CHAPTER 7

COMPARATIVE STUDY OF THREE APPROACHES

7.1 INTRODUCTION

The research work has three main progressive stages. In each stage a new approach was designed and implemented. Based on the result of that stage the progression to the next stage was performed. Based on the developed approaches the whole research work can be partitioned into three main phases. Result of each phase has its effect in improving to the next progressive phase. The system developed in the final phase is found to be the best that overcomes the drawbacks of the previous approaches and produces maximum efficiency in malignancy detection. In this chapter the comparative study of the three phases is given in detailed manner.

Each algorithm has three common steps preprocessing, segmentation and feature extraction. The classification is drawn in second and third phases. Region of Interest is included in the final approach. Since the first CAD system has three steps in mass diagnosis for identity purpose it is named as 3 Step Malignancy Detection Technique (3SMST). Similarly since Classification is included in the second phase it is named as Malignancy Detection Technique with Classification (MDTC). Finally due to the inclusion of Region of Interest extraction the last phase has 5 major processes in mass diagnosis and it is named as Malignancy Detection Technique with Region of Interest extraction (MDTR). So the three approaches will be mentioned by its name in this section.

In each phase different combination of algorithms have been used. In MDTR new segmentation algorithm has been designed and implemented.
Gray level Co-Occurrence matrix was used for feature extraction in all the three phases. In the third phase in addition to GLCM, local binary pattern was used. Classification process was performed using simple if else operation in first phase. Support Vector machine was used to classify the result in the second and third phase. The performance of the three proposed algorithms have been evaluated using partest method of ROC curve.

But three CAD approaches has been implemented and tested with different sets of mammograms. 3SMDT was tested with 50 real time mammograms. MDTC was tested with 150 mammograms which was taken from DDSM data base mammograms. During the implementation of MDTR large collections were available from MIAS, DDSM and real time mammogram collection. Among them 400 mammogram images were chosen for the implementing MDTR. The mammogram inputs for the three approaches vary both in quality and quantitywise. So the result may also vary based on that. To get the unique result all the approaches should be tested with same input of mammograms. So all the three algorithms were tested with a set of 400 mammograms. The result of the implementation is given in this chapter. Similarly the performance of the three algorithms was evaluated using same method. The comparison result suggests the best of all the three algorithms.

7.2 PREPROCESSING RESULT

7.2.1 3SMDT Preprocessing Result

In 3SMDT down sampling and quantization is performed for the purpose of digitization. Median filter is applied on the digitized image to remove the noise. The result of this preprocessing is shown in Fig.7.1. To
remove the variation in brightness of different mammograms normalization is performed on the median filtered mammogram. The region of interest is the important preprocessing steps which will reduce the unnecessary computation. In phase I region of interest is selected manually using MATLAB. After completion of preprocessing message box will appear on the screen to intimate the selection of region which is suspected by radiologists as malignant region. The message box is shown in Fig.7.2. Normally brighter region will be selected manually as region of interest. Histogram equalization is applied over the region of interest image which is shown in Fig.7.3

![Fig.7.1. 3SMDT Preprocessing result (Digitization, Median filter)](image)

![Fig.7.2. Message Box to intimate ROI selection](image)
Fig 7.3. 3SMDT Preprocessing Result (Normalization, ROI extraction, Histogram equalization)

7.2.2 MDTC Preprocessing Result

In MDTC mammogram is not digitized as in 3SMDT. Simply median filter is applied over the raw mammogram to remove the noise. Fig.7.4 shows the original mammogram and median filtered image is shown in Fig.7.5.

Fig.7.4. Original raw mammogram (MDTC)
Contrast of the image is enhanced using Adaptive histogram equalization method as a part of preprocessing step. The result of contrast enhancement process is shown in Fig.7.6.

Fig.7.5. Mammogram after noise removal process

Fig.7.6. Contrast Enhancement by Adaptive histogram equalization method
7.2.3 MDTR Preprocessing Result

In MDTR region of interest is selected using the specially designed abnormal center based RoI selection algorithm. Median filter is applied over the ROI extracted image. Fig 7.7 shows the region of Interest extracted image. Fig.7.8. shows the result of median filtered image.

