6.1 Introduction

ROC analysis is based on statistical decision theory, developed in the context of electronic signal detection, and has been applied extensively to diagnostic systems in clinical medicine. The ROC curve is a plot of the classifier’s true positive detection rate versus its false positive rate. The False Positive (FP) rate is the probability of incorrectly classifying a non-target object (e.g. normal tissue region) as a target object (e.g. tumor region). Similarly, the True Positive (TP) detection rate is the probability of correctly classifying a target object as being a target object.

The TP and FP rates are specified in the interval from 0.0 to 1.0, in the mammogram image. The TP rate is referred to as sensitivity and 1.0 minus FP rate is called specificity. The input to the BPN classifier has parameters such as threshold and hidden neurons for SRDM, that can be varied to alter the TP and FP rates. Using these parameters ROC curve can be generated.

The performance of intelligent systems is best described in terms of their sensitivity and specificity, quantifying their performance related to false positive and false negative instances. These metrics are based on the consideration that a test point always falls into one of the following four categories:

§ False Positive (FP) if the system labels a negative point as positive.
§ False Negative (FN) if the system labels a positive point as negative.
§ True Positive (TP) and True Negative (TN) if the system correctly predicts the label.

The sensitivity or True Positive Fraction (TPF) of a BPN classifier is defined as the ratio between the number of true positive predictions and the number of positive instances in the test mammogram set. It is defined as follows:
TPF/Sensitivity = \( \frac{T_P}{T_P + F_N} \)

while, the specificity or True Negative Fraction (TNF) is defined as the ratio between the number of true negative predictions and the number of negative instances in the test mammogram set. It is defined as follows:

TNF/Specificity = \( \frac{T_N}{T_N + F_P} \)

The overall accuracy is the ratio between the total number of correctly classified mammograms and the test set size (total number of images). It is defined as follows:

Overall Accuracy = \( \left( \frac{N_r}{N} \right) \times 100 \% \)

where, \( N_r \) is the number of correctly classified mammogram images during the test run and \( N \) is the complete number of test mammograms. To make the ROC graph, the X-axis is 1 minus the specificity and the Y-axis is the sensitivity. Draw a diagonal line on the graph from \((0, 0)\) in the lower left hand corner to \((1, 1)\) in the upper right hand corner. The ROC is the best suited to analyze the performances of segmentation, feature extraction, selection and classification.

Figure 6.1: A typical ROC curve
A typical ROC curve is shown in Figure 6.1. The area under the ROC curve is an accepted way of comparing classifier performance. A perfect classifier would have a TP rate of 1.0 (or 100%) and a FP rate of 0.0 and therefore would have an Area under curve of 1.0.

6.2 Performance Analysis of Classifiers

The BPN network is tested by using a Jack Knife method. The results are analyzed by using ROC analysis. ROC analysis is employed to evaluate the performance of the texture analysis methods in classifying the benign and malignant. The area under the ROC curve, Az value is used as a measure of the classification performance.

The optimal parameters for each texture analysis method are analyzed. Figure 6.2 shows values for the SRDM with respect to the threshold q and the number of hidden neurons. The optimal performance is achieved when q is 150 and the number of hidden neurons is ten. From the observation, the larger the value of q, a large number of positive image can be classified as negative, whereas the smaller the value of q, a large number of negative image can be classified as positive.
In the case of single image segmentation the optimal values for the SRDM is 0.993. In the textural features from the SRDM have the best performance in terms of the area under the ROC curve, Az, whereas those of the GLRLM have the worst performance[108]. Table 6.1 shows the classification performance of SRDM. Figure 6.2 shows the classification performance of SRDM[109]. Figure 6.3 Shows the Chart for Classification Performance of SRDM.
### Table 6.1 Classification performance of SRDM

<table>
<thead>
<tr>
<th>Threshold</th>
<th>Az values</th>
<th>MRF - ABC</th>
<th>PSO</th>
<th>FSDCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>q=120</td>
<td>0.872</td>
<td>0.865</td>
<td>0.859</td>
<td></td>
</tr>
<tr>
<td>q=130</td>
<td>0.876</td>
<td>0.869</td>
<td>0.855</td>
<td></td>
</tr>
<tr>
<td>q=140</td>
<td>0.897</td>
<td>0.887</td>
<td>0.877</td>
<td></td>
</tr>
<tr>
<td>q=150</td>
<td>0.991</td>
<td>0.966</td>
<td>0.938</td>
<td></td>
</tr>
<tr>
<td>q=160</td>
<td>0.920</td>
<td>0.906</td>
<td>0.892</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 6.3: Chart for classification performance of SRDM**
6.3 Jack Knife method

The classification performance is studied using the Jack Knife method and ROC analysis. For the Jack Knife method, one half of the segmented images are selected randomly from the database for training of the neural network; subsequently, the other halves of the segmented images are used for testing the trained neural network. The training set is used to train the BPN algorithm[110]. Each training in this experiment is completed once the value of the error is less than 0.1. In this thesis, ten combinations of training and testing pairs are used to generate the ROC curves. Figure 6.4 shows ROC curves for texture analysis method based on Jack Knife method.

![ROC curves for SRDM texture analysis method based on Jack Knife method](image.png)

Figure 6.4: ROC curves for SRDM texture analysis method based on Jack Knife method
## Table 6.2 Performance analysis

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Authors</th>
<th>Methods</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cordella et al. (2000)</td>
<td>Multiple expert system</td>
<td>Area under the ROC curve is 0.786 for 40 images</td>
</tr>
<tr>
<td>2</td>
<td>K. Thangavel et al.[13,14], M. Karnan And Thangavel [8]</td>
<td>ACO, GA</td>
<td>Area under the ROC curve 0.984 for 322 images. Area under the ROC curve 0.932 for 322 images.</td>
</tr>
<tr>
<td>3</td>
<td>The Proposed Approach</td>
<td>ABC, PSO, FSDCM</td>
<td>Area under the ROC curve 0.993 for 322 images. Area under the ROC curve 0.966 for 322 images. Area under the ROC curve 0.938 for 322 images.</td>
</tr>
</tbody>
</table>
6.4 Summary

The experiments and results show that ABC performs better than other existing algorithms. It is observed that proposed ABC outperforms the existing methods. Comparatively the approach, Segmentation using MRF-ABC, Feature Extraction using SRDM, Feature selection using combination of GA, PSO and ABC has higher detection rate that is 0.993. Table 6.2 and Figure 6.5 show performance analysis of previous works and proposed work.