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IMPLEMENTATION OF SUPPORT VECTOR MACHINES (SVM) TECHNIQUE FOR AUTOMATED DETECTION OF CANCEROUS LUNG NODULE FROM THE COMPUTED TOMOGRAPHY IMAGES

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Abstract: Traditional approach for Lung Nodule Cancer detection is somehow tedious, there is need of precise and efficiency mechanism for which image processing tool that supports pre-processing, segmentation, feature extraction and classification of computed tomography image of lung outperforms the existing Technology. CT Images are more efficient and provide more detail information required for diagnosis than X-ray. There are two types of lung nodule cancerous and non-cancerous nodules. Lung nodules are classify with the help of computer aided diagnosis (CAD) system. The CAD system can classify the lung nodule from CT images on the basis of nodule growth rate, density, shape and boundary of the nodule.

Keywords: Image Enhancement, Segmentation, Feature Extraction, Thresholding, Fuzzy Rules, Computed Tomography (CT).

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INTRODUCTION

Lung cancer is becoming the prime factor in cancer deaths due to increasing rate of smoking and air pollution in different countries. According to statistics 31% of cancer deaths for males and 26% for females are caused by the lung cancer [1]. There has been a great effort to improve the diagnosis and treatment of the lung cancer. Medical imaging is the main tool for cancer diagnosis and lot of researchers are focused on this area. Computed Tomography (CT) is considered to be the best modality for cancer diagnosis. It provides good details on anatomical features of the tissues. But still there is need for automatic detection of lung nodule in CT scan images. It can eliminate the health risks and complications involved in invasive operations significantly and improve the chances for successful treatment of the patient. Time and cost are two crucial factors in any treatment of a lung cancer. There is need to diagnose the lung nodule of person and classify whether nodule is cancerous or not by using automated detection of cancerous lung nodule system. It helps the radiologist to improve the diagnosis efficiency by calculating the quantity of nodule growth in each stage accurately.

1.1 Types of lung nodules

The Lung Nodules majorly classified into four [2] types:

1. Normal lung nodule

2. Benign lung nodule

3. Malignant lung nodule

4. Advanced lung nodule

The fig. 1 shows the nodule growth and nodule types from the normal stage to the last advanced nodule stage. The figure also indicates the nodule structure and boundary at each stage.

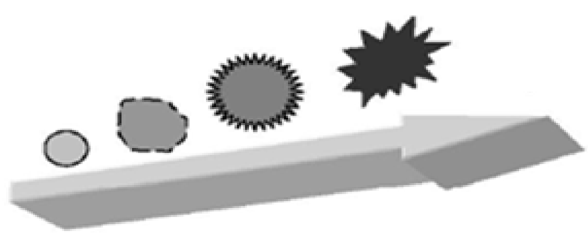

Fig.1 Nodule growth

1.1.1 Normal nodule

Normal nodule is the type of non-cancerous lung nodule. If the lung nodule area is minimum and nodule sizes vary in range of 0 to 0.5 then it is called normal nodule. Such a small normal lung nodules are not diagnosis with the help of needle biopsy due to the minimum area and density.

1.1.2 Benign nodule

Benign nodule is the type of non-cancerous lung nodule. If the nodule area is minimum and nodule sizes vary in range of 0.5 to 1 then it is called benign nodule. It has regular structure and hard core boundary without spike.

1.1.3 Malignant nodule

Malignant nodule is the cancerous lung nodule and it spread in lung region. If the nodule area is maximum and nodule sizes vary in range of 1 to 1.5 then it is called malignant nodule. The malignant nodules have irregular structure and cover with spike.

1.1.4 Advanced nodule

If lung nodule area is maximum and nodule sizes vary in range of 1.5 to 2 then it is called advanced cancer nodules. Advanced cancer nodule is the cancerous lung nodule and it spread in affected area. The advanced cancer nodule also affects normal lung region tissues. It is most dangerous type of nodule. It has irregular structure and nodule boundary with spike.

