AI BASED CHEST X-RAY CLASSIFICATION

[1] Srinivasulu M,[2]Ambrutha T N, [3]Anusha D N, [4]Divya S, [5]H N Sujana

[1] *Associate professor,Dept of MCA,UBDTCE,Davangere*

[2,3,4,5] *PG students,Dept of MCA,UBDTCE,Davangere*

ABSTRACT

India faces acute shortage of radiologists. As per NCBI, USA India has one radiologist per 1,00,000 people. In past two years we have seen unprecedented COVID-19 pandemic which has posed a huge burden on our health care infrastructure and health care professionals. The rural parts are hit worst struggling to provide lifesaving health care access causing millions of Indians to lose their lives. In this regard our project focuses on developing a web based application which may reduce the burden on health care professionals and help in timely diagnosis of chest x-ray findings without delays and withprecision. This will help to treat patients with utmost care, can avoid unnecessary surgeriesand save lives.

In the recent years Artificial Intelligence(AI) empowered systems have proven to be dominant in all domains. Artificial Intelligence has attracted most of the researchers of the recent past. Artificial Intelligence which encompasses all the industries has been proven tobe vital in Health care by helping healthcare professionals in taking decisions and also in diagnosis and detection of several critical ailments like cancers and others.

In this project we have leveraged the transfer learning as benchmark to obtain the models for our task of classification. We have executed the experiment through the various standard models available retaining the similar experimental conditions and did the comparative analysis to evaluate them and to pick the best one among them. The results achieved show that DenseNet-169 provided the best results with 95.56 percentage validation accuracy which has been used for making predictions in the web application

1 INTRODUCTION

Access to healthcare is one of the basic and most important necessity for the human life when compared other necessities of life. India is a country of villages which directly takesus to conditions where we are striving to provide with basic amenities. During last two years the healthcare and the healthcare professionals are over burdened with the pandemicsince our population and the health care facilities are still not matching the expected thresholds especially in the rural regions of the nation. The pandemic has made us understand that the healthcare needs to upgraded drastically and it needs scaled up as per the need of the hour. The reality is that we cannot overcome the acute shortage of doctors and other support staff and we cannot scale up the human resources overnight to match theneeds instead we can assist the working professionals with technology to speed up the diagnosis by automating the processing of the different medical tests conducted during theprocess of treatment and we can draw inferences from the tests through artificial intelligence powered systems without waiting for the human to interfere and extract the results from the tests. Chest X-ray is one of the predominant test carried out to diagnose the ailments in the chestregion and can study the abnormalities if any in the internal organs like heart and lungs. The procedure is not invasive in nature and we can derive the results swiftly. The bottleneckin this case is the availability of the radiologists who will examine the chest x-ray and reportthe findings to further treatment. As specified earlier we face shortage of radiologists whichwill delay the process of treatment. Deep Learning inset of Machine Learning(ML) which deals with Artificial neural networksis performing exceptionally well in the areas of Computer vision (consisting of Image recognition and object detection) and speech recognition. Deep Learning (DL) especially Convolutional Neural Networks (CNNs) have given extremely good outcomes in the image classification by doing exceptionally well in featureextraction tasks.

In this project we are leveraging the most important potential of CNNs through transfer learning where we use the previously trained CNN models to classify the images of chest X-ray. Convolutional neural networks are trained with Chest x-ray images to extract the features in them and later classify them whether there are any findings in them or they areNormal. The pre trained models like VGGNet, Xception, Inception, ResNet, DenseNet and NASNet which are trained on largescale dataset like ImageNet are employed to our required task offeature extraction and image classification task at hand. We do a comparative analysis of the results based on the metrics for which the model has been evaluated. We find a best model to use it in the web based application for making predictions.

There are different services offered to combat the shortage of the radiologists like Teleradiology where the radiologists located far away from the patients receive thetransmitted digital radiographs and examine them and provide the diagnosis. But yet thereis a human radiologist sitting at the other end and doing the duty. Again since the radiologists are getting overloaded from the demand from every geographical area we mayface lag in obtaining results. Our work goes further to remove this bottleneck of having radiologists to infer the chest x-ray by delegating the task to the artificial intelligence enabled machines which can work round the clock without fatigue and with same precisionon each case it handles.

