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Linguistic and Precise Fuzzy Modeling Classification System for Lung Nodule Detection on Computed Tomography Scans

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Abstract: The most fatal and demotic disease that scatter among men and women is Lung Cancer caused by Tobacco Smoking, air pollution, genetics etc. As the manual nodule detection is very time consuming and costly so computerized system can be helpful for this purpose. But sometimes due to issues in the image quality, color of the image, edge detection, image restoration, segmentation and due to enhancement of an image may cause false detection of lung cancer. So the methodology for the detection of tumor is quite concrete to overcome such cases and for more precise results. In this paper a system is proposed for the detection of malignant nodule by using two classifiers i.e. Linguistic Fuzzy Modeling (LFM) and Precise Fuzzy Modeling (PFM). The system consists of two stages i.e. lung segmentation and enhancement, feature extraction and classification. Segmentation will result in separating lung tissue from rest of the image. A feature vector for possible abnormal regions is calculated and regions are classified using the two classifiers LFM and PFM. LFM is used to interpret the result and PFM is used to evaluate the accuracy. The system is implemented in MATLAB.Experimental results shows the validity of the system.

Keywords: Lung , Linguistic, Neuro Fuzzy, Precise, Tumor.

I. INTRODUCTION

Lung cancer is currently the 2nd most common cancer in both men and women and is the top cause of all cancer deaths. There is a direct association of tobacco smoking and other pollutant and toxic exposures to lung cancer making it the leading preventable cause of death. Since the early 1900's, lung cancer rates have grown until now where it is a national epidemic. Like other cancers lung cancer is capable of spreading to other parts of the body like brain, bones, glands etc. Lung cancer is responsible for more than 25% of all cancer-related deaths every year and lung cancer kills more people than breast, colon and prostate cancers combined.

In recent years the image processing mechanisms are used widely in several medical areas for improving earlier detection and treatment stages, in which the time factor is very important to discover the disease in the patient as possible as fast, especially in various cancer tumors such as the lung cancer, breast cancer. Early detection of lung cancer is very important for successful treatment. Diagnosis is mostly based on CT images. The current work focuses on finding nodules, early symptoms of the diseases, appearing in patient's lungs. Most of the nodules can be detected if process parameters are carefully selected. These selections are aimed to be computerised. The available lung cancer images are passed onto three basic stages to achieve more quality and accuracy in our experimental results: pre-processing stage, feature Extraction stage and Lung cancer cell identification. For the detection of malignant nodules these features are fed in the LFM(Linguistic Fuzzy Modeling) and PFM(Precise Fuzzy Modeling) based systems for lung nodule classification and detection.

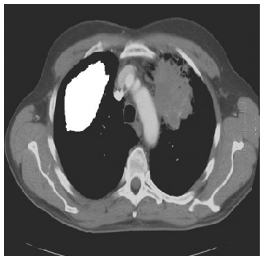

Figure.1 Lung CT scan image

II. PROPOSED METHOD

The systematic overview of the computerized system is shown in Fig. 2. The system takes sample lung CT image as an input and applies segmentation techniques on this image to remove background and extracts the nodules from image. Then the post-processing technique is applied to remove as many false regions as possible. The remaining malignant nodules are classified based on their properties which are extracted in feature extraction phase.

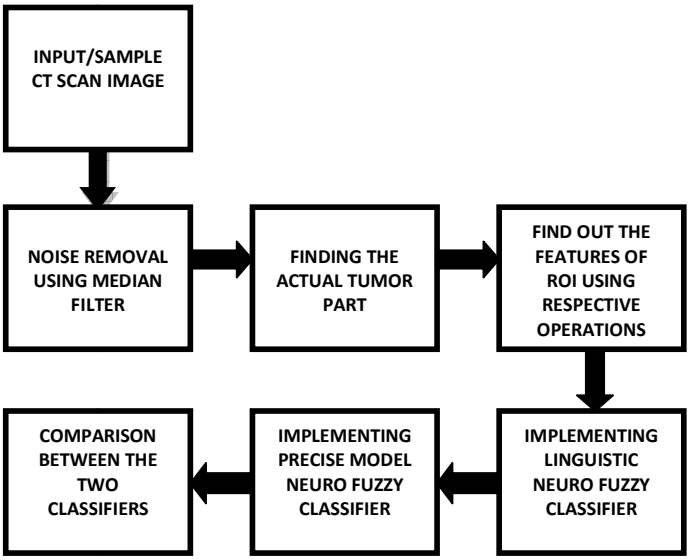

Figure.2 Flow diagram of proposed system

1. Lung CT Image Segmentation and Post-processing Enhancement

a) Sample Image:
CT (Computed Tomography) scan is the sample image for this process of determining the tumor in the lungs. These images are applied to the system. First step is to convert each image into grayscale image.

b) Noise removal using Median Filter:
To remove the noise content present in the image median filter is used. The median filter is preferred because the blurring of the edges in the image is less as compared to other filters. Fig.3 shows noise removal image.

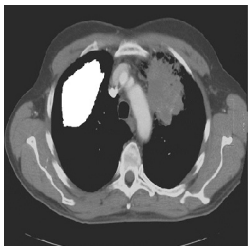

Figure.3 Noise removal image

c) Thresholding:
The gray image is converted into the binary image using segmentation shown in Fig.4**.**Segmentation is the process of partitioning the CT image into different segments i.e. different set of pixels.In binary image only two levels are assigned to the pixels that are below or above the specific threshold value. Here global thresholding is used (T).So pixels values greater than T are set as 1(White) and the values less than T are set as 0(Black).