![Input Image](image1)

**Fig.7.7. Result of Region of Interest Extraction process (MDTR)**

![Median Filtered Image](image2)

**Fig.7.8. Result of median filtered image (MDTR)**
Contrast of the image is enhanced using Contrast Limited Adaptive Histogram Equalization Method. Result of Contrast Enhancement process is shown in Fig.7.9.

Fig.7.9. Result of Contrast enhancement process

7.3 SEGMENTATION PROCESS

7.3.1 3SMDT segmentation process

In 3SMDT after preprocessing step circular Gaussian filter is applied over the preprocessed image. Based on histogram values the image is segmented according to the gray levels. Result of this initial segmentation process is shown in Fig.7.10. Otsu method is applied on the image to get the final segmentation which is shown in Fig.7.11. Gabor filter is applied over the segmented image. As a result of Gabor filter the segmented image is viewed in different angles and frequencies. Frequencies $f=6, f=12, f=24, f=48, f=80$ and angles $\theta=0^\circ, \theta=45^\circ, \theta=90^\circ, \theta=135^\circ$ are applied to get the Gabor features. Gabor filtering allows viewing and
analyzing the segmented image in different angles and frequencies. Result of Gabor filter is show in Fig.7.12.

**Fig.7.10.** segmentation based on gray levels (3SMDT)

**Fig.7.11.** final segmentation of Phase I (3SMDT)
7.3.2 MDTC Segmentation

In MDTC segmentation process involves two methods which are alarm region generation process and seeded region growing method. Alarm region generation process provides the seed point. This seed point is applied in Seeded region growing method which gives the result of final segmentation. Result of alarm region generation process is shown in Fig.7.13. Result of final segmentation by seeded region growing method is shown in Fig.7.14.
7.3.3 MDTR Segmentation

In MDTR segmentation is performed using Sobel edge detector and newly designed Gray Level Gradient Buffering algorithm based on the edge detection process. Fig.7.15. Shows the result of edge detection process.
Result of segmentation is given in 7.16, which is directly given as input to feature extraction process.

**Fig.7.15 Result of Edge detection Process**

**Fig.7.16. Result of GLGB Segmentation process**

### 7.4 FEATURE EXTRACTION RESULT

In all the three methods Gray level Co–Occurrence Matrix is used for feature extraction process. MDTR Local Binary Pattern is used with GLCM.
7.4.1 3SMDT Feature Extraction Result

In 3SMDT, GLCM features are extracted on pixel basis. The result will be derived for all mammogram on pixel basis. Sample result of some pixels is given in Table 7.1. In 3SMDT feature values are extracted for each tile region not for the whole mammogram. Row and Column number shows the tile region. 3SMDT was tested with 400 mammograms. Sample values of 18 tile regions of single mammogram are shown in Table 7.1.

