IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Computer Aided Diagnostic System for Detection of Lung Cancer by Using Image Processing – A Comparative Analysis.

Ms. Ashwini Dattatraya Gopwad, Research Scholar, Dept. CS & IT, Dr. BAMU, Aurangabad.

Dr. Ajit A. Maslekar, Principal, Dept. Computer science & IT, K. T. Patil college Osmanabad, INDIA.

***ABSTRACT*:** Deep Literacy is an emergent and influential system which is used for point literacy and pattern recognition. We give a comparison between Computer backed opinion scheme using Deep literacy fashion and traditional Computer backed opinion scheme in our paper. In our study, we find that Convolutional neural networks are used for pulmonary cancer discovery in utmost of the cases, as compared to other algorithms in deep literacy ways. In conclusion, we address the many difficulties in the perpetration of the systems for pulmonary cancer, also we summarise the advantages and disadvantages of the being algorithms for opinion of pulmonary cancer.

***Keywords*-** Pulmonary Cancer Detection, Lung Nodule, Deep Learning Network, Computer Aided Diagnosis scheme, Convolutional neural network.

INTRODUCTION: Currently, pulmonary cancer is considered as one of the fatal diseases (1). Every time we've new records of over and over1.6 million cases with pulmonary cancer. The early discovery of lung nodes with Computer- backed- opinion (CAD) (3) schemes is especially significant for the analysis and recovery of lung cancer cases (2). Though, classifying huge figures of CT images is veritably hard and time consuming for radiologists. thus, the automatic recognition of lung nodes is important field for exploration and significantly enhances the effectiveness of pulmonary bump discovery fabrics. In order to ameliorate the clinical individual systems for lung cancer, automated discovery algorithm is an exploration sphere that's related with representation of computable assessments. Automatic opinion of nasty/ benign character of pulmonary nodes is generally the most important pretensions of CAD schemes and it's done on point birth in order to decide every time there's logical vacillation and difference.

Conventional CAD systems generally involve a number of image processing way and also perform categorization job for discovery of excrescence or bruise. Performance of traditional CAD systems depends a lot on the central issues of the image processing way for harmonious features. In numerous CAD schemes, fresh issues may be integration and selection of uprooted features. The nasty/ benign character of the training CT images can be canning simply linked commentator without the need for particular delineation of the excrescence perimeters on the training dataset. There are numerous automatic opinion systems grounded on traditional systems, as exploration area grounded on deep leaning ways are less explored, so we're presenting our study which concentrates on CAD Schemes grounded on deep literacy ways. From our study, we can see that from the perspective of CAD for lung cancer discovery, Deep learning ways haven't been that much explored. In this paper, automated discovery systems dependent on different types of deep literacy infrastructures are analysed. Lung nodes can be classified as benign or nasty pulmonary nodes with the operation of these networks to the CT images with some revision.

❖ *TRADITIONAL COMPUTER AIDED DIAGNOSIS SYSTEMS:*

A CAD method is a research domain for study of the detection of pulmonary nodule and identification of pulmonary cancer, and it incorporates Computed Tomography images as input and based on an algorithm assists radiologists to perform an image analysis and malignant/benign tumours classification. Five important steps of Diagnosis of pulmonary nodules in CAD systems are: Database Acquisition, Pre-processing of Image, Segmentation Operation, Analysis and Classification. In Figure 1, we can see the important steps of a traditional CAD system; the first step is acquisition of CT images from accessible databases like LIDC, LIDC-IDRI, ELCAP [1]. Second step is pre-processing of Lung CT image in order to enhance the image and to remove unnecessary noises. Some of the commonly used pre-processing techniques are Adaptive Median Filter, Alpha-Trimmed Mean Filter, Gaussian Filter [19]. Third step is segmentation of the pre-processed CT image using a standard segmentation technique like thresholding technique, Markov random field, region growing, watershed and histogram-based segmentation [22]. The fourth step is analysis, in which during feature extraction, some of the extracted features are for example area, perimeter, eccentricity, centroid, diameter [16]. The fifth nodule structure are distinguished on the basis of CT images [19]. Classification algorithms are used for recognition and classification of malignant nodules for which the algorithms use extracted features for training features and the trained model is used for the sorting succeeded by system valuation. The resultant models have superior specificity, sensitivity and accuracy. Commonly used methods for classification are SVM, Neural Networks, CNN and ANN [1].

