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A SURVEY OF LUNG CANCER DETECTION AND CLASSIFICATION USING CAD SYSTEM

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Abstract: The Computer-aided Diagnosis or Detection (CAD) approach for Lung Cancer detection and classification is a developing field of research. This article aims to provide a complete literature review and analysis of numerous publications. These articles are examined and précised in a number of different ways to contribute vital information regarding the methods for the progress of CAD systems. CAD systems help scan digital images, e.g. from Computed Tomography (CT), for typical appearances and to highlight obvious sections, such as focal areas of lung nodules.

Index Terms - Computer-aided diagnosis, Lung nodule, Computed Tomography.

I. *INTRODUCTION*

Cancer cell is an improper enlargement of cells and one of the day-to-day diseases in India which leads to death. It may take any forms and is very hard to detect during primal stages. Most newly diagnosed cases of cancer are lung malignancies. Lung cancer is the most prevalent cancer form that claims the lives of both men and women [1]. Getting a clear cut categorization from a biopsy image is inconvenient task as the medical specialist must know the detailed features of a normal and the affected cells. Manual recognition of cancerous cells from the microscopic biopsy images is time overwhelming and requires good expertise. When lung cancer is found by CT imaging at an early stage, the candidates' rate of survival can rise to 90% after ten years [2].

The survival rate for persons with lung cancer at 5 years after diagnosis is approximately 10% to 20% in the majority of countries among those diagnosed between 2010 and 2014, however it is higher in Japan (33%), Israel (27%), and the Republic of Korea (25%). The effectiveness of yearly low-dose CT screening in reducing lung cancer mortality has been proven by a large number of independent, international, randomized controlled clinical trials.

In order to identify and categorize different lesions in the context of diagnosing lung cancer, computer-aided diagnostic (CAD) systems are excellent resource. Such systems' main goals are to assist the radiologist during all phases of analysis and to provide a second opinion on his choices. The CAD system is a crucial piece of the technology used in medical radiography. The elements that radiologists find most useful for locating and diagnosing disease, however, are absent from many systems. By providing great sensitivity in diagnosis, the techniques outlined below will aid radiologists in performing better.

Performance-wise, deep learning-based CAD systems for classifying and identifying lung nodules result in acceptable results. But there are still several challenges and limitations, including over-fitting, a lack of interpretability, and a dearth of annotated data. Researchers and radiologists will have a better grasp of CAD technology for pulmonary nodule identification, segmentation, classification, and retrieval as a result of this review. By summarizing, we examine the challenges and offer suggestions for moving forward.

Lung Cancer Image

Benefits of CAD

1. **Saves time:** You can create better, more effective designs faster when you use computer-aided design software. It also saves you time.

2. Easy to edit: You might need to make changes while creating designs. Making adjustments will be considerably simpler when you utilize computer-aided design software since you can quickly correct mistakes and alter the drawings.

3. **Reduction in error %:** Because the CAD program uses some of the greatest tools, there is a large decrease in the percentage of errors that resulted from manual designing.

4. **Reduce design effort:** Because the program automates the majority of the task, there was a significant reduction in the amount of effort required to create the various models.

5. **Code reuse:** Because the entire process is completed with the aid of computer tools, the issue of labor duplication is eliminated. You can duplicate the various code and design components, which can then be reused repeatedly and endlessly.

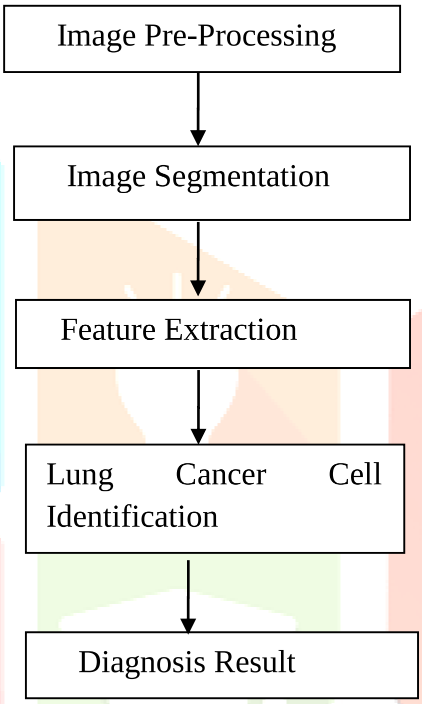
6. **Simple to share:** The CAD tools simplify the process of saving and storing files so you may use them again and distribute them without any unnecessary complications.

