International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING

ISSN:2147-6799 www.ijisae.org Original Research Paper

Classification of X-ray Images for Pulmonary Diseases Using Deep Learning Techniques

Issac Neha Margret [1], Chalumuru Suresh [2], B.V. Kiranmayee [3]

Submitted: 10/09/2022 **Accepted:** 20/12/2022

Abstract: In the present day, a chest x-ray is the most effective method for distinguishing different pulmonary diseases, however finding multiple pulmonary diseases can be very challenging, especially in places where gifted radiologists are hard to reach. The chest X-ray cannot diagnose many lung disorders because they often resemble one another. Due to the increasing mortality rate and insufficient health supplies, hospitals and radiologists across the globe have been working tirelessly to diagnose patients. Using deep learning systems, it is possible to distinguish pneumonia, tuberculosis, and covid-19 from chest x-rays with advances in automation. Clinical nursing and observational studies are indispensable when chest x-rays are required, although we cannot ignore the conditions leading to the illness where pneumonia, TB, and covid-19 are extreme categories. By automating pulmonary diseases classification based on chest X-rays, we are able to identify pneumonia, TB, covid-19 allowing for quicker intervention and improved accuracy.

Keywords: Convolutional Neural Network (CNN), pulmonary diseases, Chest X-ray (CXR), Tuberculosis, Deep Learning (DL), Pneumonia, Recurrent Neural Network (RNN), Covid-19.

1. Introduction

Respiratory illnesses, often known as pulmonary diseases, are infections, allergies, and various illnesses that affect the tissues, numerous organs, and specialized cells of the human respiratory system, including the lungs. Respiratory system problems are caused by a variety of reasons as shown in Fig.1.

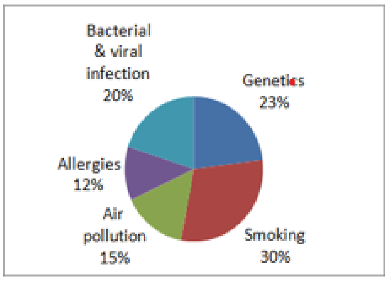


Fig.1: Causes for Pulmonary disorders

Genetics, allergies, smoking, air pollution, bacterial and viral infections are only a few of these factors. A recent WHO survey indicates the degree of increase in pulmonary diseases such as Pneumonia, Asthma, Covid, Tuberculosis, Lung Cancer, and others, which should be treated early to lower the risk factors of these disorders. The proposed system is primarily concerned with the classification of the disorders like pneumonia, tuberculosis, and covid, since these are considered as severe issues that need to be treated efficiently.

People with pneumonia usually cough up phlegm or pus, experience fever, chills, and face difficulty in breathing. The infection is deadly for anyone, but especially for infants, children, and the elderly. A vaccine may be able to prevent some types of pneumonia. There are a number of types of pneumonia that can be treated with antibiotics.

The primary organs affected by TB are the lungs. TB is a potentially serious infectious bacterial disease. When an infected person coughs or sneezes, TB-causing bacteria are transmitted. The majority of tuberculosis victims exhibit no indications of their infection. A cough (often with a bloody tint), weight loss, nocturnal sweats, and fever are typically present when symptoms do arise. If there are no symptoms, treatment may not always be necessary. Patients who still have symptoms after a long period of treatment will need to take several antibiotics.

It is common for people to fall ill with Covid-19 because it is caused by the SARS-CoV-2 virus. Symptoms may range from mild to moderate at first, including sore throats, diarrhea, aches and pains, rash on fingernails and toes, headaches, tiredness, and loss of taste and smell with most people recovering without special treatment, however, some will require medical attention.

Chest scans are a frequent technique of diagnosis. If a doctor suspects a patient has a heart or lung issue, a chest scan is usually one of the first procedures conducted. Radiographs of the chest and spine demonstrate the heart, lungs, blood arteries, and spine bones. CXRs can show fluid within or

[1] *Department of Computer Science and Engineering VNR VJIET – 500090, INDIA*
ORCID ID : 0000-3343-7165-777X
[2] *Department of Computer Science and Engineering VNR VJIET – 500090, INDIA*
ORCID ID : 0000-3343-7165-777X
[3] *Department of Computer Science and Engineering VNR VJIET – 500090, INDIA*
ORCID ID : 0000-3343-7165-777X
* *Corresponding Author Email: isaacneha4@gmail.com*

around the lungs, as well as air surrounding them resulting in pneumonia, tuberculosis, and covid. The image assists the health professional decide if the patient has a disintegrated lung or any other illness like pneumonia, TB, covid. Certain patients have a set of chest X-rays taken gradually to examine if the illness has been improving or deteriorating. Lung problems can be diagnosed and treated with the use of X-rays. Because lung diseases like pneumonia, tuberculosis & covid have similar appearances, recognizing them with a chest X-ray is a challenging process that requires practice. As a result, there is a solution in the form of deep learning technique that teaches computers to do what people do naturally, such as learn by illustration.

A computer model learns to do bracket tasks directly from photos (in this case X-Rays), textbooks, or sound using deep learning (DL) like CNN, MLP, RNN, etc. Deep literacy models can attain cutting-edge delicacy, even surpassing mortal-position performance on rare occasions. Models are trained using a vast amount of labelled data and multiple-layer neural network infrastructures. Because of its ability to handle vast amounts of data, deep learning has proven to be extremely useful technology.