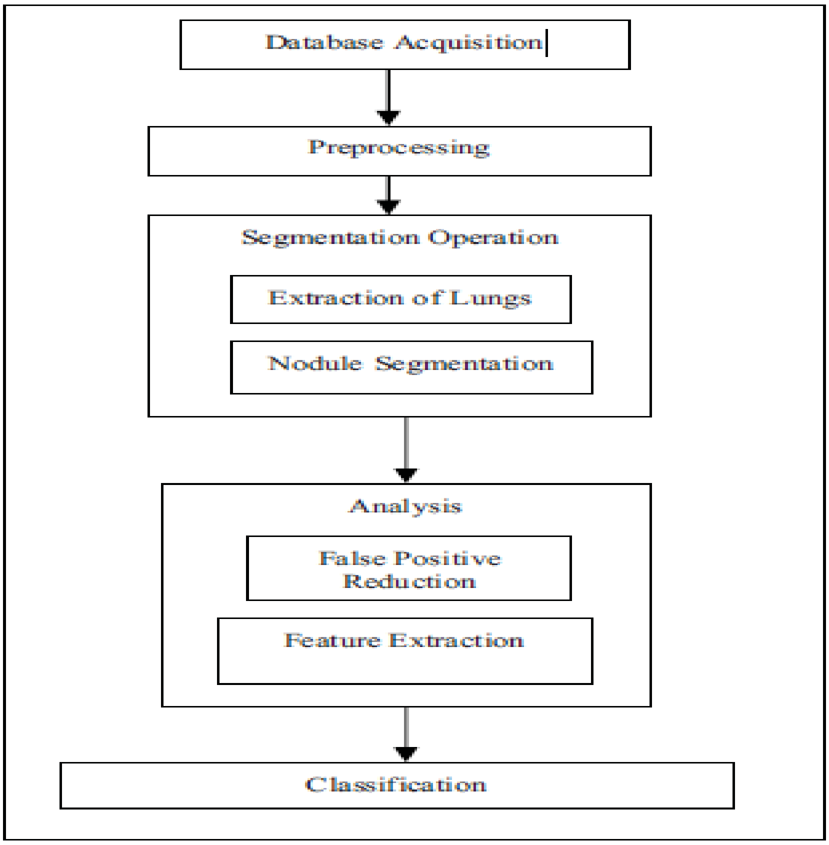

Fig. 1. Steps of a Traditional CAD system.

In 2018, Suren Makaju etal (9) proposed a model that uses the pulmonary CT image to distinguish the nasty and benign bump of lung cancer. Their proposed system has achieved delicacy of 92 in discovery of cancer and delicacy of86.6 in bracket of nasty cells from benign cells. In 2018, for recognition of lung cancer in the early hours, Emre Dandil proposed a new CAD system. They've used top element analysis (PCA) to reduce number of features and probabilistic neural network PNN) to classify benign/ nasty nodes. Their proposed channel system has achieved95.91 delicacy,97.42 perceptivity,94.24 particularity. In 2016, T. Manikandan et (18) morphological algorithm. The algorithm presented byT. Manikandan et.al. has achieved 100 of perceptivity and 93 of particularity. In 2016, an Automaton system is developed by Md. Badrul Alam Miah etal (19), and they have designed the system to identify pulmonary cancer at an early phase. For discovery of lung cancer, they developed a system that used steady point birth styles like restatement, gyration, scaling. delicacy rate of their system is 96.67%.

Year/ Authors	Database	Key Techniques	Features Extracted /Number of features	Sensitivity/ Specificity/ Accuracy
In 2018 by Suren Makaju et al.[9]	LIDC-IDRI	Gabor Filter, Watershed segmentation , Support Vector macine	Area, Perimeter, Centroid, Eccentricity, Diameter, Mean Intensity	100%, 50%, 92%
In 2018 by Emre Dandil[17]	LIDC-IDRI, CT images from Sincan Nafiz Koen Hospital.	Lung Volume Extraction method, Self Organising maps(SOM) Principal Component Analysis (PCA) Probabilistic Neural Network (PNN)	Standard deviation, entropy, means, skewness, kutosis, Variance, 123 Features	97.42%, 94.24%,95. 91%
In 2016 by T. Manika ndan et. al [18]	106 CT scan images from Bharat Education and Research foundatio n.	Fuzzy Auto Seed cluster means morphologic -al segmentation . Support Vector machine (SVM) kernel Classifier	Area, Eccentricity, Texture	100%, 93%, 94%
In 2015 by Md. Badrul Alam Miah et. al[19]	300 Lung CT images from the Internet and Hospital.	Image Acquisition, Preprocessin g, Binarization, Thresholding ,Segmentation, Feature Extraction, And Neural Network Detection.	33 Features	96.67%

