COMPUTER ASSISTED LUNG NODULE DETECTION IN DIGITAL CHEST RADIOGRAPHS - A SURVEY

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Abstract - *This survey paper explains about the various methods for feature extraction and detection of pulmonary nodules in digital chest radiographs (CXR)s, as an early and accurate detection of the nodules could be saving lives. This survey focuses on various techniques which are used to spot and classify the lung nodules which in turn will assist the domain experts for better diagnosis. In most of the surveyed papers, four stages of works are carried out such as: (i) Image Acquisition (ii) Image Pre-processing (iii) Image Segmentation and (iv) Feature Extraction. Since the volume of the X-rays is very large, Computer Aided Detection/Diagnosis (CAD/x) has more advantages in addition to manual interpretation with respect to speed and accuracy. This paper aims at summarizing various methods that have been introduced by several authors over the years of research in this field.*

Key Words: **Lung, Solitary pulmonary nodule, Thresholding, Segmentation, Feature extraction.**

1. INTRODUCTION

Cancer is one of the deleterious diseases that a person can contract. It is extremely difficult to treat, and can take a toll on the psyche of the sufferer. The lung cancer is the major cause of the cancer related death in India [1]. The report says that India, with 18% of the worlds' population also has 32.0% of the global burden of COPDs. In India approximately 63,000 lung cancer cases are reported every year. Early diagnosis of lung cancer is the key to provide the best possible clinical treatment for patients. It can be diagnosed at an early stage by regular health screening. As an initial diagnostic tool for a variety of clinical conditions, Chest X- Ray (CXR) is the most commonly used radiological examination in health screening by far making up at least one third of all examinations in a typical radiology department [2], [3]. Radiologists define a lung nodule in chest x-ray radiographs as "solitary white nodule-like blob" [4], [5]. It is usually round or oval in shape. This definition contains two different descriptions, i.e. "white nodule-like blob" and "solitary". The "white nodule-like blob" has been represented by many texture features. Early researches about lung nodule detection used the difference of candidates' shape under various thresholds as the features to identify nodules from other candidates [6]–[8]. Present day research about lung nodule detection [9]–[13] added gradient features (including intensity and direction) and texture features to identify lung nodules from pre-detected candidates. Wei *et al* [9] extracted 210 texture features for lung nodule representation. Performing chest radiography is the primary step in the diagnosis of nodule, if a patient shows symptoms such as: long-term tobacco smoking, exposure to radon gas, asbestos, second-hand smoke, or other forms of air pollution and often caused by a combination of genetic factors that may suggest lung cancer. Because of its simplicity, it gives clear images of bones, is non-ionizing so aren't dangerous on developing fetuses and are cost effective. Despite its advantages, interpreting abnormalities in a CXR is difficult. Sometimes even radiologists can fail to detect nodules on CXR, because of its complexities like: 1) Nodule appearance in radio graphs varied in size which ranges from few millimeters to several centimeters. 2) Some nodules are slightly denser than the surrounding lung tissue (less visible). 3) Nodules can appear anywhere in the lung field, and can be obscured by ribs and structures below the diaphragm and heart (CXRs are projection images contains superimposed structures).

Amid various non-invasive medical imaging modalities such as CT scan, MRI and Ultrasound, X-ray is commonly used as initial diagnostic tool for detection of nodule. Computed tomography (CT) is another widely used radiological examination. CT scan is not feasible due to its high cost and high dose. However, MRI is more expensive than x-ray and is less detailed than x-ray. The CXR has low noise when compared to CT and MRI images. Nodules are found in 1 out of every 4 CXRs. Most nodules (more than 90%) are benign and not cancerous which are caused by previous infections or old surgery scars. Characteristics of nodule: Most nodules that exceed 3 cm in diameter are malignant. Nodules below 1 cm are less likely to be cancerous although in some cases, there is a risk of malignancy if the person is a smoker. A nodule that is rough (spiculated irregular margin with lines) is more likely to be cancerous. Malignant lesions are usually partly solid whereas benign tumors are generally solid. Calcified nodules are less likely to be cancerous.

