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A Survey of Research Advancements in Diagnosis of Pulmonary Abnormalities Using Artificial Neural Networks

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Abstract: Artificial neural networks (ANN) have evolved to process data from various Computer-aided detection systems in the medical field. ANNs automate the diagnosis and reporting models of the radiological images, which aids medical practitioners in effectively managing various abnormalities. This paper presents various techniques used in radiology to interpret the images generated by CAD systems. We surveyed current advancements in this field and analyzed the advantages and disadvantages of such systems, which we think would result in a more practical and challenging approach to detecting critical information from the available data. Specialized areas of ANNs such as convolutional neural networks, Group Method of Data Handling (GMDH) neural networks, Feed-Forward Neural Networks, and Feed-Forward Back Propagation Neural Networks are considered, and their efficiency in this application is analyzed. This paper provides a critical discussion of the role of ANNs in the medical imaging field as well as future directions and research recommendations.

Keywords: Deep Learning, Artificial Neural Networks, Convolutional Neural Networks, Pulmonary Abnormalities

I. INTRODUCTION

Artificial neural networks (ANN) are rapidly evolving and have found varied applications in society. ANNs provide viable techniques to situations, problems, and solutions that are hard to comprehend by humans. ANNs provide insights into areas that were once out of reach for human cognizance. One important field in which ANNs are found useful is in medical diagnosis [1]. The

Fig. 1 Applications of Artificial Neural *Networks* provides details of the areas of applications for ANNs.

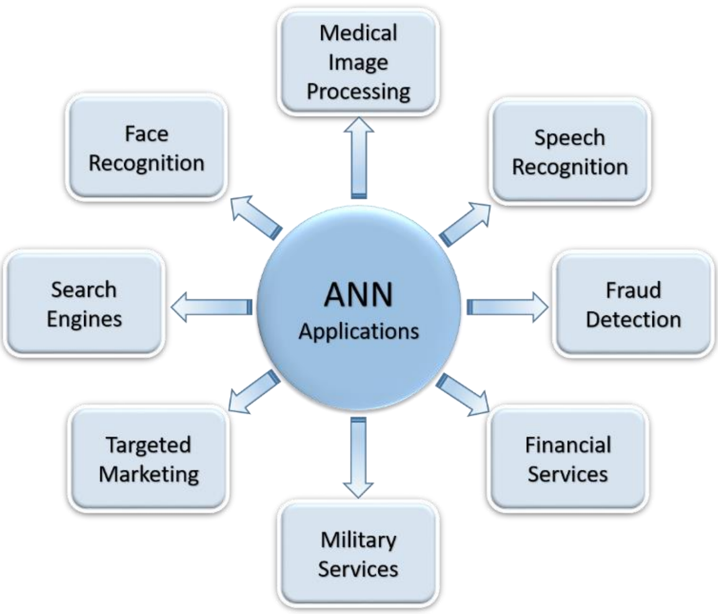

Fig. 1 Applications of Artificial Neural Networks

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Proper functioning of the pulmonary system is necessary for humans. Historically, pulmonary abnormalities remained a critical area in medicine. It is estimated that a lot of people suffer from pulmonary abnormalities in their lifetime. There are also very severe pulmonary abnormalities such as lung cancer that are life-threatening [2]. However, most lung cancer cases were reported and diagnosed at a later stage where there is limited scope for the medical practitioners to help people recuperate. Usually, it is too late when the medical practitioners identify the abnormalities at a later stage as it is difficult for any viable treatment. Hence, a need for early diagnosis of any abnormalities is inevitable. An early diagnosis allows a more specific and personalized treatment, thereby reducing the mortality rates [3].

