Detection of Novel Corona Virus and Related Lung Diseases from X-Ray Images

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ABSTRACT

The risk of lung disease is more and increasing day by day. According to a survey of WHO nearly 4 million deaths occur due to lung diseases like pneumonia, asthma, tuberculosis etc.. There are many different existing convolutional neural network models and vanilla neural networks for lung disease prediction. All these models provide high accuracy for smaller image size or for smaller datasets. Therefore, here we propose a deep learning framework by processing the chest x-ray images with a convolutional neural network. The proposed idea is to reduce the clinical testing time and to increase the accuracy and precision of the result. This helps to identify and differentiate COVID-19 and related lung diseases. This may guide the medical interventions for easy diagnoses and research purposes.

Keywords: *Vanilla Neural Network, Capsule Network, Convolutional Neural Network, COVID-19, Visual Geometry Group.*

Introduction

Image processing

An image processing technique is the usage of a computer to manipulate a digital image. This technique has many benefits such as elasticity, adaptability, data storing, and communication. With the growth of different image resizing techniques, the images can be kept efficiently. This technique has many sets of rules to perform into the images synchronously. The 2D and 3D images can be processed in multiple dimensions. In medicine, many techniques are used such as segmentation and texture analysis, which are used for cancer and other disorder identifications. Image registering and fusion methods are widely used nowadays, especially in new modalities such as PET-CT and PET-MRI. In the field of bioinformatics, telemedicine and format-less compression techniques are used to communicate the image remotely. The images are classified according to different qualities such as illumination, contrast, entropy, and signal-to-noise ratio. The histogram is the simplest image processing technique. The image display does not change the image quality. The grayscale histogram considers the basic type of images that are used to evaluate and improve the images. Medical image processing encompasses the use and exploration of 3D image datasets of the human body, obtained most commonly from a Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) scanner to diagnose pathologies or guide medical interventions such as surgical planning, or for research purposes.

X-ray images

X-rays are a type of radiation called electromagnetic waves. X-ray imaging creates pictures of the inside of your body. The images show the parts of your body in

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different shades of black and white. This is because different tissues absorb different amounts of radiation. Calcium in bones absorbs x-rays the most, so bones look white. Fat and other soft tissues absorb less and look grey. Air absorbs the least, so the lungs look black. The most familiar use of x-rays is checking for fractures (broken bones), but x-rays are also used in other ways. For example, chest x-rays can spot pneumonia. Mammograms use x-rays to look for breast cancer. When you have an x-ray, you may wear a lead apron to protect certain parts of your body. The amount of radiation you get from an x-ray is small. For example, a chest x-ray gives out a radiation dose similar to the amount of radiation you're naturally exposed to from the environment over 10 days.

X-ray images in image processing

Digital x-ray images are routinely processed to enhance diagnostic information and suppress irrelevant detail, and also to extract quantitative information. The basic concepts and terminology of image processing as it applies to x-ray projection radiography are discussed and defined. Regardless of its design, every x-ray machines have 3 principal parts: The x-ray tube, The Operating Console, and The High Voltage Generators. In some types of machines such as dental and portable machines, these 3 components are housed compactly.

Radiography

Radiography examination can be conducted faster and have greater availability gave the prevalence of chest radiology imaging systems in modern healthcare systems and the availability of portable units, making them a good complement to RT-PCR testing, particularly since CXR imaging is often performed as part of standard procedure for patients with respiratory complaints. It is also suggested that the COVID-19 pandemic department with worsening symptoms [5]. Motivated by the urgent need to develop solutions to aid in the fight against the COVID-19 pandemic, inspired by the open-source and open-access efforts of the research community, and intrigued in exploring the efficiency of AI systems leveraging the more readily available and accessible chest X-ray imaging modality, this study introduces a deep convolutional neural network design for the detection of COVID-19 cases and all related lung diseases from CXR images that is open source [5]. Illustration is shown in figure 1,

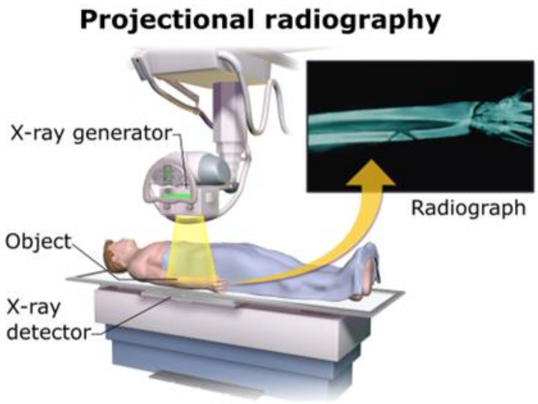

Figure 1 Radiography mechanism

Lung diseases

COVID-19

The novel Coronavirus is an infectious acute disease. The Coronavirus is a Greek word that means crown or halo which indicates the virus's appearance. That's why this coronavirus is also called a crowned virus. This emerged as an epidemic disease in China, Wuhan city, in December 2019. Now, this has changed to a pandemic as a very dangerous public health problem [7]. It is said that COVID-19 is transmitted from anteaters and bats to humans for the first time then it is spread by humans. To date, there are 40 different species in the coronavirus family have been found that are transmitted by humans [10]. Common symptoms of this virus are dry cough, fever, and breath shortness. Also,

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muscle pain, sputum production, and sore throats are mild symptoms of the COVID-19. In serious cases, this causes pneumonia, acute respiratory disorders, septic shock, multi-organ failure, and finally death. This virus is mainly spread through tiny droplets of the carrier through coughing. It takes nearly 2 to 14 days for the virus to develop its complete form. By using X-ray images from the chest doctors can visually diagnose Viral, Bacterial, COVID-19 infections, and so on [12]. On the other hand, these image diagnoses have certain demerits like blurred images, less contrast, and overlapped organs. This is usually considered an incorrect process. So, according to all these elements recently an automatic detection of viruses including coronavirus from chest scan images has attracted more. This helps in reducing the workload of the hospital workers. Machine learning and deep learning can play a major role here. Many researchers have examen to relate machine learning techniques to X-ray image diagnostic information. This elucidation put up with decreasing costs for health and medical science projects [12].