2. Literature Survey

Pablo et.al [1] examined 7 DL architectures coupled to transfer learning methodologies like CNN [15], Grad-CAM & data augmentation to diagnose different types of pneumonia. They also demonstrated an image scaling technique that preserves anatomical chest components while utilizing the maximum window function. Results are encouraging with a 99.88% accuracy rate when comparing bacterial pneumonia, coronavirus, normal, viral, & bacterial classes.

Using DL techniques like Tailored Convolutional Neural Networks. (CNN/ConvNet), CNN, RNN for dynamic chest X-ray image evaluation was the subject of this article by Hammoudi et.al [2] to provide health professionals with precise devices for diagnosis covid affected patients and identifying those who have been confirmed. By merging actual along with synthetic health data with health factors for analyzing risk to the covid-19 and infection rate, pneumonia, the suggested study was able to create a scenario of patients with infections and health issues.

Ayaz et.al [3] proposed an original tuberculosis detection strategy utilizing Ensemble Learning (EL) [20] that merges hand-crafted features and deep features. The initial results indicate that the proposed method could be used as a mass testing device for diagnosing tuberculosis using chest X-rays.

Varela-Santos et.al [4] described a method for evaluating medical pictures, such as computerized CXRs by utilizing Artificial neural network, Genetic Algorithm (GA) that combine local binary pattern texture features and gray-level co-occurrence matrix descriptors. A CAD (Computer-aided design) system is a tool that helps the doctors make a diagnosis based on the system's results and their knowledge.

Shengfeng Chen et.al [5] aimed to develop a model to help classify CXR medical images using different techniques like K-nearest neighbor, Decision tree, Random Forest, AdaBoost, CNN, Image Pooling, Image Convolution. into normal and abnormal categories. Researchers were able to reach expert-level diagnostic accuracy in a range of medical approaches, like identifying skin cancer and classifying illness in chest X-rays.

Models of Convolutional Neural Networks like DenseNet-169, SVM, VGG16 are presented by Nagrath, P et.al [6] for exploring x-rays to detect Pneumonia. Medical officers can adopt VGG19 models to diagnose pneumonia early in both children and adults.

Irfan et.al [7] looked at using deep transfer learning and CNN to diagnose pneumonia in X- ray pictures of the chest. The findings back up the usefulness of transfer learning, indicating that it may be used to construct low-cost deep learning systems for faster and more efficient clinical deployment.

By merging VGG, augmented by data and a spatial transformer network using CNN Bharati et.al [8] presented a fusion DL system. This proposed VDSNet platform made lung disease diagnosis easier for both specialists and clinicians.

In paper [9] Maozhen Li et.al developed a way for providing decision support to doctors to aid in the faster and more precise consultation of each case using Neural Networks and ML techniques [18] for accurately predicting diseases in the lung X-rays.

Bhandary et.al [10] developed a way for providing decision support to doctors by using Moth-Flame, Neural Networks, Ant Lion, and Heuristic Algorithms to aid in the faster and more precise consultation of each case. The approach suggested here was created to assist medical experts in identifying the deformed cells [19]. The outcome of this detection offers information about the deformed cells in the X- Ray films.

The main purpose of this study by Wang, et.al [11] using DCNN Transfer learning, Inception- v3 was to classify pulmonary pictures and develop a table and practicable CAD model. The CAD approach might help clinicians diagnose thoracic disorders more accurately and quickly.

Lung cancer is investigated using a DL model, Machine Learning, Deep learning, Modified AlexNet deep learning technique in this study by Jiangshe Zhang et.al [12]. To improve the feature vector, this study uses serial fusion and Principal Component Analysis. Medical practitioners in a variety of nations have found this method to be quite useful.

Monsi, Justin et.al [13] provided a dataset from the National Institutes of Health that included illness designations from 30,000 different patients by using Artificial Intelligence and DL [16]. Weakly supervised learning is used with this dataset since the labels are predicted to be more than 90% correct. This may be used as a means of verification for doctors in a hospital management system.

In traditional poster anterior chest radiographs, Zotin et.al [14] by making use of different techniques such as Probabilistic Neural Network (PNN) [17], Balance contrast enhancement technique (BCET suggested a technique for round boundary detection and CXR classification. Medical specialists can use the system based on the presented methodologies as a decision support system.

According to the findings of the literature review, various pulmonary disease such as viral and bacterial pneumonia, asthma, tuberculosis, respiratory system diseases, and lung nodules can be accurately predicted using various Deep learning and machine learning methodologies such as CNN, ANN, RNN, Ensemble Learning, and Genetic Algorithm. CNN proves to best in accurately predicting the results. Because tuberculosis, pneumonia, and COVID-19 were the subjects of several studies, there aren't many cases of these diseases occurring together. Therefore, this system's primary goal was to categorize these illnesses.

3. Proposed System

The proposed system is primarily concerned with the classification of the disorders like pneumonia, tuberculosis, and covid, since these are considered as severe issues that need to be treated efficiently.

Proposed work for the project consists of Data Collection, Data Pre-processing, and Performance analysis of CNN, RNN and Model Deployment. Below Fig.2 depicts the proposed methodology.