Recent developments in ANNs and their capability to detect abnormalities play a significant role in diagnosing any pulmonary abnormalities. Various imaging methods like electromagnetic radiation X-rays, Magnetic Resonance Imaging (MRI), and Computerized Tomography (CT) scans, collectively known as Computer-Aided Detection (CAD) systems, are used to produce all-inclusive images of the inner lungs [1]. Radiologists process these images and use them to identify various features and abnormalities in the imaged area. Reports are generated from these findings that medical practitioners use to provide appropriate treatment to the patients. CAD systems expedite this process besides providing faster identification of the required details [4]. Researchers have found that using CAD systems increases performance measures such as accuracy and sensitivity in abnormality detection besides improving time complexity. CAD systems are capable of identifying even slight abnormalities and hidden features in the radiological images, which would result in better diagnostic conclusions [5].

Various methods in ANNs are used for this purpose. Convolutional neural networks (CNN) are one of the very extensively techniques in use. It is because usually, the images are large, and processing takes high space-complexity and time-complexity. CNN reduces the size of the images by combining multiple nearby nodes to reduce space-complexity and time-complexity without losing details when processing the images. Several recent surveys of ANN applications have been published in medicine, radiology, medical image analysis, and machine learning [6]. However, no existing surveys focus on the role of ANNs in identifying pulmonary abnormalities in the area of bio-medical images. This investigation is the result of such a survey conducted on the role of ANNs in identifying pulmonary abnormalities in bio-medical images. Research papers in recent years that propose techniques to improve the existing techniques in radiology are surveyed and analyzed. We found that literature in which the scope of ANNs in diagnosing pulmonary abnormalities is rare and far apart. In this survey, we studied various ANN approaches applied in medical imaging systems. Unlike other recent surveys, our survey focuses on the application of ANN developed specifically to improve the quantitative information generated from images taken on the pulmonary system.

II. OVERVIEW

Various advancements in the field of computer science are used to automate the image recognition ability by machines. Techniques in artificial intelligence, such as ANN and CNN, are mainly used.

Artificial intelligence (AI) enables machines to mimic and perform tasks that a human or a living organism would perform. It employs various algorithms and techniques to program the machines so that they can mimic human intelligence. Although in general AI is suitable mainly for routine tasks, recent advancements suggest that AI could also be used for non-routine activities and perform those activities that are difficult for an average human. AI could now perform those activities that are not necessarily cognitive. AI could be used for cancer management [7]. Web search engines, decision-making systems, recommendation systems are places where we use AI extensively.

Machine Learning (ML) is a variety of AI in which the machines are programmed such that it learn from the past behavior of the data and predict the future outcome of the data. The ML algorithm uses a part of existing data, understands the data structure, and predicts future inputs. The ML algorithm enables machines to learn from the existing data and predict the outcomes of new data. Also, ML algorithms could process the input data, and based on that; it will be able to take other similar data as input and predict the behavior of the new output values. ML is also used in healthcare [8]. We should consider it significant to note that Machine Learning algorithms are capable of improving continuously on each iteration. Artificial Neural Networks (ANN) are a variety of machine learning where the machines are programmed by simulating the functioning of the human brain, primarily the biological neural network consisting of neurons in the computer so that the machines can learn and make decisions similar to humans. It is also commonly referred as Neural Networks. The ANNs could learn from the training data and continuously improve their accuracy on each iteration. ANN consists of one input node layer, one output node layer besides having one or more (multiple) hidden layers between them. Similar to the human brain structure, the ANNs have neurons connected by a complex and non-linear arrangement of edges that uses weights and bias. All the steps are processed iteratively through learning and training methods. There are multiple algorithms to train the ANNs. ANNs are required to be trained a lot before putting them to use.

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It requires that we require a lot of existing data (cases) to train the ANNs. ANNs are not usually suitable for sparse or rarely used events as we usually will have insufficient data to train the ANNs for such events. However, when a large amount of data exists and for applications having substantial routine tasks, ANNs are very effective.

