO to the problem: Given the details of the image, removal of pectoral muscle region in the mammogram image problem can be defined as: Energy of monkeys is represented as:

$$\| PE \|_2 = \sqrt{\int_{-\infty}^{\infty} f(p) e^{-ihw} dp} \quad (2)$$

Where:

$$f(p) = (hw)_{ij} \quad (3)$$

where, hw is the energy required by each monkey for moving from one place to another. Total energy is calculated based on:

$$T(p) = \| PE \|_2 (hw)_{ij} = \| PE \|_2 \sum_{i=1, j=1}^{M} (hw)_{ij} \quad (4)$$

With the following conditions:

$$PI_m \, PI_v = PI_a - PI_d \quad (5)$$

$$-PI_l^M \le PI_l \le PI_l^M, l \in L \cup L' \quad (6)$$

$$0 \le p_j \le p_j^M, j \in \{1, 2, ..., n\} \quad (7)$$

Solution representation: The solution for the problem is represented in the following equation:

$$P_i = (p_{i,1}, p_{i,2}, p_{i,3}, \ldots p_{i,n})^T$$

Objective function: The objective function is modified as follows:

$$\min f(p) = \begin{cases} PE \sum_{i=1, j=1}^{M} (hw)_{ij} + G_0 \sum_{l \in L \cup L'} \max\{0, |PI_l| - PI_l^M\} \\ G_1 \end{cases}$$

Generate initial population for M monkeys:

$$p_i = (p_1, p_2, p_3, \ldots, pn)^T$$

While (t<MaxGeneration) or (segmentation completed).

Where:

- Im = Image matrix
- Pi_v = Pixel value
- PE = Total energy
- Pi_a = Active pixels in the image
- G_0 = Gravitational force when monkey jumps from one tree to another
- G_1 = Penalty if monkey is unreachable
- PI_l^M = Maximum of how many pixels affected in the image
- PI_l = Original image
- p_j = Number of monkeys in correct position
- p_j^M = Maximum number of monkeys
- L = Set of existing path for movement
- L' = Set of new path for movement

Climb process: Initialize random position for M monkeys as P_i $(p_{i,1}, p_{i,2}, p_{i,3}, \ldots p_{i,n})^T$ evaluate its current position to reach the border for which select either of large-step or small-step climb process:

The large-step climb process:

(i) $\Delta P_i = (\Delta p_{i,1}, \Delta p_{i,2}, \Delta p_{i,3}, \ldots \Delta p_{i,n})^T$

Interval $[-p_L, p_L]$ where p_L is the length of large-step climb process.

(ii) Calculate: $f(P_i+\Delta P_i)$, $f(P_i-\Delta P_i)$

(iii) if: $f(P_i+\Delta P_i)<f(P_i-\Delta P_i)$ and $f(P_i+\Delta P_i)<f(P_i)$

Then, $P_i = P_i+\Delta P_i$.

Else if $f(P_i+\Delta P_i)<f(P_i-\Delta P_i)$ and $f(P_i+\Delta P_i)<f(P_i)$.

Then, $P_i = P_i)-\Delta P_i$

(iv) Repeat (i) to (iii) of large-step climb until $N_{C,L}$ has been reached.

The small-step climb process:

(i) Generate $\Delta P_i = (0, \ldots, 0, p_{i,j}, 0, \ldots, 0)^T$

where, $j \in \{1, 2, \ldots, n\}$ and $\Delta p_{i,j}$ is a non-zero integer with an interval of $[-p_S, P_S]$ where p_S is the length of small-step climb process.

(ii) and (iii) steps for small-step climb process is similar to the (ii) and (iii) steps in large-step climb process.

(iv) repeat (i) to (iii) of small-step climb process until $N_{C,S}$ has been reached.

Watch-jump process: Check whether there is higher position when compared to current position based on the eyesight b.

