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COMPUTER ASSISTED SYSTEM FOR FEATURES DETERMINATION OF LUNG NODULE FROM CHEST X-RAY IMAGE

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ABSTRACT:

The Computer based / assisted system is proposed in this paper for feature extraction of lung nodule from the simple chest X-ray image. In recent years, the image processing mechanisms are widely used in several medical areas for early detection and in deciding treatment stages, where the time and cost factor is very important to discover the disease in the patient. According to WHO -among the cancer, lung cancer is one of the most common causes of death worldwide. Therefore, early detection using diagnostic tests promises to reduce mortality from lung cancer. At present, increased work load on interpretation of digital images (X-Ray and CT) by radiologist can be a potential source of error due to fatigue in detecting subtle lesion. In this work, the problem of developing a computer based system for the extraction of maximum statistical / mathematical features from the lung X-ray image is considered. Further, these properties can be used to classify lung nodule as benign or malignant from the chest X-ray image directly.

Images obtain from the public JSRT database and the images collected from nearby local hospitals are scanned and stored in bitmap format, 800×1200 dpi, 8-bit. After these images are pre-process by using median filter, high boost filter, histogram equalization and contrast stretching. Segmentation is carried out by using histogram and thresholding techniques. Extracted suspicious region from the lung nodule X-ray image is then used for feature extraction such as area, perimeter, irregularity index, mean, variance, standard deviation, entropy etc.

KEYWORDS: Lung Nodule, Malignant, Benign, Feature Extraction, Irregularity Index, Variance.

INTRODUCTION:

The term neoplasia means new growth, the new growth produced is called neoplasm or tumor (except new growth of tissues and cells those exist in the process of embryogenesis, regeneration, hormonal stimulations etc.). Satisfactory definition of neoplasm or tumor is a mass of tissues formed as a result of abnormal, excessive, uncoordinated, autonomous and purposeless proliferation of cells. The branch of science dealing with the study of neoplasms or tumors is called Oncology. Neoplasm may be benign when they are slow growing and localized without causing much difficulty to the host or malignant when they proliferate rapidly, spread throughout the body and may eventually cause death of the host. The common term used for all malignant tumors is cancer. The cancer means crab, reflecting the true character of cancer since it sticks to the part of the body stubbornly like a crab [1] – [3].

Today, cancer is one of the most formidable health problem faced by mankind. Worldwide survey indicates cancers in all forms are causing almost 17% of death and in the developed countries; cancer is second cause of death next to cardiovascular diseases. According to WHO (World Health Organization), estimation during year 2008, more than 12 million death are because of cancer. In India during year 2008, about 950000 new cancer cases being detected and nearly half of these cases die each year. The noble cause for this will be because of changes in life style, changes in environment and increase in life expectancy. World-wide survey indicates that LUNG CANCER is first most common cause of death in both men and women together [4] – [6].

Nodule detection is one of the most challenging tasks in medical imaging. Nodules are difficult to detect in digital images (X-ray) because of low contrast, large variation in density, varying size and location of the lung nodule within an area of a complicated anatomy (such as the hilum and ribs). The main objective of the proposed work is to develop a computer assisted system to detect suspicious region in a lung and to extract as many possible feature from it, so that further artificial intelligent system will classify them as malignant or nonmalignant nodule [7] – [11]. Fig. 1 indicates flow chart / algorithm of the feature extraction process from chest X-ray image.