7. **Increased accuracy:** It goes without saying that using manual drawings would never yield the same level of accuracy that CAD software can. You have instruments at your disposal to gauge the designs' degree of correctness, skill, and precision.

II. Computer Aided Lung Cancer Diagnosis

The latest development in CT imaging technology vastly enhances scanning time & image resolution. With the progress of Multi-Detector Computed Tomography, more than 300 thin section images per thoracic CT examination may be obtained. This additional information assists the radiologists identify the abnormalities more precisely. Moreover, the pressure of this increasing workload inevitably falls on radiologist at the point of interpretation. The reported Computed Tomography interpretation error in routine radiology practice is 3% to 4% and even greater (30%) in studies involving abnormalities.

Steps to lungs diagnosis:



III. LITERATURE SURVEY

To predict lung cancer, different researchers have used various image processing approaches which are found in the literature. This section illustrates the research works present in the field of computer aided lung cancer diagnosis.

Efficient & effective means of technological lung cancer detection technique is presented in the research work in [3] Ravi et al. utilized a collection of CT scanned images corresponding to lungs as input that were originally attained from records of lung image then implemented techniques such as segmentation, feature extraction for processing of image.

A research work presented at [4], consists of two varieties of cancer images that is CT & MRI. Using Gabor filter, scan images are being improved & Canny filter is introduced due to its precision for detection of edge & ultimately segmentation of super pixel is done. Full phases of medical image processing are addressed.

Research in [5] resumed on lung tumor identification techniques, where Fast Fourier transform & Gabor filter techniques are compared but greater results are obtained by Gabor filter image enhancement method. Approaches like thresholding and Marker-Controlled Watershed Segmentation are analogized in the stage of image categorization. Around 4% greater results were produced by Watershed Segmentation method. Masking techniques & Binarization are matched for image feature extraction, but binarization method provides better results. Computer aided identification technique on the basis of hierarchical vector quantization scheme has been suggested by Sandhiya et al. [6] & it offers more precise segmentation compared to threshold method.

CT images are generally used for processing medical images, because of their low noise level and high resolution. Some other methods aim to forecast nodules of cancer through nodule candidate patches, ignoring explicit nodules detection [7]. An intermediate nodule detector is discovered by our system whose recognition are afterward fed as input for predicting the cancer.

Roy, Sirohi, and Patle [8] developed a system to detect lung cancer nodule using fuzzy interference system and active contour model. This system uses gray transformation for image contrast enhancement. Image binarization is performed before segmentation and resulted image is segmented using active contour model. Cancer classification is performed using fuzzy inference method. Features like area, mean, entropy, correlation, major axis length, minor axis length are extracted to train the classifier. Overall, accuracy of the system is 94.12%.

Ignatious and Joseph [9] developed a system using watershed segmentation. In pre processing it uses Gabor filter to enhance the image quality. It compares the accuracy with neural fuzzy model and region growing method. Accuracy of the proposed is 90.1% which is comparatively higher than the model with segmentation using neural fuzzy model and region growing method. The advantage of this model is that it uses marker controlled watershed segmentation which solves over segmentation problem. As a limitation it does not classify the cancer as benign or malignant and accuracy is high but still not satisfactory. Some changes and contribution in this model has probability of increasing the accuracy to satisfactory level.

Anam Tariq et.al. (2013) [10] has developed a computerized system, that was detected the lung nodules with the help of CT scan images. The computerized system consists of two stages, first one is lung segmentation and enhancement and second one is feature extraction and classification. For removing background and extracts the nodules from an image, the threshold segmentation technique was applied.