1.1 DIFFERENT STAGES IN DETECTION OF LUNG NODULES ON CXRs

1. Image Acquisition:

The CXRs are acquired from the digital X-ray machines, with the main advantage being better clarity, low noise and distortion.

2. Image Preprocessing:

Image pre-processing is a way to improve the quality of image and remove the irrelevant information, so that the consequential image is better than the original one. Contrast, brightness and intensity problem are removed by using contrast stretching, histogram equalization, negativity and power law transformation etc. Using modified thresholding, labeling algorithm and edge detection, segmentation of the lung nodule X-ray image is carried out. Features such as geometrical, textural and mathematical properties are used as input to the Computer Aided Diagnostic (CAD) system. Present CAD system will not reduce the role of radiologist but it will provide a second opinion. The result of this system along with the analysis of the diagnostician will increase the accuracy of the diagnosis.

Various types of selective enhancement filters are used to enhance blob like structures and to suppress vessel like structures by [14] [15] [16] [17] and [18] recommended a selective enhancement filter to enhance dot like objects and to repress lung vessels. Cylindrical and spherical filters were combined for a better visualization of nodules by [19]. The Laplacian of Guassian (LoG) filter is preferred in enhancing blob like structures whose intensity is differs from that of background. [20] used LoG filters to enhance the input image. [21] and [22] recommended LoG filter for enhancement. Median filter: Median filter was used by [23] and [24] to remove the noise from the image. The advantage of this filter is that it doesn't distort the edges.

3. Image segmentation:

Image segmentation (division of an image into its constituent region or object) is an important process that is required to perform eventual tasks for image analysis. The goal of segmentation is to make simpler or change the representation of an image into more meaningful and easier to analyze. The segmentation algorithms either partition an image based on abrupt change in intensity, such as edges, or partitioning an image into regions that are similar according to a set of pre-defined criteria. Hence segmentation is based on the two basic properties of intensity values: discontinuity and similarity.

4. Feature Extraction:

In the present study, image feature extraction is very important stage of computer based system. This extraction provides certain parameters, on the basis of which computer system takes decision. The entire feature which are calculated from the image, convey information regarding lung nodule. In this literature, the features extracted from the X-ray image can be used as diagnostics indicators: Area, Perimeter, Irregularity index, Equivalent diameter, Gray-level Co-occurrence Matrix properties, Solidity, Contrast.

Frequently used methods and some of the earlier studies for detection of lung nodules are:

A. Pixel Based White Nodule-Likeness Map Extraction:

1) Stationary Wavelet Transform,

2) Convergence-Index Filter,

3) AdaBoost Based White Nodule-Likeness Extraction.

B. Solitary Degree Based Lung Nodule Blob Ranking:

1) Lung Nodule Blob Detection,

2) Solitary Degree Based Blob Ranking,

3) SVM Based Blob Classification.

C. A feature-based classification approach to nodule detection has shown promising results in preliminary studies. A segmentation algorithm is applied to generate candidate nodules, and then features are calculated and used to classify each candidate as nodule or non-nodule (usually a broncho-vascular structure). Most features relate to size and shape on the premise that nodules are of greater diameter and tend to be spherical, while vessels are tubular. Giger et al have used multiple gray-level thresholds for extracting nodules, and then found 2-D geometric features such as perimeter, compactness and circularity for every nodule at each threshold. A rule-based approach was used to assign a confidence rating, in the range 1–5, to each 2-D candidate, with 1 being definite vessel and 5 being definitely nodule. Confidence ratings were altered based on ratings of the nodule in adjacent slices. Armato et al. included some 3-D features such as sphericity, and gray-level features such as mean and standard deviation, to classify nodules using a linear discriminant analysis. Kanazawa et al. segmented candidates by using fuzzy clustering to partition the histogram of pixels within the lung fields into two classes: “air part” and “blood vessels and tumors.” They then used similar features in a heuristic, rule-based approach to classify nodules and vessels.

2. LITERATURE SURVEY

The following section elaborates on some of the papers presented in the literature.