The process of RT-PCR takes 4 to 6 hours to get results which is considered a long time as COVID-19's rapid spread. Chest X-ray is one of the important intra-operated clinical adjuncts in the primary analyses of different pulmonary abnormalities. As said earlier clinical symptoms include fatigue, fever, and cough while other patients can sometimes be asymptomatic. In severe cases, patients may develop ARDS and need ICU or oxygen assistance therapy [1]. Further, many deep-learning models like deep convolutional networks, recursive networks, transfer learning models, etc. have been implemented to automatically analyse the radiological disease characteristics [11]. Hence much more X-ray image processing system is needed for easier and more accurate detection and analysis of lung disorder. Latter, to avoid the overfitting of the models, the studies used data augmentation techniques, which generate different variants of the source image by applying random photometric transformations like blurring, sharpening, contrast adjustment, etc. [11]. The main contribution of this research is the development of a new deep learning algorithm suitable for predicting lung disease from X-ray images [10]. It is essential to investigate more comprehensive scenarios for the classification of various pneumonia types.

According to these different issues, in the current study attempts have been made to overcome the related issues [12]. Generally, the chest X-ray images are first acquired from publicly accessed databases and used in training samples. Then in the pre-processing step, images are augmented to enhance the classification performance and resized since the acquired images appeared in various sizes. Later, the transfer learning technique is employed to extract features and do the classification. Finally, unseen test images are supplied to the network to evaluate the performance by calculating accuracy, precision, and recalling of the proposed method [6]. A pilot study using publicly available chest X-rays of no pneumonia patients and patients with coronavirus should promise that it is possible to train a Convolutional Neural Network (CNN) to distinguish between these two groups with approximately 90% accuracy. In addition, there is the potential to distinguish viral from bacterial pneumonia, which is particularly relevant to COVID-19 infection because pneumonia is directly associated with the virus rather than a bacterial complication [2]. However, it still requires experienced radiologists to analyse and diagnose X-rays, which is very labour-intensive and time-consuming, and automated COVID-19 detection methods can settle these problems. In addition, deep learning methods have long been successfully used to detect pneumonia and perform lung segmentation from X-ray images. Artificial Intelligence (AI) is lately

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being applied toward stimulating biomedical study and in numerous fields such as image identification, object categorization, image segmentation, and deep learning approaches. Individuals affected with COVID-19 will possibly have pneumonia since the infection reaches the lungs. Many deep learning investigations identify the condition using X-ray images of the chest. Three different deep learning models have been employed in the past to distribute X-ray images of pneumonia, and those are the fine-tuned model, the non-fine-tuned, and the scratch-trained model. On the other hand, most prediction models use X-ray and CT images based on the deep learning method, which requires more time to extract the features and train the model [4]. Famous classical mathematical differential equations and population prediction models have limitations in predicting the population in the time series and significant estimation errors. Analytical methodologies, for instance, Auto Regressive Moving Average (ARIMA), Moving average (MA), and Auto-Regressive (AR) methods, are primarily formulated on the premises. Still, they have difficulties in predicting live circulation rates. A vast variety of demographic and competitive models were developed for modelling COVID-19's rampant transmission dynamics. However, in multiple situations, these approaches don't adhere to the provided information, and the accuracy of the forecast is usually low [4].

Pneumonia

Non-COVID-19 viral pneumonia is also one of the leading causes of death of people of young and old ages. According to the Centres for Disease Control and Prevention (CDC), over 1 million adult pneumonia patients are hospitalized, and almost 50,000 patients die every year from this disease in the USA alone. As stated by WHO, chest X-rays are the best available way of diagnosing pneumonia. Pneumonia is a respiratory infection that affects the lungs that can be caused by bacteria, viruses, or fungi. Diagnosing pneumonia is considered a tedious task, even by expert radiologists, because its symptoms appear to be similar to other pathologies that affect the lungs [8]. Hence a CNN model is proposed by using three-class classifications for COVID-19, pneumonia, and normal cases. Pneumonia is a leading cause of death all around the world. On average, it kills 7 lakh children per year and affects 7% of the world's population. An existing image processing-based deep learning approach to detect pneumonia using the concept of transfer learning and image augmentation has an accuracy of 96%. The respiratory virus is like influenza, rhinovirus is the main cause of this disease. The COVID-19-based pneumonia epidemic that broke out in 2019 still threatens the survival of all mankind due to this rapid rate of infection of new crown pneumonia, how to quickly detect new crown pneumonia has placed great demands on the global medical system. Deep learning assists in the diagnosis of new crowns.