Gao et al. [11] proposed another threshold-based segmentation approach consisting of four processing steps: (i) removing the large airway from the lung region by using isotropic diffusion to smooth edges followed by region growing, (ii) finding an optimal threshold to remove pulmonary vessels, (iii) separating the left and the right lungs by the detection of anterior and posterior junctions using the largest threshold, and (iv) morphological smoothing of the lung boundary along the mediastinum and lung wall based on the structure of the airway tree.

In order to find different-sized lung nodules, Schilham [12] et al. (2006) suggested employing a k-nearest neighbor (k-NN) classifier to search the Gaussian scale space maxima in multi-scale utilizing images from the JSRT database.

According to Gajdhane [13] et al. (2014), CT scan pictures can be used to diagnose lung cancer utilizing a variety of image processing approaches. A total of three processes—pre-processing, feature extraction and classification were mostly used throughout the report.

By employing another ANN to select only true findings, Penedo et al. (1998) introduced a neural network-based method for nodule enhancement [14]. The results were displayed on a moderately sized, private database that was extended by simulated nodules.

Using a fuzzy interference system and an active contour model, Sirohi, Patle, and others [15] created a system to identify lung cancer nodules. This technique enhances visual contrast by using gray transformation. Prior to segmentation, an image is binarized, and the resulting picture is then segmented using an active contour model.

Ye et al. [16] used 3D adaptive fuzzy thresholding to segment the lung region from CT data. The segmentation was followed by smoothing the segmented lung contour, represented as chain code [17], by 1D Gaussian smoothing. They further applied a methodology to detect the lung nodules in the segmented lung fields.

Sharma et al. (2011) presented an automatic computer aided diagnosis system for the detection of lung cancer by evaluating this lung CT scans [18], which were taken from the NIH/NCI Lung Database Consortium. For the purpose of detecting lung cancer, the paper's authors employed a number of procedures. First, they used a variety of image processing techniques, including bit image slicing, erosion, and wiener filter, to extract the lung region from the computer tomography image.

Using eight texture features that were taken from the histogram and the gray levsel concurrence matrix, Madero Orczco et al. (2013) suggested an SVM-based technique to identify images with or without nodules without taking the segmentation stage into account [19].

Further training of the users may be crucial, as Hoop et al. (2010) caution, as they frequently struggle to distinguish between the machine's accurate and inaccurate conclusions [20].

In order to diagnose lung cancer using CT scan pictures, Jaber et al. (2014) proposed an automatic computer-aided diagnostic (CAD) method that entails three processes [21], including thresholding the CT image by segmentation, labeling the founded regions, and regions are extracted for further analysis.

A combination of Bayesian classification and a Hopfield Neural Network (HNN) has been proposed by FatmaTaher [22] et al. (2012) to extract and segment sputum cells for the purpose of diagnosing lung cancer. It was found that the HNN segmentation algorithm performs better than the Fuzzy CMean clustering, allowing the successful extraction of nuclei and cytoplasm areas.

The objective of Chaudhary [23] et al. (2012) was to improve results through the use of various augmentation and segmentation strategies. The processes for processing images, including segmentation, feature extraction, and image pre-processing, were carried out.

A system was created by Ignatious and Joseph [24] employing watershed segmentation. The Gabor filter is used during pre-processing to improve the image quality. It contrasts the accuracy of the region-growing approach and the neural fuzzy model.

In order to find different-sized lung nodules, Schilham [25] et al. (2006) suggested employing a k-nearest neighbor (k-NN) classifier to search the Gaussian scale space maxima in multi-scale utilizing images from the JSRT database.

According to Gajdhane [26] et al. (2014), CT scan pictures can be used to diagnose lung cancer utilizing a variety of image processing approaches. A total of three processes—pre-processing, feature extraction and classification were mostly used throughout the report.

In order to make images with nodules enhanced and images with nodules repressed, Giger [27] et al.(1990) presented a different picture approach. They discovered that the suggested procedure completely gets rid of the shadow of the nodule-like items. They used numerous geometrical features to filter out misleading findings and less effective classification techniques.

By employing another ANN to select only true findings, Penedo et al. (1998) introduced a neural network-based method for nodule enhancement [28]. The results were displayed on a moderately sized, private database that was extended by simulated nodules.