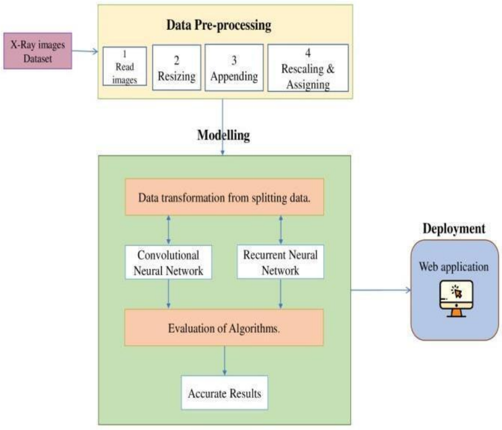


Fig.2: System Architecture

This design helps to demonstrate the entire system including the views, behavior, models, and structure of the system.

A. Dataset

The chest x-ray dataset utilized in this system was taken from a publicly accessible dataset on Kaggle under the name "Chest X-Ray (Pneumonia, Covid-19, and Tuberculosis)". This dataset consists of 6404 x-ray images, which are further separated into 4 folders. This can be depicted in the below Table 1.

Folder Name	Total Images
Covid-19	538
Normal	1341
Pneumonia	3875
Tuberculosis	650

Table 1: Total no. of images in the dataset

In this experiment, the dataset contains 6404 X- ray images and are loaded into our model for both testing & training purpose.

B. Data Collection

For this study, each individual Kaggle dataset for pulmonary disorders like tuberculosis, pneumonia, and covid-19 was collected. The dataset was compiled with the intention of doing research. There are several resolutions of X-ray images in this data set. So, data pre-processing is performed to fix the images for better accuracy, and we had fixed this in later stages.

C. Data Pre-Processing

Before pre-processing, the dataset is to be loaded and we need to print the labels and categories. Pre-processing the dataset to make the data suitable for building and training the model. Before the dataset is fed into the prediction model, data preparation has to be done. This includes resizing the X-ray images, appending the image and the label (Categorized) into the list (dataset). Rescaling and assigning categorical labels are the last step in the data pre-processing. To transform the chest x-ray dataset, images were resized to 100x100, converted to an array, and normalized, then reshaped using NumPy.

D. Splitting of data into train and test

In this phase, the dataset is partitioned into two subsets — training and test sets. In order to avoid over fitting or under fitting, a 70-30 split is selected considering the size of the dataset. The more data a data scientist uses about training, the better the potential model will perform, and testing results lead to better model performance and generalization capability. The data is split into training and testing data using train_test_split function in Sci-Kit Learn.\

E. Modelling

As part of this process, a variety of models are trained to see which one provides the best results. After pre-processing and splitting the collected data into two subsets, we proceed with model training. Two DL models are used- CNN, Recurrent Neural Network to classify the x-ray images accurately. We have conducted experiments in Jupyter Notebook and performed classification using the dataset. Accuracy of the models was drawn as assessment criteria to compare these deep learning models. The model with higher accuracy is considered as the best – fit model for classifying the X-ray images.

1. Convolutional Neural Network (CNN):

CNN is a DL model also known as ConvNet. As one type of NN, CNN enables machines to recognize and classify images, detect objects, recognize faces, etc. Image classification by CNN processes a given image & classifies it based on certain criteria. The working of the CNN model is depicted in the below Fig 3.

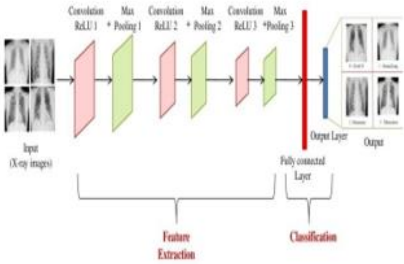


Fig.3: Architecture of CNN

i.) Convolutional Layer:

This is the CNN's primary building component, from which high-level variables are extracted from the input images & this layer performs the majority of computations. A processed version of each input channel is created by sliding the kernels of the filter across them.

ii.) Pooling Layer:

Feature maps are pooled by decreasing their width and height while keeping their key characteristics intact, and Max pooling and Average pooling can be used. In this case max pooling is utilized. Convolution and max pooling layers are used to extract features from chest X-ray images.

iii.) Fully Connected Layer:

During CNN's final layers, the convolutional or pooling layer output is flattened, before being fed into the fully connected layer, where it is transformed by the network into the required class quantity.

iv.) Output Layer:

Using this output layer, the results of the chest X-ray classification are displayed. In the fully connected layer, the features are learned for the next classification.

v.) Working of CNN for proposed system:

There are three convolutional blocks in this CNN architecture [29][30], each consisting of a Convolutional layer and Max pool layer. After the layers are flattened, two dense layers are applied to the flattened layers.