Table 7.1. Feature extraction result for 3SMDT

<table>
<thead>
<tr>
<th>Homogeneity</th>
<th>Energy</th>
<th>Contrast</th>
<th>Frequency</th>
<th>Angle</th>
<th>Row</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.890</td>
<td>1.000</td>
<td>0.025</td>
<td>m 4.000</td>
<td>n 1.000</td>
<td>j 3.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>1.000</td>
<td>0.990</td>
<td>0.030</td>
<td>m 4.000</td>
<td>n 1.000</td>
<td>j 4.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.995</td>
<td>0.873</td>
<td>0.014</td>
<td>m 4.000</td>
<td>n 1.000</td>
<td>j 5.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.945</td>
<td>0.794</td>
<td>0.032</td>
<td>m 4.000</td>
<td>n 1.000</td>
<td>j 6.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.989</td>
<td>0.870</td>
<td>0.040</td>
<td>m 4.000</td>
<td>n 1.000</td>
<td>j 7.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.972</td>
<td>0.780</td>
<td>0.056</td>
<td>m 4.000</td>
<td>n 1.000</td>
<td>j 8.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.980</td>
<td>1.000</td>
<td>0.035</td>
<td>m 4.000</td>
<td>n 2.000</td>
<td>j 6.000</td>
<td>i 1.000</td>
</tr>
<tr>
<td>0.993</td>
<td>0.950</td>
<td>0.014</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 6.000</td>
<td>i 6.000</td>
</tr>
<tr>
<td>0.893</td>
<td>0.936</td>
<td>0.024</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 7.000</td>
<td>i 6.000</td>
</tr>
<tr>
<td>0.986</td>
<td>0.890</td>
<td>0.038</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 8.000</td>
<td>i 6.000</td>
</tr>
<tr>
<td>0.970</td>
<td>0.930</td>
<td>0.028</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 6.000</td>
<td>i 7.000</td>
</tr>
<tr>
<td>0.926</td>
<td>0.890</td>
<td>0.015</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 7.000</td>
<td>i 7.000</td>
</tr>
<tr>
<td>0.978</td>
<td>0.920</td>
<td>0.042</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 8.000</td>
<td>i 7.000</td>
</tr>
<tr>
<td>0.990</td>
<td>0.870</td>
<td>0.014</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 5.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.999</td>
<td>0.894</td>
<td>0.052</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 6.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.975</td>
<td>0.920</td>
<td>0.042</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 7.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.967</td>
<td>0.830</td>
<td>0.036</td>
<td>m 4.000</td>
<td>n 4.000</td>
<td>j 8.000</td>
<td>i 8.000</td>
</tr>
<tr>
<td>0.923</td>
<td>0.756</td>
<td>0.070</td>
<td>m 4.000</td>
<td>n 3.000</td>