(i) if higher position is available, then generate an integer $p'_{i,j}$ for an interval of $[p_{i,j}-b, p_{i,j}+b]$ randomly where $j \in \{1, 2, ..., n\}$. Let $P'_1 = (p'_{i,1}, p'_{i,2}, ..., p'_{i,n})^T$
(ii) If $f(P'_i)<f(P'_i)$, let $P_i = P'_{i,1}$
(iii) Repeat (i) to (ii) until maximum allowable number N_w been reached.

Co-operation process: Assume optimal solution in one iteration as:

$$P^* = \left(p_1^*, p_2^*, ..., p_n^*\right)^T$$

Initial position is $P_i = (p_{i,1}, p_{i,2}, ..., p_{i,n})^T$
(i) Generate real number β in [0, 1] randomly.
(ii) Calculate:

$$p''_{i,1} = \text{round}\left\{\beta p_j^* + (1-\beta) p_{i,j},\ j \in 1, 2, ..., n\right\}$$

Let $P_i = (p_{i,1}, p_{i,2}, ..., p_{i,n})^T$
(iii) set $P_i = P_i''$ and repeat the climb process.

Somersault process:
(i) Generate the real number α in [c, d].
(ii) Calculate:

$$u_j = \frac{1}{M}\sum_{i=1}^{M} p_{i,j},\ j \in \{1, 2, ..., n\}$$

Where:

$$\hat{U} = \left(u_1, u_2, ..., u_n\right)^T$$

as pivot of Somersault process.
(iii) For, $\forall i \in \{1, 2, ..., M\}$, $\forall j \in \{1, 2, ..., n\}$.
Calculate:

$$p'''_{i,j} = p_{i,j} + \text{round}\left(\left|u_j - p_{i,j}\right|\right)$$

Let:

$$P_i''' = \left(p'''_{i,1}, p'''_{i,2}, ..., p'''_{i,n}\right)^T$$

(iv) Set $P_i = P_i'''$ and repeat climb process. If $p'''_{i,j}$ is new position > upper limit p_j^M.
Then:

$$p'''_{i,j} = p_j^M$$

Else if:

$$p'''_{i,j} < 0$$

Then:

$$p'''_{i,j} = 0$$

Stochastic perturbation mechanism: When $p_{i,j}$ is same for all monkeys then $u_j = p_{i,j}$ and hence, $p'''_{i,j} = p_{i,j}$ for monkey k, $k \in \{1, 2, ..., M\}$, let $P_{k,j} = e$ where e is a uniformly distributed integer from is $[0, p_i^M]$.

EXPERIMENTAL RESULTS

MSO algorithm is carried out for MIAS database of 322 images for removing the pectoral muscle region in the mammogram image. Results of few image samples after the removal of pectoral region are shown in Fig. 2-11 and Table 1 gives the details regarding the image dataset. The

Table 1: Details of the pectoral muscle removed image

Datasets	Mean	Entropy	Energy	CPU time
1	42.4077	2.6224	265362	135.8709
2	46.0998	2.8173	290968	167.5701
3	56.8704	3.3148	431168	114.7041
4	39.7186	2.5601	290951	124.3491
5	50.6872	2.9700	324773	118.8855
6	36.6517	2.4355	249786	118.6049
7	38.4353	3.0171	358510	120.6249
8	24.7736	1.7662	169147	119.5697
9	67.9566	3.6785	423088	118.6411
10	62.2022	3.5665	406144	118.7646

