

CHAPTER FIVE

RESULTS AND DISCUSSION

This chapter encompasses a description about the different methodologies implemented, as well as exemplifications of their results and their evaluation and the observations that were made throughout.

5.1 Results

With the breast cancer system fully developed using MATLAB, the means to evaluate the efficacy of the methods and algorithms used, is crucial. A total of 51 samples of breast images containing masses have been compiled for this project from the mini-MIAS (Mammographic Image Analysis Society) Mammographic database.

- 18 breast images which contain malignant cases
- 33 breast images which contain benign cases.

5.1.1 Results for the Image Processing and Enhancement System

With breast lesions such as masses imperceptible from surrounding breast parenchyma due to features obscured or similar to that of normal tissue, their clear visibility and detection poses a major challenge. Therefore, image processing and enhancement techniques aim to improve the contrast of these features, elevating the ability to perceive the subtle lesions and leading to a more accurate diagnosis.

The types of noise distribution seen in the images were Rayleigh and Gaussian distribution. It means that the type of filter has to be a low pass filter.

A breast image loaded onto the system is filtered using a 7X7 adaptive wiener filter followed by a contrast limited adaptive histogram equalization.

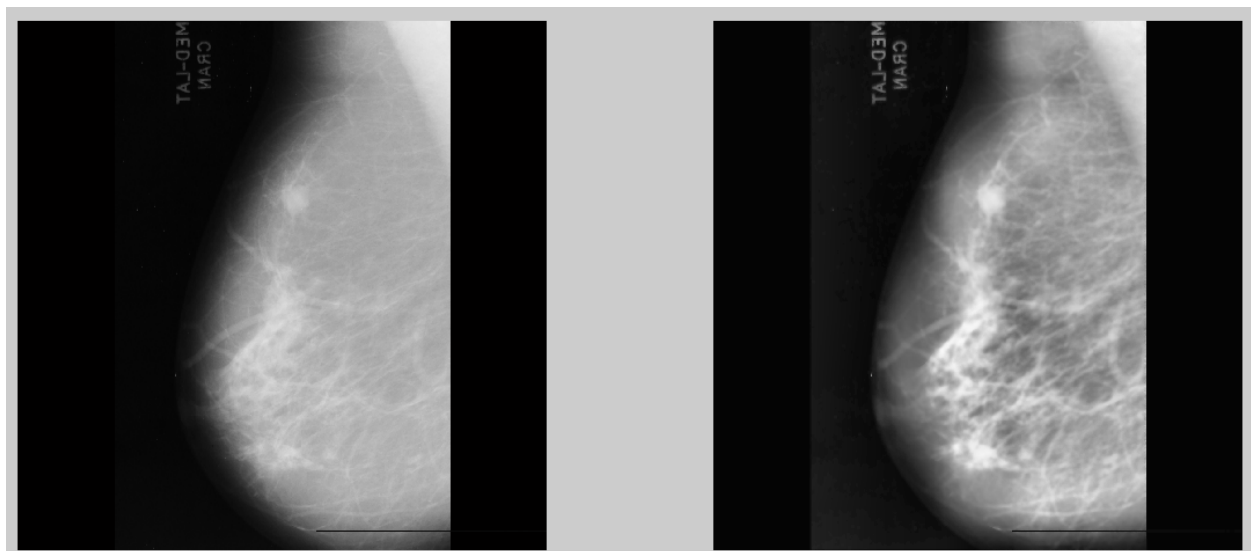


Fig. 5.1 Image before and after processing

As explicitly illustrated, the specified suspicious region whose location has been obtained from the database of the mini-MIAS is demonstrated in a much more clarified view to the naked eye when the breast image was processed under the named enhancement technique.

The adaptive wiener filter used showed the highest value for the PSNR (Peak Signal-to-Noise Ratio) which make it the most appropriate filter to use.

The CLAHE algorithm is a widely used technique which results in contrast enhancement of medical images because it perform local contrast enhancement without noise amplification.

5.1.2 Results for the Pattern Recognition and Classification System

Detection, localization of ROIs and their categorization into malignant or benign classes is regarded a pertinent issue of interest. This fact escalated by the statistic that radiologists' sensitivity is at a stop hold of just 75% accuracy [2] compels the need for an automated pattern recognition and classification system.