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The use of several image processing and data mining approaches, Prashant Naresh et al. (2014) were able to predict lung cancer in its early stages [30]. He was given the suggestion to use an automated approach for diagnosing lung cancer.

Sharma et al. (2011) presented an automatic computer aided diagnosis system for the detection of lung cancer by evaluating this lung CT scans [31], which were taken from the NIH/NCI Lung Database Consortium. For the purpose of detecting lung cancer, the paper's authors employed a number of procedures. First, they used a variety of image processing techniques, including bit image slicing, erosion, and wiener filter, to extract the lung region from the computer tomography image.

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A system was created by Ignatious and Joseph [37] employing watershed segmentation. The Gabor filter is used during pre-processing to improve the image quality. It contrasts the accuracy of the region-growing approach and the neural fuzzy model.

Sofka et al. [38] aligned a shape model using a set of automatically detected anatomical landmarks and refined the shape model through an iterative surface deformation approach in order to segment lungs that involve pathologies. The main limitation of the shape based segmentation techniques is that their accuracy depends strongly on how accurately the prior shape model is registered with respect to the CT image.

Computed Tomography (CT) is considered as one of the best methods to diagnose the pulmonary nodules [39]. It uses x-rays to obtain structural and functional information about the human body. To prevent the human body from all kind of risk, radiologists are obliged to reduce the radiation dose, which affects the quality of image and is responsible for noises in lung CT images.

S.No	Author	Year	Types Of Images	Technique	Accuracy
1	Disha Sharma et al.[40]	2011	CT Image	Diagnostic Indicators	80%
2	Anam Tariq et al.[41]	2013	CT Image	Neuro-Fuzzy	95%
3	Magesh, B et al. [42]	2011	CT Image	Median Filter	90%
4	Yang Liu et al.[43]	2020	CT Image	SVM(GRBF kernel type)	87.82%
5	S.K VijaiAnand et al.[44]	2010	CT Image	Back propagation network Classification	86.30%
6	Suren Makaju et al [45]	2018	LIDC – IDRI	SVM	92%
7	Md.Badrul Alam Miah et. Al [46]	2015	CT Image	Image Acquisition	96.67%
8	Emre Dandi [47]	2018	CT Image	Probabilistic Neural Network (PNN)	91%
9	T. Manikandan et. Al [48]	2016	CT Image	SVM	93%
10	Pranjal Sahu et Al [49]	2019	LIDC-IDRI	Multi section CNN	95.61
11	Guanghui Han et Al [50]	2018	LIDC-IDRI	CNN	82.51
12	Xinzhuo Zhao et al.[51]	2018	LIDC-IDRI	Convolutional Neural Network	82.23