<td>j 5.000</td>
<td>i 5.000</td>
</tr>
</tbody>
</table>
7.4.2 MDTC Feature Extraction Result

In MDTC, GLCM Features are derived for the whole image. MDTC with tested with a set of 400 mammograms. In addition to the Homogeneity, Contrast and Energy, Correlation is also accounted as feature. The sample result of 20 mammograms is shown in Table.7.2.

<table>
<thead>
<tr>
<th>Image id</th>
<th>Image class</th>
<th>Homogeneity</th>
<th>Energy</th>
<th>Correlation</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mam1</td>
<td>Cancer</td>
<td>0.992</td>
<td>0.912</td>
<td>0.920</td>
<td>0.191</td>
</tr>
<tr>
<td>Mam2</td>
<td>Cancer</td>
<td>0.993</td>
<td>0.723</td>
<td>0.923</td>
<td>0.161</td>
</tr>
<tr>
<td>Mam3</td>
<td>Cancer</td>
<td>0.989</td>
<td>0.900</td>
<td>0.879</td>
<td>0.160</td>
</tr>
<tr>
<td>Mam4</td>
<td>Cancer</td>
<td>0.992</td>
<td>0.921</td>
<td>0.917</td>
<td>0.160</td>
</tr>
<tr>
<td>Mam5</td>
<td>Cancer</td>
<td>0.990</td>
<td>0.865</td>
<td>0.852</td>
<td>0.161</td>
</tr>
<tr>
<td>Mam6</td>
<td>Cancer</td>
<td>0.992</td>
<td>0.895</td>
<td>0.931</td>
<td>0.185</td>
</tr>
<tr>
<td>Mam7</td>
<td>Cancer</td>
<td>0.994</td>
<td>0.843</td>
<td>0.912</td>
<td>0.133</td>
</tr>
<tr>
<td>Mam8</td>
<td>Cancer</td>
<td>0.995</td>
<td>0.741</td>
<td>0.911</td>
<td>0.132</td>
</tr>
<tr>
<td>Mam9</td>
<td>Cancer</td>
<td>0.987</td>
<td>0.909</td>
<td>0.890</td>
<td>0.189</td>
</tr>
<tr>
<td>Mam10</td>
<td>Cancer</td>
<td>0.992</td>
<td>0.900</td>
<td>0.956</td>
<td>0.108</td>
</tr>
<tr>
<td>Mam11</td>
<td>Normal</td>
<td>0.842</td>
<td>0.848</td>
<td>0.850</td>
<td>0.190</td>
</tr>
<tr>
<td>Mam12</td>
<td>Normal</td>
<td>0.828</td>
<td>0.806</td>
<td>0.902</td>
<td>0.198</td>
</tr>
<tr>
<td>Mam13</td>
<td>Normal</td>
<td>0.825</td>
<td>0.986</td>
<td>0.969</td>
<td>0.094</td>
</tr>
<tr>
<td>Mam14</td>
<td>Normal</td>
<td>0.842</td>
<td>0.838</td>
<td>0.933</td>
<td>0.021</td>
</tr>
<tr>
<td>Mam15</td>
<td>Normal</td>
<td>0.770</td>
<td>0.511</td>
<td>0.840</td>
<td>0.310</td>
</tr>
<tr>
<td>Mam16</td>
<td>Normal</td>
<td>0.772</td>
<td>0.897</td>
<td>0.847</td>
<td>0.670</td>
</tr>
<tr>
<td>Mam17</td>
<td>Normal</td>
<td>0.774</td>
<td>0.919</td>
<td>0.880</td>
<td>0.431</td>
</tr>
<tr>
<td>Mam18</td>
<td>Normal</td>
<td>0.779</td>
<td>0.819</td>
<td>0.884</td>
<td>0.521</td>
</tr>
<tr>
<td>Mam19</td>
<td>Normal</td>
<td>0.825</td>
<td>0.886</td>
<td>0.769</td>
<td>0.294</td>
</tr>
<tr>
<td>Mam20</td>
<td>Normal</td>
<td>0.826</td>
<td>0.775</td>
<td>0.846</td>
<td>0.497</td>
</tr>
</tbody>
</table>
7.4.3 MDTR Feature Extraction Result