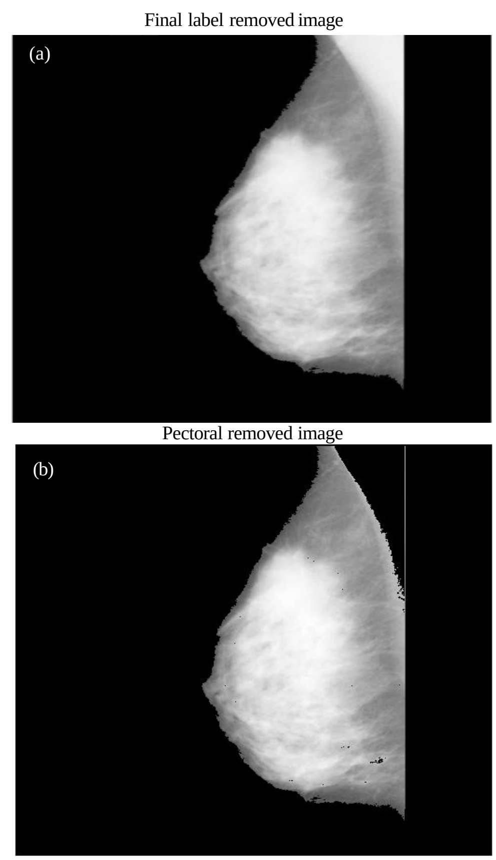

Fig. 2: a) Original image; b) pectoral region removed image for dataset 1

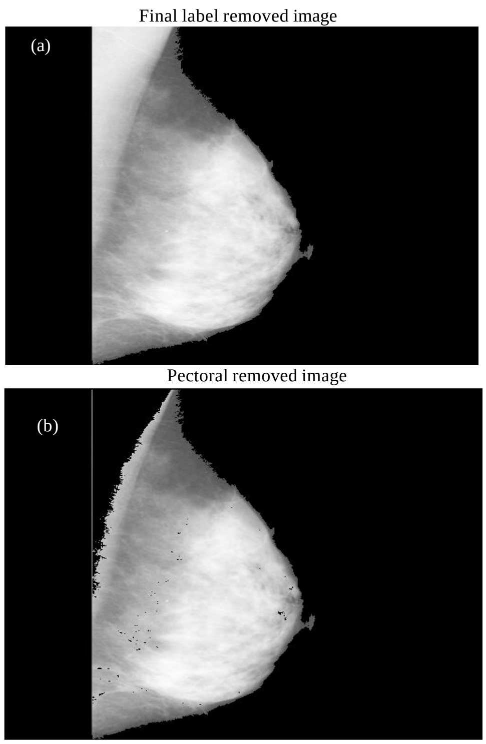

Fig. 3: a) Original image; b) pectoral region removed image for dataset 2

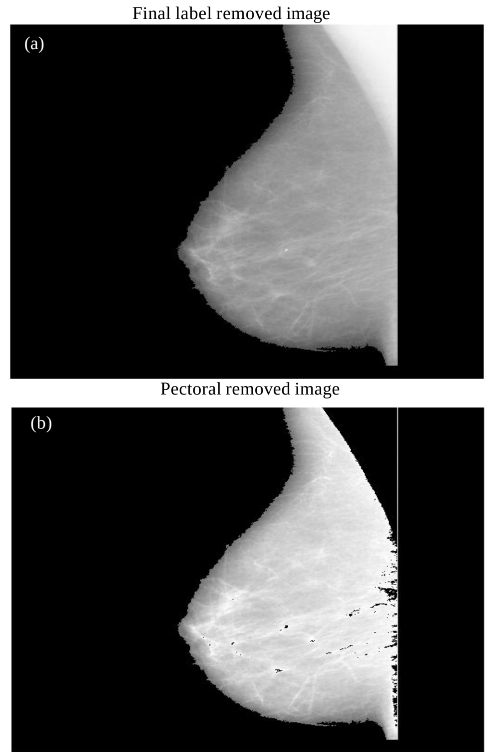

Fig. 5: a) Original image; b) pectoral region removed image for dataset 4

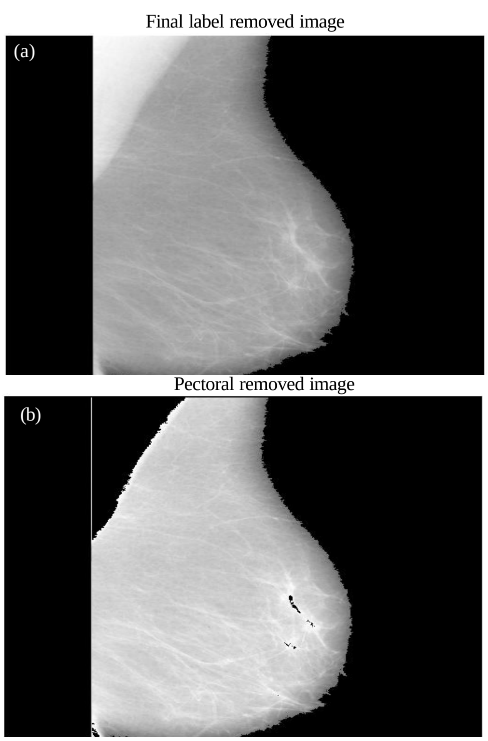

Fig. 4: a) Original image; b) pectoral region removed image for dataset 3

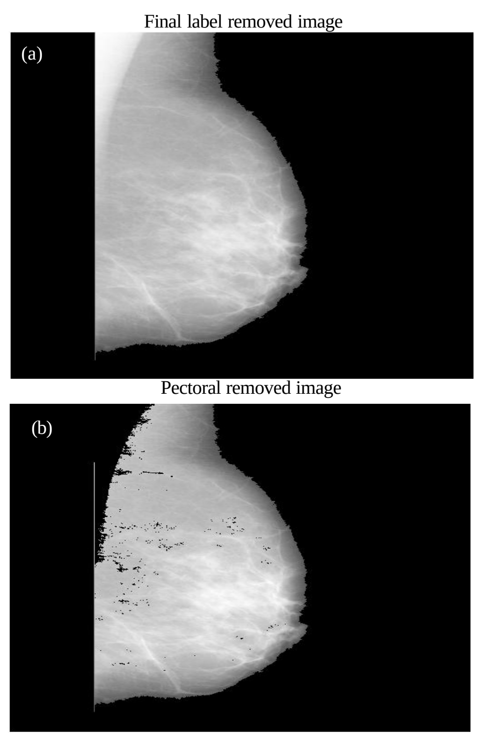

