



Deep learning approach for detection of multiple respiratory diseases from chest X-ray analysis: A survey

Sandip Buradkar^a Dr. Prashad Joshi^b Dr. Pradnya Ghare^c

^aPhD Scholar, ECE, IIIT, Nagpur, India.

^bAssistant Professor, ECE, IIIT, Nagpur, India.

^cAssistant Professor, ECE, VNIT, Nagpur, India

Abstract

Deep learning approach for detecting various respiratory diseases has been a challenging and most demanding research area. With a rapid increase in the number of patients suffering from respiratory diseases, a quick method has become necessary for classification and detection of respiratory diseases. This survey paper offers a comparative study of various deep learning techniques that can be used for chest X-ray detection of various thoracic diseases. There is a possibility of severe respiratory failure in some thoracic diseases if they are not treated in the initial stages. Many digital image processing techniques, machine learning, and deep learning models have been developed for this purpose [17]. Different forms of existing deep learning techniques including convolutional neural network (CNN), visual geometry group based neural network (VGG-16 and VGG-19) have been developed for respiratory disease prediction. But these all models have some limitations that they do not cover all respiratory diseases including Covid-19, Viral pneumonia, and Tuberculosis on a single platform. Therefore, we propose our customized new deep learning model Clx-Net by using data augmentation technique to enlarge the area of available dataset [1][2] to make the model more efficient with less time consumption per epoch and provide localization to identify the infected region by examining chest X-ray images. Our focus is to develop a new unique deep learning based model Clx-Net which will be able to detect almost all major respiratory diseases including Covid-19. It will simplify the detection of respiratory diseases and also find the location of the infected chest area to make the task easy for radiologists.

Keywords: Deep learning Thoracic disease CNN GG Data augmentation.

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Contents

- Abstract.....
 - 1. Introduction
 - 2. Material and Methods.....
 - 3. Conclusion.....
 - 4. References.....
 - 5. Biography of Authors.....
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1 Introduction

For detection of respiratory diseases, Chest X-ray imaging process is always preferred over CT imaging process because CT imaging process is time consuming and high quality CT scanner is not available in many rural and suburban regions. X-ray imaging is most common and widely available diagnostic imaging technique. There are many regions across the world where we find shortage of expert healthcare practitioners and radiologists for timely diagnosis of such diseases. Computer aided diagnosis using deep learning is the best solution for this because this facility is available to large population at lowest cost. Another issue with these diseases is that many times features that describe the existence of disease often get mixed with other diseases and radiologists find it difficult and challenging to diagnose them. Deep learning techniques solve these problems with good accuracy and less time consumption.

In a pandemic situation like COVID-19, it was most demanding to search for accurate and rapid diagnosis methods in addition to available virus testing modalities. Because X-ray machines are widely available all over including clinics of underdeveloped areas, they can be used for rapid detection of possible COVID-19 lung infections. X-rays are safe for children and pregnant women as they use very small amount of radiation as compared to CT scanner. In this paper, we propose an efficient deep learning-based chest radiograph classification architecture to distinguish COVID-19 from other respiratory diseases. Furthermore, we justify our customized CNN model by comparing it with widely adopted CNN architectures for image classification such as VGG-16, VGG-19, AlexNet, ResNet 50, and

DenseNet which are well known for their performance and utility in the field of healthcare. The high classification and detection accuracy of our proposed model implies that it can efficiently detect COVID-19, pneumonia and other lung diseases from radiograph images to provide a rapid and reliable evidence of existence of infection in the lungs. As the symptoms of respiratory diseases are almost similar, it can be difficult and time consuming for doctors and radiologists to diagnose the lung disease of patient properly. Our customized model Clx-Net can solve these problems efficiently with good accuracy and less time consumption.

2 Materials and Methods

Literature survey

For literature survey papers are selected using a PubMed search. For methodical search and paper title we selected research papers presented in different conferences like MICCAI, ISBI, MIDL, SPIE and EMBC. Here we found multiple publications of same title. After listing yearwise, only the latest publications were included. This search method resulted in around 120 listed papers. After removing some duplicate papers and papers which are not related to deep learning approach for chest X-ray analysis, after excluding publications which were not peer reviewed, our research finally reached to latest 50 research papers.

Deep Learning Approach

Deep learning is a part of artificial intelligence which proves a milestone in the field of healthcare. It is very useful to data scientists who are working on collection, analysis and interpretation of large



amount of data. By using concept of Deep learning they can make this process faster and easier. This approach is final and most probable solution for the literature reviewed in this work. Convolutional neural networks are provided in many other modalities as basic model for medical image analysis. Different networks may be constructed with different types of layers included and worked as 'architecture'.

Convolutional Neural Networks (CNN/Conv-Net)

CNNs were first developed and used in initial period of 1980s (Fukushima and Miyake, 1982). The CNN is a part of deep neural network and it requires a large amount of data for training. It also requires a lot of computing resources. This was a drawback for CNNs at that time. CNN specializes in processing data of image. Today the role of the Conv-Net is to reduce the images into a form that is easier to process, without losing features which are necessary for getting a good prediction. [3][4].