Convolutional Neural Networks (CNNs) could be considered as a variety of multi-layer ANN where multiple nodes are combined, and their weights are used to calculate the next layer. When combining multiple nodes, the output will depend on each node's weight in the combination in each layer. It is optimized for processing visual patterns from images where we could combine multiple pixels within a single layer and still retain the image recognition without losing details. It would effectively reduce the computation time of each function. Another advantage of CNN is that it could effectively abstract low-level features into higher-level features in each computational layer. It is broadly used in medical imaging to study various images and scans [9]. Deep CNNs are also used for image analysis purposes [10].

III. DISCUSSION

This section presents a preliminary report on the various existing research papers on ANNs and their application in diagnosing pulmonary diseases.

The research paper authored by Kashyap et al. [11] aims to investigate the detection of cancerous cells in CT images using image processing methods and do a clinical study using results collected on blood samples. It will result in better cancer tumor detection. The authors achieve this by performing detailed research on various detection methods for lung cancer using simulation methods. The KRAS mutation of lung cancer is analyzed in patients, and lung images are used for interpreting medical images. The authors have used the morphological image processing computational technique for simulation. It primarily detects the shape and topology of the scan images. The simulation of medical scan images and calculation of attributes is done to analyze computational work results. First, for removing noises in the image they use the median filter. Then, morphological operators are used for post-processing the image for feature extraction. Then, an outline is created to plot the tumor region in the image. To find tumors and to analyze them with proper parameters, cognitive approaches can be used. Recently, in the clinical approach, the KRS mutations NSCLC is also used. The authors conclude that the KRAS mutations are effective predictors that could be used in chemotherapy. Also, they suggest that more treatments for patients with KRAS mutant MSCLCs should be developed.

The research paper authored by Ajin et al. [12] aims to improve the identification of lung disease by using the pattern classification method. There are four distinct steps in the diagnosis of ILD. Image preprocessing and feature extraction are made first, and then selection and classification are made. The author achieves this by doing feature extraction, classification, and feature selection. Feature extraction is done using textons and Linear Ternary Co-Occurrence Pattern methods. Classification is done using ANN, KNN, and CNN. ReLu activation and histograms are used for feature selection. The authors suggest a novel method named Hybrid kernel-based SVM classification. This method produces an improved accuracy over the ANN, CNN, and deep CNN classifiers. For pattern classification, when using the ANN classification, the authors get an accuracy of 57.5%, whereas they achieve an accuracy of 72.94% when using the KNN classification. However, compared to both ANN and KNN classification methods, the authors achieved a high accuracy of 84.14% when using the Deep CNN classification method. Finally, the authors perform the classification using the new hybrid kernel-based SVM classification method. The authors achieved an accuracy of 90.52% using this method. This improved accuracy is attributed to the combination of two kernel functions in this method. The authors analyzed pattern classification performance. The observations suggest that the hybrid kernel-based SVM classification improves pattern classification performance. Hence, the authors conclude that the hybrid kernel-based SVM classification method is effective for diagnosing interstitial lung disease. The authors suggest replacing the LTCOP feature extraction with other feature extraction methods to increase the classification performance of the proposed classifier.

The research paper authored by Makajua et al. [13] aims to assist doctors in identifying the cancerous cells accurately in the CT scan images, which in general is challenging to interpret and identify cancerous regions. The authors propose a new model that has an improved performance over the existing computer-aided techniques. The authors achieve this by evaluating various computer-aided techniques that facilitate interpreting the CT scan images. They listed out and sorted the various computer-aided techniques based on their detection accuracy. Each technique was analyzed and implemented, and the limitations and drawbacks were recorded. To detect cancer in the CT scan image, the authors propose a new system that uses watershed segmentation for detection and SVM to classify. The authors achieved an accuracy of 92% while using their proposed model. The accuracy has improved by almost six percent over the existing best classification model. The authors conclude that the new proposed model improves classification accuracy over the existing classification models using the CT scan images.

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The authors point out that the proposed model does not classify cancer into different stages, leaving it open for future scope. Also, they suggest introducing appropriate pre-processing and false object elimination techniques to improve accuracy.