Tuberculosis

Tuberculosis (TB) is a communicable disease caused by a bacterium called Mycobacterium tuberculosis. Early diagnosis of tuberculosis and consequent administration of proper medication can cure this deadly disease. Recently artificial intelligence-based solutions have been proposed for many biomedical applications including brain tumors, lung nodules, pneumonia, physiological monitoring, and social sensing. CNN's have been used in several recent studies for the detection of lung diseases including pneumonia and tuberculosis by analysing chest X-ray images. Several research groups used classical machine learning techniques for classifying TB and non-TB cases from CXR images. The use of deep machine algorithms has been reported in the detection of tuberculosis by varying the parameters of the deep learning framework used for the detection of tuberculosis utilizing pre-trained models and their ensembles. In clinical applications, an increase in the accuracy of TB detection from chest radiographs with a robust and versatile method can make computer automatic diagnostic tools more reliable.

The classification accuracy can be improved either by using different deep learning algorithms or by modifying the existing outperforming algorithms or by combining several outperforming algorithms as an ensemble model. CNN-based techniques have been used for the detection of the novel coronavirus families using transfer learning of various pre-trained CNN models with sensitivity values greater than 90%. The deep learning approach to classify CXR images into TB and non-TB categories with an accuracy of 82.09%. Common findings include segmental or lobar airspace consolidation, ipsilateral hilar and mediastinal lymphadenopathy, and/or pleural effusion. Atelectasis may occur in primary pulmonary tuberculosis, often as a consequence of tuberculous airway involvement. There are multiple light areas (opacities) of varying sizes that run together (coalesce). Arrows indicate the location of cavities within these light areas. The x-ray on the left clearly shows that the opacities are located in the upper area of the lungs toward the back.

The appearance is typical for chronic pulmonary tuberculosis but may also occur with chronic pulmonary histiocytosis and chronic pulmonary coccidioidomycosis. Pulmonary tuberculosis is making a comeback with new resistant strains that are difficult to treat. Pulmonary tuberculosis is the most common form of the disease, but other organs can be infected. The chest X-ray may be normal in primary TB most patients infected are never unwell enough to require a chest X-ray. Here, in the given system a similar deep learning system that is more accurate than the existing systems also indicates some special features like, whether the patient has covid and all related lung diseases like pneumonia or not [10].

Related works

This section provides a detailed view of researchers in this domain which explains the existing models and methods. Various proposed deep CNN's that provide a clear study of lung diseases are given.

In [1] Aniello Castiglione et. al proposed an optimized CNN model (ADECO-CNN) to divide infected and non-infected patients. Furthermore, this approach is compared with pre-planned CNN-based models1. Techniques for detecting COVID-19 infection are faster. This removes noise from lung images and improves image quality. The pooling layer also helps in reducing the overfitting issue. Using CT images with high sensitivity and accuracy is still a challenging job due to the variation in size, position, and texture of infections. This model cannot differentiate similar diseases like pneumonia. There is a need to develop models capable of differentiating COVID-19 cases from additional similar diseases like pneumonia.

In [2] Jie Hou & Terry Gao has built a diagnostic system that uses open to public coronavirus infector chest X-ray images from training. The data are split into training and validation sets, which are composed of 3 samples normal, coronavirus infection, and viral infection. The CNN is then trained on the training set and the predictive value of the tool once trained and determined by using the validation set. The system is very robust to many X-ray images. The proposed system has a 96.03% accuracy. They have 96.15% precision. They are capable of investigating X-ray images with different body positions, and angle sizes. This model cannot detect bacterial infections. A larger dataset of COVID-19 images should be used. This proposed system can be improved by using more techniques such as Elephant herding

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optimization, Bull optimization algorithm, and Parliamentary optimization algorithm.

In [3] Kedong Rao et. al in the COVID-19 detection method based on SVRNet and SVDNet in lung X-ray proposed combined deep learning and transfer learning model is proposed. Lung x-ray images in the COVID-19 image database were used as experimental data sets and the representative image classification models. VGG16, ResNet50, InceptionV3, and Xception were fine-tuned and trained. 2 new models for lung X-ray detection SVRNet and SVDNet were proposed. Reduce the number of parameters. This model has improved accuracy and increased operating speed. In the case of layer jumping connection, the number of model parameters and network operation speed is reduced.

In [4] Recurrent Neural Network and Reinforcement learning model for COVID-19 prediction by R. Lakshmana Rao et. al proposed two learning algorithms, namely deep learning and reinforcement learning were developed to forecast COVID-19. A model using RNN particularly the MLSTM model, to forecast the count of newly affected individuals, losses, and cures in the following few days. This study also suggests deep learning reinforcement optimizes COVID-19's predictive outcomes based on symptoms. This system has the lowest error rate compared to other systems. The predictive results can only suggest general patterns and are restricted. Future work can be proposed by using a semi-supervised hybrid design to identify the COVID-19 and social media platforms to prevent further spread.

In [5] Linda Wang et. al proposed a human-machine collaborative design strategy that is leveraged to create COVID-Net. Human-driven principled network design prototyping is combined with machine-driven design exploration to produce a network architecture tailored for the detection of COVID-19 cases from CXR images. There is considerable architectural diversity in the COVID-Net architecture. This helps the clinicians to discover new insights into the key visual indicators associated with SARS-CoV-2. Scarcity of COVID-19 case data available in the public domain. Not accurate for long-term predictions. Future directions include continuing to improve sensitivity and PPV to COVID-19 infections as new data is collected. As well as extend the proposed COVID-Net to risk stratification for survival analysis, predicting risk status of patients, and predicting hospitalization.