Transfer learning for image classification

In Transfer learning process the model is trained on one problem is used in some way on second related problem. We use the concept of transfer learning in Chest X-ray analysis for pre-training of model. The network architecture is first trained on a large dataset to perform different task, and the trained weights are then used to perform task for fine-tuning [16]. Depending on availability of data from the target domain, all layers can be re-trained or sometimes only the final fully connected layer can be re-trained. This concept of transfer learning is used in the research survey related to this work. [19], Localization networks

Proposed Architecture

Localization is the term used for identification of region of interest within the image, it is generally indicated by bounding box technique or by a point location. The

RCNN (Region Convolutional Neural Network) was introduced in 2014 [5], to identify regions of interest in the image. In this network CNN architecture is used to extract features of these identified regions. SVM (support vector machine) was used to classify the regions based on feature extraction. This method passes through several stages and is relatively very slow. The performance of this method was later improved by fastRCNN which changed the processing pipeline structure, which removes the necessity of initial region identification or SVM classification. Here speed and performance both are improved as compared to previous one. Another popular architecture for object localization is YOLO (You Only Look Once), which was first introduced in 2016 (Redmon et al., 2016). It was single-stage object detection method and further improved in eventually versions in 2017 and 2018 [18]. Another popular localization network that used in medical imaging field is RetinaNet [14]. Similar to YOLO, this is also single-stage detector, works on the concept of a focal loss function. Most of the localization works used in review use one of the described architectures. Deep learning depends on large amounts of annotated data. The quality of images available in public datasets is not good. This may decrease performance in deep learning systems. We are using dataset of chest X-ray image showing multiple respiratory diseases from Kaggle repository (<https://www.kaggle.com/datasets>)



Fig. 2. Block diagram of proposed architecture

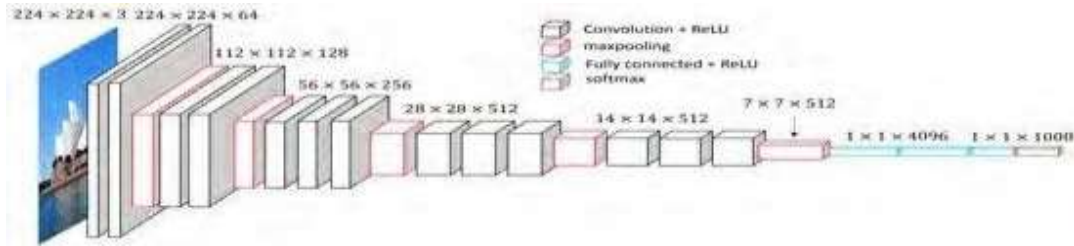
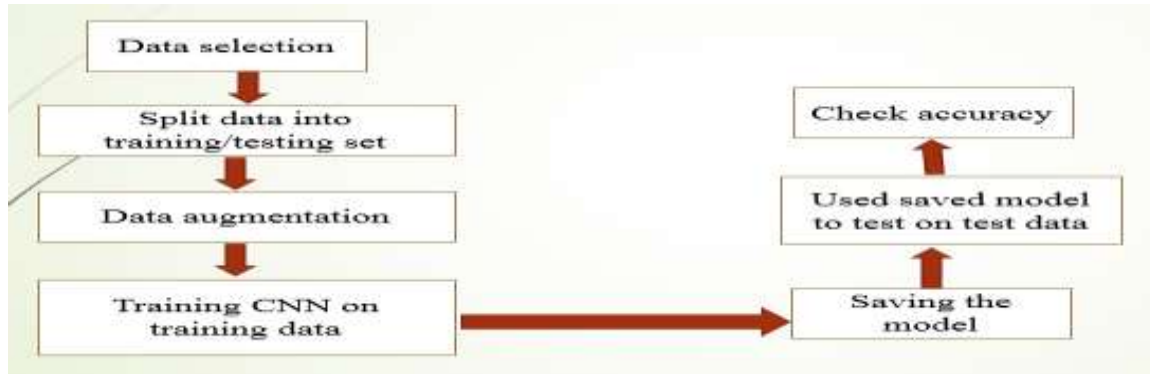