1. All the samples in our dataset are input into the input layer and are of the same size 100x100, so it accepts the same shape as the size of the image.
2. After this, 3 pairs of convolutional pooling layers are connected to the input layer. Here all the convolutional layers are using the Relu activation function as it is faster in computation than sigmoid.
3. With the help of Relu activation, these layers are then flattened and connected with dense layers.
4. The last one is the output layer, with a sigmoid activation function and it consists of one neuron. Where the output is generated in the form of a confusion matrix that classifies the given dataset of chest X-ray images into classes like 0: Covid19, 1: Normal Lung, 2: Pneumonia & 3: Tuberculosis.

vi.) CNN Activation Functions:

Normal activation functions include the sigmoid function after an image has been passed through a convolutional layer as follows:

$$s(a) = \frac{1}{1 + e^{-a}}$$

Also,

$$a = \sum_{j=1}^{n} Wjyj + c$$

Where W = Weight, y = input and c = bias.

And taking the positive component from an input is what is known as a ReLU function:

$$f(x) = maximum\ (0, x)$$

Activation functions add nonlinearity to CNNs; if they were not present, all layers could be thinned down to a matrix multiplication. A ReLU function applied to the pneumonia/tuberculosis/covid19 images highlights the vertical lines by increasing contrast. This also removes noise from other non-vertical features.

2. Recurrent Neural Network (RNN):

Basically, in traditional neural network, let us consider three hidden layers with weights (w1, w2, w3) with bias (b1, b2, b3) where input is fed and output is generated based on the calculations in the three hidden layers [22], such that the output from the previous hidden layer is the input for the next hidden layer. When coming to the recurrent neural network there will be only one hidden layer such that the hidden layers in neural networks are merged together to form a single hidden layer. In RNN output from the previous steps are fed as an input to the current step, so the loop is defined in the below Fig 4. In this way the RNN works.

Similar to standard ANN, an RNN is made up of nodes with three unique levels that stand for various stages of the process [27].

- Firstly, _init_(...) declares a few variables, followed by the basic RNN and a fully connected layer to process chest X-ray images of 100x100 size.
- The init hidden function assigns a zero value to hidden weights in the hidden layer. There are n steps for each batch size and n neurons for each input within the forward function.
- The RNN layer passes the data through the fully connected layer, which then displays the result.

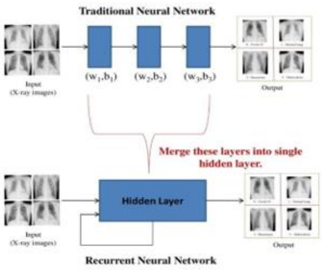


Fig.4: Architecture of RNN

The formula to calculate the next step is:

$$hs = f\ (hs-1, xs)$$

Where hs-1 = previous state, hs = current state & xs = input state.

To calculate the Activation, function the formula is as follows:

$$hs = \tanh\ (w_{hh}hs-1 + wxhxs)$$

Where hs = current state, W_{hh} = weight at recurrent neuron, xs = input, & wxh = weight at input neuron.

To calculate the output the formula is as follows:

$$ys = whyhs$$

Where ys = output, why= weight at output layer & hs= current state.

3. Algorithm:

Since our proposed methodology involves two sections likely selecting the best DL model for classification based on the overall accuracy & second phase is to deploy the model onto a website where the best-chosen model will predict the class of the CXR image by taking CXR image as an input & prediction result as an output [28]. Below are the 2 algorithms which depict the overall logical design of our proposed methodology.

Algorithm 1 below provides a detailed description of the suggested training in light of all the aforementioned derivations.

Algorithm 1: Training, Testing and evaluating the algorithms

1: Input: characteristics of X-ray images X that were taken out of the dataset with labeled data

2: Initialization of CNN:

3: for data X in the dataset from 1 to n do:

4: train_test_split

5: print Accuracy as A

6: End for

7: Save CNN model as classifier c

8: return c

9: Initialization of RNN:

10: for data X in the dataset from 1 to n do:

11: train_test_split

12: print Accuracy as B

13: End for

14: save RNN model as classifier r

15: return r

16: if A>B:

17: CNN is the best model

18: else

19: RNN is the best model

20: Choose the best model as model.h5

21: save model.h5

The pseudo code below is designated as Algorithm 2 and describes the diagnosis of pulmonary illnesses from a webpage.

Algorithm 2: The suggested strategy for detecting pulmonary disease

1: Input: Provide image file

2: Deploying of model.h5 to webpage

3: for input do

4: the CNN model loaded as a classifier

5: get the result R

6: End for

7: return R

The two algorithms mentioned above illustrate the general operation of our suggested model, "X-ray image categorization using Neural Networks for Pulmonary Diseases."

F. Evaluation:

Evaluation of model performance using the appropriate parameters is important. The following metric will be used to assess the performance of the models discussed in this project.

1.) Accuracy: The equation for calculating the overall accuracy is provided below:

$$Accuracy = (Tn+Tp)/(Tn+Fn+Tp+Fp)$$

Where, Tn = True Negative, Fn = False Negative, Tp = True Positive, Fp = False Positive.

2.) Confusion Matrix: Is a table that displays the effectiveness of DL algorithms. There are four different projected and actual value combinations in the table: false negative, true positive, and true negative, false positive. The model's prediction of a good outcome being realized is referred to by true positives. False positive refers to a model's positive prediction that is untrue. False negative refers to a model's negative prediction that is untrue. True positive denotes that a model accurately predicted a negative outcome.

Since our proposed methodology consists of 4 variables like pneumonia, tuberculosis, covid-19 & normal our confusion matrix looks like as shown in the below Fig 5. Where the green column indicates the correctly classified instances by the model and the remaining all the columns which are red in color indicate the incorrectly classified instances by the model.