Table I. Performance comparison of traditional CAD systems

The CAD model proposed by Suren Makaju et. al (9) detected cancerous nodes from lung CT images and classified Malignant/ Benign nodes using SVM. In the system, image pre-processing styles similar as noise junking, image smoothing are applied on CT images. The system has not performed false positive reduction. Computer- backed Pipeline proposed by Emre Dandil (17) has used PCA for point reduction step. Advantage of this system is that it has achieved94.68 delicacy in bracket of nasty/ benign nodes, further icing discovery of cancer at early stage. CAD algorithm proposed byT. Maniknandan etal. (18) is concentrated to diagnose pulmonary cancer at original phases (phase I, phase II), the cases in advanced phases (phase III and phase IV) are not included in their work. So, this is a limitation of this study that they're unfit to diagnose cancer in advance stages. They calculate delicacy of the system is 94 with false positive of 0.38. But they don't perform false positive reduction step too. System proposed by Md. Badrul Alam Miah etal (19) used neural network to classify between cancerous and non-cancerous CT- images. This system has performed noise reduction using median sludge to lessen "swab and pepper" noise. In Table I, we can see that all the CAD systems use different databases but we compare them on the base of Features uprooted, crucial ways used and perceptivity, particularity, and Accuracy attained by the system. We observe that all the systems bandied over do not classify the nasty nodes further into several stages.

❖ *DEEP COMPUTER AIDED DIAGNOSIS SYSTEMS:*

The present state- of- the- art machine literacy system, in which a number of layers of data computational stages in a hierarchical configuration are utilised for characteristic literacy and pattern recognition, is known as Deep literacy fashion (3). In recent time, one type of neural networks known as deep literacy which has numerous retired layers and each subcaste has different number of neurons with trainable weights and impulses. Deep literacy algorithms are useful in numerous fields of pattern recognition for illustration image recognition, object discovery, speech recognition, etc. Four popular Deep literacy infrastructures are Convolutional neural networks (CNN), Completely convolutional networks (FCNs), bus- Encoder (AEs), Deep Belief Networks (DBNs). Deep literacy ways use complication drivers in its subcaste and are considerably useful in cancer discovery and opinion with a remarkable donation in with high perfection. In this paper, we present the study of discovery of lung bump and Computer backed individual systems for classifying lung bump campaigners in CT images as bump or nonnodular using popular deep literacy ways. Two way of pulmonary bump discovery systems are written below

A. Nodule detection systems.

B. False positive reduction systems.

A. Nodule detection systems:

In the last two decades, Automated Recognition of lung nodules in CT images has become a known research domain. In this paper, we have discussed several recently projected CAD systems based on neural learning networks. In 2018, Pranjal Sahu et al. [5] introduced a novel Multi-section Convolution Neural Architecture in order to classify pulmonary nodules from volumetric data and malignancy estimation. The empirical results of the proposed framework show that it achieves accuracy of 93.18% in classification and the performance is better than other classification methods. Their architecture is lightweight; therefore, the proposed system can be easily installed in mobile devices, for example tablets and embedded system. In 2018, using the combination of mixed resampling and layer wise fine-tuning CNN frameworks, Guanghui Han et al.[6] presented an automatic diagnosis system for 3D Ground Glass Opacity (GGO) CT imaging signs. This system achieved brilliant outcome with sensitivity of 96.64%, specificity of 71.43%, and score of 0.83 F1. Novel Agile CNN is constructed to classify lung nodule in CT images by Xinzhuo Zhao et al. [7]. Higher accuracy of 0.822 and an AUC of 0.877 is achieved with this Agile structure, and compared to other redundant CNN structures there is less chance of overfitting. From the results of the proposed system, it is evident that the proposed CNN architecture is able to classify pulmonary nodules with small datasets of CT images and small size pulmonary nodules. In 2018, Anum Masood et al. [11] presented a new IOT enabled classifier using deep fully convolutional neural network (FCNN).

