Image Analysis Based Diagnosis of Dento-Facial Deformities and Pathological Lesions

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AUTOMATED DIAGNOSIS AND SEVERITY MEASUREMENT OF DENTAL CYSTS

Objective

➤ To automate the system to diagnose the cyst in dental radiographs using radial basis function with neural network and Fuzzy logic for severity measurements.

Problem in conventional method

➢ The cyst in some radiographs could not be detected by the radiologist because of its early stage or due to low-quality images.
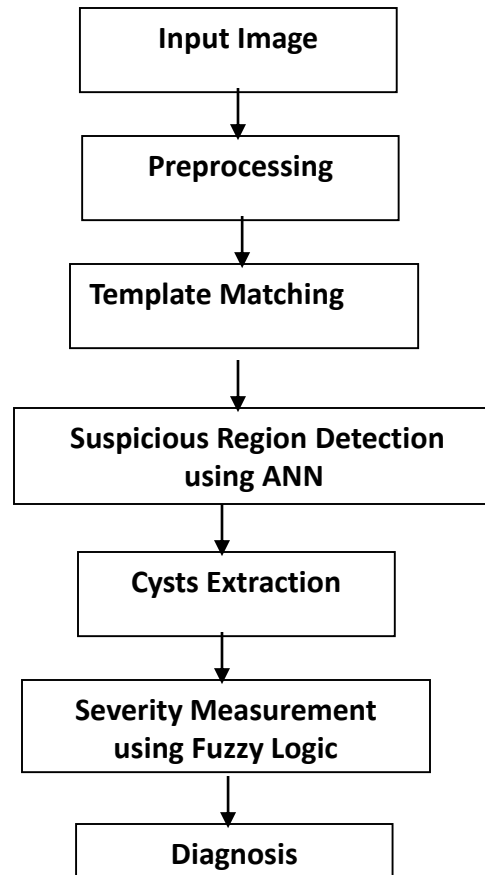
Figure 4.1 Block Diagram of the Proposed Methodology

Preprocessing

- preprocessing is carried out by **contrast stretching** of the input dental radiograph image.

- Since the histogram of dental radiographs is not covering the complete dynamic range, the contrast stretching method enhances the edges of the region of interest better.

Normalized cross correlation

- The input image and 5different templates are correlated.
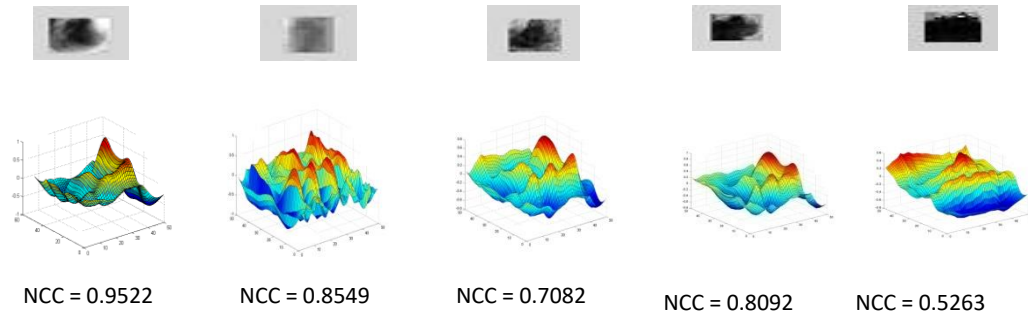- The normalized correlation coefficient is given by

$$\gamma(s,t) = \frac{\sum_x \sum_y \left[f(x,y) - \bar{f}(x,y)\right]\left[w(x-s, y-t) - \overline{w}\right]}{\left\{\sum_x \sum_y \left[f(x,y) - \bar{f}(x,y)\right]^2 \sum_x \sum_y \left[w(x-s, y-t) - \overline{w}\right]^2\right\}^{\frac{1}{2}}}$$

Where, s=0,1,2,3,.....,M-1

t=0,1,2,3,......,N-1

$\overline{w}$=avg value of pixel in w (x,y)

$\bar{f}$=avg value of f (x,y) in the region coincide with the current location of w

NCC = 0.9522   NCC = 0.8549   NCC = 0.7082   NCC = 0.8092   NCC = 0.5263

Figure 4.8 The 3D Plot Showing the NCC Values for 5 Different Templates.