Fig. 6: a) Original image; b) pectoral region removed image for dataset 5

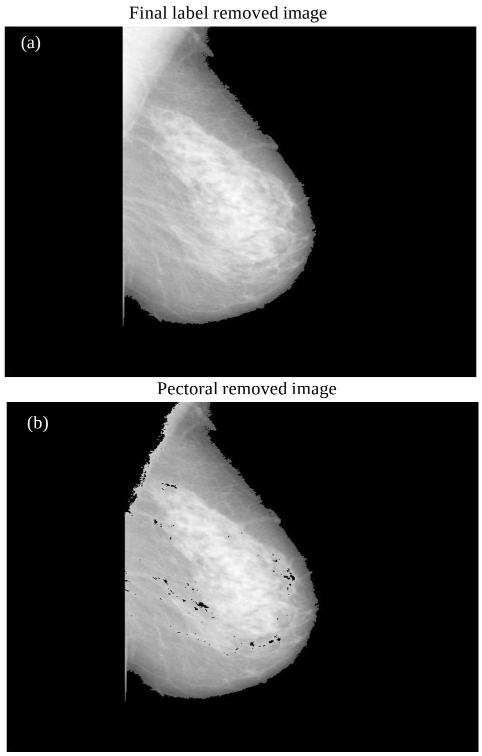

Fig. 7: a) Original image; b) pectoral region removed image for dataset 6

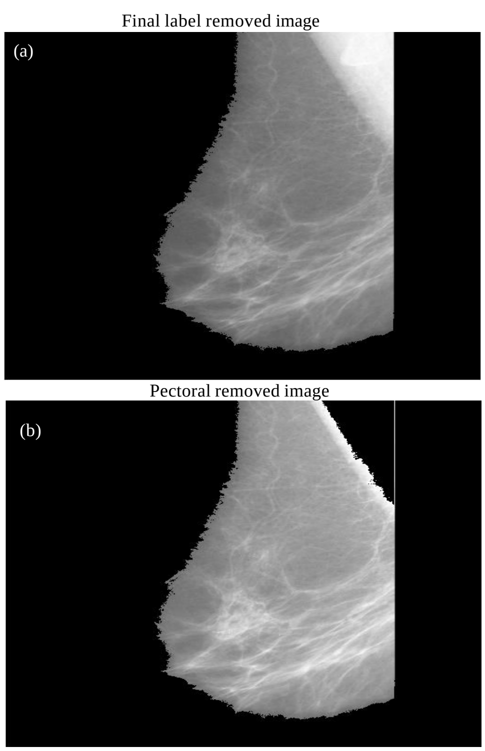

Fig. 8: a) Original image; b) pectoral region removed image for dataset 7

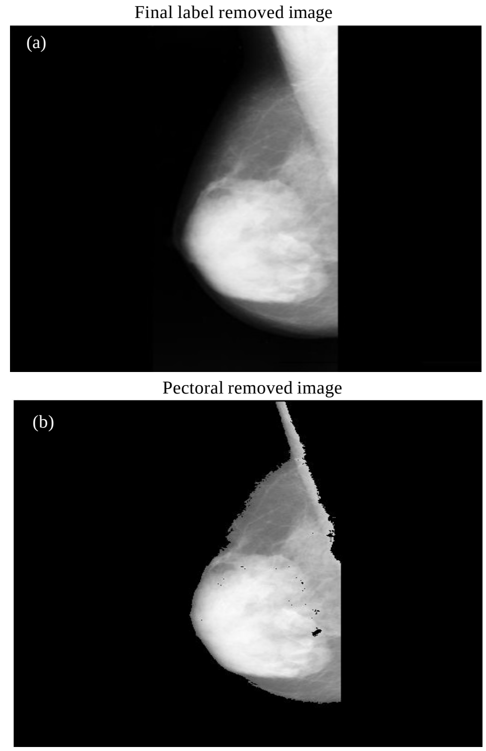

Fig. 9: a) Original image; b) pectoral region removed image for dataset 8

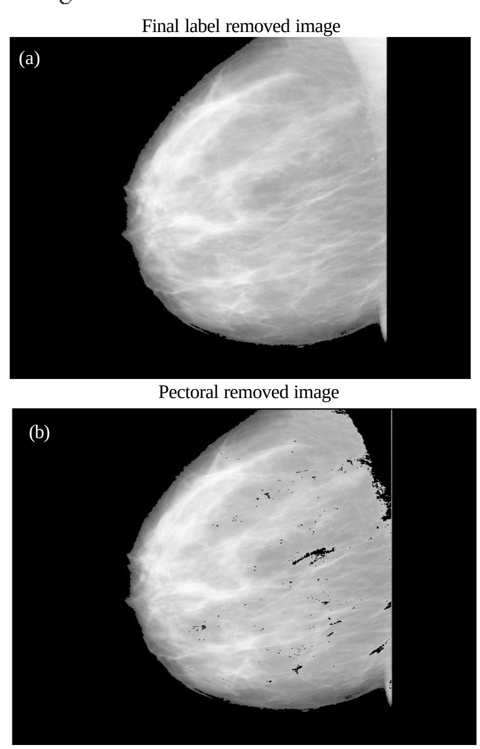

Fig. 10: a) Original image; b) pectoral region removed image for dataset 9