In MDTR in addition to GLCM, Local Binary Pattern is also used to extract the features. GLCM features are extracted for the whole image. 400 mammograms are given as input to test MDTR. Sample results of 20 mammograms are shown in Table 7.3. Since LBP extracts single feature value in the pixel basis its values cannot be tabulated. The values are directly given for the classification process.

Table 7.3. Result of Feature Extraction Process for MDTR

<table>
<thead>
<tr>
<th>Image id</th>
<th>Image Class</th>
<th>Contrast</th>
<th>Correlation</th>
<th>Energy</th>
<th>Homogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mam1</td>
<td>Cancer</td>
<td>0.0447</td>
<td>0.5598</td>
<td>0.8970</td>
<td>0.9806</td>
</tr>
<tr>
<td>Mam2</td>
<td>Cancer</td>
<td>0.1083</td>
<td>0.6608</td>
<td>0.8722</td>
<td>0.9716</td>
</tr>
<tr>
<td>Mam3</td>
<td>Cancer</td>
<td>0.1109</td>
<td>0.6943</td>
<td>0.6899</td>
<td>0.9497</td>
</tr>
<tr>
<td>Mam4</td>
<td>Cancer</td>
<td>0.0302</td>
<td>0.6728</td>
<td>0.9515</td>
<td>0.9905</td>
</tr>
<tr>
<td>Mam5</td>
<td>Cancer</td>
<td>0.1275</td>
<td>0.7445</td>
<td>0.7855</td>
<td>0.9566</td>
</tr>
<tr>
<td>Mam6</td>
<td>Cancer</td>
<td>0.1473</td>
<td>0.7070</td>
<td>0.7704</td>
<td>0.9523</td>
</tr>
<tr>
<td>Mam7</td>
<td>Cancer</td>
<td>0.1269</td>
<td>0.6614</td>
<td>0.6790</td>
<td>0.9433</td>
</tr>
<tr>
<td>Mam8</td>
<td>Cancer</td>
<td>0.0149</td>
<td>0.6255</td>
<td>0.9691</td>
<td>0.9943</td>
</tr>
<tr>
<td>Mam9</td>
<td>Cancer</td>
<td>0.1599</td>
<td>0.6565</td>
<td>0.7044</td>
<td>0.9398</td>
</tr>
<tr>
<td>Mam10</td>
<td>Cancer</td>
<td>0.1507</td>
<td>0.7403</td>
<td>0.6908</td>
<td>0.9408</td>
</tr>
<tr>
<td>Mam11</td>
<td>Normal</td>
<td>0.4424</td>
<td>0.7334</td>
<td>0.8067</td>
<td>0.8204</td>
</tr>
<tr>
<td>Mam12</td>
<td>Normal</td>
<td>0.3741</td>
<td>0.7185</td>
<td>0.9340</td>
<td>0.8372</td>
</tr>
<tr>
<td>Mam13</td>
<td>Normal</td>
<td>0.1452</td>
<td>0.7541</td>
<td>0.8500</td>
<td>0.9326</td>
</tr>
<tr>
<td>Mam14</td>
<td>Normal</td>
<td>0.3233</td>
<td>0.7103</td>
<td>0.9143</td>
<td>0.8225</td>
</tr>
<tr>
<td>Mam15</td>
<td>Normal</td>
<td>0.3073</td>
<td>0.7173</td>
<td>0.9886</td>
<td>0.8199</td>
</tr>
<tr>
<td>Mam16</td>
<td>Normal</td>
<td>0.2596</td>
<td>0.6656</td>
<td>0.9003</td>
<td>0.8966</td>
</tr>
<tr>
<td>Mam17</td>
<td>Normal</td>
<td>0.2300</td>
<td>0.7459</td>
<td>0.9016</td>
<td>0.8968</td>
</tr>
<tr>
<td>Mam18</td>
<td>Normal</td>
<td>0.3065</td>
<td>0.6795</td>
<td>0.8249</td>
<td>0.8641</td>
</tr>
<tr>
<td>Mam19</td>
<td>Normal</td>
<td>0.1725</td>
<td>0.6849</td>
<td>0.8357</td>
<td>0.9202</td>
</tr>
<tr>
<td>Mam20</td>
<td>Normal</td>
<td>0.2150</td>
<td>0.7100</td>
<td>0.8972</td>
<td>0.9069</td>
</tr>
</tbody>
</table>
7.5 CLASSIFICATION RESULT

7.5.1 3SMDT Classification Result

In 3SMDT there is no separate Classification process involved to classify the feature extracted values. Based on simple if else operation hundreds of the feature extracted values of single mammogram are checked out and then the result is obtained manually by verifying the result.

7.5.2 MDTC Classification Result

Sample result of 20 mammograms is given in Table 7.2. Feature extraction result of all 400 mammograms was given as input to SVM classifier. 200 mammograms were taken for training phase. 200 mammograms were taken for testing phase in which 250 are malignant and 150 are Benign. Result of classification process for MDTC is shown in Table 7.4.

Table 7.4. Result of Classification Process (MDTC)

<table>
<thead>
<tr>
<th></th>
<th>True positive</th>
<th>True Negative</th>
<th>False Positive</th>
<th>False Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>400</td>
<td>237/250</td>
<td>143/150</td>
<td>13/250</td>
</tr>
<tr>
<td>Percentage</td>
<td>100</td>
<td>94.8%</td>
<td>95.3%</td>
<td>5.2%</td>
</tr>
</tbody>
</table>

7.5.3 MDTR Classification Result

Both the results of GLCM and LBP were given for training phase in SVM classifier. Result of the classification process is given in Table 7.5. 400 mammograms have taken for experiments in which 150 are normal and 250 are abnormal. 50% of images are used for training and 50% of the images are used for testing phase.
Table 7.5. Result of Classification Process (MDTR)

<table>
<thead>
<tr>
<th>Number of cases</th>
<th>True positive</th>
<th>True Negative</th>
<th>False Positive</th>
<th>False Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>246/250</td>
<td>147/150</td>
<td>4/250</td>
<td>3/150</td>
</tr>
<tr>
<td>Percentage</td>
<td>100</td>
<td>98.8%</td>
<td>97.4%</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

Based on the feature extraction process and classification process the result is given as message box which is shown in Fig.7.16.