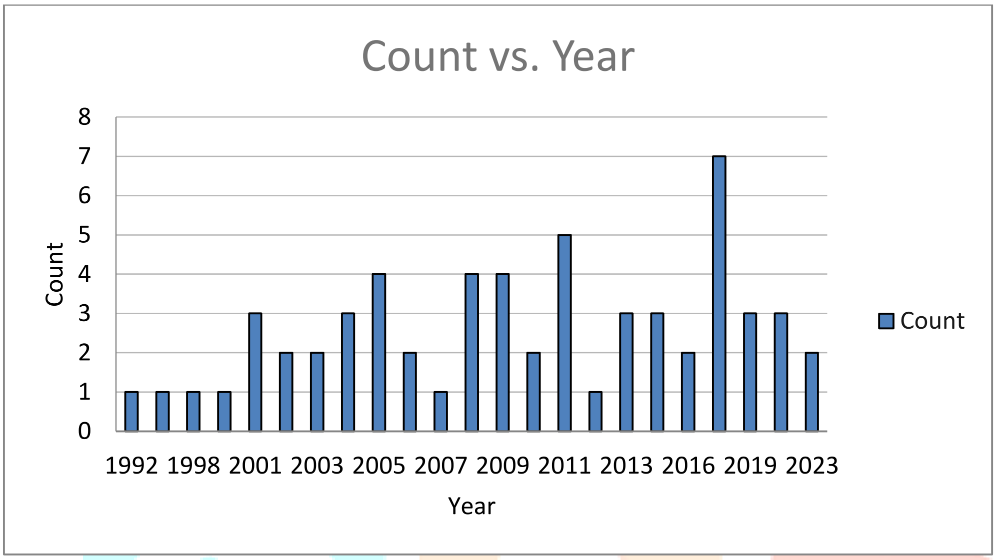
13	Anum Masood et al.[52]	2018	LIDC-IDRI	Deep Fully Convolution neural network.	75.23
14	Issa Ali et al.[53]	2018	LUNA	Deep reinforcement learning model	64.4
15	Hongsheng Jin et al [54]	2018	LIDC/IDRI	Residual Learning	98.30%
16	Qi Dou et al. [55]	2016	LIDC/IDRI	3 D CNN	90%
17	Genlang Chen et Al [56]	2019	LIDC/IDRI	3D Filtration	90.1
18	Hongyang Jiang et al. [57]	2019	LIDC/IDRI	CNN	80.06%
19	Giger et al.[58]	1994	CT Image	Comparison of geometric features	94%
20	Suzuki et al.[59]	2003	LDCT	Multiple MTANNs	84%
21	Kanazawa et al.[60]	1998	CT Image	Rule based scheme	90%
22	Gurcan et al.[61]	2002	CT Image	Rule-based scheme and LDA	84%
23	Armato et al[62].	2001	CT Image	Rule-based scheme and LDA	70%
24	Wiemker et al[63].	2002	HRCT	NA	86%
25	Lee et al.[64]	2001	CT Image	Rule-based scheme and LDA	72%
26	Brown et al[65]	2001	CT Image	Fuzzy matching	86%
27	Mekada et al. [66]	2003	CT Image	Rule-based	71%
28	Ge et al. [67]	2005	CT Image	LDA withWilks' lambda	80%
29	Arimura et al. [68]	2004	LDCT scans	Rule-based	83%
30	Farag et al.[69]	2005	LDCT scans	Template modeling approach using LS	93%
31	Aggarwal, Furquan and Kalra[70]	2015	CT Image	LDA	84%
32	Paik et al. [71]	2004	CT Image	Rule-based	90%
33	Mendonca et al.[72]	2005	CT Image	Rule-based	67.50%
34	Golosio et al. [73]	2009	CT Image	Fixed-topology ANN	79%
35	Matsumoto et al.[74]	2006	CT Image	LDA	90%
36	Ye et al. [75]	2009	CT Image	Rule-based	90.20%
37	Yuan et al. [76]	2006	CT Image	R2 Technology	73%
38	Retico et al. [77]	2008	CT Image	Voxel-based neural	80–85%
39	Pu et al. [78]	2008	CT Image	Scoring method	81.50%

40	Murphy et al. [79]	2009	CT Image	KNN	80%
41	Riccardi et al.[80]	2011	CT Image	SVM	71%
42	Tan et al. [81]	2011	CT Image	Genetic algorithm	87.50%
43	Messay et al[82]	2010	CT Image	LDA	83%
44	Farag et al[83]	2011	CT Image	speed up robust feature (SURF)	96%
45	McNitt-Grayet al. [84]	1999	HRCT scans	LDA	90.30%
46	Matsuki et al.[85]	2020	CT Image	CAD System	70.30%
47	Aoyama et al [86]	2004	CT Image	gray-level thresholding technique	80.30%
48	Nakamura al. [87]	2005	CT Image	fluorescencein situhybridization	87.10%
49	Iwano et al.[88]	2009	CT Image	CAD System	96.30%
50	R. Indumathi al [89]	2023	CT Image	CAD System	97%
51	Mori et al [90]	2023	CT Image	Mediastinoscopy	82.50%
52	Suzuki et al.[91]	1992	x- ray images	image processing techniques	73.3 %
53	Lee et al.[92]	2020	CT Image	DLAD	62%
54	El-Baz et al [93]	2008	LDCT images	CAD System	93.30%
55	Falk et al [94]	2007	LDCT images	CAD System	95%
56	Aparna Kanakatte [95]	2008	PET	k-NN, SVM	97%
57	S.Sivakumar [96]	2013	CT Image	SVM(RBF kernel type)	80.36%
58	Hiram Madero Orozco [97]	2015	CT Image	SVM	84%
59	Fatma Taher [98]	2012	Sputum	Bayesian	88.62%
60	Kesav Kancherla [99]	2013	Sputum	Random forest(bagging)	87%