Xuechen Li et al [27] proposed an automated method for detecting lung nodules in chest x-ray radiographs using JSRT [67] database. Method shows three steps which employ stationary wavelet transform and convergence index filter to extract the texture feature using Multi resolution method and further used Adaboost to produce white nodule-likeness map using Laplace of Gaussian (LoG) blob detection method. From reported studies of JSRT gives 78% for false positive of 2 and 90% for false positive of 4 above results BJH method showed 80% for false positive of 2 and 93% for false positive 0f 5. Comparing with the best previously reported study, the proposed method obtained equal sensitivity when the FPs is two and much higher sensitivity when FPS is 5 along with a good lung nodule sensitivity.

M. Mercy Theresa et al [29] proposed to detect lung nodules in chest radiography for finding and mapping the presence of small nodules using JSRT database. The proposed approach involves 4 stages: Stage 1-Image registration using geometrical transformation method, is performed to correct the GT for the input images. This provides errorless diagnosis. Stage 2- Lung segmentation using thresholding method. Lung region is segmented from x-ray image by conducting thresholding and other reconstruction processes. Stage 3-Feature extraction using CWT and Shearlet transform methods used to extract the feature and then classified as normal & abnormal random forest classification method. Stage 4- Image classification using random forest and classification. RFC has many trees where each tree grown using some form of randomization. All the trees considered are binary tree and in top down structure. Images are tested and classified based on proposed algorithm.

Cesar Supanta et al [36] extracted the feature and detected pulmonary nodules in CXRs of JSRT [67] database. This approach involves 4 steps :A) Pre-processing- By comparing original image with correlated image, the changes in the image will make impact on processing and are performed by the gamma correction and re-quantization. B) Lung segmentation performed using OTSU method and projection analysis. C) Identification of pulmonary nodules, are made in the region of interest using convergence and ring filter. D) Extraction of feature-Image obtained from the convergence filter is analyzed for differentiating the nodule from noise and minimize false positive and extracting characteristics. The reported performance indices are: sensitivity (91%), precision (94%) and specificity (96%).

Haoyan Guo et al [40] proposed an optimal feature subset used for detecting lung nodules. The two main methods for feature involves: filter and wrapper. Filter is performed before the classification task. The selection of attributes is independent of learning algorithm in filter approach while it is dependent in wrapper approach. Multilevel optimal feature selection (MOFS) eliminates the redundant and irrelevant features from the candidate features. It reduces the computation time. Evaluation is done using bagging construction by reduced features. This model consists of three major steps: 1. Selection of initial nodule candidates which includes 198 RoI’s (6464 pixels) taken from a private collection. 2. Extraction of morphological features based on wavelet snake model. 3. Reduction of false positives based on combination of features by artificial neural network and then detecting nodules. This paper establishes the accuracy of the ensemble using a MOFS method over a single CAD system.

Vinod Kumar et al [46] proposed a method for diagnosing the X-Ray image using statistical features. This method uses filters, segmentation, threshold and edge detection approaches. This is classified into 5 stages. First stage is Image segmentation to group the similar characteristic image parts using thresholding. Second stage is median filter used for noise reduction and also replaces the worth of a pixel by the median of the intensity level within the surrounding of that pixel. Third stage is edge detection. This technique reduces the irrelevant information which will be used for further processing. Fourth stage is Region of Interest. This outlines the boundaries and also limits the cancerous cells during detection process. Finally the detection is done with the statistical features which include: energy, entropy, mean, variance, standard deviation, skewness and kurtosis. The result shows that the skewness is high which means feel of respiratory organ becomes symmetry before the energy increases and in turn entropy decreases. The quality of the gray level pixels within the X-Ray image increase gray level. The tissue of respiratory organ becomes lumpy which makes detection easier.

Zaw Zawhtike et al. [43] performed a three layer work to detect nodule in chest X-ray. Images were collected from JSRT [67] database. The first layer executes pre-processing of CXRs by Laplacian filter followed by second layer extract texture feature based on gray-level co-occurrence matrix. Third layer checks whether image contains nodules or not using rotation forest technique. Detection of nodule is done with the help of 44 dimensional GLCM texture feature and rotation forest. The author reports an accuracy of 75.6% in detecting the nodule.