2. Literature survey

Lung cancer was not known before the advent of cigarette smoking. It was not even recognized as a disease until 1761 [3]. Different aspects of lung cancer were described further in 1810 [4]. In 1929 German; physician Fritz Lickint recognized the link between smoking and lung cancer [5]. The CT described by Bhandauria and Dewal[6] is widely used in diagnosing different diseases. The computer-aided detection (CAD) scheme is efficient for the better diagnosis for large volume of CT image data. Zhenghao Shi et al [7] used the Laplacian of Gaussian filter for enhancing nodules in a chest radiograph. It used the high intensity transmission and then applied a LOG filter to calculate the differences in contrast within inside and outside region of interest. Vivekanandan D et al [8] applied edge based segmentation using snakes on CT images. A snake was used as the energy function in term of internal energy and force that acts on image. Anita chaudhary et al [9] was performed segmentation by using thresholding and watershed segmentation techniques. The thresholding segmented image requires smaller storage space and it have fast processing speed and it is easy in manipulation. Watershed segmentation extracts the object from background with the help of seeds. But it is a bit difficult to differentiate region of interest so our implementation technique is more suitable and accurate.Jia Tong et al. [10] described a new CAD scheme for detecting lung nodules. In their approach the lung region was segmented from the CT data using adaptive threshold algorithm and then nodule features were extracted by Rule-Based Classification (RBC). The RBC was used to distinguish nodules type and they claim the accuracy of 85%.The alternative and promising method was suggested by Li Shen et al. [11] to detect lung cancer at an earlier stage. In their method nodule segmentation was performed in a nodule region to extract nodule boundary. They used thin-plate spline interpolation for nodule registration along the temporal dimension. Their resulting spatio-temporal model was used for distinguish between cancer and benign nodules. Maciej Dajnowiec et al. [12] proposed a method for automatic segmentation of the lung region. In his method optimum threshold value was calculated from the image of the data set. This threshold values were used to differentiate the organ and solid tissue from air region of the lung. After that the images was sequentially checked from the beginning until the two objects whose size exceeds 1% of the total pixel were found. It was considered as base slide. Then remaining region was obtained by applying region growing technique. This final result was multiplied with the original CT images to extract the lung portion of each slide. But it gives whole lungs left and right lobes with nodules region. But in our project; in the final step we get the lung nodule segmented part. CT technology was also adopted by K.Devaki et al. [13] to acquire high resolution of the lungs in a single breath hold. Analysis of these large volumes of image data was manually performed, which was time consuming task. So they used automated analysis of CT scan images by addressing segmentation result of various lungs anatomical structures. Noriyasu Homma et al [14] used N-quoit filter to find ROI from the CT images. To extract the lung nodule they binaries original image and then calculated mean, variance and entropy of intensity. After that they applied a Gabor filter to find orientation output for new feature. But drawback is that they find nodules manually and calculated their values. Thresholding classifier was proposed by FatmaTaher et al. [15] for the distribution of sputum pixels and non-sputum pixels in RGB space for extracting the sputum cell from the raw image. Qingxiang Zhu et al. [16] used a method to classify pulmonary nodules from blood vessels. This concept was based on the idea of low contrast of the intensity between nodules and vessels in CT images. Their method shows structure enhancement and active evolution, which can detect pulmonary nodules at a high accuracy. S.L.A. Lee et al [17] proposed random forests (RF) based classification aided by clustering (CAC) method. Lung nodules were classified by using clustering. In clustering the group of objects of same category belongs to same cluster. The cluster based classification improves the classification accuracy. The proposed method consists of training and test stages. The clusters were obtained by merging the nodule and non-nodule parts of training sets. Then each cluster was divided into two groups: nodule and non-nodule. Pei Xiaomin et al [18] used rule-based classifier. It required a large overtraining effect to classify the nodules. The rule-based classifier consists of two steps selection of a feature and cut off threshold. The optimal composite feature determines from separation metric and it was distinguish nodules from non-nodules. Separation metric maximizes due to the linear combination of simple feature. This method proved that the overtraining in the process of threshold selection is eliminated by passing cut off threshold through one of the nodules. The result was obtained by calculating the ratio of number of non-nodules removed to the nodules sacrificed. Then determine k-ratio for k -possible threshold. If one of them achieved maximum value then it was defined as gain of feature. The optimal threshold for the feature was considered from corresponding feature.