In [6] Identification of COVID-19 samples from chest X-ray images using deep learning: A comparison of transfer learning approaches. Md Mamunur Rahman et. al proposed an automated CAD system developed for detecting COVID-19 from healthy and pneumonia cases using CXR images. Here deep transfer learning techniques were employed to examine 15 different pre-trained CNN models to find the most suitable one. In VGG the network architecture is straightforward. VGG uses a small receptive field which helps to improve performance VGGNets are less expensive and hence easier to train. Scarcity of publicly accessible CXR images. The network demands more time for training. The future work can be proposed by practical development of software for the proposed concept.

In [7] Md Zabirul Islam et.al aims to introduce a deep learning technique based on the combination of a CNN and an LSTM to diagnose COVID-19 automatically using X-ray images. In this system, deep feature extraction and LSTM are used for detection using the extracted feature. This system has higher efficiency. Training and validation accuracy is more. The result of the proposed system is superior compared to other existing systems. The sample size is relatively small. It focuses only on the Posterior-Anterior view of X-ray hence it cannot differentiate other views like Anterior-Posterior, lateral, etc… The

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sample size can be increased to test the generalizability of the developed system. The performance of the proposed system can be compared with more images in the coming days. Anterior-posterior and lateral views of X-rays can be differentiated.

In [8] COVID-19 and pneumonia diagnosis in X-ray images using CNN by Rahib H. Abiyev and Abdullahi Ismail proposed a CNN model is proposed by using 3 class classifications on COVID-19, pneumonia, and normal cases. The effect of transfer learning on model constriction has been demonstrated. A small number of images is enough to easily identify the important features The dataset used in this research was imbalanced and the CNN used can be severely affected by this imbalance by creating bias among the classes.

In [9] A survey of deep learning for lung disease detection on medical images: State-of-the-art, taxonomy, issues and future direction by Stefanus tao Hwa Kieu et.al presents a taxonomy of the state-of-the-art deep learning-based lung disease-based detection systems, visualize the trends of recent work on the domain and identify the remaining issues and potential future directions in this domain. The taxonomy consists of 7 attributes that are common in the surveyed articles, image types, features, data augmentation, types of deep learning algorithms, transfer learning, the ensemble of classifiers, and types of lung diseases. The usage of both CNN and transfer learning is high' This can be used by other researchers to plan their research and activities. The primary source of work considered were those indexed in the Scopus database. Future work can be proposed for training using cloud computing to overcome the problem of using huge image sizes. Usage of more variety of features SIFT, GIST, LBP, and HOG.

In [10] Subrato Bharati et. al proposed a new hybrid deep learning framework by combining VGG, data augmentation, and STN with CNN. This new hybrid method is termed here as VGG data STN. As implementation tools, jupyter notebook, tensor flow, and Keras are used. The new model is applied to the NIH chest X-ray image dataset, and full and sample versions of the dataset are considered. Best validation accuracy. They have less training time. Can detect the inflammatory areas in chest X-ray images. Gives accuracy only for small datasets. Not that effective in real-time applications. This model needs testing to differentiate each type of lung disease. The probability of getting significant features will be increased if the size of training shots can be increased. Several pre-trained models can experiment with. ZDNet can be applied to X-ray images of suspected COVID-19 patients to predict whether patients have COVID-19-related pneumonia or not.

In [11] Tej Bahadur Chandra et. al proposed an automatic COVID screening (ACoS)system that uses radiomic texture descriptors extracted from CXR images to identify normal, suspected, and nCOVID-19, infected patients. This system can be easily modelled using the limited number of annotated images that can be deployed even in a resource-constrained environment. The subtle radiographic responses of different abnormalities like TB, pneumonia, influenza, etc… confuses the classifier, limiting the diagnostic performance of the system. The future work of the study focuses on improving the reliability and clinical acceptability of the system. The integration of the patient's symptomology and radiologist's feedback with the CAD system could help make a robust screening system.

Problem statement

In recent times, a big dataset of x-ray data is available in Kaggle repository [10]. This dataset is implemented using a deep learning method by a CNN model.

This dataset is very complex. Moreover, it has a lot of noise and it does not have enough information for easily predicting diseases. So, processing these datasets is a challenging task. In this model patients are classified by using a CNN deep learning method on patients x-ray images. Capsule network is considered as one of the strongest algorithms having generative and deterministic capabilities. But this is more sensitive to images than the simple CNN structures [10]. As CNN's are intensively used in medical applications. Hence, this paper aims in developing a model which can predict lung diseases in x-ray images with a greater accuracy than the existing models.

Dataset analysis

Here the complete analysis of dataset like dataset description, exploration, visualization of the taken data samples will be described.

Dataset description

(i) The given sample dataset contains 3204 images with a resolution of 1024 x 1024.
(ii) The description of the class is as follows.
   - There are 4 classes – 1 is healthy and another 3 are diseases.
(iii) There are Covid-19 – 357 images, pneumonia – 2119 images, tuberculosis – 502 images and finally 226 healthy x-ray images.

This proposed model helps in developing and analysing a CNN model based on given datasets. From x-ray images doctors can diagnose patient's medical conditions. From the output of x-ray images this system helps doctors to diagnose lung diseases.

Visualization of dataset

Initially, a sample data is analysed. figure.2 shows the sample dataset for covid and pneumonia with a resolution of 1024 x 1024.