B. Nemade et al [48] proposes an advanced computerized scheme for detection of lung nodules, incorporating the CAD scheme on VDE images. The proposed method involves the following steps: A) the images collected were in the form of DICOM images. B) The images were enhanced using histogram equalization in order to obtain the images with better contrast. C) The feature was extracted on considering the Region of Interest. D) With the help of Support Vector Machine classifiers the nodules were classified as benign, or malignant. Due to the effective classification, the false positives in detecting the nodules were found to be reduced. Since this method is cost effective, it can be used as primary tool in detecting the lung nodules.

Arnold M.R Schilham et al [51] proposed the method of Multiscale nodule detection in chest radiographs. The objective of this paper in the chest radiographs used computer algorithm to detect nodule as taken into account of wide size range of lung nodule with the help of multiscale image processing technique on JSRT CXRs. This method consists of following stages are: 1.The CXRs are subsampled to 1024X1024 pixels. 2. Segmentation of lung nodule, extracted with an active shape model. 3. The preprocessing stage of blob detector, in which contrast image is locally enhanced with local normalization filter (LN). 4. To find blob in lung field in the LN image by using Lindeberg’s multiscale blob detector method. 5. Based on feature with simple classification that result blob detector in which number of nodule are reduced.6. After this, finally a selected set of feature to find the probability that a candidate shows nodule with the help of K nearest neighbor (KNN) classifier from this complete JSRT database shows that as average of 2 false positive per image, but gives 50.6% of all nodules are detected, with some more false positive increased to 10 gives 69.5%.

Changmiao Wang et al [53] propose using deep feature fusion method from the non-medical training and hand crafted feature in order to reduce false positive value. Based on performing public dataset, this method can obtain a result in terms of sensitivity and specificity (69.3% & 96.2%) then false positive per image at 1.19. But in case of hand crafted features (62% & 95.4%), this reduce false positive per image at 1.45 on made use of machine learning. Deep fusion feature method improves current CAD scheme and more effectively detect the presence of lung nodule.

Haoyan Guo et al [60], proposes a practical feature selection approach that is based on an optimal feature subset of a single CAD system, which is referred to as a multilevel optimal feature selection method (MOFS). CAD systems consist of three major phases: 1) initial nodule candidate selection from lung nodule-enhanced images,2) extraction of features from these nodule candidates and nodule feature subset selection, and 3) discrimination of nodules from false positives based on these feature. Thus, the different optimal feature subsets are selected in order to eliminate features that are irrelevant and obtain optimal features. And also it is seen that the accuracy and sensitivity obtained is high.

S. Savithri et al [28] proposed three methods to detect the nodule region from PA chest radiograph images which employs JSRT [67] database. Method 1 extracts the nodule region from PA chest radiographic image and detects geometrical features for nodule region. This Method involves: preprocessing, lung field segmentation and nodule extraction. Lung region is segmented from the original image. Based on the region growing, thresholding and morphological operations are applied to extract nodule region from the image. Method 2 involves enhancement and segmentation, thresholding and nodule detection (multiscale blob detection, thresholding method) SVM classifier and features used for classification. This method automatically detects nodule regions and is capable of reducing false positives using thresholding and nodule detection using SVM classifiers. Method 3 involves enhancement and segmentation, lung patch feature extraction and classifications. It is mainly used to find nodules including subtle and more subtle nodules using restricted Boltzmann machine and SVM classifier.

Paola Campadelli et al[37] proposed an automated system processing digital PA Chest radiographs by segmenting the lung field area using JSRT database. This approach involves following steps: A) Segmentation of the lung. B) Enhancing the nodules of various size and contrast characteristics. C) Extracting the nodule candidates, based on different characteristics of the nodule. D) Classification of the nodules is done using SVM(support vector machine).Tests are performed on 2 different data sets which are 36 feature data set and 9/1 trained /test ratio and 36 features data set and 7/3 train/test ratio. These 2 data sets were compared by employing guassian and polynomial SVMs trained with different parameters results were reported.