Fig. 7.17. Final Result is shown as message box

7.6 PERFORMANCE EVALUATION RESULT

Partest of ROC Curve method is used to evaluate the performance of the three algorithms. Result of 3SMDT is shown in Fig.7.18. Result of MDTC is given in Fig.7.19. Result of MDTR is shown in Fig.7.20. Partest method gives the Sensitivity and Specificity of the algorithms with the graphical representation of the result. Result of the performance evaluation method is calculated based on four factors True Positive, True Negative, False Positive and False Negative which are described as follows,

True Positive: mass region is present and algorithm shows the same result

True Negative: mass region is absent and algorithm shows the same result
False Positive: mass region is absent and algorithm shows that mass region is present

False Negative: mass region is present and algorithm shows that mass region is absent

Fig. 7.18 performance evaluation result (3SMDT)
Fig. 7.19 performance evaluation result II (MDTC)

Fig. 7.20 performance evaluation result I (MDTR)
7.7 COMPARISON ON THE EFFICIENCY OF THREE METHODS

7.7.1 Features, Advantages and Disadvantages of 3SMDT

7.7.1.1 Features of 3SMDT
- It needs 3 major processes to construct CAD system (Preprocessing, Segmentation and Feature Extraction).
- Gaussian and Gabor filtering was used to perform segmentation.
- The sensitivity of the system is 94.5%.
- The Specificity of the system is 81.3%.
- The accuracy of the system is 92.5%.

7.7.1.2 Advantages of 3SMDT
- As it was designed initially with minimum knowledge it has comparatively no main advantages, But the experience and knowledge gained during this 3SMDT implementation provides better idea and perfect guidance to progress to the next stage.

7.7.1.3 Disadvantages of 3SMDT
- Film artifacts are not removed in preprocessing which will reduce the efficiency of segmentation process.
- Down sampling and Quantization process in preprocessing blur the suspected region in mammogram.
- Need manual interruption for ROI extraction.
- Due to manual selection there is a chance of missing some important regions.
- Gabor filtering process is used to analyze the segmented area in different angles and frequencies.
- But the best angles and frequencies should be selected manually.
• In feature extraction process features are extracted for each and every pixel in all the mammograms.
• 1000’s of Homogeneity, Contrast and Energy values should be computed for each of single mammogram to classify it as benign and malignant, this is very complicated process.
• Correlation is not included in 3SMDT feature extraction.
• There is no separate classification method.
• Classification should be performed manually by analyzing 1000’s of feature values for each mammogram.
• It may take several hours to complete the classification process.

7.7.2. Features, Advantages and Disadvantages of MDTC

7.7.2.1. Features of MDTC
• It needs 4 major processes to construct CAD system (Preprocessing, Segmentation, Feature Extraction and Classification).
• Classification was included to classify the mammogram as benign and malignant
• Region growing was implemented to segment the mammograms.
• The sensitivity of the system is 95.6%
• The Specificity of the system is 85.7%.
• The accuracy of the system is 94.1%.

7.7.2.2. Advantages of MDTC
• The efficiency of the algorithm is comparatively better than 3SMDT.
• The insertion of Classification process improves the system performance to the good level.
7.7.2.3. Disadvantages of MDTC

- There is no separate ROI Extraction process.
- Hence, whole mammogram should be analyzed instead of suspected region, which results in unnecessary complexity.
- Edge information is not taken into account during segmentation, Hence some essential features will be missed in feature extraction process.
- Obtained Classification result should be computed manually to classify the mammogram as benign or malignant.

7.7.3. Features, Advantages and Disadvantages of MDTR

7.7.3.1. Features of MDTR

- It needs 5 major processes to construct CAD system (ROI Extraction, Preprocessing, Segmentation, Feature Extraction and Classification).
- New ROI Extraction algorithm has been designed and implemented.
- New Segmentation algorithm has been designed and implemented.
- The sensitivity of the system is 99.3%.
- The Specificity of the system is 98.1%.
- The accuracy of the system is 99.1%.