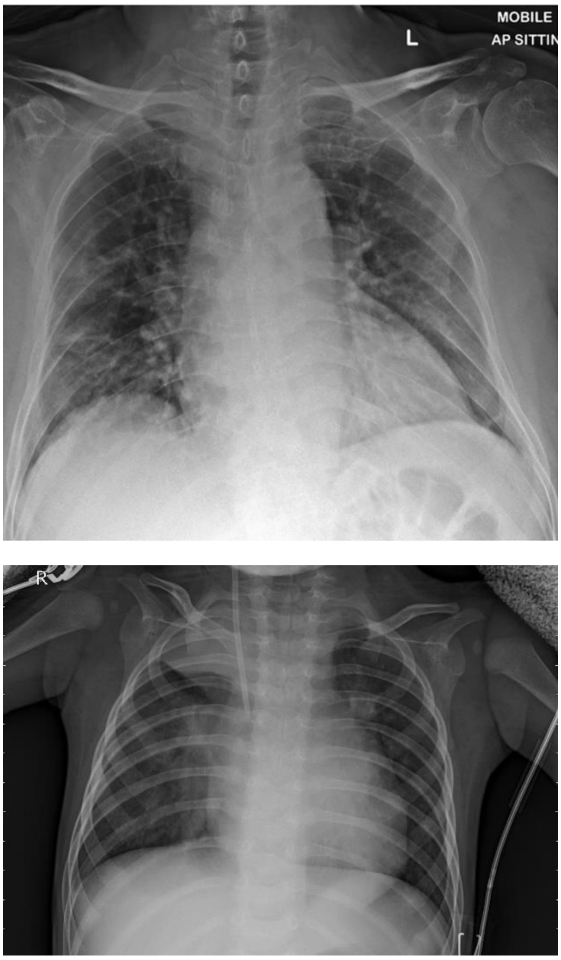

Figure 2. Sample dataset with resolution 1024 x 1024

Description of existing models

Reviews of existing studies show that many models have been proposed in this regard. Since the outbreak of the pandemic, many researchers have shown interest in using radiology images in identifying COVID-19 infection [12]. The common idea is a set of medical images with different categories are used to train a deep CNN that will differentiate noise and useful diagnostic information. Many new deep learning frameworks say VGG data STN with CNN(VDSNet)

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represented in figure 3, CNN-LSTM model, COVID-Net, SVRNet, SVDNet, VGG16, ResNet50, InceptionV3, Xception, Automatic COVID screening system (ACoS), Recurrent neural network (RNN), Modified long short-term memory (MLSTM) model [3, 7,10, 11]. On analyzing all these existing models, the validation accuracy is 73% and other models like vanilla grey, VGG, basic cabinet, and modified CapsNet shown in figure 2 have accuracy values of 69% and 60.5% respectively. These models are designed by fusing CNN with other networks [10]. All these models have smaller image sizes and so special features cannot be detected. More than 800 images have been employed to investigate the performance of the existing models where 70% of images of each class are accepted for training. The trained CNN is capable of interpreting new images by recognizing patterns that indicate COVID-19 and related lung diseases in the individual images. By using all these techniques, the medical cost can be decreased. These systems have a lower error rate when compared to other systems.

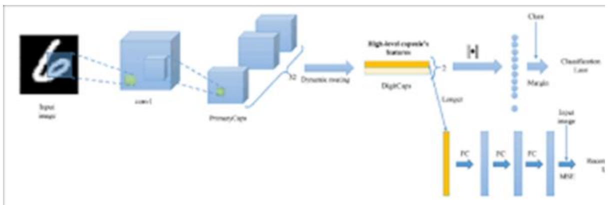

Fig 2. Architecture of capsule net

These existing models help the clinicians to discover an accurate and deep understanding of the key visual indicators related to SARS-CoV-2. These models provide good performance, precision, specificity, accuracy, and sensitivity. However, all these existing models have many limitations like they give better accuracy only for the smaller dataset as the image size is small. The performance of the existing models is low because a small number of datasets is used. The dataset used in these researches was imbalanced and the CNN used can be severely affected by these imbalances by creating bias among classes. These models demonstrate the deep transfer learning techniques for the identification of COVID-19 cases using chest X-ray images. It is necessary to develop better systems to overcome the limitations of existing systems. From the above study, it is clear that research is required for the classification and detection of COVID-19 and all related lung diseases for new and large datasets.

ZDNet:

The deep learning method that combines Convolution Neural Network (CNN), Visual Geometry Group (VGG), Data augmentation, and Spatial Transformer Network (STN) is known as VDSNet.

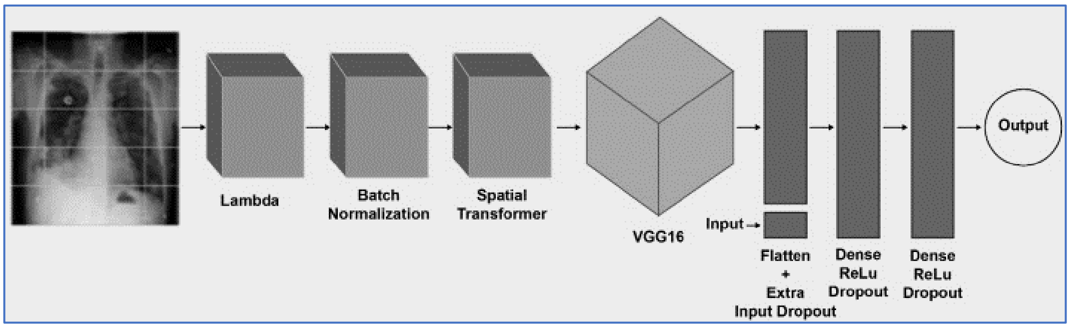

Figure 3. Architecture of VDSNet

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CNN-LSTM MODEL

A CNN-LSTM (Long Short-Term Memory Network) is a model architecture that has a CNN model for the input and an LSTM model to process input time steps processed by the CNN model.