Paola Campadelli et al [47] described a method for lung field segmentation and extraction of nodule candidate regions in Postero Anterior chest radiograph and data was extracted from JSRT database. This method consists of three steps. First step, two different edge detection techniques are used: 1) based on application of first derivatives of Gaussian filters.

2) application of Laplacian of Gaussian operator at three different scales. Second step includes multiscale approach and convolution of gaussian filter to enhance, increase brightness and to produce smooth version of the image. Third step is to extract the nodule candidates based on shape, size, and characteristics by combining set of binary images. Applying statistical features, simple thresholding rules and gray level distribution it was found easy to discard about 20000 false positives without the loss of any true positives. They obtained a sensitivity of 0.96 and total number of candidates equal to 12000.

Jyh-Shyan Lin et al [35] proposed hybrid neural-digital computer-aided diagnosis (N-CADx) system is introduced to detect lung nodule by using digital image processing techniques. Database used for testing consists of 42 chest radiographs. This system consists of following stages: 1. Image processing technique (subtraction) is used to amplify the nodules. 2. contour searching algorithm is applied to locate SNA's(suspected nodule areas) PA CXR's of size 2048X2048X10 bits are used for Acquisition, Enhancement, Extraction , Pre-processing of SNA's. 3. CNN (convolution neural network) nodule classifier is used to classify and spot the malignant nodules among detected SNA's from the images. From the 42 CXR's 575 SNA's are detected which contains 117 nodules (52 true nodules, 65 false nodules).Results are examined using receiver operating characteristics (ROC) method.

Ryoichi Nagata et al[41] introduced an automated lung nodule detection in CXRs of JSRT[67] database. This approach consists of two steps. 1. Detection of initial nodule candidates by an active shape model-based scheme (ASM). 2. Classification of detected candidates into nodules and false positives uses multilayer artificial neural networks trained by back propagation. It classifies nodule candidate locations using a two- stage classification method: First stage classifier uses Gaussian filter with standard deviation and average radial gradient (ARG). Second stage classifier consists of a template matching technique for detecting nodule candidate locations. This proposed scheme gave results of 6.6, 64.1, 69.7% and time taken is 8.2 seconds per image on an average of 40 datasets using 3.3GHz Intel PC.

Kavita et al [50] proposed the method of developing CAD scheme is to detect lung nodule by using VDE (virtual dual energy) here ribs and clavicals are suppressed by SVM (support vector machine). This system consists of five different stages are follows as: A) Segmentation of lung nodule and creation of VDE, utilizing by morphological operation method. B) Detection of candidate nodule on VDE image with the help of gradient edge detection method. C) Nodule segmentation on original candidate image and VDE image using method of Otsu's. D) Feature extraction from VDE by using boundary box algorithm and GLCM (gray level co-occurrence).then finally, classification of candidate nodule by using ANN (artificial neural network) after gives output. For dual energy, two X-ray images were merged together to form single energy level known as virtual dual energy. Compared to other result, this technique is very promising. The detected geometrical features are mainly as area and perimeter.

Amin Zarshenas et al [57] developed a deep-training scheme to separate ribs and clavicles from soft tissue in chest radiographs. A mixture of anatomy-specific to separate bony structures from soft tissues, orientation-frequency-specific to decompose bone and soft tissue structures and deep neural network convolution (NNC) was developed for detection of lung nodules in chest radiographs.

Ryoichi Nagata et al [32] proposed improved scheme for initial nodule candidate detection and false positive reduction using template matching on CXRs of JSRT database. There are 2 methods: 1) Initial candidate detection involves 3 steps: A) A method to produce a nodule enhanced image. B) Location of ROIs on a nodule enhanced image. C) Detection of initial nodule candidates within each ROI (region of interest). 2) False positive reduction using template matching involves 5 steps: A) Similarity value between a template and a test candidate. B) Modeling of non-nodule templates. C) Modeling of nodule templates. D) Elimination of nodule like non nodules from the set of non-nodule templates. E) Classification of nodule candidates. The proposed scheme examined the performance of 96% with 136.5 false positives per image.