1.1 PROBLEM STATEMENT

Diagnosis of the chest x-ray to pick up the inferences is a skillful task and requires expertisein the job. Several images may get misinterpreted as different diseases since the images will be unclear and ambiguous. India faces shortage of these skilled radiologists to meet the growing demand due to increase in population and hence leading to poor access to health care especially in remote areas and over burden on the currently serving professionals. Developing an artificial intelligence powered system to diagnose and reportthe results will help us to extend the access to healthcare to the remotest part of the countryand help us in saving lives.

1.2 EXISTING SYSTEM

The images of chest x-ray are examined by a radiologist who is trained and possessing expertise will study the image and report the findings so that doctors will decide and plan the treatment of the patient accordingly. The speed with which the treatment is given to the patient relies on how fast we diagnose the chest x-ray and get the result report. This phaseis very crucial to patients since delay in the diagnosis and starting the treatment will lead to increase in the severity in the disease. In several cases timely diagnosis can avoid unwanted surgeries also. Due to less number of available radiologists they are overloaded and hence we suffer delays in getting results.

1.2.1 DEMERITS OF THE EXISTING SYSTEM

The existing procedure requires an expert radiologist to examine the chest x-ray andreport the findings.
Expert radiologists are very less in number and are overburdened.
The turn around time to get the results increase with increase in number of patients.
Every radiologist needs the same level of expertise and should work without fatigue.

1.3 PROPOSED SYSTEM

The proposed system is an artificial intelligence empowered web application hosted in a typical web server which will receive the image of chest x-ray from the user and uses the deep learning model which will diagnose the image and report us the findings.

1.3.1 MERITS OF THE PROPOSED SYSTEM

The proposed system will help us provide access to healthcare to the rural areas as well.
The system will scale up and handle the demand in case of pandemic and will reduce the burden on the healthcare professionals.
The system will reduce the dependency on the radiologists and help us diagnose faster.
The system has consistent accuracy and precision dealing with all the cases and it does notsuffer fatigue.

2 PROPOSED METHODOLOGY

2.1 SYSTEM ARCHITECTURE

The proposed system has an architecture as shown in the figure 4.1 below.

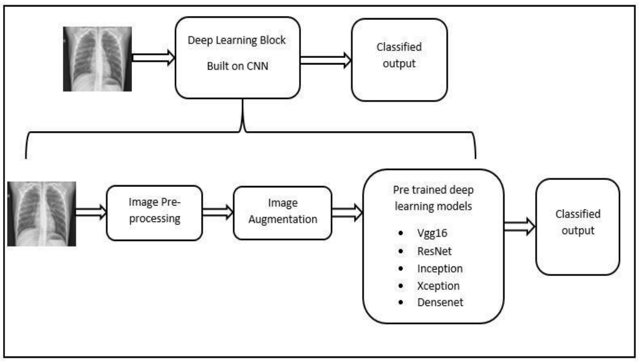


Figure 4.1 Showing the architecture of the system.

The block diagram depicts the overall architecture of the system where it illustrates the important components which are explained in this chapter. The system takes input in the form of chest x-ray image which is fed in to deep learning block for the classification. Theclassified output is rendered to the user through the web page.

2.2 TRANSFER LEARNING

The project leverages technique known as transfer learning where in the models which are trained over a large dataset like ImageNet [6] can be adapted to similar classification taskswith respect to smaller datasets. This technique may be used in different scenarios. We can use different models with the already learned weights straight away in similar image classification tasks. We can leverage the previously trained models with learned weights and these weights can be used as initial weights instead of random weights in training the models with new datasets which will help the models to converge faster. We can use the pre trained models and train only the last few layers of the neural network by freezing the initial layers which can prove effective in fine tuning the model to the task in hand. The process of the transfer learning is depicted in the figure 4.2 below.