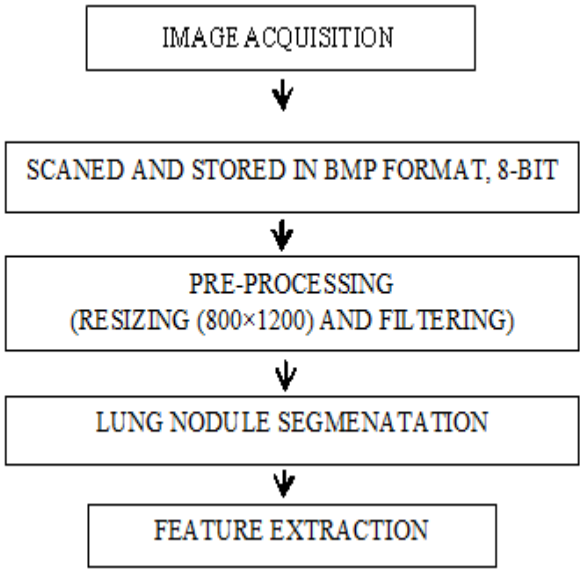

Fig.1 stages of propose algorithm

METHOD:

Digital images are obtain using image acquisition method and then applied for pre-processing algorithm, including size normalization and image filtering. Segmentation of lung nodule from the lung image is required for calculating features [10]. All the database images which are obtain from JSRT public database and images which are collected from nearby hospitals are digitized with the help of high resolution scanner (Scanjet 2400, HP India). Every image data is acquired with 255 gray levels (8 bit) and stored in bitmap (.bmp) format. Scanned images are resized to 800×1200 pixels for standardization process. Pre-processing is used to reduce irrelevant information and to enhance the image quality, which make feature measurement easier and more reliable. For removing various types of noise such as Gaussian and salt & pepper noise, median filter is used. High boost filter is used to sharpen the edges in the image. Histogram equalization and contrast stretching is used to improve the quality of the image [12]

Segmentation of the lung nodule is carried out with modified thresholding. In this technique, two thresholds are selected in such a way that the value of the pixel which is showing lung nodule should lie in between the two threshold value. By doing this, pixel of the lung nodule will be preserve and rest of the pixel will be set to zero value. There is a possibility that pixel with the same value can lie at another location. In that case, for separating a lung nodule from rest of the pixel labeling method is used. By using this method, lung nodule is segmented [13].

Basic MATLAB programming and using digital image processing toolbox, these pre-processing various techniques and segmentation procedures are easily implemented and executed. Above steps are explained with the help of images Fig. 2(a)-2(j).

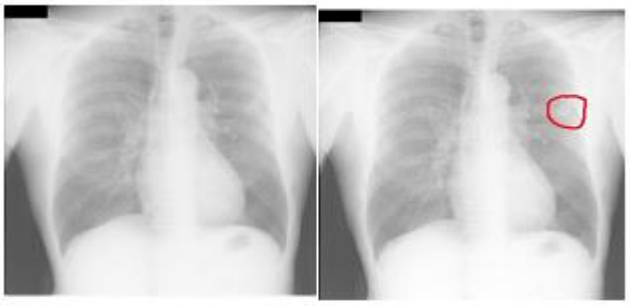

Fig. 2(a) original image
Fig. 2(b) location of lung nodule marked with red circle

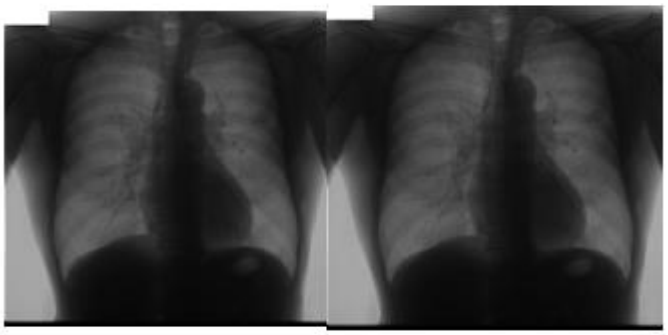

Fig. 2(c) negative image
Fig. 2(d) median filter (5×5 mask)