COVID-NET

COVID-Net is a deep CNN design tailored for the detection of COVID-19 cases from chest X-ray (CXR) images that is open source and available to the general public.

SVR-NET and SVDNet

SVR-Net (Separable VGG-ResNet) and Separable VGG-DenseNet (SVDNet) are a set of algorithms that automatically select network structure.

Automatic COVID Screening System (ACoS)

ACoS uses a two-phase classification approach (Normal vs Abnormal and n-COVID 19 vs Pneumonia) using a majority vote-based classifier ensemble of five benchmark supervised classification Algorithms.

Recurrent neural network (RNN)

A Recurrent Neural Network (RNN) is a class of artificial neural networks where connections between nodes form a directed or undirected graph along a temporal sequence. This allows it to exhibit temporal dynamic behaviour.

Methodology

Block diagram description

In recent times a big dataset of X-rays is available. Here this dataset has been implemented using a novel deep learning method. This project applies a new algorithm to the lung disease dataset to predict COVID-19-related lung diseases. There is a need of analyzing special features to detect covid-related lung diseases. As a result, the data problem can be explained for each disease which is very skew. The proposed model will be trained with a huge number of epochs with the change of a few parameters for getting fast convergence. Here, the size of the training shots will be increased to increase the probability of getting significant features. Particularly this can be applied to X-ray images of suspected COVID-19 patients to predict whether the patients have COVID-19-related pneumonia or not.

The pre-processing steps are:

i. At first all the images are rescaled to increase the image size leading to more accuracy.
ii. All the images are transformed from RGB and grey, and are mutually conducted for various models.
iii. The NumPy array used for reading the images at that time is normalized by separating the image matrix.

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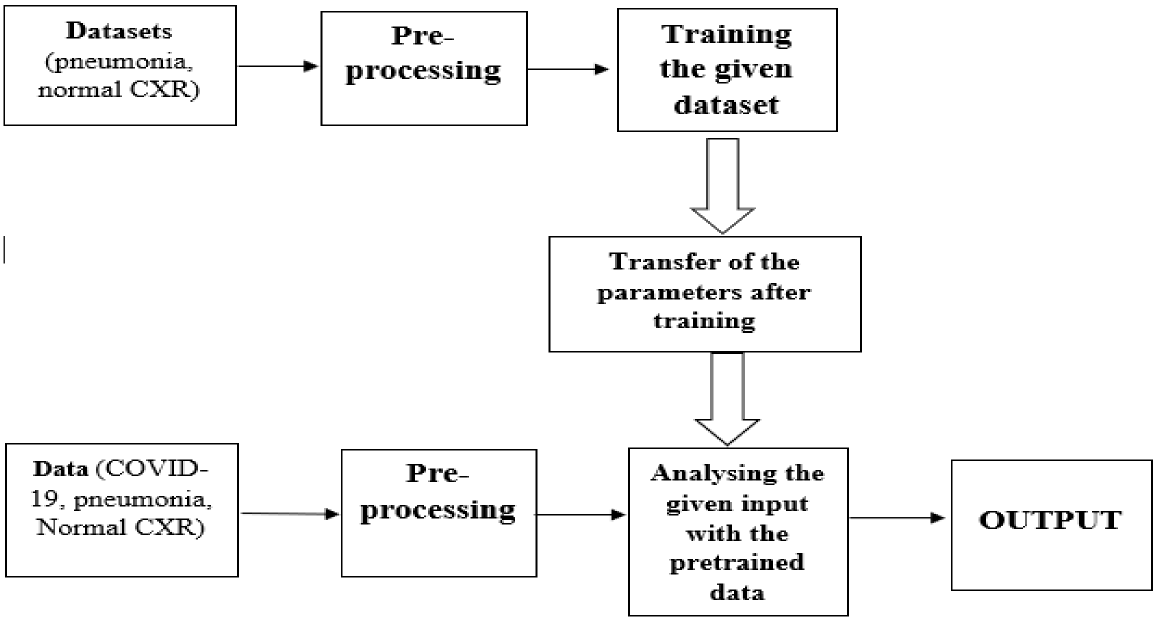

Figure 4. Block diagram

This work considers several metrics for the diagnosis of lung diseases. The metrics considered for this work are testing accuracy, precision, recall, and F score which is described with several terms including true positive (TP), true negative (TN), false negative (FN), and false positive (FP). TP refers to the suspected lung patients that are correctly classified as having lung disease. The term TN is the number of samples having the normal conditions of the lungs. The term FN refers to the suspected patients who have lung disease but remains undetected by the system. Moreover, FP is the number of patients who are wrongly detected to have lung diseases.

Recall=TP/(TP+FN) (1)

Precision=TP/(TP+FP) (2)

F Score = (2 x precision x recall)/(precision + recall) (3)

Fscore is the combination of recall and precision

The sequence of steps in this process is given in figure 4 is,

i. Loading of the dataset into random access memory.
ii. Implementing the network structure designed.
iii. Implementing the metric function as well as precision score, binary accuracy through the threshold.
iv. Training model using training parameters.
v. Testing the dataset.