7.7.3.2. Advantages of MDTR

- Proposed abnormal center based ROI Extraction method extracts the suspected region efficiently.
- Proposed Gray level Gradient Buffering Method segments the suspected region in more efficient manner.
- Analyzed with two way feature extraction method.
• Fully automatic does not need any human interruption.
• Easily operatable and understandable.
• For the given input the result will be obtained as message box.

Simply the methods used in the whole research work to design a perfect CAD system for automatic screening of mammogram can be tabulated as shown in the Table.7.6.

**Table.7.6. Comparative study on the methods used in the three approaches**

<table>
<thead>
<tr>
<th>Steps</th>
<th>3SMDT</th>
<th>MDTC</th>
<th>MDTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preprocessing</td>
<td>Down Sampling, Quantization, Median Filter, HE</td>
<td>Median Filter, Morphological operators, AHE</td>
<td>Median filter, CLAHE</td>
</tr>
<tr>
<td>ROI Extraction</td>
<td>Manual</td>
<td>-------</td>
<td>Abnormal center based ROI Selection</td>
</tr>
<tr>
<td>Segmentation</td>
<td>Gaussian &amp; Gabor features</td>
<td>Alarm region generation &amp; Region growing</td>
<td>Sobel &amp; Gray Level Gradient Buffering</td>
</tr>
<tr>
<td>Feature Extraction</td>
<td>GLCM</td>
<td>GLCM</td>
<td>GLCM &amp; LBP</td>
</tr>
<tr>
<td>Classification</td>
<td>-------</td>
<td>SVM</td>
<td>SVM</td>
</tr>
</tbody>
</table>

The comparison of the performance and features of the three methods are tabulated in the table 7.7. Sensitivity, Specificity and Accuracy of diagnosis are the important scales in evaluating the efficiency of Malignancy Diagnosis system. The efficiency measuring parameters for the three methods are tabulated table 7.8.
Table 7.7 Comparative study on the performance of the three methods

<table>
<thead>
<tr>
<th></th>
<th>3SMDT</th>
<th>MDTC</th>
<th>MDTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual ROI Selection</td>
<td>No ROI Selection</td>
<td>Abnormal center based automatic ROI Selection</td>
<td></td>
</tr>
<tr>
<td>Film artifacts are not removed in preprocessing</td>
<td>Film artifacts are removed by Morphological operation</td>
<td>ROI selection process will automatically filter out the film artifacts</td>
<td></td>
</tr>
<tr>
<td>Existing filters are used for segmentation</td>
<td>Existing algorithm is used for segmentation</td>
<td>New algorithm is innovatively implemented especially for mammogram segmentation</td>
<td></td>
</tr>
<tr>
<td>Single Feature Extraction method is used</td>
<td>Single Feature Extraction method is used</td>
<td>Combination of two methods are used for improved feature extraction</td>
<td></td>
</tr>
<tr>
<td>Manual Classification</td>
<td>Semi automatic classification</td>
<td>Fully automatic Classification</td>
<td></td>
</tr>
<tr>
<td>Need manual interruption</td>
<td>Semi automatic</td>
<td>Fully automatic</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.8. Comparative study on the efficiency of the three methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>3SMDT</td>
<td>94.5%</td>
<td>81.3%</td>
<td>92.5%</td>
</tr>
<tr>
<td>MDTC</td>
<td>95.6%</td>
<td>85.7%</td>
<td>94.1%</td>
</tr>
<tr>
<td>MDTR</td>
<td>99.3%</td>
<td>98.1%</td>
<td>99.1%</td>
</tr>
</tbody>
</table>
Comparative study on the efficiency was given as graph as shown in Fig.7.23.

![Comparative Study on Efficiency](image)

**Fig.7.21. Comparative study on the efficiency of Three CAD systems**

From the analysis it is found that the final approach MDTR is comparatively better than the other two approaches in all aspects. The efficiency of MDTR is compared with other existing CAD systems. The result of the Comparative study is given in the next chapter.