In their work, they have used DFCNet to detect and classify lung nodules from CT images. The proposed model is used for initial classification between two classes i.e., nodule and no nodule as well as the images which are detected as lung nodules are in addition to that classification is extended to the four phases of pulmonary cancer. The accuracy of DFCNet is 96.33% and sensitivity is 83.67%. In 2018, a reinforcement learning model established on deep learning techniques for premature stage pulmonary cancer recognition is proposed by Issa Ali et al. [12]. A major advantage of this model is that the system is always in learning state due to RL approach, and it always expanded its learning by factoring new information with every new patient. They have used LUNA dataset for testing, they were able to achieve sensitivity of 58.9%, specificity of 55.3%, accuracy of 64.4%, PPV is 54.2 % and NPV 60.0%.

Year/ Authors	**Database**	**Key Techniques**	**Sensitivity/ Specificity/ Accuracy**
In 2018 by Pranjal Sahu et al.[5]	LIDC-IDRI	Multi section CNN	89.40, 93.18, 95.61
In 2018 by Guanghui Han et al.[6]	LIDC-IDRI	Hybrid resampling method with multi models fusion strategy based on layer wise fine tunning CNN models	96.64, 71.43, 82.51
In 2018 by Xinzhuo Zhao et al.[7]	LIDC-IDRI	Convolutional Neural Network	82.23
In 2018 by Anum Masood et al. [11]	LIDC- IDRI, RIDER, SPIE challenge, LUNA16,	CNN- Deep Fully Convolutional neural network.	75.35 80.91, 75.23 83.67, 86.46 96.17,
	LungCT-Diagnosis, Shanghai Hospital No.6		89.67 96.33
In 2018 by Issa Ali et al. [12]	LUNA dataset	Deep reinforcement learning model	58.9%, 55.3%, 64.4%,

Table II. Performance comparison of Nodule detection systems based on Deep Learning Techniques

In the Table II, we can see that all the CAD systems use different databases but we compare them on the base of crucial ways used and perceptivity, particularity, and delicacy attained by the system. Advantage of multisection CNN armature proposed by Pranjal Sahu et (5) is that it's veritably light weight and the model can be installed in movable bias, in this manner control of Artificial intelligence can be handed straight to the croaker CAD system proposed by Guanghui Han etal.(6) applied deep literacy fashion for automatic recognition of specific CT imaging signs with inadequate labelled images, one particular type of bump i.e. Ground- glass nebulosity GGO) nodes which is more likely to be nasty compared to common solid lung nodes. Xinzhuo Zhao et (7) proposed a new nimble convolutional neural network CNN) Framework for small scale medical image database and small size of the nodes. They've tested both the topologies and set up that double CDNN can descry cancer at stage 3 whereas regular CDNN is unfit to descry cancer indeed at stage 4. Advantage of CAD system proposed by Annum

Masood etal.(11), they've used IOT grounded health care systems along with deep completely convolutional neural network for discovery of lung nodes and bracket of stages on CT reviews. Among all the papers bandied in this section only this work is suitable to classify the detected pulmonary bump into different nodes in hierarchical style i.e., Stage T4, Stage T3, Stage T2 and Stage T1. The lung bump discovery system proposed by Issa Ali etal (12) employed underpinning literacy, specialty of this approach is that new information is included in knowledge of the model and expand its knowledge and literacy system. One common limitation of all the CAD Systems grounded on deep literacy infrastructures bandied over is that they don't include False Positive Reduction System. In the coming section, we've bandied multitudinous CAD systems enabled with false reduction system.

A. False positive reduction systems:

In an automatic lung bump recognition system, False positive reduction step is one of the primarily significant medium. To cipher the performance of the automated system for discovery of lung cancer, the perceptivity and false positive rate are united. In 2018, Hongsheng Jin etal. proposed a fashion for false positive reduction by means of a deep 3D residual complication network in (2). For representing features, Deep D network is deeper as compared to the networks in other styles with potentially superior capability. In 2017, Hongyang Jiang etal.(14) proposed an effective automatic discovery system for pulmonary bump which is dependent onmulti-group patches taken from CT images of lung, bettered by means of the Frangi sludge. To descry nodes of four stages of cancer, they've combined images from two groups, and planned a four- channel complication neural networks (CNN) system to prop the knowledge of doctors.