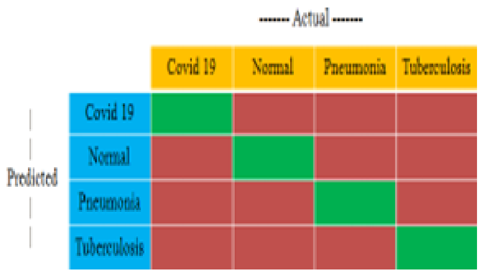


Fig.5: Matrix of Confusion Matrix for 4 diseases

G. Deployment:

Model deployment is done to integrate the model with the existing environment where it can take input from the user and return the output. Flask is a Python-based micro framework used for developing websites [24][25]. Flask is very simple to use to make Restful API's. We have developed a model i.e., model.h5 that can classify the CXRs into Normal, Covid-19, Pneumonia & Tuberculosis classes. Then we designed a web page where the user will give an image of CXR as an input and based on the model's training, the model will predict the class of the X-ray image.

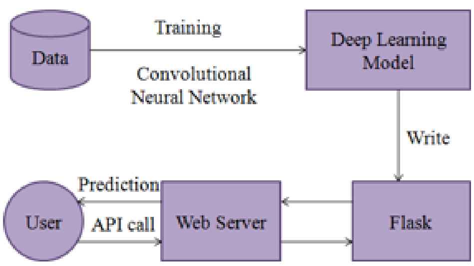


Fig.6: Deployment of DL model using Flask

Deploying a model of DL, known as model deployment, simply means implementing a model of DL and integrating it into an existing environment of production where it can take input and return output. Fig 6 illustrates model deployment using Flask. Flask is a Pythonwritten Web application framework. It has multiple modules that make writing applications easier for a web developer without having to worry about the details like protocol management, thread management etc.

4. Experiment Analysis

The implementation model is designed to classify X-ray images of the pulmonary diseases [23], which follows the overall system architecture of the project. Implementation was done using python programming language, in the Anaconda Jupyter environment to do the data preparation, data transformation as well as modelling the algorithm. The implementation outline is shown in the below Fig.7.

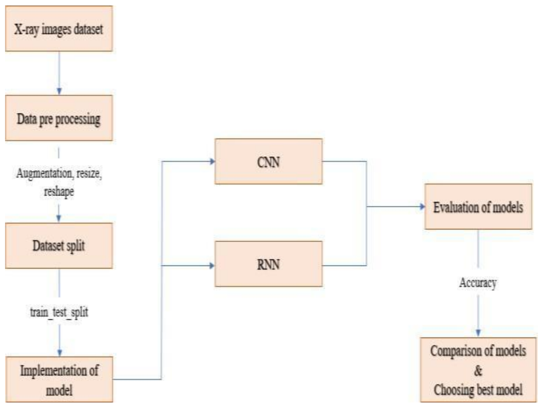


Fig.7: Process of Implementation Flow

The chest x-ray dataset utilized in this model was taken from a publicly accessible dataset on Kaggle under the name of "Chest X-Ray (Pneumonia, Covid-19, and Tuberculosis)". The dataset must be loaded before pre-processing, and the labels and categories must be printed. preparing the dataset to make it acceptable for the model's construction and training. Data preparation must be done before the dataset is fed into the prediction model. The x-ray images will be resized to 100x100, and the image and label (Categorized) will be added to the list (dataset). The final stage in the data pre-processing is rescaling and categorical labelling.

In the next phase, the dataset is split into testing & training data, which are then fed into CNNs and RNNs for evaluation. The accurate model is chosen for the deployment.

5. Results and Discussion

As suggested in our algorithms 1 & 2, the findings of our experiment are presented in the below Table 2 using CNN and RNN for a total of 20 epochs. We acquired the result in the forms of Accuracy and loss. Loss represents the amount of images incorrectly classified during the training and testing phase.

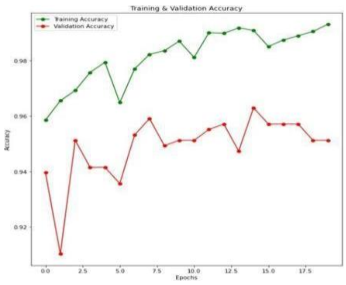
1.) **Performance comparison based on Accuracy of CNN and RNN:**

A performance comparison is made of the models tested in this project, and their performance metrics are presented in the below tabular format. See Table 2.

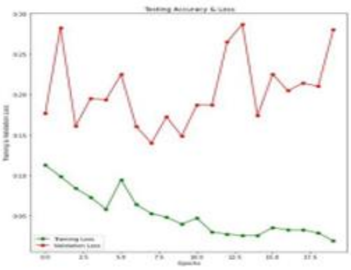
Model	Epochs	Loss	Accuracy
CNN	05	0.201	0.963
	10	0.137	0.980
	15	0.192	0.990
	20	0.180	0.996
RNN	05	0.188	0.948
	10	0.144	0.959
	15	0.149	0.958
	20	0.147	0.959

Table 2: Comparison of RNN and CNN

The above table can be depicted in the form of graphs as shown in the below 2 figures Fig 8 & Fig 9.