Fig. 3. VGG16 architecture

335

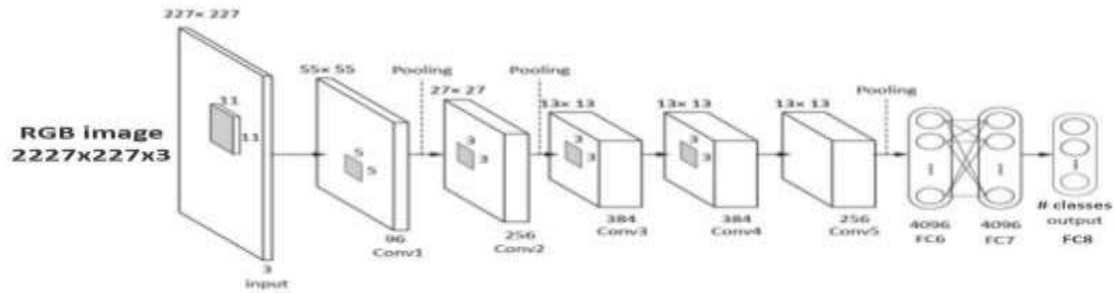


Fig. 4 AlexNet architecture



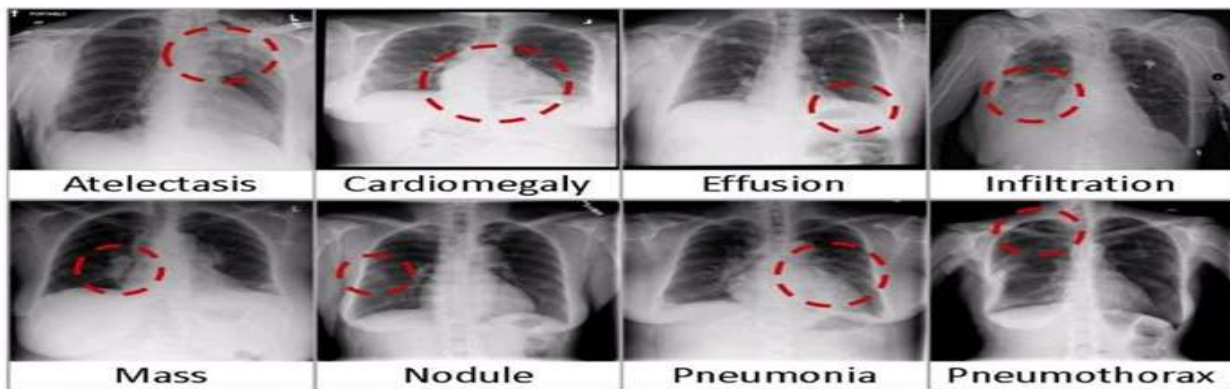


Fig. 5. Images of different respiratory diseases and location of infected region.

Comparison

VGG16/VGG-19 is a convolution neural network (CNN) architecture which is considered to be most popular and widely adopted excellent vision model architecture. It consists of fixed arrangement of convolution and maxpool layers consistently throughout the whole architecture. It is trained on ImageNet dataset and applicable for more than 1000 classes for prediction.

Alex-Net is CNN based classic network architecture. It consists of convolutions layers, max pooling layers and dense layers as the basic building blocks. The layer arrangement of Alex-Net is non uniform but no. of layers in architecture are less as compared to VGG-16 and VGG-19.

Our proposed model Clx-Net will be comparable in performance with VGG16, VGG-19, AlexNET and other widely adopted networks in terms of accuracy, no. of convolution layers, max pooling layers, no. of dense layers, and run time per epoch.

3. Conclusion

After studying and comparing methods and techniques, I came to know that the research methodologies available to diagnose respiratory diseases are not sufficient to diagnose all the diseases caused due to chest infection with accuracy and less time consumption. My conclusion supported the statement that there is no research

to differentiate pneumonia, covid-19, tuberculosis and other respiratory diseases on same platform. It is not mentioned clearly on which platform does the model was trained. What will be the result if we combined all the problems into one like classifying pneumonia, Tuberculosis and other respiratory diseases and localization of infected region as well. How big dataset we need if my research goes in this direction and what Type of evaluation metric we should use if work on this problem. If we combined the problems shall we get the balanced dataset for all the classes. If dataset is balanced, can we get location coordinates in the images for abnormality detection. Shall we need external resources to train our proposed model Clx-Net. What type of implementation we can do with CNN architecture to improve accuracy of our model by using available data for training testing and validation on same platform.

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5. Biography of Authors



	<p>Sandip B. Buradkar, PhD scholar, Indian Institute of Information Technology, Nagpur. Qualification: M.Tech.(Electronics) Areas of interest: Deep learning, Machine learning, Digital image processing, Biomedical Engineering. <i>Email:</i> sandipburadkar2@gmail.com</p>
	<p>Dr. Prasad V. Joshi, Assistant Professor, Indian Institute of Information Technology, Nagpur. Qualification: Ph.D. Areas of interest: Deep learning, Machine learning, Digital signal processing, Digital image processing Research projects-Modernization . <i>Email:</i> pjoshi@iiitain.ac.in</p>
	<p>Dr. Pradnya H. Ghare Assistant Professor, Visvesvaraya National Institute of Technology, Nagpur, Qualification: Ph.D. Areas of interest: Body Area Networks, Wireless Sensors Network, Analog Circuit Design <i>Email:</i> ghareph22@gmail.com</p>