Template Matching

- The correlation coefficient is scaled in the range -1 to 1.

- The correlation coefficients are then normalized and converted into an equivalent gray scale values to obtain expanded normalized cross correlation (ENCC) coefficients varying from 0 to 255.

- The ENCC generated are the input vectors to Artificial Neural Network (ANN). The criteria for selecting the template size are the size of the cyst.

Neural Network with back propagation

- A three layer perceptron architecture having one hidden layer is used to detect dental cyst.

- The input layer consists of *MXM* neurons.

- Sigmoid activation function, will have a value in the interval (0, 1).

- The neural system learns the rules simply from a set of input ENCC values.

- In the learning rule the ENCC values are categorized as highly suspicious, suspicious, slightly suspicious and not suspicious based on the range of gray scale values, which are the desired output image(DOI).

Radial Basis Function

- The main distinction is that RBF has a hidden layer which contains nodes called RBF units.

- Each one of the units in the hidden layer has two parameters; the center and the width of Gaussian basis function which determines the output of the units.

- Gaussian basis function has the following form

$$\phi_j(X) = \exp\left(-\left\|\frac{X - c_j}{\sigma_j^2}\right\|\right)$$

- The output of ith neuron in the output layer of RBF is determined by the linear combination of the output of the RBF units in the hidden layer as follows

$$y_i(X) = \sum_{j=1}^{m} w_{ij}\phi_j(X) + b_i$$

Output layer

- Having trained the hidden layer with some unsupervised learning, the final step is to train the output layer using a standard gradient descent technique such as the Least Mean Square algorithm.

- The network will replace the ENCC values into corresponding Desired Output Image (DOI) values.

Output of ANN

- To find output of ANN
- The Desired output image of ANN

$$\text{DOI} = \begin{cases} 0.1 & \text{if} & \text{ENCC(x,y)} \in & [0,160] \\ 0.3 & \text{if} & \text{ENCC(x,y)} \in & [160,180] \\ 0.6 & \text{if} & \text{ENCC(x,y)} \in & [180,200] \\ 0.9 & \text{if} & \text{ENCC(x,y)} \in & [200,255] \end{cases}$$

- Not suspicious (0-160) slightly suspicious (160-180), suspicious (180-200),highly suspicious (200- 255).

Cyst Extraction and Severity Measurement

- The connected components from the original image where ANN output is greater than the threshold value of 0.6 are considered for calculating the circularity given by,

$$circularity = \frac{\text{Area of the region inside the equivalent circle}}{\text{Area of the suspicious region}}$$

- If circularity is greater than threshold value, then the number of pixels in that region (area) and the gray scale intensity value at that region are calculated to extract the cyst portion from the original image.

- The measured values are the inputs for fuzzy logic system to find the severity of the cyst.

Fuzzy Based Severity Measurement

- The purpose of this work is to develop an expert system based on fuzzy reasoning, which could infer an optimum decision in respect of the severity of the dental cyst diagnosed by neural network.

- In this study, three variables, i.e. area, gray value and circularity of the dental cyst are used as input variables and severity forms as output variable to the system.