The research paper authored by Masood et al. [14] aims to assist radiologists in identifying and classifying lung cancer and categorizing them into its stages. The authors achieve this by proposing a new classifier model for classifying cancer nodules into four cancer stages using the deep fully convolutional neural network (FCNN). The DFCNet is used in identifying and classifying the cancer nodules in CT scan images. The authors have used computer-assisted diagnosis (CADx) and Internet-of-Things (IoT) systems to improve this classification accuracy. This computer-assisted decision support system uses the novel deep learning-based model. Initially, the images are classified. Then, those images that are classified as nodules are further classified into four stages of lung cancer. The authors have used the data augmentation technique to overcome the limited dataset availability for nodule classification. The suggested method is tested on multiple datasets and they were then compared with the existing methods. The authors achieve an accuracy of 77.6% while using the neural network, 84.58% while using the DFCNet. Also, the authors achieve an improvement in average FP from 3.1 to 2.79 while using the elimination technique. The authors conclude that the proposed method has improved effectiveness in the detection and classification of lung cancer. The authors suggest that the proposed CAD system enabled with IoT could also be used to detect other types of cancers.

The research paper authored by Skourt et al. [15] aims to assist medical practitioners in interpreting various medical images and provide a uniform diagnostic segmenting approach. In particular, this paper focuses on the segmentation of lung CT images. The authors propose to segment the lung CT images using the U-net architecture. The U-net architecture has encoders and decoders. The encoders are used to reduce the spatial dimensions of objects using pooling layers, and the decoders are used to recover the object details with up-sampling layers. This network can be trained using some images and corresponding masks from the initial stages. Later, the same images is used to generate the corresponding masks as output. This capability aids this architecture to outperform many standard methods. The authors had achieved an accuracy of 0.9502 in segmentation using the Dice-Coefficient index. The authors conclude that the U-net deep neural network architecture can be effectively used to segment lung ct images in particular and segment any medical images in general. The authors also suggest performing lung nodule segmentation using this U-net architecture as a future scope.

The research paper authored by Souza et al. [16] aims to assist radiologists in efficiently detecting and diagnosing pulmonary diseases by adopting a fully automatic method to segment the lung fields in the chest -rays. The main challenge faced here is that those dense abnormalities are known as opacities and generally have a pattern similar to lung boundaries. So frequently, the automatic methods interpret such opacities as lung boundaries. To overcome this issue, the authors propose a new method to rebuild the regions lost due to lung abnormalities in the chest X-rays so that the segmentation of lungs can be performed accurately. The authors achieve this by using two convolutional neural networks (CNN), morphological operations, and filtering techniques. The authors had used AlexNet to perform pattern classification and ResNet18 to rebuild missing parts. The final output is obtained by combining both AlexNet and ResNet18. The proposed method used four main steps. The authors had validated the proposed method on Montgomery County Chest X-ray dataset, a public database from Montgomery County's Tuberculosis Control Program. It is a heterogeneous and complex database with several chest X-ray exams from patients with tuberculosis. The authors had achieved improved results. The authors conclude that the abnormalities can be rebuilt using a deep CNN so that the lung segmentation can be performed more accurately.

The research paper authored by Shaukat et al. [17] aims to assist radiologists in diagnosis and provide decisive additional opinion for the CAD to detect lung nodules. The authors achieve this by using a marker-controlled watershed technique. This technique uses a hybrid feature set and ANN. First, the lung volume is segmented. Next, image enhancement is done. The authors have used feature vectors from lung nodule candidates and artificial neural networks to reduce false positives. Intensity, texture, and shape features are used. Data set from Lung Image Database Consortium (LIDC) is used to assess this system. The authors had achieved 95.5% sensitivity. The authors conclude that the marker-controlled watershed technique can effectively improve lung nodules detection in CAD systems. The authors also suggest improving the technique to select the lung nodule feature set as a future scope.