Figure.4 Segmented image

d) Morphological opening and closing operations:
Morphological Opening removes the small objects (dark pixels) in the foreground of image and Morphological closing removes the foreground as well as background pixels in an image.

e) Extraction of ROI:
To extract the region of interest from the lung image, region growing algorithm is used. In this algorithm, a pixel value is considered as a seed point. This seed point continuously checks the neighbourhood pixels, if the difference between the region and new point is less than the threshold value then it is added to the region, if the new pixel value is greater than the threshold value then the region growing process terminated. ROI is shown in Fig. 5.

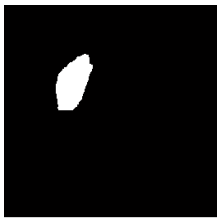

Figure.5 Region of interest

2. Lung Nodule Feature Extraction and Classification

A portion of image that is to be filtered and on which operations are to be performed is known as region of interest. More than one ROI can be defined in an image. This is the most difficult step is nodule detection because in CT scan images most of the lung nodules are attached with the blood vessels and the gray scale level of both are almost same. Hence we are considering various other features which is used to find the region of interest. Feature vector which we have made is $Fv = \{F1, F2, F3, F4, F5\}$. These features are:

1) Area (F1): A specific nodule consists pixels within it, total number of that pixels refer to its area.
2) Perimeter (F2): This tells us about the length of the region.
3) ROI Mean (F3): The mean intensity value indicates the average intensity value of all the pixels that belong to the
   same region.
4) Shape Complexity (F4): This feature is the texture feature which tells us about shape of the ROI.
5) NROI Mean (F5): In lung CT scan image, number of black pixels is much greater than the number of white pixels.
   It the number of black pixels in the new image is greater than the threshold value then the image is normal
   otherwise it is abnormal.

All the parameters calculated are stored in a database for each image. A total set of 150 images are applied to the system of which 75 are tumor images and 75 are non-tumor images. For classification purpose, the feature vector is fed to a classifier based linguistic fuzzy modelling and precise fuzzy modeling .This helps in differentiating between nodule and non-nodule regions. By performing different experiments, we come across to a result that our proposed method is more tolerant to the noisy data related to nodules. The purposed system is designed in order to improve the classification accuracy.

3. Comparison Graph of two Classifiers

The proposed work have pointed the main problem regarding the accuracy of tumor detection in lungs via CT scan images through further processes such that we get a clear image of tumor in lungs. Fuzzy Modeling is the

process used for further clarification of the CT scan image to get a clear status of tumor. For that two processes with further accuracy enhancing measures are proposed which are LFM and PFM.
After simulating both the processes in MATLAB, accuracy graphs of both the classifiers is obtained. Both techniques have very good accuracy and the comparison graph for both is shown in Fig. 3 which clearly shows that the PFM technique shows greater accuracy.

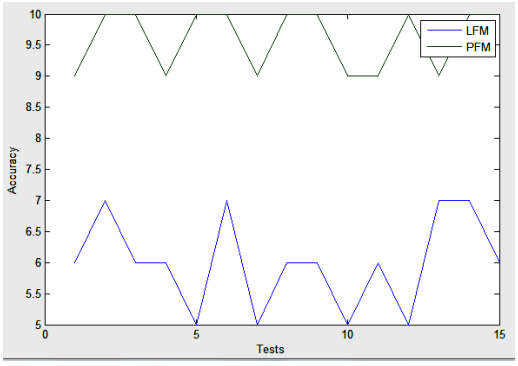

Figure.3 Comparison graph

III. EXPERIMENTAL RESULTS

The proposed scheme is thoroughly tested using different lung CT scan images. Accuracy is defined as a ratio of the total number of correctly classified pixels to the number of pixels in the image.

$$\text{Accuracy} = \frac{TP + TN}{TP+TN+FP+FN} * 100$$

Table 1: LFM Accuracy Result

Test no.	Total Images tested	No of positive results	Accuracy
1	10	6	60%
2	10	7	70%
3	10	6	60%
4	10	6	60%
5	10	5	50%
6	10	7	70%
7	10	5	50%
8	10	6	60%
9	10	6	60%
10	10	5	50%
11	10	6	60%
12	10	5	50%
13	10	7	70%
14	10	7	70%
15	10	6	60%
AVERAGE	**150**	**90**	**60%**

Table 1: PFM Accuracy Result

Test no.	Total Images tested	No of positive results	Accuracy
1	10	9	90%
2	10	10	100%
3	10	10	100%
4	10	9	90%
5	10	10	100%
6	10	10	100%
7	10	9	90%
8	10	10	100%
9	10	10	100%
10	10	9	90%
11	10	9	90%
12	10	10	100%
13	10	9	90%
14	10	10	100%
15	10	10	100%
AVERAGE	**150**	**144**	**96%**

IV. CONCLUSION

The proposed system elaborates the accuracy issues and objectives and also gives brief summary of Fuzzy Modeling using different technologies in the literature. The detection through Fuzzy Modeling is further elaborated in two techniques in order to achieve more accurate results regarding tumor in lungs. Both techniques are listed below:

- Linguistic Neuro Fuzzy Modeling
- Precise Neuro Fuzzy Modeling

Both the techniques are compared on the basis of accuracy and the comparison is clearly shown. It is clear from comparison that both techniques are highly accurate and precise. But PFM showed more accurate results than LFM.

VI. FUTURE SCOPE

This paper have presented two new techniques to enhance the accuracy in the detection of tumor in lungs from CT scan image by applying Fuzzy modeling over it. These techniques are able to detect major tumor in lungs. The future scope will be detecting multiple tumors available as:

- Two major tumors.
- One major or one minor.

In future the technique for detecting multiple tumors will be presented.

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