- For each fuzzy set, the fuzzy trapezoid function was employed to construct membership functions.
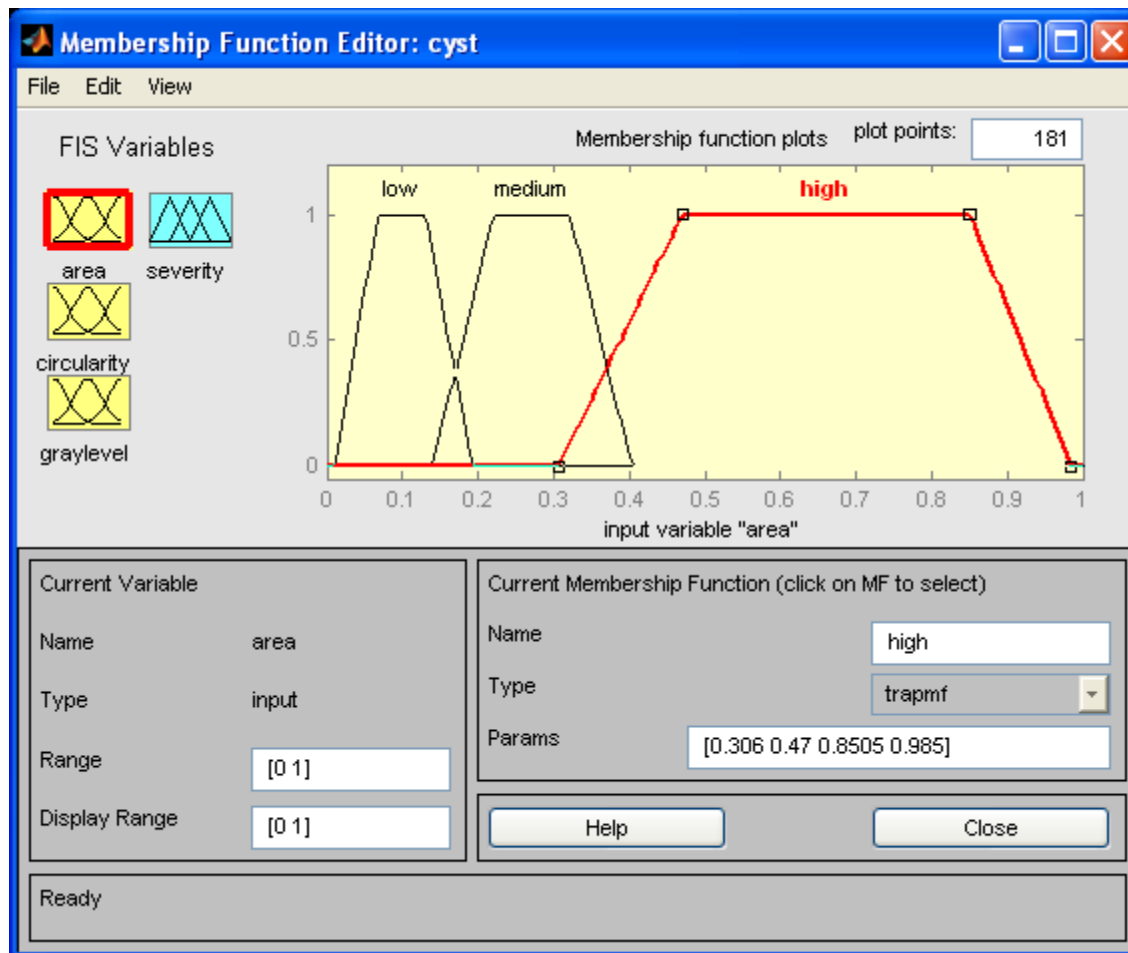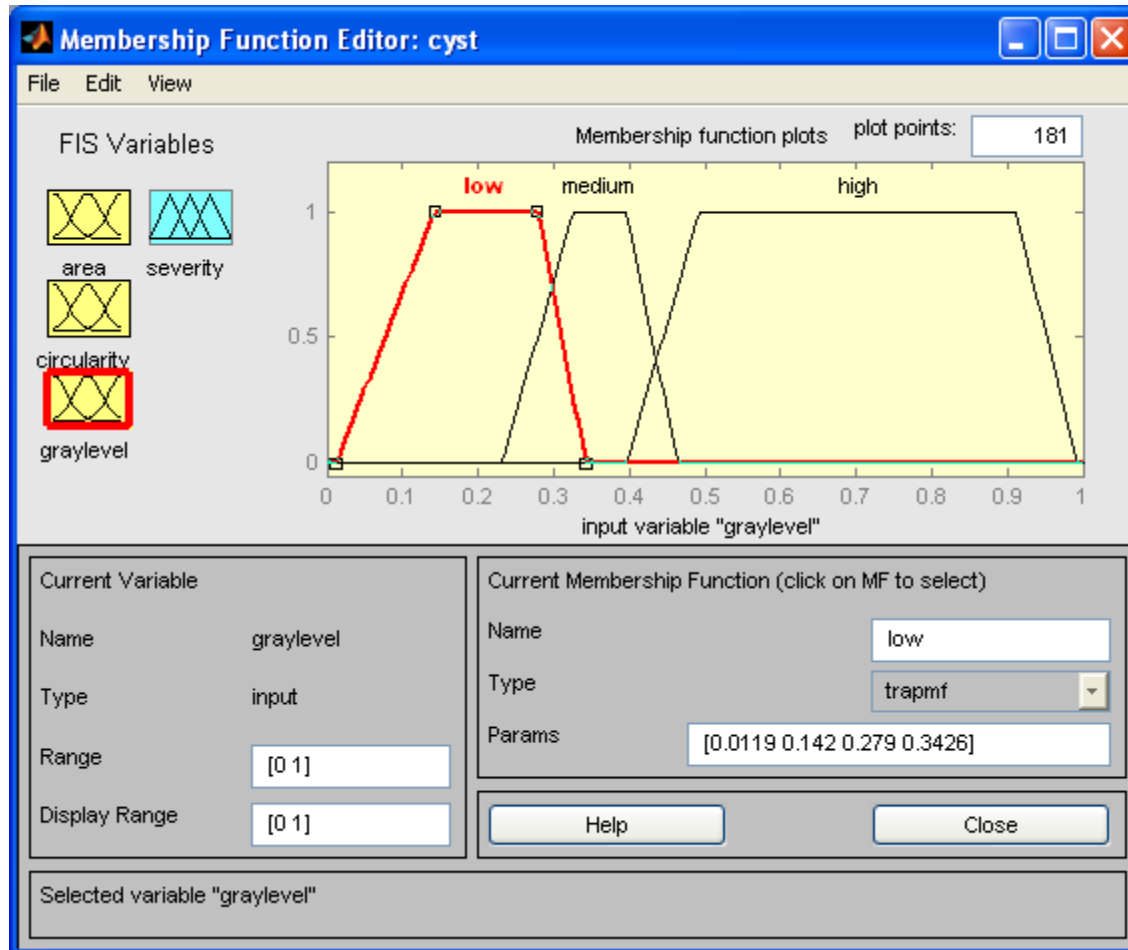