The research paper authored by Alzubi et al. [18] aims to increase diagnosis performance, minimize the classification time, and reduce the error of classification. The authors had analyzed Weight Optimized Neural Network with Maximum Likelihood Boosting (WONN-MLB). The author had proposed a novel method to achieve this. The proposed method consists of two stages. First, the classification time is minimized using an integrated Newton–Raphsons Maximum Likelihood and Minimum Redundancy (MLMR) model. It minimizes the classification time by removing the irrelevant features. The Second Stage is the ensemble classification stage, where the selected attributes are classified using Boosted

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Weighted Optimized Neural Network Ensemble Classification algorithm. It increases accuracy. The authors had improved accuracy, false-positive rate, and reduced delay compared to the existing techniques for big data. The performance of this proposed method is compared with existing standard methods. The feature rate had increased by 10% for NSCLC, 18% for SVM, 28% for NPPC, and 41% for MV-CNN. The authors conclude that the proposed approach improves accuracy while using big data while using this method. The authors suggest applying the Weight Optimized Neural Network with Maximum Likelihood Boosting (WONN-MLB) in a vast data set to study the results as a future scope.

The research paper authored by Shakeel et al. [19] aims to improve the quality of the lung CT images and reduce the misclassification of lung cancer in the CT images. The authors achieve this by analyzing the lung CT images using the Improved Profuse Clustering Technique (IPCT) and the Instantaneously Trained Neural Networks (DITNN) approach for deep learning. The authors suggest that the noise signals in CT image quality result in low performance of classification of this disease features. It can be improved by preprocessing the image. Among these, image denoising is important as it enables further preprocessing of the image to reduce the noise and retain the edges and additional features as much as possible. The authors had eliminated the noise in the image by applying the Weighted Mean Histogram Equalization approach. Also, the authors had enhanced the quality of the image by applying the IPCT approach. The authors had collected the CT images from the Cancer Imaging Archive (CIA) dataset. The authors had achieved an accuracy of 98.42%. The authors conclude that the quality of the lung CT images can be improved the misclassification can be reduced by using the IPCT and the DITNN approach.

The research paper authored by Rajan et al. [20] aims to assist radiologists in lung cancer diagnosis. The authors had done a detailed study on the prevailing computer-based tools and techniques in diagnosing cancer. The authors observe that if the cancer is diagnosed during stage one, the rate of survival of the patients is 85%. They suggest data mining on the patient records to identify potential people who have cancer at stage 1. The authors propose to use a multi-class neural network. The proposed method follows supervised learning. It tried to identify the underlying structure of the data so that the data could be used for further analysis. The proposed method does classification using training data. The multi-class neural network has 100% accuracy. It will aid in identifying stage one cancer, which will improve the survival rate of the potential patients. The authors suggest using this as a pre-diagnosis tool. The authors had implemented this using the Azure Machine Learning Studio. The authors observe that the accuracy had improved when using this supervised learning method. The authors conclude that the proposed ANN will improve performance compared to the other methods.

The research paper authored by Cao et al. [21] aims to improve the nodules detection in the CT images of the lungs. As the lung nodules are heterogeneous, it is difficult to detect nodules in lung CT images. The authors proposed a Two-Stage Convolutional Neural Network (TSCNN) to improve this lung nodule detection. The first stage is to do an initial nodule detection using an improved U-Net. It uses the ResDense for nodule detection. In this stage, the authors propose a new method for training to achieve a high recall rate with limited false positives. The second stage reduces the false positives. A random mask is used for data augmentation as this will require a lot of data for training. Also, the authors had used ensemble learning to improve the generalization ability. The sampling region is divided into three types: current voxel point, intensity information, and background region. The authors had conducted experiments and confirmed on the LUNA dataset. The authors achieved competitive results compared to the existing models. The authors conclude that their proposed two-stage method is effective against the existing methods.