3. Proposed work

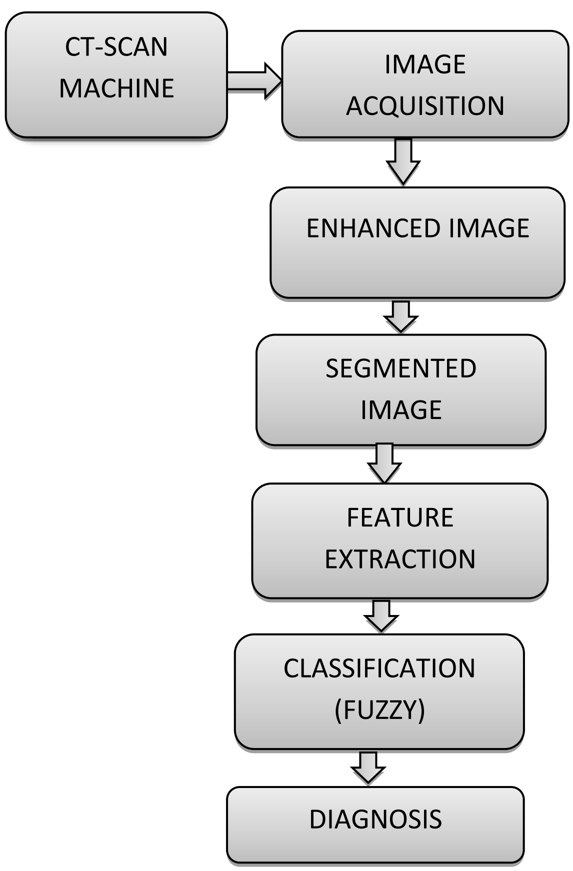

Fig.2 Overall architecture

Proposed framework is model into six parts image acquisition, image enhancement, segmentation, feature extraction, fuzzy classification and diagnosis. These six processes are described as follows.

3.1 Image acquisition

The images collected from cancer hospital in the form of DICOM (Digital Image Communications in Medicine) image format which are of cancerous and non-cancerous patients. It is not just the image or file format. DICOM image provides all necessary tools for diagnostically accurate representation and processing of medical imaging data.

Fig.3 Input image

3.2 Enhancement

Enhancement technique enhances the contrast of images. The contrast enhancement can limit in order to avoid the noise which is present in an image. We used histogram equalization to improve the contrast of images by transforming the values in an intensity of an image.

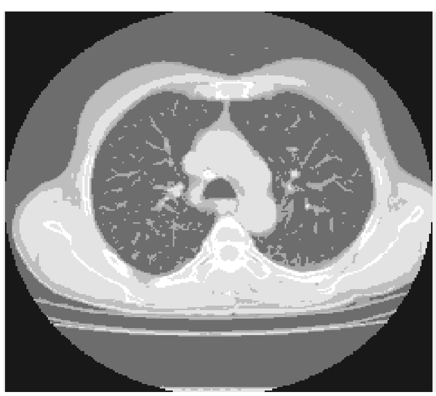

Fig.4 (a) Enhance image

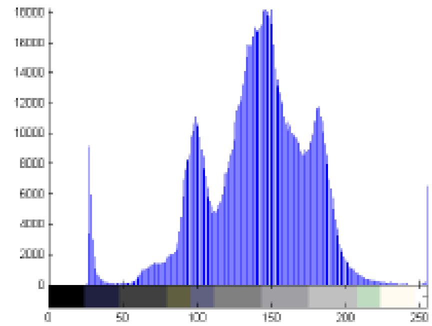

Fig.4 (b) HE plot

3.3 Segmentation

In the image segmentation the CT image is sub-divided into small regions. Segmentation distinguishes the nodule from background part of the lung CT images.

The diagram below illustrates the same. We extract the lungs left and right region by using thresholding, imclearborder and bwareaopen functions. The thresholding method is based on a threshold value to turn a gray-scale image into a binary image.