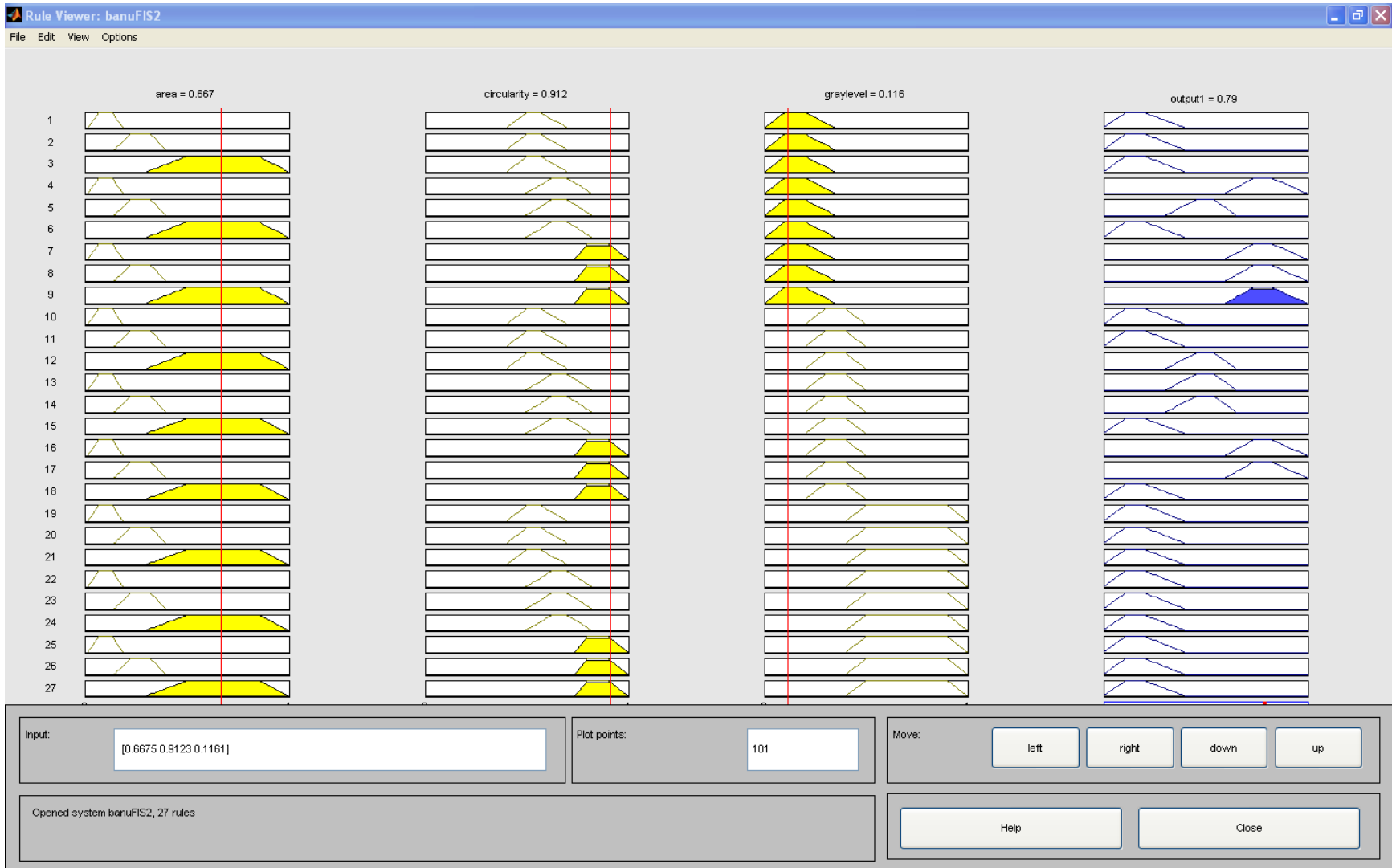**Figure 4.2 Membership Functions for Area of the Cyst Region**