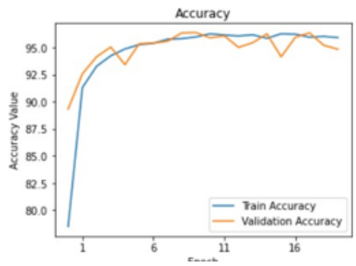


(1)

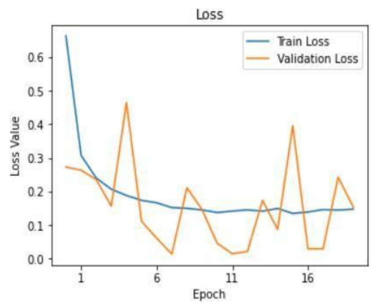


(2)

Fig.8: On the CNN model, plots are shown for (1) Accuracy and (2) Loss



(1)



(2)

Fig.9: On the RNN model, plots are shown for (1) Accuracy and (2) Loss

Firstly, we did a classification with epochs 5 with the entire 2 model and the results are as shown in the above Table 2, Fig 8, & Fig 9.

For 05 Epochs the CNN model got an accuracy of 96.3% and RNN model got an accuracy of 94.8%.

For 10 Epochs the CNN model got an accuracy of 98.0% and The RNN model got an accuracy of 95.9%.

Similarly for 15 and 20 Epochs the CNN model got an accuracy of 99.0 and 99.6% while the RNN model got an accuracy of 95.8 and 95.9%.

Comparing CNN accuracy with RNN accuracy, we observed that CNN accuracy is increasing.

From the above table of performance comparison and from Fig 9 & 10 the accuracy calculated for every 5 epochs is noted and accuracy of CNN is 99.6% much better compared to RNN. CNN is therefore the best technique to classify pulmonary diseases and it is chosen to be used for further model deployment.

2.) Confusion Matrix:

Since CNN performed well in terms of accuracy the confusion matrix is also drawn for the CNN model and it is neglected for RNN. The below Fig 10 depicts the overall confusion matrix for the CNN model.

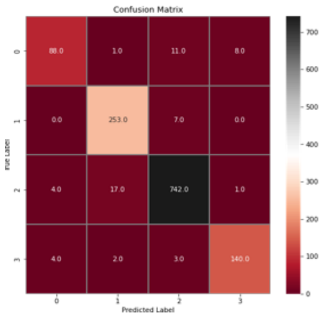


Fig.10: Confusion Matrix for CNN

The anticipated label is calculated from the true label in the preceding picture, where 0 is Covid 19, 1 is normal, 2 is pneumonia, and 3 is tuberculosis. 88 Covid 19 chest X-rays, 253 Normal chest x-rays, 742 pneumonia x-rays, and 140 tuberculosis chest x-rays have all been accurately identified and classified using the CNN model. The inaccurate classifications of the 4 categories of CXR images are what are left.

6. Conclusion and Future Scope

Chest X-ray diagnosis of pulmonary infection requires skill. The diagnosis of diseases that mimic one another is challenging for doctors. The therapeutic outcome of an inaccurate diagnosis may put a patient's life in danger. In this study, we present a novel framework for detecting TB, Pneumonia, and Covid chest x- rays using CNN classifier. Previous studies in this field were less accurate than ours since they only took into account the height and breadth of the image while excluding the depth information. For our framework, we've also taken photos of chest X-rays from various angles, moved them horizontally and vertically, adjusted their sizes, and reshaped them. The framework that is so produced has a phenomenal accuracy level of 99.6%. Our proposed framework not only classified chest x-rays but also produced a simple homepage that foretells the classification of the image as "Pneumonia," "Tuberculosis," or "Covid." If none of these illnesses are present, it returns "Normal". Currently, it can be challenging to discern between lung cancer on X-ray pictures and other respiratory disorders that can appear quite similar. This problem will be the main focus of our next strategy.

Acknowledgment

I am thankful to Dr. C.H. Suresh, Assistant Professor, Department of Computer Science and Engineering at VNR Vignana Jyothi Institute of Engineering and Technology, for encouraging and guiding me with deep learning & machine learning related concepts to classify pulmonary diseases. I am also thankful to Dr. B.V. Kiranmayee, Professor, Department of Computer Science and Engineering at VNR Vignana Jyothi Institute of Engineering and Technology to guide me in the concepts of Deep Learning Algorithms.

Author contributions

Issac Neha Margret: Conceptualization, Methodology, Software, Field study **C.H. Suresh:** Data curation, Writing-Original draft preparation, Software, Validation Field study **B.V. Kiranmayee:** Visualization, Investigation, Writing-Reviewing and Editing.

References

[1] Vieira, P., Sousa, O., Magalhães, D., Rabêlo, R., & Silva, R. (2021). Detecting pulmonary diseases using deep features in X-ray images. Pattern Recognition, 119, 108081.

[2] Hammoudi, K., Benhabiles, H., Melkemi, M., Dornaika, F., Arganda-Carreras, I., Collard, D., & Scherpereel, A. (2021). Deep learning on chest X-ray images to detect and evaluate pneumonia cases at the era of COVID-19. Journal of medical systems, 45(7), 1-10.