The research paper authored by Khan A. I. et al. [22] aims to assist medical practitioners in detecting COVID-19 cases using radiography images. The author aims to achieve a 100% detection success rate and observes that no positive case should go undetected. The author proposed a novel model based on the Xception architecture. This dataset is also trained and verified on of pneumonia and COVID-19 patients' lung images taken from different data sources. This proposed method is named CoroNet, which is a less expensive, deep convolutional neural network. The authors had implemented 3 setups of this method. This proposed model is implemented and pre-trained using Tensorflow and Keras. Using the four classes, namely, COVID-19, bacterial pneumonia, viral pneumonia, and regular, the authors had achieved 89.6% overall accuracy, 93% precision, and 98.2% recall rate. Using the three classes, namely, COVID-19, pneumonia, and regular, the authors had achieved 95% overall accuracy. The authors conclude that CoroNet achieved significant detection accuracy in a small trained dataset. However, they also observe that these results might vary when provided with a vast real-world dataset. The authors suggest that further research should be conducted on this CoroNet as the results are promising.

The research paper authored by Huang et al. [23] aims to aid radiologists in interpreting CT lung images to determine the tumor levels as benign and malignant, which would result in proper treatment to the patients and thereby reduce mortality. The authors propose a novel method based on the Deep Transfer Convolutional Neural Network (DTCNN). The authors

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observe that due to the redundant organization, the deep learning-based diagnosis is not effective. The proposed method has two stages. First, an automatic feature extractor is constructed and trained. Next, the extreme learning machine is applied to this. It classifies the datasets into benign and malignant nodules. To investigate this proposed method, the authors have used data datasets from Lung Image Database Consortium and Image Database Resource Initiative (LIDC-IDRI) and First Affiliated Hospital of Guangzhou Medical University in China (FAH-GMU). The authors achieved improved results on both the datasets. The authors conclude that the new model shows the most reliable outcomes when evaluated against the existing methods. The authors also observe that this proposed method will reduce computational costs besides improving the classification performance of benign–malignant nodules.

The research paper authored by Chen S. et al. [24] aims to assist radiologists in detecting nodule candidates via Chest radiographs and CT. The authors achieve this by developing a Computer-aided detection scheme that uses a balanced CNN with candidate detection via experiments. The authors observe that a two-stage Computer-aided detection scheme has nodule candidate detection as the first stage and false positive reduction as the next stage. However, this model has not yet reached the required performance. It is because the Computer-aided detection scheme has a relatively large size. There are obstructions in structures such as ribs for the Computer-aided detection scheme to identify the nodules. Compared to this, CNN is an effective method in reducing false positives. The authors had first applied a Multi-Segment Active Shape Model to this scheme so that the pulmonary parenchyma could be segmented. Next, the authors had used the grayscale morphological enhancement technique to this scheme. Next, 200 nodules were selected, and they identified a Region of Interest (RoI) for each image. They encoded the original image for false-positive reduction. The authors experimented on the Japanese Society of Radiological Technology database and had reached 91.4 % sensitivity with 2.0 false positives and 97.1 % sensitivity with 5.0 false positives. The authors conclude that this pulmonary nodule detection scheme, which the radiologists could use to improve diagnosis and efficiency of lung nodule detection, shows promising results and is a classic scheme with balanced convoluted neural networks.