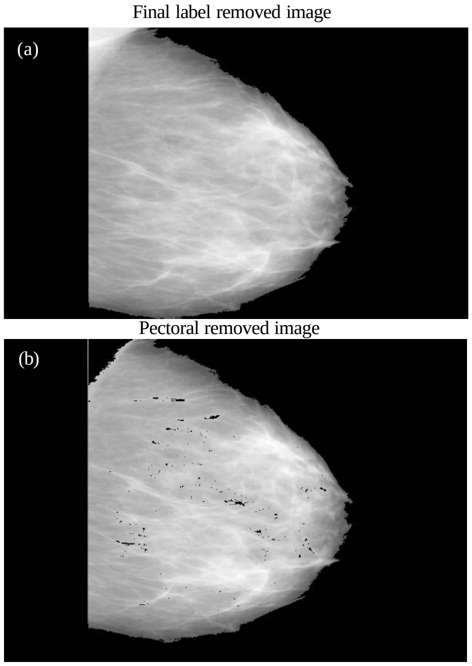

Fig. 11: a) Original image; b) pectoral region removed image for dataset 10

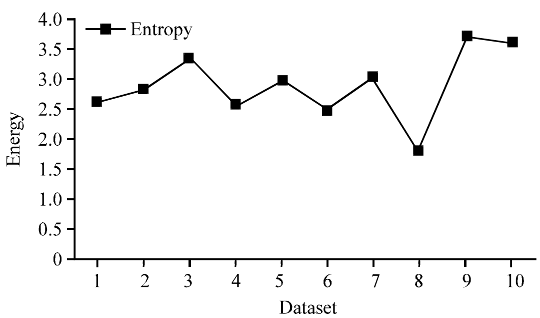

Fig. 12: Graph showing variation in entropy for the dataset

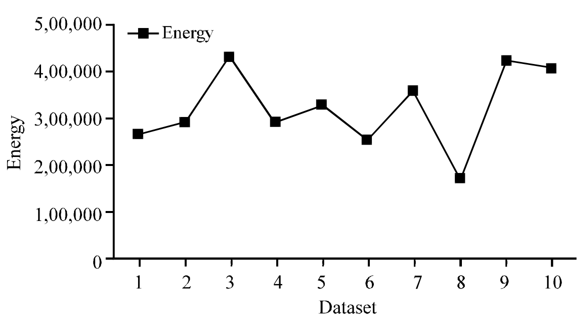

Fig. 13: Graph showing variation in energy for the dataset

following graphical figures made for Table 1 shows the variations in the values of the datasets. Figure 12-15 show the variation based on entropy, energy, mean and CPU time between datasets.