[3] Ayaz, M., Shaukat, F., & Raja, G. (2021). Ensemble learning based automatic detection of tuberculosis in chest X-ray images using hybrid feature descriptors. Physical and Engineering Sciences in Medicine, 44(1), 183-194.

[4] Varela-Santos, S., & Melin, P. (2021). A new modular neural network approach with fuzzy response integration for lung disease classification based on multiple objective feature optimization in chest X-ray images. Expert Systems with Applications, 168, 114361.

[5] Al Mamlook, R. E., Chen, S., & Bzizi, H. F. (2020, July). Investigation of the performance of machine learning classifiers for pneumonia detection in chest X-ray images. In 2020 IEEE International Conference on Electro Information Technology (EIT) (pp. 098-104). IEEE.

[6] Jain, R., Nagrath, P., Kataria, G., Kaushik, V. S., & Hemanth, D. J. (2020). Pneumonia detection in chest X-ray images using convolutional neural networks and transfer learning. Measurement, 165, 108046.

[7] Irfan, A., Adivishnu, A. L., Sze-To, A., Dehkharghanian, T., Rahnamayan, S., & Tizhoosh, H. R. (2020, July). Classifying pneumonia among chest x-rays using transfer learning. In 2020 42nd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC) (pp. 2186- 2189). IEEE.

[8] Bharati, S., Podder, P., & Mondal, M. R. H. (2020). Hybrid deep learning for detecting lung diseases from X-ray images. Informatics in Medicine Unlocked, 20, 100391.

[9] Yan, F., Huang, X., Yao, Y., Lu, M., & Li, M. (2019). Combining lstm and densenet for automatic annotation and classification of chest x-ray images. IEEE Access, 7, 74181-74189.

[10] Bhandary, A., Prabhu, G. A., Rajinikanth, V., Thanaraj, K. P., Satapathy, S. C., Robbins, D. E., ... & Raja, N. S. M. (2020). Deep-learning framework to detect lung abnormality–A study

with chest X-Ray and lung CT scan images. Pattern Recognition Letters, 129, 271- 278.

[11] Wang, C., Chen, D., Hao, L., Liu, X., Zeng, Y., Chen, J., & Zhang, G. (2019). Pulmonary image classification based on inception-v3 transfer learning model. IEEE Access, 7, 146533-146541.

[12] Ke, Q., Zhang, J., Wei, W., Połap, D., Woźniak, M., Kośmider, L., & Damaševĭcius, R. (2019). A neuro-heuristic approach for recognition of lung diseases from X-ray images. Expert systems with applications, 126, 218-232.

[13] Monsi, J., Saji, J., Vinod, K., Joy, L., & Mathew, J. J. (2019). XRAY AI: Lung Disease Prediction Using Machine Learning. International Journal of Information, 8(2).

[14] Chawla, A. (2022). Phishing website analysis and detection using Machine Learning. International Journal of Intelligent Systems and Applications in Engineering, 10(1), 10–16. https://doi.org/10.18201/ijisae.2022.262

[15] Zotin, A., Hamad, Y., Simonov, K., & Kurako, M. (2019). Lung boundary detection for chest X-ray images classification based on GLCM and probabilistic neural networks. Procedia Computer Science, 159, 1439-1448.

[16] Suresh C., Ravikant Suresh C., Ravikanth M., Srivani B., Satish T. (2021) Cognitive IoT- Based Smart Fitness Diagnosis and Recommendation System Using a Three-Dimensional CNN with Hierarchical Particle Swarm Optimization. In: Gupta D., Hugo C. de Albuquerque V., Khanna A., Mehta P.L. (eds) Smart Sensors for Industrial Internet of Things. Internet of Things (Technology, Communications and Computing). Springer, Cham. https://doi.org/10.1007/978-3-030- 52624-5_10.

[17] Sally Fouad Shady. (2021). Approaches to Teaching a Biomaterials Laboratory Course Online. Journal of Online Engineering Education, 12(1), 01–05. Retrieved from http://onlineengineeringeducation.com/index.php/joee/article/view/43

[18] C. Suresh, C. Chandrakiran, K. Prashanth, K. V. Sagar and K. Priyanka, "“Mobile Medical Card” – An Android Application For Medical Data Maintenance," 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA), 2020, pp.143-149, doi: 10.1109/ICIRCA48905.2020.9183307.

[19] C. Suresh, B. C. Pani, C. Swatisri, R. Priya and R. Rohith, "A Neural Network based Model for Predicting Chronic Kidney Diseases," 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA), 2020, pp.157-162, doi: 10.1109/ICIRCA48905.2020.9183318.

[20] Maneesha A., Suresh C., Kiranmayee B.V. (2021) Prediction of Rice Plant Diseases Based on Soil and Weather Conditions. In: Kiran Mai C.,Kiranmayee B.V., Favorskaya M.N., Chandra Satapathy S., Raju K.S. (eds) Proceedings of International Conference on Advances in Computer Engineering and Communication Systems. Learning and Analytics in Intelligent Systems, vol 20. Springer, Singapore. https://doi.org/10.1007/978-981-15-9293-5_14.

[21] Vasundhara, S., B. V. Kiranmayee, and Chalumuru Suresh. "Machine Learning Approach for Breast Cancer Prediction."