This automated system has acquired the4.7 false cons per check-up when perceptivity is80.06 and the15.1 false cons per check-up when perceptivity is 94. In 2019, a system for automatic identification of the lung nodes to professionally trace the nodes is presented by Genlang Chen etal.(8) using common tackle surroundings with a reasonable response time. They've achieved high delicacy and low time cost by tuning the network structures with the integration of segmentation and junking of false cons using hierarchical FCNs and 3D CNNs. This system has achieved97.78 perceptivity rate for segmentation, outflow is low with significant performance and automatic bracket of pulmonary nodes with better delicacy rate of90.1. In 2016, for recognition of automatic lung bump in volumetric CT images, Qi Dou et al. (13) presented a 3D Convolutional neural network CNNs). LUNA16 challenge held in confluence with ISBI2016 is used to corroborate the system presented then. Score achieved by this largely effective system is 82.7 in the false positive reduction track.

Year/ Authors	Database	Key Techniques	Sensitivity/ False positive perscan
In 2018 by Hongsheng Jin et al.[2]	LIDC/IDRI	Residual Learning, Special Pooling and Cropping(SPC) Layer, Online Hard Sample Selection(OHSS), Multi-Test	98.3%, 7
In 2017 by Hongyang Jiang et al. [10]	LIDC-IDRI	Convolutional NeuralNetwork	80.06% , 4.7f 94%, , 15.1
In 2019 by Genlang Chen et al.[8]	LIDC-IDRI	2D Fully ConvolutionalNetwork, 3D Filtration	97.8%, Accuracy =90.1
In 2016 by Qi Dou etal. [13]	LIDC dataset	3 D CNN	90% , 8

Table III. Performance comparison of CAD systems with false positive reduction

In the Table III, we can see that all the CAD systems use different databases but we compare them on the basis of Key Techniques used and Sensitivity, Specificity, and Accuracy obtained by the system. Deep 3D residual CNN presented by Hongsheng Jin et al.[2] for recognition of Lung Nodule along with False positive reduction step. The model is benefitted from the increased depth of 3D residual unit but restricted by the overhead of memory and computing resources consumed by the deep 3D CNN structure. CAD system for Pulmonary Nodule proposed by Hongyang Jiang et al. [14] greatly reduced false positive with a dataset containing a large of CT images with 80.06 % sensitivity and 4.7 false positives per examine. The pulmonary nodule detection system proposed by Genlang Chen et al. [8], is used for segmentation and extraction the suspected nodules from CT images is done. Many false positive cases may be produced by the use of 2D FCNs. False positives are reduced by passing the nodule candidates which are identified with 2D FCNs through 3D CNNs. The proposed system has lesser overhead with enhanced performance and automatic classification is done with better precision rate of 90.1% Benefit of Multi-level Contextual 3D CNNs for False Positive Reduction in Automated Detection System for Lung Nodule by Qi Dou et al. [13] lies in two aspects. 3D convolutions and max-pooling present in 3D CNNs are more appropriate for volumetric medical image processing and produce representations with higher discrimination capability. The proposed approach is impressively efficient for the reduction of false positive cases.

❖ ***COMPARISON BETWEEN AUTOMATED DIAGNOSIS SYSTEMS BASED ON TRADITIONAL AND DEEP LEARNING TECHNIQUES:***

For classification of the malignance of the detected lung nodules, traditional computer aided diagnosis (CAD) frameworks are widely employed, via image processing techniques. The handcrafted feature-based CAD systems have plenty of flaws which restrict the further improvements. At first, the extracted features are dependent on the segmentation of the pulmonary nodule. Next, the second point to consider is that features are dependent on former information, and it is matter of the competence of the designers of the CAD schemes. Because of the complications, the utilisation of the systems for automatic recognition of pulmonary cancer in medical treatments is more complicated. The aforesaid challenges might prevail over with Deep learning techniques, by utilizing the significant achievement of Deep learning architectures in object detection as well as localization in nature images. Advantage of CNN is that raw images without image pre-processing can be fed into CNN and it can produce feature representation of high level directly from the raw image, and that is extremely acquiescent to analysis of CT image. Deep learning technique permits concept of high levels and better anticipations from data as because it consists of more numbers of layers then the conventional techniques [3]. The majority of the CAD systems discussed above are using Deep Convolutional Neural Networks (CNN). Usually, CNN have several layers like convolutional layers, ReLU correction layer, pooling layers, deconvolutional layers, fully-connected layer and so forth.