In this work, a deep learning framework is proposed for detecting lung diseases from X-ray images. By increasing the image size to obtain increased accuracy. However, the training time is increased slightly when the image size is more which can be rectified by other works in the future

Results and Discussion

The performance and efficiency results of the proposed model and existing models are presented in this section. A validation set was used to estimate the model. We have found that the vanilla CNN stops and overfills by the model of early stopping of VDSNet. The convergence is fast as well as is still too useful convergence, will also have provided higher results by training the model using more epoch. The performance of the capsule network is better than vanilla CNN, however it has slower convergence. VDSNet exhibits the best performance with some specific parameters analysed from table 1. Based on the accuracy of the approaches on the full dataset and the sample dataset, different models can be compared.

The training time is greater than vanilla CNN. However, VDSNet model can be improved by training with more epochs. The number of parameters is only equivalent to VDSNet but the training time is much longer. This proposed model has a validation accuracy of 85%. It still does not meet the requirement to use in hospitals, need more time and computer power to further analyze the data. By improving the algorithm these requirements can be met. The achieved accuracy of the proposed VDSNet is less than the reported in Ref [10].

We have evaluated and detected the illness of patients before moving forward with the investigation on more significant levels. Most of the results are exactly the same. Here in this proposed model, we got a validation accuracy of 90% for COVID-19 detection shown in figure 7. The confident score for tuberculosis finding is 85% in figure 8 and the confident score of pneumonia finding is 83% from figure 6.

There are some demerits of the prediction that the ill person is not ill. This can be improved by increasing the training datasets.

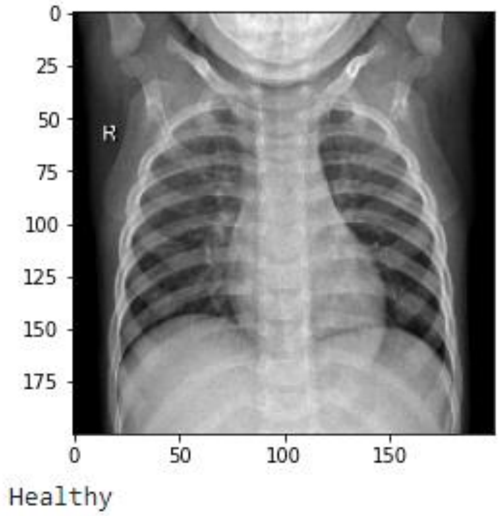

Figure 5. No abnormality finding case.

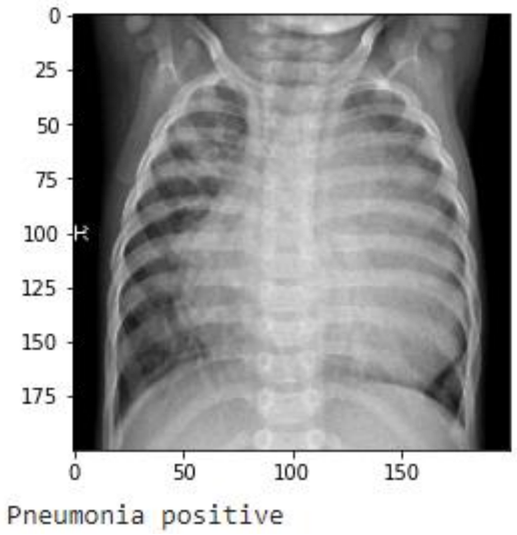

Figure 6. Pneumonia finding case

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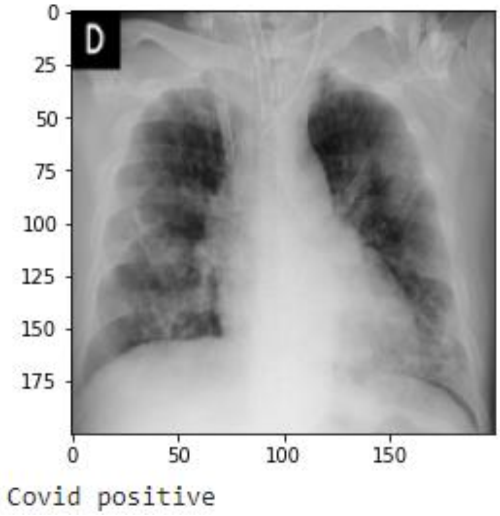