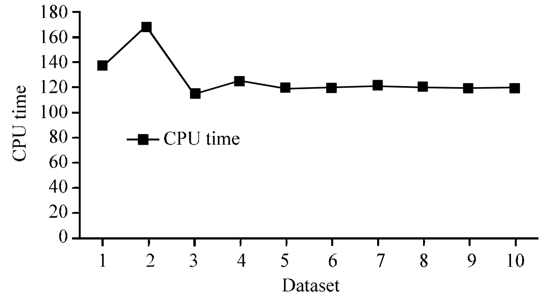

Fig. 14: Graph showing variation in CPU time for the dataset

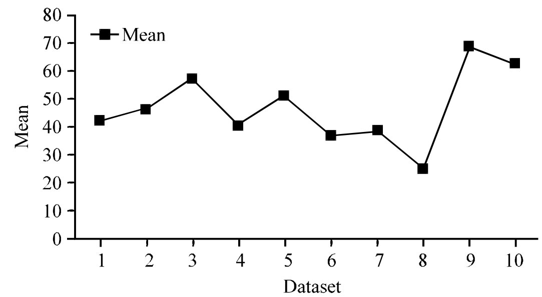

Fig. 15: Graph showing variation in mean for the dataset

CONCLUSION

This study proposes a Monkey Search algorithm for performing pectoral region removal in mammogram image. As a result the output image can be used for the selection of region of interest. Further the process of feature selection and classification is in progress.

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