Eman Kumar Dey et al [31] proposed semi-automated system which detects lung mass tissue from chest x-ray using 924 digitized grey scale images. Techniques such as image processing, template matching etc. are adopted. This approach consists of 2 stages. In the First stage, it uses pre-processing method to identify the set of nodules .In the second stage, classification of detected regions using pattern recognition technique (combination of feature extraction process and classification process). False positives are eliminated by using rule based technique and statistical approach. They extracted two ROI (region of interest), one from position where the nodule is located, another from corresponding location in the opposite lung. Matching of 2 ROI's are performed by applying a wavelet based multi resolution image registration. This reduces 44% of false positives. The overall accuracy and precision of this work is 76.12% and 76.16% respectively.

Mickias Assefa et al [63] proposes the method of detecting lung nodule using multi-resolution analysis, This work aims to develop a CAD system to detect pulmonary lung nodules from Low Dose CT (LDCT) scan images using template matching algorithm integrated with multi-resolution feature analysis technique in order to enhance the false positive detection rate. 134 out of 165 nodules were correctly detected by this scheme. That results in a detection rate of 81.212%.

Amal M. Al Gindi et.al [52], proposes multi-scale wavelet transform for the comparison of four different wavelet families, which notices the characteristics of malignant and benign nodules. JSRT database containing 247 chest x-ray images are used for testing and evaluating CAD scheme involves image enhancement techniques by applying high frequency emphasis filter. By comparing the result of four wavelets through their ROI's, classification of lung nodule is made.

Chen Bao et al[30] presented a parameterized logarithmic image processing (PLIP) method based on Laplacian of Gaussian(LOG) filtering to amplify lung nodules in Chest X-rays using JSRT [67] database. The method introduced involves 3 steps: 1) LOG arithmetic and PLIP model is performed to soften the image and minimize the effect of noise. 2) PLIP model based on LOG filtering, this performs filtration and gives clarity edge enhanced image in CXR with high constraint.3) Enhancement of entropy (EMEE), used to examine image enhancement quality of nodules. The comparison is made between the enhanced images with the original images and also with the images obtained from the other approaches, thus examined the performance.

Maher Rajab et al. [44] worked on concepts of enhancement of radiographic images with lung nodule. There are two main phases: first phase consists of two steps in which DICOM images were reduced. The selection of ROI including lung lesions was done. The second phase involves the enhancement of lung lesions in the selected ROI using Frequency Domain Filtering. The noise reduction was also carried out in this phase. Thus, emphasis high pass frequency filters was applied to enhance images. These enhanced images were judged by the radiologists. The lung lesions characteristics were further identified.

Xuechen Li et al [54] proposed a method of machine learning were used to detect the lung nodule in chest radiographs. The thesis consist of three major steps are: 1) in first stage, for lung field segmentation by using SSM (statistical shape model) and SAM (statistical appearance model) method. 2) In second stage, rib recognition and suppression by using machine learning method.3) in third stage, adaboost and Laplace of Gaussian filter were used to detect the nodule candidate. As a result obtained, more than 94% of nodule in the lung field in the JSRT database is detected, when false positive per image was 5.

Jun Wei et al [62] proposes a different method using effective filters for detecting lung nodule candidates on chest X-ray images. This filter evaluates the degree of convergence of gradient vectors in the neighborhood of the pixel of interest. The output of this filter does not depend on the contrast of the region of interest to its background. Three types of CI filter are investigated and their theoretical response characteristics for typical models are seen. The results show the effectiveness of the proposed filters. And also the performance seems to be better.

Jorge Novo et al [65] proposed the detection of 3D lung nodule candidate in multiple scales which uses a 3D median Hessian-based filtering to locate round shape structures. This approach signifies its accuracy in extraction of lung vesselness, gives clearer nodules than other approaches, providing less response in the presence of noise and provides a better continuity in vessels, mainly accountable for false positives. That way, they are distinguishable from the nodules appear in posterior analysis. Database gathered from the LIDC/IDRI image data set. The results are capable of locating most of the nodules and have less false positives than other approaches, enabling a posterior task for false positive removal.