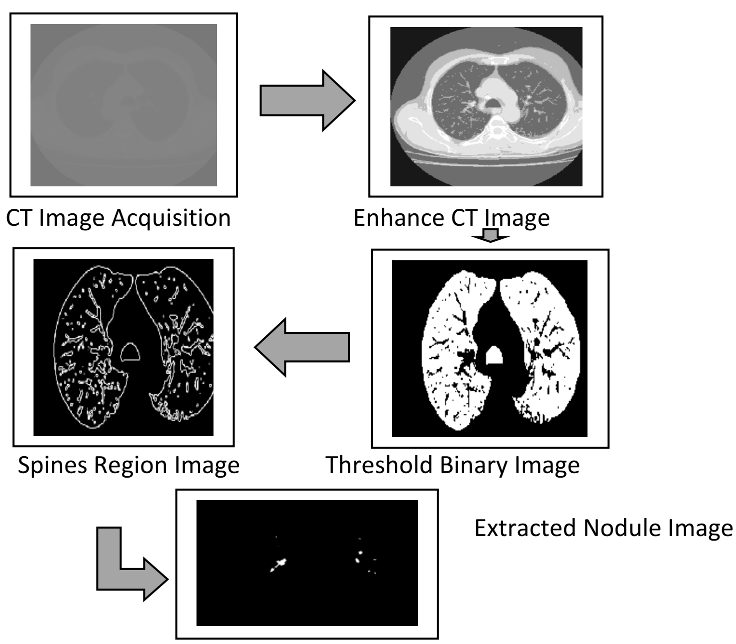

Fig.5 Segmentation method

The threshold is used to isolate lung tissues and the imclearborder is used to remove artifacts attached to border. The bwareaopen is used to remove objects in less pixel size.

Fig.6 Threshold binary image

In second step, we used the gradient magnitude as the segmentation function to show the nodule and nodule spine borders. For this we used the sobel edge masks, and some arithmetic functions to compute the gradient magnitude. The gradient value is high at the borders of the objects and low inside the objects. The output image fig. 7 shown below displays the spike border clearly. Spike border is used to find the nodules are cancerous or not.

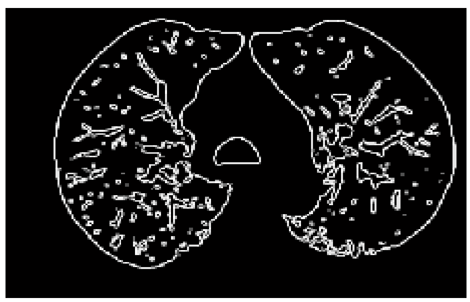

Fig.7 Spike region image

Generally the cancerous nodules have spine border. The cancerous nodules are fully covered by the spikes.

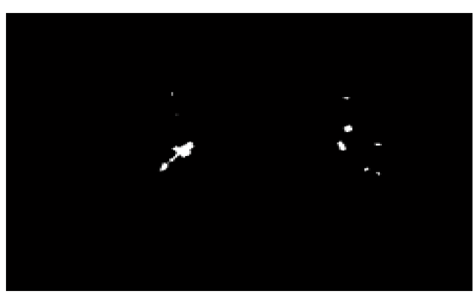

Fig.8 Nodule image

To get the exact lung nodule image we perform further operation on previous output image of segmentation. The nodule image shows the cancerous and non-cancerous lung nodules are extracted from the CT scan image

3.4 Feature extraction

The feature extraction is very essential and important step to extract region of interest (ROI). The nodule size, structure, volume and nodule spikes are considered as feature in our proposed system. In feature extraction method we extract the feature from the images to differentiate the cancerous and non-cancerous lung nodules.

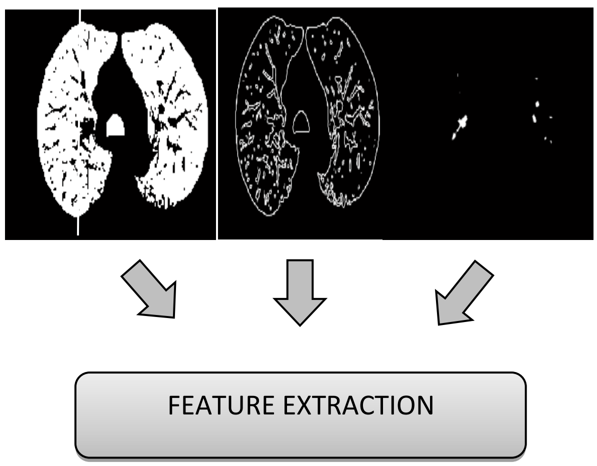

Fig.9 Feature image

The spike values are pre-calculated by using threshold binary images in fig. 6 and gradient magnitude method in fig.7 of our segmentation method. The fig.8 shows different nodule size, structure and volume.

3.5 Classification

The feature images are calculated in feature extraction methods are used for the classification and diagnosis of cancerous and non-cancerous lung nodules. First we calculated the number of nodules present in the nodule images.