❖ *CONCLUSION & FUTURE PERSPECTIVE:*

In our review paper, we've presented the analysis of being literature on traditional Automatic Discovery schemes for pulmonary cancer with CT images for bracket of challenges for forthcoming studies. In this review paper, we've also presented several deep CAD systems and fabrics to follow the general thing of reducing the task of doctors in pulmonary bump recognition. Incipiently, comparison between Traditional CAD systems and deep CAD systems is bandied.

Automated Discovery system proposed by M.B.A. Miah etal.(19) can classify the nasty bump into four stages of lung cancer along with False Reduction step. In terms of performance also, it has advanced delicacy of96.67. In section3.1. we have bandied numerous Automated Discovery systems ways grounded on deep neural networks, Guanghui Han et al.(6) proposed CAD system that detects only one specific type of nodes with Ground Glass nebulosity(GGO) CT imaging signs for recognition and analysis of pulmonary cancer. GGOs as compared to other types of nodes are known to be nasty in utmost of the cases. CAD system proposed by Annum Masood etal (11) can classify the nasty nodes into several stages of lung cancer for illustration phase 1, phase 2, phase 3 and phase 4. In section., we've bandied systems which are suitable to do false reduction along with recognition and analysis of pulmonary cancer. From our check, we've set up that pulmonary cancer recognition using deep literacy ways on CT images performed better than traditional lung cancer discovery systems. In conclusion, data and their imbalanced character is one of the being limitations in deep CAD systems. We believe that superior outgrowth can be attained by means of added image datasets and fresh stable data. We hope that our review paper will be helpful for experimenters to antecede the progress of Automated systems for pulmonary cancer recognition. In unborn work, we will explore operation of Deep Learning Algorithms in Lung Cancer Detection and estimate advance varied data sets for more in- depth realistic studies.

❖ *REFERENCES:*

[1] Faridoddin Shariaty, Mojtaba Mousavi, "Application of CAD systems for the automatic detection of lung nodules", Informatics in Medicine Unlocked Volume 15, 2019, 100173,https://doi.org/10.1016/j.imu.2019.100173.

[2] Hongsheng Jin, Zongyao Li, Ruofeng Tong, Lanfen Lin, "A Deep 3D Residual CNN for False Positive Reduction in Pulmonary Nodule Detection", Med Phys. 2018. May; 45(5):2097-2107. doi: 10.1002/mp.12846. Epub 2018 Mar 25.

[3] Kai-Lung Hua, Che-Hao Hsu, Shintami Chusnul Hidayati, Wen-Huang Cheng, Yu-Jen Chen3, "Computer-aided classification of lung nodules on computed tomography images via deep learning technique", Onco Targets Ther. 2015 Aug

4;8:2015-22. doi: 10.2147/OTT.S80733. eCollection 2015.

[4] Shuo Wang, Mu Zhou, Zaiyi Liu, Zhenyu Liu, Dongsheng Gu, Yali Zang, Di Dong, Olivier Gevaert, Jie Tian, “Central focused convolutional neural networks: Developing a data-driven model for lung nodulesegmentation”, Medical Image Analysis 40 (2017)172- 183,http://dx.doi.org/10.1016/j.media.2017.06.014.

[5] Pranjal Sahu , Dantong Yu, Mallesham Dasari , Fei Hou , and Hong Qin, “A Lightweight Multi-Section CNN for Lung Nodule Classification and Malignancy Estimation”, IEEE Journal of Biomedical and Health Informatics (Volume: 23 , Issue: 3 , May 2019), 960 – 968,DOI: 10.1109/JBHI.2018.2879834.

[6] Guanghui Han, Xiabi Liu, Guangyuan Zheng, Murong Wang, Shan Huang, “Automatic recognition of 3D GGO CT imaging signs through the fusion of hybrid resampling and layer-wise fine-tuning CNNs”, Medical & Biological Engineering & Computing, https://doi.org/10.1007/s11517-018- 1850-z.

[7] Xinzhuo Zhao, Liyao Liu, Shouliang Qi, Yueyang Teng, Jianhua Li, Wei Qian , “Agile convolutional neural network for pulmonary nodule classification using CT images”, International Journal of Computer Assisted Radiology and Surgery, 23 Feb 2018, 13(4):585-595, https://doi.org/10.1007/s11548-017-1696-0.