Sheng Chen et al [33] developed a CAD scheme that involves 3 techniques for detecting lung nodules by using virtual dual energy CXRs and also used MTANNs for ribs and clavicles suppression. They operated on JSRT database. Techniques are: 1) Original computerized scheme for nodule detection, performs segmentation, nodule enhancement and detection and segmentation by using an algorithm (clustering watershed) and feature analysis and classification of nodules using SVM classifier. 2) Creation of VDE images, image processing techniques used for suppression of ribs and clavicles using MTANN technique. 3) CAD scheme combined with VDE technique used for minimization of false positives and detection of lung nodules. Sensitivity of the image of this scheme achieved 78.6% and 5 false positives per image.

Sridhar.R et al [49] proposed the method of Detection & Classification of Lung Nodules Using multi resolution MTANN in CXRs, with the following steps: A) Image processing technique named as virtual dual energy (VDE) radiography was used for suppressing the ribs and clavicles in CXRs with the help of multi resolution. B) Segmentation of the lungs is done using 1) Rule-based segmentation method, 2) Hybrid methods 3) Pixel-based methods, and 4) deformable model-based methods. C) By applying the gradient method, the VDE bone images were created. D) Enhancement of the lung nodules was done using two stage approaches. E) The feature was extracted and the analysis of the feature was done. It has been reported that the false positive results in detection of nodules were reduced. It is also seen that this method has low radiation dose. It is cost effective and can be used as initial diagnostic tool for detection of lung nodules.

Ryoichi Nagata et al [34] introduced C-sub scheme which uses rib cage boundary and global matching for nodule detection using JSRT database. Methods involved are : 1) Rib cage boundary detection, are done by rule based approach and supervised approach and performs edge pixels extraction, right and left ribcage boundary detection, lung top and lung bottom detection. 2) Lateral inclination correction, which performs rotation and horizontal shifting for proper alignment with the image. 3) Image warping, where shift values are determined for pixels in image. From this paper, ribcage boundaries are determined with accuracy 97.6% images and in fair accuracy for 1.6% images.

Sejin Park et al [38] worked on semi- supervised reinforced active learning, which is used to train a reward based active learning algorithm. CXR database consists of 931 images with pixel labels and 2986 images without labels, with the following stages: A) Pre-processing is performed to minimize the variance of intensity amongst the radiographs. B) Semi-supervised reinforced active learning, according to MDP (markov decision process) state space is considered as output of model. If state space is below negative threshold (normal case) or above the positive threshold (ROI will be considered as true nodule). The proposed model is divided into 2 phases. Comparison alone to test the improvement following active learning. This approach can effectively leverage performance of deep neural network and reduce label burden to 50% while maintaining performance.

Paola Campadelli et al [61] propose the method of detection and classification of lung nodule. Image processing techniques and Computer Aided Diagnosis (CAD) systems have proved to be effective for the improvement of diagnosis. A set of candidate regions were extracted by the system. By applying the different multi-scale schemes, the results obtained were observed to show the efficacy of their multi-scale framework. Learning systems using as input different sets of features have been experimented for candidates classification, showing that Support Vector Machines (SVMs) can be successfully applied for this task.

M.G Penedo et al [39] implemented an automatic lung nodule detector which uses first processing block for suspicious region. The private collection consists of image of size 560*560*8. The proposed approach involves two stages. Firstly, a knowledge-based segmentation which extracts lung boundaries, then a first level analysis which detect the suspected areas labeled as lung. Second level is applied to the detected suspicious region to distinguish true nodules from false nodules. Here, a new feature called curvature space is introduced. Classification uses a multilayer perceptron network made up of input layer, hidden layer, output layer. Input layer consists of 33*33 units as input patterns in curvature space. In the hidden layer the size is reduced to 12*12 units and 6*6 units. Output layer consists of 2 units Rprop and back propagation for classification of image as nodule and no-nodule. The results are obtained with a set of 23 chest images with at least one nodule showing sensitivity in the Global Selection Process of 93% with a mean number of two false positives per image. The results obtained are promising but needs larger dataset to make the proposed system better.