Fig.10 Numbers of nodules

In next step, we calculate the nodule area and classify the nodule type by using SVM classifier.

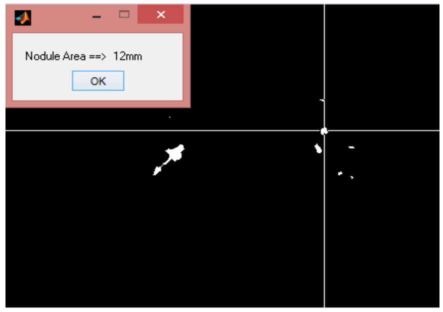

Fig.11 Nodule types

Here nodule belongs to which one of the types such as normal, benign, malignant and advanced cancerous lung nodules are define. In last step, we check the nodule of interest is cover by spike or not by plotting box of nodule image on spike image and adding nodule image with threshold binary image and also get the color map image to visualize nodule structure and its surrounding region to diagnosis.

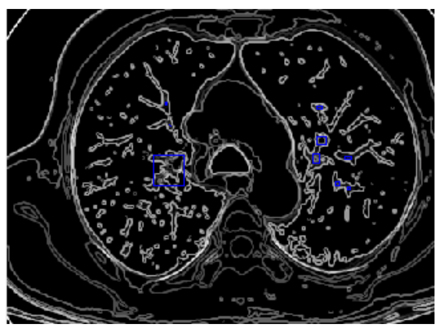

Fig.12 (a) Spike position

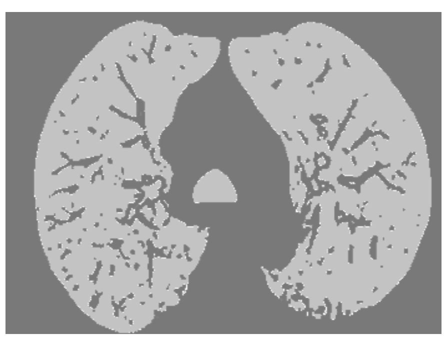

Fig.12 (b) Spike check

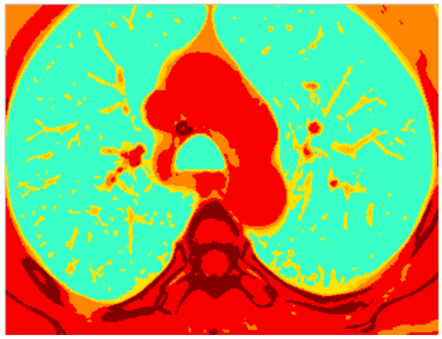

Fig.12 (c) Color image

4. Diagnosis

The classifiers differentiate the non-cancerous (Benign) from cancerous (Malignant) lung nodules. The proposed system used the support vector machines (SVM) for classification of lung nodules. The system use features which were extracted from CT images to train the SVM classifier. SVM classifier maps the input into high dimensional feature space through nonlinear mapping. The optimal hyper plane was constructed to differentiate the nodules. By using the kernel mappings such as radial basis function a nonlinear hyper plane was constructed. The reduce dimensionality help to reduce the computational complexity.

The nodules were classified in following criteria:

1. True Positive (TP): The percentage of nodules defined as nodules.

2. False Positive (FP): The percentage of non-nodules defined as nodules.

3. False Negative (FN): The percentage of nodules defined as non-nodules.

4. True Negative (TN): The percentage of non-nodules defined as non-nodules.

Finally they calculated classifier in term of Sensitivity, Accuracy and Specificity.

The proposed system is implemented and is applied to 2 clinical cases containing 183 cancerous and 22 non-cancerous slices of lung CT images. The size of nodule we can detect is between 0mm to 100mm within lung field. Most of the missed nodules are less than 0.5mm in area and located on the lung wall. The overall performance of the proposed system is 97% correct detection rate and 94.642% accuracy.

5. CONCLUSION

The proposed research work is performed on computed tomography images i.e. CT scan images for the detection of Lung Nodule is cancerous or not. Existing approaches has certain drawbacks but there is need of precision in the Medical diagnosis domain, so there is a scope of improvement. Hence the different classification, Image enhancement technique are used for taking precise decision and proposed classification technique outperforms the existing available techniques.

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