5.1.2.1 Extracting the ROIs

From the entire data sample, 51 ROIs with standard window size of (300x300) pixels with the mass centered were extracted using watershed segmentation. They were then used in a preprocessing stage to calculate the features that will be used as the input to the classifier and in correspondence, train and test the ANFIS classifier. An example of an extracted ROI is illustrated below.

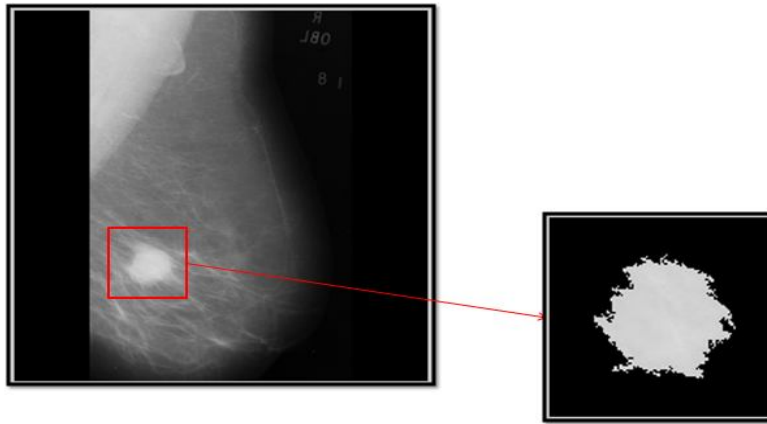


Fig. 5.2 watershed segmentation result

This method effectively achieves extracting the suspicious mass region and puts it into complete focus.

5.1.2.2 Classification stage

5.1.2.2.1 Performance measures

A set of standard measures were used to measure the classification accuracy of the proposed classifier and the performance of the feature dataset in discriminating between malignant and benign images.

Sensitivity (SE) is the ratio of malignant tissue which were marked and classified as malignant, to all marked tumors.

$$SE = \frac{TP}{TP+FN} \quad (5.1)$$

Specificity (SP) is the ratio of tumors which were marked and classified as benign, to all marked tumors.

$$SP = \frac{TN}{FP+TN} \quad (5.2)$$

Positive Predictive Value (PPV) is the proportion of malignant cases correctly identified

$$PPV = \frac{TP}{TP+FP} \quad (5.3)$$

Negative Predictive Value (NPV) is the proportion of benign cases correctly identified.

$$NPV = \frac{TN}{FN+TN} \quad (5.4)$$

Over all system accuracy is measured by

$$accuracy = \frac{TN+TP}{TN+TP+FN+FP} \quad (5.6)$$

Where;

True Positives (TP): Tumors marked as malignant which were also classified as malignant.

True Negatives (TN): Tumors which were marked as benign, and that were also classified as benign.

False Positives (FP): Tumors which were marked as benign, but were classified as malignant.

False Negatives (FN): Tumors which were marked as malignant, but which were classified as benign [54].

5.1.2.2.2 Confusion matrix

The **confusion matrix** is a performance measure used to demonstrate the number of correct and incorrect predictions made by the classification model compared to the actual outcomes (target value) in the data. The matrix encompasses the above stated parameters.

Using the **plotconfusion** function in MATLAB, the following values for the proposed classifier were obtained:

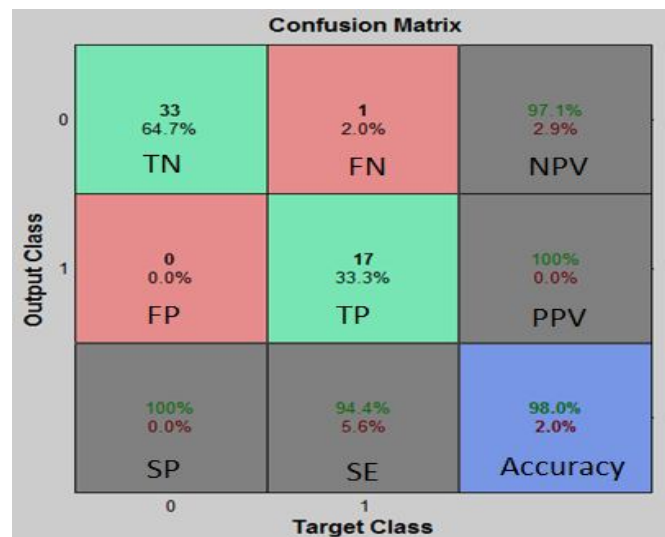


Fig. 5.3 confusion matrix

The accuracy in Figure 5.3 is the overall evaluation of the classifier for the pattern recognition and classification of the tumors. Therefore, the proposed system has successfully been able to discriminate between malignant and benign tissue with a precision level of 98%.

5.1.2.2.3 ROC curve and Area Under Curve (AUC)

Since the sensitivity and specificity is affected by the threshold value the classifier uses to partition into the specified categories, [47] the ROC (receiver operating characteristic) curve is a superseding, better performance measure. It demonstrates the tradeoffs between the sensitivity which in this study is the share of malignant tumors that is correctly classified, which is plotted against 1-specificity, the share of benign tumors that is falsely classified. It thus describes the innate discrimination capacity of the system.

The total Area Under the (ROC) Curve (AUC), also referred to as the *Az* value is a measure of the classification performance since it reflects the test performance at all possible threshold values. The area normally lies in the interval of 0.5 (the worst classifier performance) and 1 (the ideal classifier performance). The larger this area is, the better the performance of the classifier [56].

In this project, the *Az* value computed to determine an overall classification accuracy for the proposed system was at a value of 0.972.

5.1.2.2.4 Obtained results

The overall results defining the classification performance of the proposed system has been summarized below.

Table 5.1: Summary of classification performance

Sensitivity	Specificity	Accuracy	Az value
94.4%	100%	98%	0.972

The percentage of malignant cases correctly identified is at a high percentage value of 94.4% and the specificity at a value of 100%. This is in accordance with the established aims of computerized classification in reducing the number of benign cases sent for biopsy because the ‘cost’ of a missed cancer is much greater than the misclassification of a benign case [38].

The classification performance obtained in this study with classification accuracy of 98% is consistent with values achieved in previous literature as per work of Manisha Arora [44] with an accuracy of 100%, Elif Derya [40] with an accuracy of 99.08%, and Mei-Ling Huang et al [41] with an accuracy of 92.8%.

The system parameters were 94.4% sensitivity, 100% specificity, 97.1% NPV and 100% PPV which is higher than the results obtained by the work of Ali Keles et al [42] with 97% specificity, 76% sensitivity, 96% positive and 81% negative predictive.

5.2 Graphical User Interface (GUI) of the systems

Figure 5.4 and 5.5 show the designed Graphical User Interfaces (GUI) that elucidates the major outcomes and the implementation of the algorithm software.