Figure 7. COVID-19 finding case

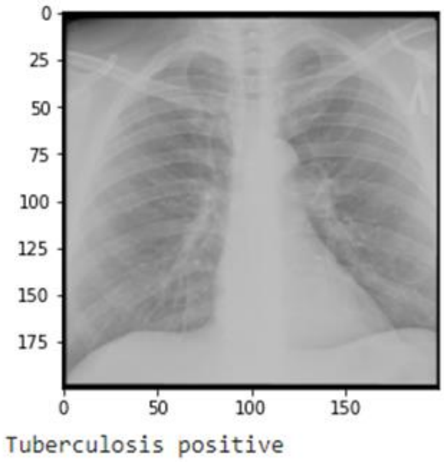

Figure 8. Tuberculosis finding case

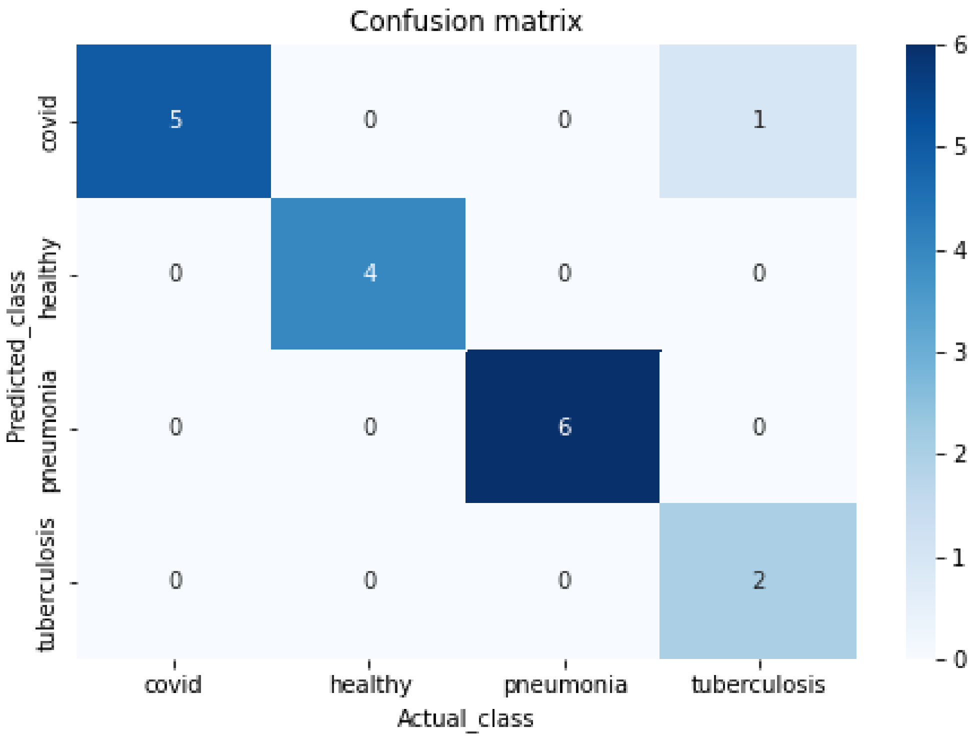

Figure 9. Confusion matrix

This matrix which is shown in figure 9 compares the actual class values with those predicted class values by the CNN model. This gives us a holistic view of how well our classification model is performing and what kinds of errors it is forming.

Dataset	Structural design	Recall	Precision	F_β (0.5) score	Validation Accuracy	No. parameters	Training time (seconds)
Sample Dataset	Vanilla gray	0.50	0.58	0.56	50.7%	321225	2
	Vanilla RGB	0.59	0.62	0.61	51.8%	322793	2
	Hybrid CNN VGG	0.56	0.65	0.63	68%	15252133	16
	VDSNet	**0.64**	**0.62**	**0.64**	**70.8%**	**15488051**	**19**
	Modified CapsNet	0.42	0.71	0.45	59%	12167424	37
	Basic CapsNet	0.60	0.62	0.62	57%	14788864	75
Full Dataset	Vanilla gray	0.58	0.68	0.66	67.8%	321225	51
	Vanilla RGB	0.61	0.68	0.66	69%	322793	53
	Hybrid CNN VGG	0.62	0.68	0.67	69.5%	15252133	384
	VDSNet	**0.63**	**0.69**	**0.68**	**73%**	**15488051**	**431**
	Modified CapsNet	0.48	0.61	0.58	63.8%	12167424	856
	Basic CapsNet	0.51	0.64	0.61	60.5%	14788864	1815

Table 1: Comparison of recall, precision, fscore, validation accuracy and training time of other existing models.

	covid	healthy	pneumonia	tuberculosis	accuracy	macro avg	weighted avg
precision	0.833333	1.0	1.0	1.000000	0.944444	0.958333	0.953704
recall	1.000000	1.0	1.0	0.666667	0.944444	0.916667	0.944444
f1-score	0.909091	1.0	1.0	0.800000	0.944444	0.927273	0.941414
support	5.000000	4.0	6.0	3.000000	0.944444	18.000000	18.000000

Table 2: Accuracy, Precision, Recall, F1-score of this proposed model.

Conclusion and Future work

In this work, a new CNN framework is proposed for detecting lung diseases from X-ray images. The new model is applied to NIH chest X-ray image dataset collected from Kaggle repository. For the case of full dataset, this shows the best validation accuracy of 94.4%, while vanilla grey, vanilla RGB, hybrid CNN VGG, basic CapsNet and modified CapsNet have accuracy values of 67.8%, 69%, 69.5%, 60.5% and 63.8%, respectively. This proposed model exhibits a validation accuracy value of 94.44% which is better than the 70.8% accuracy value in case of sample dataset shown in table 2. On the other hand, this requires a training time of 431 s for the case of full dataset which is much higher than the 19 s time required for sample dataset. In order to make the proposed model useful in hospitals, additional progresses are required to enhance the precision of the model. Generally, basic CNN has poor performance for rotated, tilted or other abnormal image orientation. Based on the performance the conclusions are made as follows: 1. The clinical testing time is reduced by this model and also the accuracy and precision of the proposed model is much better than the existing models, 2. This model will identify and differentiate COVID-19 and its related lung diseases. 3. This has made the medical interventions for easier diagnoses and research purposes.

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The future works for this model can be done as follows, the accuracy of the proposed can be improved using additional layers. Several pretrained models can be experimented inorder to implement CNN with fusion of VGG. This can be useful for other application as well.

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