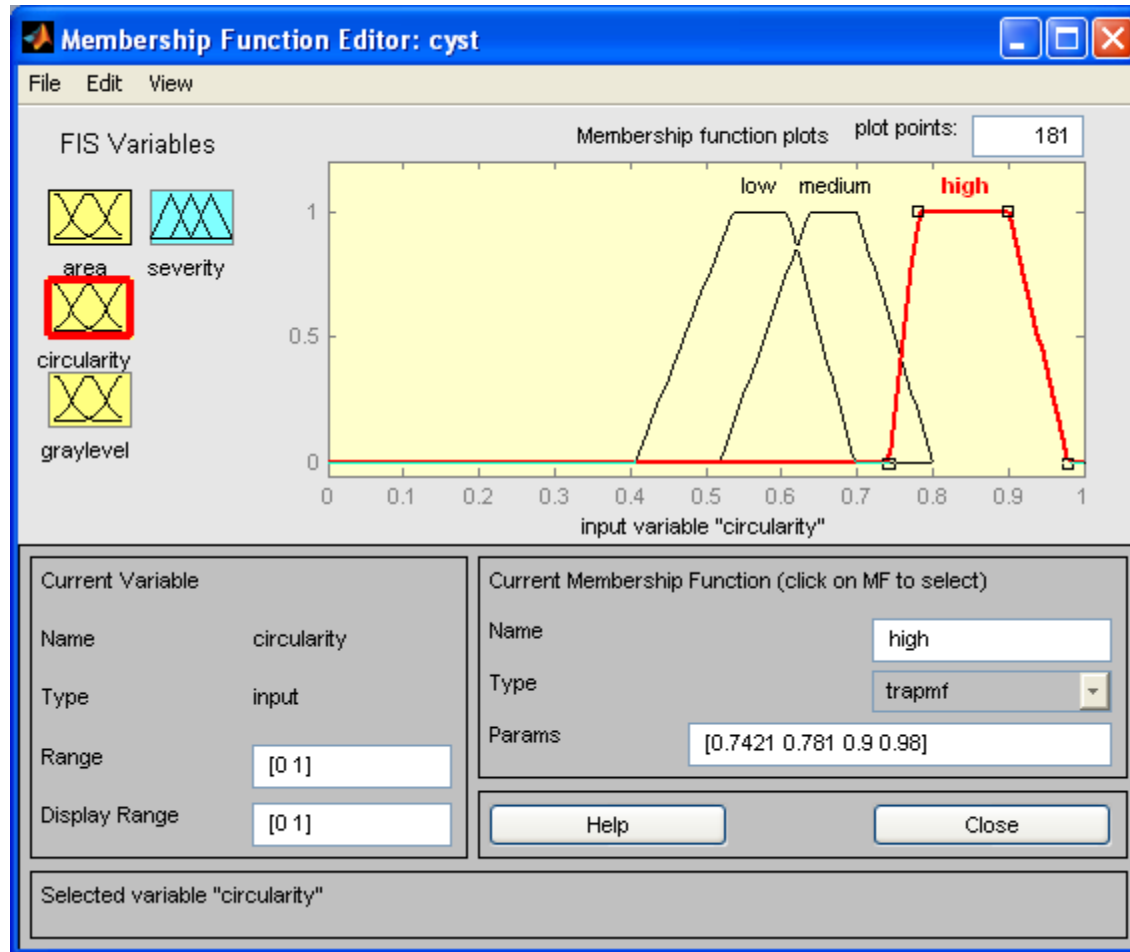
Figure 4.3 Membership Functions for Circularity of the Cyst Region