The research paper authored by Wang et al. [25] aims to assist physicians in diagnosing thorax-related diseases using chest radiography images. Of late, physicians use deep learning techniques to diagnose, even though this is a weekly supervised learning problem lacking sufficient details in large-scale chest radiograph images. To mitigate this problem, the authors propose using Thorax-Net, a novel deep CNN. It has two branches. The classification branch eliminates the construction steps of manual feature extraction and classifier. The attention branch analyzes the feature maps from the classification branch using the correlation between pathological abnormalities and the class labels. The practitioners can obtain a diagnosis by feeding the chest radiograph images to the trained Thorax-Net. The Thorax-Net suggests the output based on the outputs of the classification branch and attention branch by averaging and binarizing them. The authors had evaluated this Thorax-Net model on three deep learning models using Chest X-ray 14 datasets. They have compared this with five deep learning models to benchmark their experiments. The authors had reached 0.7876 average per-class area, and the other five datasets got 0.896 average per-class area. They achieved this on well-trained data having no other external inputs. The authors conclude that the proposed Thorax-Net model is more efficient in identifying thorax diseases using chest radiography images. The authors also suggest that, as a future improvement, we could add a correlation between the thorax diseases and bounding boxes to the computer-aided diagnosis process. Also, we could make another future improvement by adding more common features discovered in the radiomics stage. It would improve the interpretability deep learning model.

The research paper authored by Nayak et al. [26] aims to assist practitioners in improving the diagnosis of pneumonia, especially COVID-19, by designing and establishing a classification technique on X-rays. The authors observe that the artificial intelligence-based techniques consume lots of resources and time to diagnose the patients. It is not suitable for highly contagious and lethal pneumonia such as COVID-19. The authors propose a novel LW-CBRGPNet multi-class classification, an automated approach to mitigate this and reduce the memory cost and time complexity. This model can train from a new dataset instead of a more standard, traditional pre-trained model. This method would categorize the chest X-rays into two categories: normal and COVID-19 infected. The authors achieve this by using a CNN scheme combining three CBR blocks (convolutional batch normalization ReLu). The authors had used several parameters for validation. The authors had reached 98.33% overall accuracy with this proposed model and compared this with other existing pre-trained learning models. The authors conclude that the proposed model is more robust and lightweight to handle diseases such as COVID-19, provide a quicker diagnosis, and reduce diagnosis errors.

The research paper authored by Chen C. et al. [27] aims to assist radiologists in segmenting the lung lesions in the CT image of the patients affected with COVID-19. The authors propose a new segmentation method that applies ROI extraction, augmentation, and combination loss techniques. They had used 3-D attention modules to identify unclear boundaries and poor contrast. It would enable us to interpret the area in more detail. Then, post-processing was done using CRF to improve the correlation. The authors achieve this using a four-step process. Patch mechanism was applied,

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followed by extraction of spatial features. Then the combination loss function is introduced, after which data augmentation is conducted. The authors had compared this model with many of the existing models. The authors achieved an improved performance when analyzing their model with various existing models. The authors had implemented and released the code work. The authors conclude that their proposed method improves efficiency over the other existing models.

The research paper authored by Khan S. H. et al. [28] aims to help radiologists in COVID-19 pattern identification in the X-ray images, which would be accurate and fast. The authors achieve this by improving the existing deep CNNs and using them for the classification of X-rays. They propose two new architectures based on custom CNN architecture. The COVID-RENet-1 and COVID-RENet-2. These methods use convolutional operations. The proposed models are experimented with on various datasets and validated against the existing architectures using pooling operations and benchmarking them against the existing CNNs. The authors had provided their implementation code. The authors had reached improved accuracy and sensitivity. The authors suggest using textural variations, region homogeneity, and region boundaries of an image to identify patterns. The authors suggest that the proposed technique effectively identifies irregular patterns and could be used in X-ray-based analysis. The authors conclude that their proposed technique could aid radiologists in interpreting X-rays with high accuracy and throughput. As a future scope, the authors mention that this technique could be employed to analyze various lung abnormalities besides COVID-19.