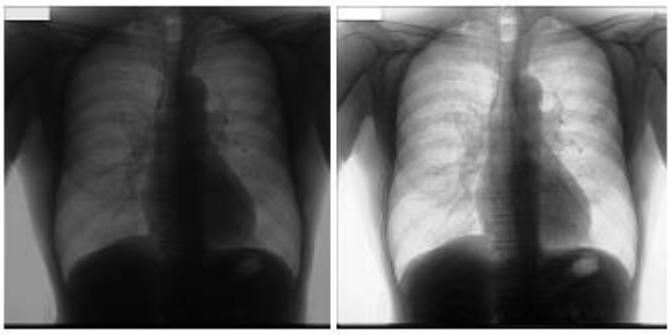

Fig. 2(e) high boost filterFig.
2(f) histogram equalized image

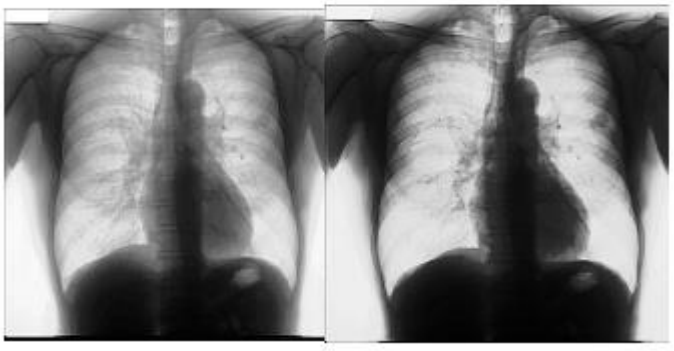

Fig. 2(g) median filter (3×3)
Fig. 2(h) contrast stretching

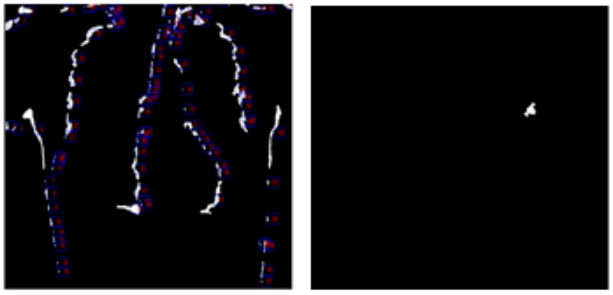

Fig. 2(i) Labeled image Fig. 2(j) extracted lung nodule

FEATURE EXTRACTION:

In the present study, Image Feature Extraction is very important stage. After the segmentation is performed on lung region, the features can be obtained from it and the diagnosis rule can be designed to detect nodules in the lung. The entire feature which are calculated from the image, convey some information regarding lung nodule. This information is very helpful in detecting lung nodule as malignant or nonmalignant. In this literature, the features extracted from the image can be used as diagnostic indicators in the analysis [5] – [13]. Segmented suspicious region using labelling algorithm and retaining pixel values within the segmented region, using MATLAB simple programming various parameters / features are extracted as follows [5], [12] – [15]:

1. Irregularity index- Lung cancer is characterized partially by the irregularity in its tumor border [1]. For this analysis, the irregularities in the tumor are computed by an index:

$$I=\frac{4\pi\times Area}{(Perimeter)^2}$$

The metric value or roundness or circularity index or irregularity index (I) is equal to 1 only for circle and it is < 1 for any other shape. Here it has been assumed that, more circularity of the object, the probability of the object being nodule is high. Here area is nothing but total number pixel values within the segmented area and perimeter is nothing but total number of pixels on the boundary of segmented region.

2. Eccentricity - Scalar that specifies the eccentricity of the ellipse that has the same second-moments as the region. The eccentricity is the ratio of the distance between the foci of the ellipse and its major axis length. The value is between 0 and 1. (0 and 1 are degenerate cases; an ellipse whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment) [2], [3].