DISCUSSION AND COMPARISION

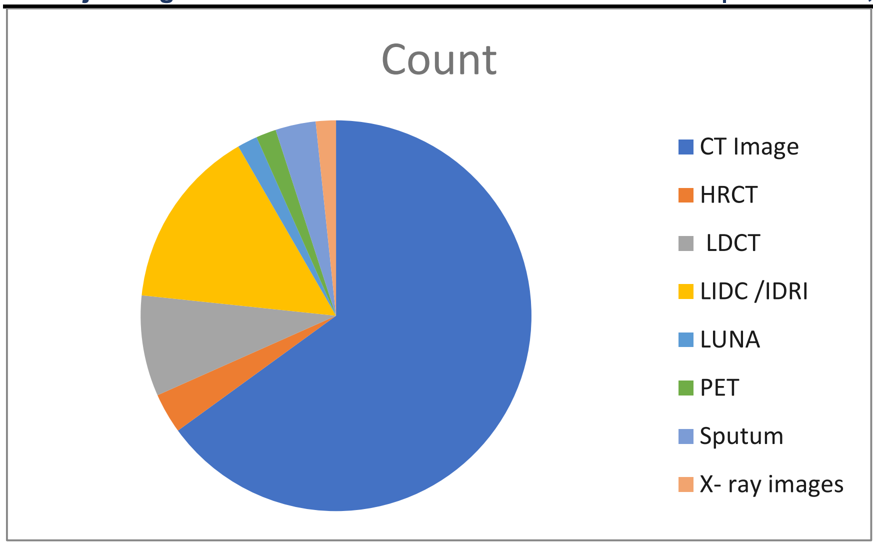
This proposed work aims to analyze research papers published in the timeline of 1992 to 2023.

We found 250 papers based on CAD system. From that we selected 150 papers and finally we analyzed 100 papers for this research.



In literature different types of Image data-set is used. Among them CT image HRCT, LIDC/IDRI, LUNA, PET, Sputum and X-Ray images are frequently used. After analyzing the data set images CT images are most common.
The CT images' shared characteristics were employed by the writers throughout all of their methodology. As comparing with other images CT images perform better results.

Image Type	No of Image
CT Image	39
HRCT	2
LDCT	5
LIDC /IDRI	9
LUNA	1
PET	1
Sputum	2
X- ray images	1



Survey Techniques

Different types of techniques were introduced in the literature to diagnose Lung Cancer. The following are the techniques are participated in the literature.

Techniques used
Diagnostic Indicators
Neuro-Fuzzy
Median Filter
SVM(GRBF kernel type)
Back propagation network Classification
SVM
Probabilistic Neural Network (PNN)
Multi section CNN
Convolutional Neural Network
Deep Fully Convolution neural network.
Deep reinforcement learning model
Residual Learning
3 D CNN
3D Filtration
Comparison of geometric features
Multiple MTANNs
Rule-based scheme and LDA
Fuzzy matching
Template modeling approach using LS
LDA
Fixed-topology ANN
R2 Technology
Voxel-based neural
Scoring method
KNN
Genetic algorithm
Speed up robust feature (SURF)
gray-level thresholding technique
Fluorescence in situ hybridization

Mediastinoscopy
DLAD
KNN, SVM
SVM(RBF kernel type)
Bayesian
Random forest(bagging)

Conclusion

The accuracy level starts from 62% to 96% is established in literature. DLAD techniques produces 62% Accuracy. CAD system produces 96% Accuracy. Different types of techniques were used and produced different results. Among all these we found that the CAD system performs better result than the other techniques.

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