W. Ausawalaihong et al [42] proposed an automatic lung cancer prediction from chest x-rays. The data is collected from ImageNet, chest X-ray 14 (120 frontal images) and JSRT database. The proposed model provides a heatmap for identifying the location of the lung nodule by three steps. 1. Data preparation uses Histogram Equalization for increasing contrast, median filter for removing the noise from images, normalizing image colour based on mean and standard deviation. 2. CNN Architecture and transfer learning involves base model and retrained model A,B,C. 3.Class activation mappings is derived from model C to show the most salient location on the image. Results showed 74.43±6.01% of mean accuracy, 74.96±9.85% of mean specificity and 74.68±15.33% of mean sensitivity.

Sotiris N Raptis et al [56] described a method based on the extraction of the major geometrical and luminance characteristics that make nodule detection easier. They used the idea of pixels of interest was introduced. This makes the growing a finite steps and is realized gradually in a finite number of iteration. At each one of which a set of criteria is evaluated.

Vinod Kumar et al [66] presented a method for diagnosis of lung nodule accurately using x-ray images and also aim at detecting nodules. This approach uses modified watershed segmentation approach to separate lung portion and evaluates further for pixels of an affected nodule based on the parameters selection. This work is processed in three stages to attain the observational results: pre-processing, feature extraction and lung nodule identification.

Carlos S Pereira et al [45] proposed a multi classifier approach for the classification of lung nodule. This approach uses image region-based classification whose result is the presence/ absence of nodules in the image region. The X-Ray images were gathered from JSRT [67] database. There are three major methods adopted. 1) Filtering the image regions with the help of multi-scale filter bank. 2) Feature extraction and selecting the best discriminatory features. 3) Multiple Classifier approach; which further involves two main approaches. First is to consider features with discriminatory power and the secondly to classify the result efficiently. This is done based on different multiple layer perceptions (MLP) by collecting each different feature and combining them to produce final classification decision. Therefore, the obtained results were found to be helpful for the reduction of false positives in CAD system.

Xuechen Li et al [55] proposed a rib-suppression method based on principle component analysis (PCA) to improve the visibility of lung nodules. There are three stages. Firstly, it is building of rib model using PCA. Secondly, calculation of pixel intensity of background and adding to the subtracted image and brightness is recovered. Finally, border of the ribs is detected and is smoothened.

Tsuyoshi Kawaguchi et al [58] proposed a C-Sub scheme which uses global and a local registration method. This method enhances the nodules in a chest radiograph by subtracting its right/left reversed mirror image from the original image. The quality of the rib elimination and nodule detection in subtracted images were evaluated by a radiologist using a three-point rating.

Dana. H. Ballard et al [59] described a hierarchic computer procedure for the detection of nodular tumors in chest radiographs. It includes five major steps. 1) Finding the lung regions. 2) Finding the candidate nodule sites. 3) Finding the boundaries. 4) Finding nodules from the candidate nodule boundaries. 5) Finding tumors among the nodules.

Hiroyuki Yoshida et al [64] propose the method of Local Contralateral Subtraction Based on Bilateral Symmetry of Lung for Reduction of False Positives in Computerized Detection of Pulmonary Nodules. This method was oriented to the reduction of false positives reported by a computer-aided diagnosis (CAD) scheme for detection of lung nodules in chest radiographs. In this method, two regions of interest (ROIs) were extracted. A wavelet-based, multiresolution image registration method was employed for matching the two ROIs, and subtraction was performed. The output was obtained on the following basis: If no structure remains in the subtracted ROI, then the original ROI is identified as negative (i.e., it contains only normal structures); otherwise, it is regarded as positive (i.e., it contains a nodule). This method resulted to be effective and also the false positives were reduced.

3. CONCLUSION

Designing effective CAD systems for detection of lung nodules has been gaining its momentum as early detection increases the survival rate. In this paper a review of various approaches towards an automated detection of lung nodules, classifications are summarized. It is apparent from the review that the algorithms with multiple detection approaches provided the better results.

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