3. Equivalent Diameter - Scalar that specifies the diameter of a circle with the same area as the region [2], [3]. Computed by formula

$$\mathrm{E}_{\text{diameter}}=\sqrt{\frac{4\times area}{\pi}}$$

4. Statistical Properties of an Image: As per pixel values of the suspicious segmented are following mathematical numerical statistical values are calculated which will act as source to differentiate one nodule to other nodule.

a. ***Entropy*** - Measures the randomness of a gray-level distribution. The Entropy is expected to be high if the gray levels are distributed randomly throughout the image.It is given by

$$E=-\sum_{i}^{m}\sum_{j}^{n}P[i,j]\log P[i,j]$$

b. ***Mean*** - Provides the mean of the gray levels in the image. The Mean is expected to be large if the sum of the gray levels of the image is high. It is given by -

$$\mu=\frac{1}{N\times M}\sum_{i=0}^{M}\sum_{j=0}^{N}P(i,j)$$

c. ***Variance*** - Variance tells us, how spread out the distribution of gray levels is. The Variance is expected to be large if the gray levels of the image are spread out greatly. It is given by

$$\sigma^2=\frac{1}{M\times N}\sum_{i=0}^{M-1}\sum_{j=0}^{N-1}(p(i,j)-\mu)^2$$

d. ***Standard Deviation***- Standard Deviation shows much 'variation' or 'dispersion' exists from the average.

$\delta=\sqrt{\sigma^2}$

RESULT AND DISCUSSION:

Chest radiographs has always played an important role in differential diagnosis and determining the extent of disease.X-ray plays a very important role in the society where people cannot afford expensive detection test such as CT-scan, MRI scan, PET scan. Therefore, X-ray is the only medium by which the radiologist can detect/suspect whether the patient is having a nodule in the lung. Further testing will classify this nodule as benign or malignant.Detecting lung nodule from X-ray image is very difficult task for radiologist. Therefore in this paper, it is tried to provide as many information as possible in the form of features using digital image processing on X-ray image. Images obtained from public JSRT database and the images collected from nearby local hospitals are used for testing

purpose. These images are scanned with high resolution scanner and stored in bitmap format (800 × 1200, 8-bit). By using median filter, salt and pepper noise is removed. Pre-processing technique is applied to enhance the image quality.The algorithm which is followed in the present study is explained in section II and III with the help of block diagram and images. For determining/classifying the suspicious area of the lung (nodule), features are calculated from their formulas as given in section IV. It may help the doctor to classify the lung nodule as malignant or non-malignant. If the malignant nodule is detected in its earlier stage, then the chance of surviving the patient increases. This method is less costly and this method will provide the second opinion to the doctor before conformation of cancer by clinical method (pathological and surgical). The proposed system will not replace the doctor's role in detection of cancer but it will help doctor to take correct decision in short time with accuracy. For implementing the algorithm Digital Image Processing and GUI toolbox in MATLAB software is used. All the images are randomly pickup from the database. Images which are used are of different age group, different sex and the location of lung nodule is also different. Following images Fig.4 (a) and Fig.4 (b) are taken from lung cancer database which are certified for malignancy and benign by radiologist.

Fig.4 (a) benign image Fig.4 (b) malignant image

The features which are calculated for the images fig.4 (a) and fig.4 (b)are listed in a table 1.

Table.1 parameter comparison table for malignant and benign lung cancer cases

PARAMETER	BENIGN	MALIGNANT
Area	2071	720
Perimeter	257.78	125.09
Irregularity index	0.391	0.579
Mean	0.549	0.191
Variance	1.34	4.69
Standard deviation	1.16	6.85
Entropy	0.022	0.0089
Eccentricity	0.933	0.767
Equivalent Diameter	51.33	30.31

CONCLUSION:

In benign nodule, area and perimeter value are large as compare to malignant nodule. But the irregularity index for benign is less. For benign nodule, mean value is higher as compared to malignant nodule but the value of variance and standard deviation is higher in case of malignant nodule. Entropy value is higher for benign nodule. Eccentricity and equivalent diameter show higher value in benign nodule. This information can also serve as an input to a system that allows automatic classification of lung nodule.

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