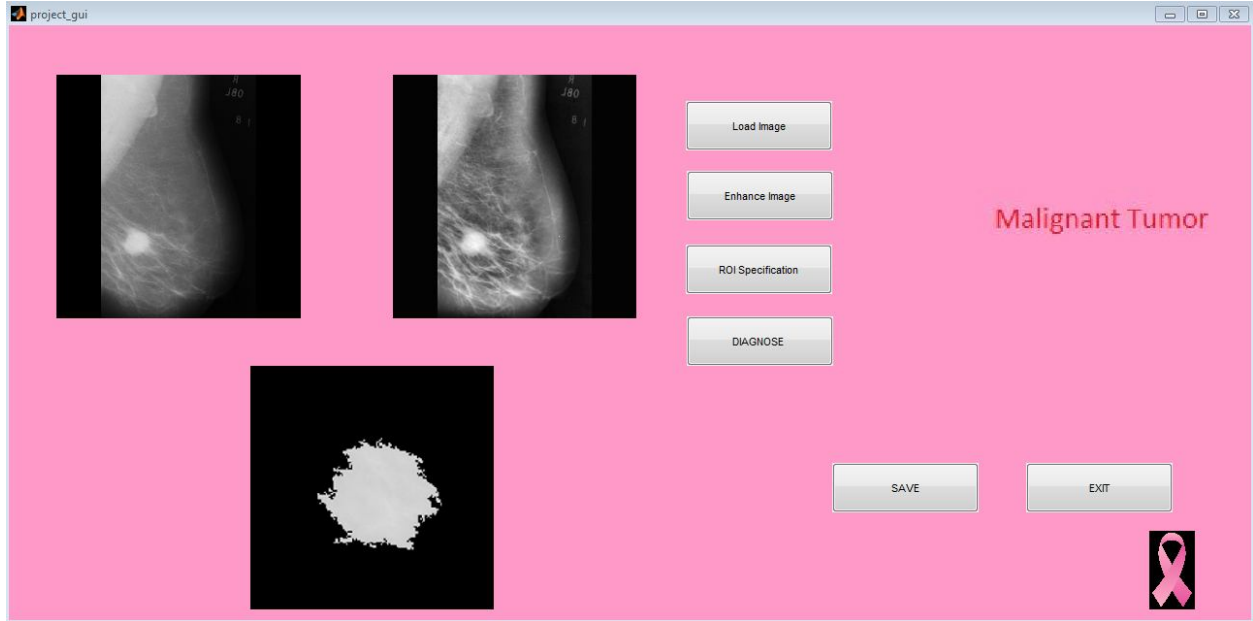


Fig. 5.4: Pattern recognition and classification system GUI with the illustration of a malignant mass in a breast image being detected and classified

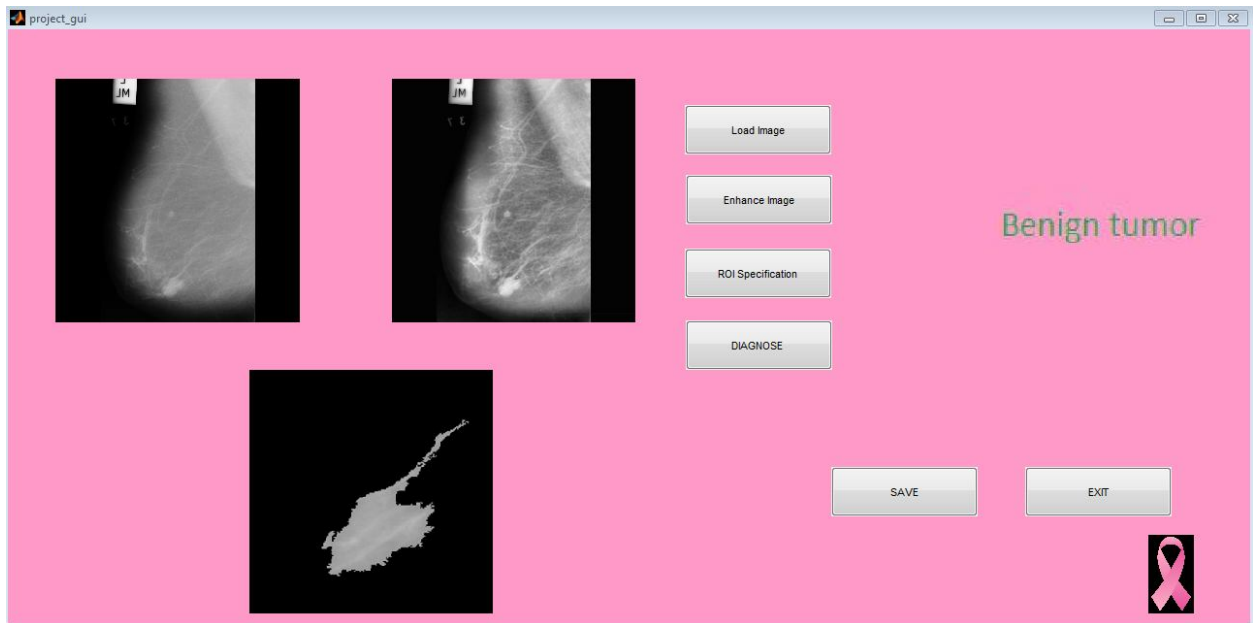


Fig. 5.5: Pattern recognition and classification system GUI with the illustration of a benign mass in a breast image being detected and classified