Figure 4.4 Membership Functions for Gray Level of the Cyst Region

Figure 4.5 Membership Functions for Severity of the Cyst Region

Cont…

- Accuracy and sensitivity of the number of cyst region extracted automatically were estimated using true positive (*TP*), True negative(*TN*),False positive(*FP*)and false negative (*FN*).

$$Sensitivity = \frac{TP}{TP + FN}$$

$$Accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

Results and Discussion

Figure 4.6 A sample Digitized Radiograph Showing the Cyst in the Maxillofacial Region

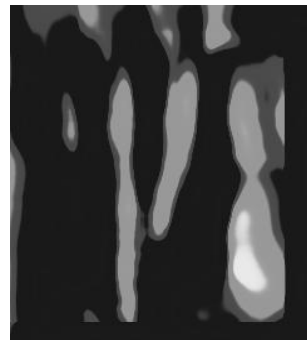**Figure 4.7   The Enhanced Image After Preprocessing**

Cont…

➢ The network is trained for $\sigma=2$

➢ The output will have a value in the interval (0, 1).

The desired output images are

DOI with ANN using
Radial Basis Function

DOI with ANN using
Backpropagation

Table 4.1 Lookup Table for Cyst Severity Thresholds

intensity	Area (pixels)	circularity	severity
0-40	1001-3000	0.75-1	Completely Perforated.
41-60	251-1000	0.61- 0.75	Involves one cortex and started Perforating.
61-150	200-250	0.5-0.6	Confined with in Medullary Bone. (Not eroding both cortical).

Performance evaluation

➢ The performance of the system can be evaluated by calculating accuracy and sensitivity.

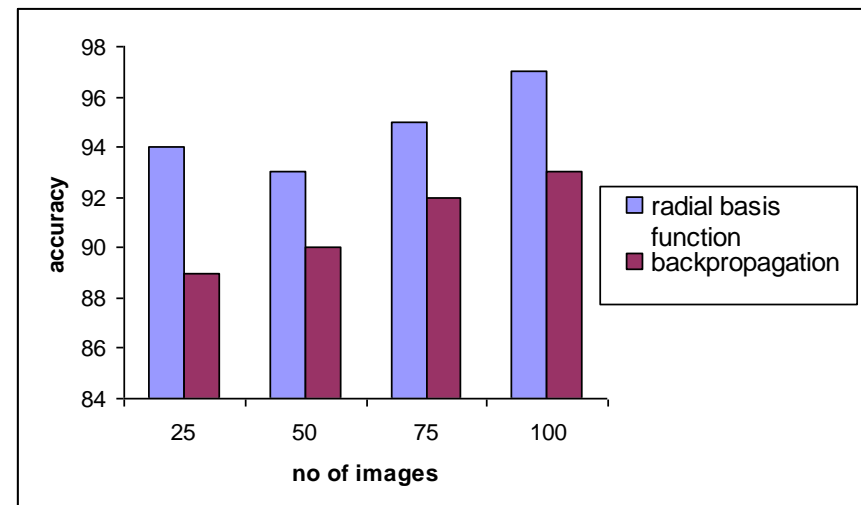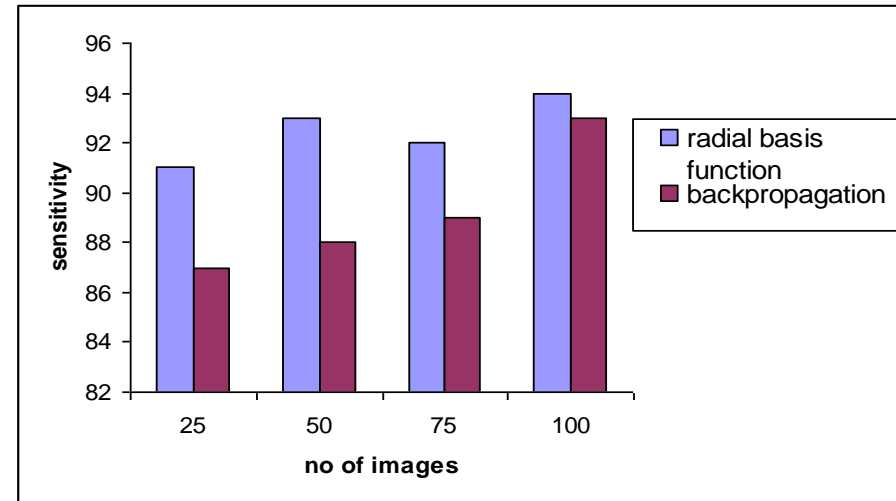$$accuracy = \frac{TP + TN}{TP + TN + FP + FN}$$

$$sensitivity = \frac{TP}{TP + FN}$$

TP-true positive

TN-true negative

FP-false positive

FN-false negative

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Cont…

Figure 4.13 The Cyst Portion is Shown by Arrow in Preprocessed Image

- The cyst has a circularity of 0.8, area of 2300 pixels and gray level values between 0 to 40.
- which indicates the completely perforated cyst