[22] Suresh, C., Kiranmayee, B.V., Sneha, B. (2022). Analysis and Prediction of Air Pollutant Using Machine Learning. In: Reddy, A.B., Kiranmayee, B., Mukkamala, R.R., Srujan Raju, K. (eds) Proceedings of Second International Conference on Advances in Computer Engineering and Communication Systems. Algorithms for Intelligent Systems. Springer, Singapore. https://doi.org/10.1007/978-981-16-7389-4_32.

[23] Suresh, C., Kiranmayee, B.V., Jahnavi, M., Pampari, R., Ambadipudi, S.R., Hemadri, S.S.P. (2022). Obesity Prediction Based on Daily Lifestyle Habits and Other Factors Using Different Machine Learning Algorithms. In: Reddy, A.B., Kiranmayee, B., Mukkamala, R.R., Srujan Raju, K. (eds) Proceedings of Second International Conference on Advances in Computer Engineering and Communication Systems. Algorithms for Intelligent Systems. Springer, Singapore. https://doi.org/10.1007/978-981-16-7389-4_39

[24] Chalumuru Suresh., Ravikanth M., Srivani B., Satish T. (2021) Cognitive IoT-Based Smart Fitness Diagnosis and Recommendation System Using a Three-Dimensional CNN with Hierarchical Particle Swarm Optimization. In: Gupta D., Hugo C. de Albuquerque V., Khanna A., Mehta P.L. (eds) Smart Sensors for Industrial Internet of Things. Internet of Things (Technology, Communications and Computing). Springer, Cham. https://doi.org/10.1007/978-3-030-52624-5_10

[25] Maneesha A., Chalumuru Suresh., Kiranmayee B.V. (2021) Prediction of Rice Plant Diseases Based on Soil and Weather Conditions. In: Kiran Mai C., Kiranmayee B.V., Favorskaya M.N., Chandra Satapathy S., Raju K.S. (eds) Proceedings of International Conference on Advances in Computer Engineering and Communication Systems. Learning and Analytics in Intelligent Systems, vol 20. Springer, Singapore. https://doi.org/10.1007/978-981-15-9293-5_14

[26] Begum S., Satish T., Suresh C., Bhavani T., Ramasubbareddy S. (2021) Predicting Type of Lung Cancer by Using K-MLR Algorithm. In: Satapathy S., Bhateja V., Janakiramaiah B., Chen YW. (eds) Intelligent System Design. Advances in Intelligent Systems and Computing, vol 1171. Springer, Singapore. https://doi.org/10.1007/978-981-15-5400-1_39

[27] Kiranmayee B.V., Suresh C., SreeRakshak S. (2022) Classification of the Suicide-Related Text Data Using Passive Aggressive Classifier. In: Shakya S., Balas V.E., Kamolphiwong S., Du KL. (eds) Sentimental Analysis and Deep Learning. Advances in Intelligent Systems and Computing, vol 1408. Springer, Singapore. https://doi.org/10.1007/978-981-16-5157-1_34

[28] Krishna, P. R. ., and P. . Rajarajeswari. “EapGAFS: Microarray Dataset for Ensemble Classification for Diseases Prediction”. International Journal on Recent and Innovation Trends in Computing and Communication, vol. 10, no. 8, Aug. 2022, pp. 01-15, doi:10.17762/ijritcc.v10i8.5664.

[29] Kiranmayee B.V., Suresh C.**,** SreeRakshak S. (2022) Classification of the Suicide-Related Text Data Using Passive Aggressive Classifier. In: Shakya S., Balas V.E., Kamolphiwong S., Du KL. (eds) Sentimental Analysis and Deep Learning. Advances in Intelligent Systems and Computing, vol 1408. Springer, Singapore. https://doi.org/10.1007/978-981-16-5157-1_34

[30] Surya Narayana G., Suresh C., Kolli K. (2021) Predicting Students’ Transformation to Maximum Depressive Disorder and Level of Suicidal Tendency. In: Kumar A., Mozar S. (eds) ICCCE 2020. Lecture Notes in Electrical Engineering, vol 698. Springer, Singapore. https://doi.org/10.1007/978-981-15-7961-5_111

[31] Agarwal, D. A. . (2022). Advancing Privacy and Security of Internet of Things to Find Integrated Solutions. International Journal on Future Revolution in Computer Science &Amp; Communication Engineering, 8(2), 05–08. https://doi.org/10.17762/ijfrcsce.v8i2.2067

[32] Chalumuru Suresh, Ravikanth M, Saketh Reddy Regatte, Sahithi Vesangi(2022),” MediSmart: An NLP driven intelligent medical assistant”, International Journal of Health Sciences, 6(S3), 8593–8608.

[33] Sahithi Vesangi , Saketh Reddy Regatte , Baby V , Chalumuru Suresh,” A Novel Approach to Predict the Reason for Baby Cry using Machine Learning”, International Journal of Computer Science Trends and Technology (IJCST), Volume 10 Issue 3,Pages 108-112, May-Jun 2022

[34] M. Ravikanth , Suresh.CH , Sudhakar Yadav.," Image based kitchen appliances recognition and recommendation system", GIS SCIENCE JOURNAL, PAGE NO: 746-751, ISSN NO : 1869-9391,(2021)