[8]]Genlang Chen, Jiajian Zhang, Deyun Zhuo, Yuning Pan, Chaoyi Pang, “Identification of pulmonary nodules via CT images with hierarchical fully covolutional networks”, Med Biol Eng Comput (2019) 57: 1567. https://doi.org/10.1007/s11517-019-01976-1.

[9] Suren Makaju, P.W.C. Prasad, Abeer Alsadoona, A. K. Singh, A. Elchouemi, “Lung Cancer Detection using CT Scan Images”, Procedia Computer Science, Volume 125, 2018, Pages 107-114.

[10] Jakimovski, Goran & Davcev, Danco. (2019). ‘Using Double Convolution Neural Network for Lung Cancer Stage Detection. Applied Sciences.’ 9. 427. 10.3390/app9030427.

[11] Anum Masood, Bin Sheng, Ping Li, Xuhong Hou, Xiaoer Wei, Jing Qin, Dagan Feng, “Computer-Assisted Decision Support System in Pulmonary Cancer detection and stage classification on CT images”, Journal of Biomedical Informatics 79 (2018) 117–128, https://doi.org/10.1016/j.jbi.2018.01.005.

[12] Ali I, Hart GR, Gunabushanam G, Liang Y, Muhammad W, Nartowt B, Kane M, Ma X and Deng J (2018), “Lung Nodule Detection via Deep Reinforcement Learning. Front. Oncol. 8:108, doi:10.3389/fonc.2018.00108.

[13] Qi Dou, Hao Chen, Lequan Yu, Jing Qin, and Pheng-Ann Heng, “Multi-level Contextual 3D CNNs for False Positive Reduction in Pulmonary Nodule Detection”, DOI 0.1109/TBME.2016.2613502, IEEE Transactions on Biomedical Engineering.

[14] Hongyang Jiang, He Ma, Wei Qian, Mengdi Gao and Yan Li, “An Automatic Detection System of Lung Nodule Based on Multi-Group Patch-Based Deep Learning Network”, IEEE Journal of Biomedical and Health Informatics 2168-2194 (c) 2017 IEEE, DOI 10.1109/JBHI.2017.2725903.

[15] Shamala B.Terdale, K.V.Kulhalli, “CAD System for Lung Cancer Detection using ANN”, IOSR Journal of Electronics & Communication Engineering (IOSR-JECE) ISSN : 2278-2834, ISBN : 2278-8735, PP : 11- 15.

[16] Ada, Rajneet Kaur, “Feature Extraction and Principal Component Analysis for Lung Cancer Detection in CT scan Images”, Volume 3, Issue 3, March 2013.

[17] Emre Dandil, “A Computer-Aided Pipeline for Automatic Lung Cancer Classification on Computed Tomography Scans”, Hindawi Journal of Healthcare Engineering Volume 2018, Article ID 9409267, 12 pages, https://doi.org/10.1155/2018/9409267.

[18] Manikandan T, Bharathi N. “Lung Cancer Detection Using Fuzzy Auto-Seed Cluster Means Morphological Segmentation and SVM Classifier”. Journal of Medical Systems. 2016 Jul; 40(7):181. DOI: 10.1007/s10916-016-0539-9.

[19] M. B. A. Miah and M. A. Yousuf, "Detection of lung cancer from CT image using image processing and neural network," *2015 International Conference on Electrical Engineering and Information Communication Technology (ICEEICT),* Dhaka, 2015, pp. 1-6.doi: 10.1109/ICEEICT.2015.7307530.

[20] A. Tariq, M. U. Akram and M. Y. Javed, "Lung nodule detection in CT images using neuro fuzzy classifier," 2013 Fourth International Workshop on Computational Intelligence in Medical Imaging (CIMI), Singapore, 2013, pp. 49-53.

[21] Giang Son Tran, Thi Phuong Nghiem , Van Thi Nguyen ,Chi Mai Luong , and Jean-Christophe Burie, “Improving Accuracy of Lung Nodule Classification Using Deep Learning with Focal Loss”, Hindawi Journal of Healthcare Engineering, Volume 2019, Article ID 5156416, 9 pages, https://doi.org/10.1155/2019/5156416.

[22] Ezhil E. Nithila, S.S. Kumar. "Automatic detection of solitary pulmonary nodules using swarm intelligence optimized neural networks on CT images", Engineering Science and Technology, an International Journal, 2017.