The research paper authored by Surendar et al. [29] aims to assist medical practitioners in identifying malignant lung nodules and classifying them in the early stages of cancer using CT images. The authors achieve this by combining an adaptive optimization algorithm with the hybrid deep ANNs. Initially, they use a Fast Non-Local Means (FNLM) filter for pre-processing. Next, they use the MasiEMT-SSA algorithm for segmentation. This step segments the CT image and identifies the nodules. Next, the Grey-Level Run-Length Matrix (GLRLM) method is used for feature extraction. Next, the Binary Grasshopper Optimization Algorithm (BGOA) is used for feature extraction. Finally, the Adaptive Sine-Cosine Crow Search (DNN-ASCCS) algorithm is used for classification. The authors mention that this hybrid classifier is highly accurate in detecting nodules. The authors had reached 99.17% accuracy in this experiment in MATLAB using the datasets from the Lung Image Database Consortium and Image Database Resource Initiative (LIDCIDRI). The authors mention that the new DNN-ASCCS algorithm is highly accurate and effective in classification involving CT images. The authors suggest that we could improve this proposed method by using other methods having lesser time complexity.

The research paper authored by Chen J. et al. [30] aims to assist radiologists in scoring the ultrasound lung images of COVID-19 patients. Using ultrasound, they estimate the lung fluids and determine if they are normal. Any abnormalities in the manifestation and excessive fluids are detected by ultrasound and reported using lung ultrasound scores. However, the lung ultrasound scores are usually not accurate and hugely vary as per the observer, and many manual and expert interventions are required. The authors intend to automate this and propose a quantitative lung ultrasound scoring system to minimize this shortcoming. The authors had experimented with the proposed system in 1527 images and compared them with the scores provided by experienced practitioners. They had processed the images using feature extraction methods. The authors had reached 87% accuracy on a 128x256 model having two fully connected layers. The authors conclude that their proposed method automates and provides a robust and highly accurate lung ultrasound scoring system.

IV. FUTURE DIRECTIONS

Artificial neural networks have the potential to aid medical practitioners in interpreting complex bio-medical images effectively. We should build future ANNs such that it is capable of addressing various shortcomings in the existing techniques. Adetiba et al. **Error! Reference source not found.** suggest that adding more biomarkers to their proposed model would increase the performance of feature extraction methods. Kashyap et al. [11] mention that we could add more cognitive approaches to make the identification of tumors faster. Also, we could add more appropriate parameters to make it more reliable. We could replace the LTCOP feature extraction method with other methods to improve classification performance in the SVM classifier, as suggested by Ajin et al. [12]. The method proposed by Makaju et al. [13] could classify cancer into benign and malignant. However, this method could not classify cancer into different stages as stages 1, 2, 3, and 4 of cancer. It is one area that we could improve in the future. Also, we could eliminate false objects by pre-processing the input data to increase performance. We could use optimization methods to determine parameters before processing them in the CNNs, as suggested by Souza et al. [16]. Shaukat et al. [17] mention that we should test the proposed CAD system on large datasets to validate its efficiency and structure it according to market needs. They also suggest that we should improve the descriptive nature of the input feature sets. Huang et al. [23] mention that we need to investigate TL and ELM to improve the robustness of the suggested model. Wang et al. [25] suggest incorporating correlations among thorax diseases into their proposed model to make it more accurate. Chen J. et al. [30] mention that

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we should consider integrating sub pleural consolidations in the LUSS besides B-lines. It would improve the effectiveness of the proposed model in detecting COVID-19. We think this proposed LUSS method could be clubbed with an efficient pre-classification stage to improve the efficiency.

V. CONCLUSION

It is definite that the use of ANNs is inevitable in the medical bio-imaging field. They play a critical role in enhancing accuracy, time complexity, & sensitivity besides improving various other performance measures. This paper presented an extensive literature survey on the recent trends and novel techniques proposed in artificial neural networks to identify pulmonary abnormalities using X-ray, CT, MRI, ultrasound images, and computer-aided diagnostic systems, besides highlighting their benefits, limitations, challenges, and future directions, aiming at achieving critical milestones to be used in the medical field in the near future. We believe this assessment will enable researchers to choose and develop many such viable models in ANNs and address the ever-increasing needs of the medical field and thus improve the quality of human life.

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