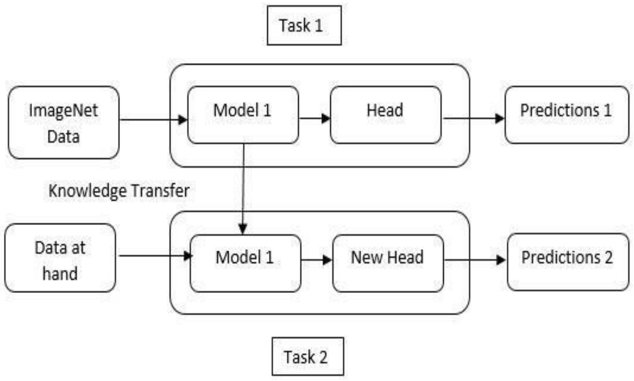


Figure 4.2 depicting the transfer learning process

The transfer learning involves adapting the previously trained model to suit the needs of the task in hand since models trained on ImageNet dataset are trained for object detection of 1000 classes. The process of adapting is shown in the figure 4.3 below.

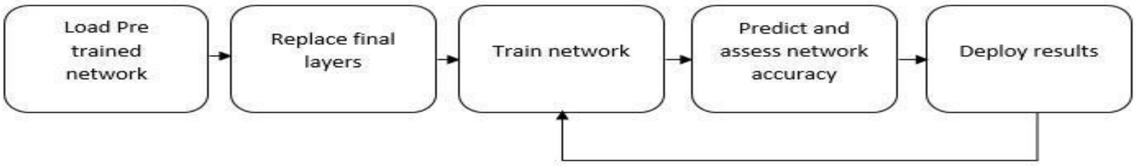


Figure 4.3 Showing the process of adapting the previously trained network.

2.3 CONVOLUTIONAL NEURAL NETWORK

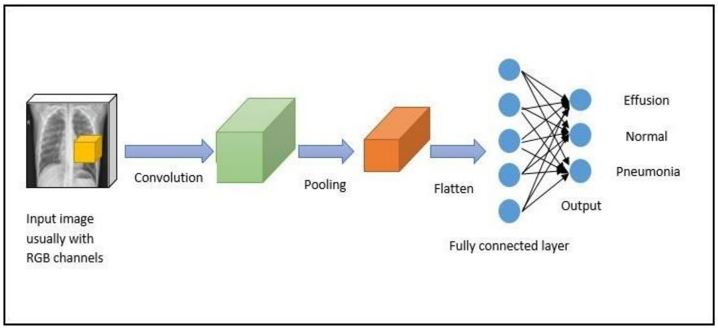


Figure 4.4 Depicting the classic architecture of the Convolutional neural network

Deep learning is based on convolution neural networks, or CNNs, a subclass of artificial neural networks. The CNNs have proven to be successful at classifying objects and images. To extract features, convolutional layers of the CNN are used. The traditional CNN architecture is made up of these components or layers.

3 IMPLEMENTATION

The initiative is put into action in two parts.

1. Creating and training various application models to find the optimal model through comparison.
2. Creation of a web application for loading the best model and making predictions using the Flask web framework.

The computer language Python was used to create the project. For the development, training, and testing of the models, Jupyter Notebook is the IDE utilized. The web application is developed using Spyder IDE.

3.1 DATASET DESCRIPTION

The dataset used in this investigation was chest x-ray, which is downloadable online. The collection contains 112120 frontal images of chest x-rays at a resolution of 1024 × 1024. The 30805 patients represented by these images are. The pictures include labels and represent 14 different thoracic illnesses. The labeling was done using Natural Language Processing (NLP), a text mining technique. There are numerous disorders, including effusion, pneumonia, atelectasis, cardiomegaly, consolidation, pleural thickening, infiltration, nodule, pneumothorax, hernia, emphysema, edema, mass, and fibrosis. In my project, I used images from the normal, effusion, and pneumonia categories. Since I only had a small number of images of pneumonia, I submitted pictures from another Kaggle dataset. I used 87 photos for testing, 1014 for validation, and 8726 from three courses for training.

3.2 IMPORTING NECESSARY LIBRARIES

The libraries that are available for developing deep learning models are actually a major benefit, and libraries were essential in popularizing deep learning.

Keras is the name of one of the most popular deep learning frameworks. This opens up a wide range of possibilities for using Keras models on embedded, Android, iOS, and web API-capable devices. On top of Tensorflow, an open-source machine learning framework, there is a wrapper known as Keras.

NumPy: Numpy is one of the most coveted and important libraries, and it serves as the foundation for the majority of the deep learning libraries. This is a comprehensive solution with its libraries for scientific, statistical, engineering, and quantum computing, to name a few. Additionally, this encompasses all fields of science, data science, and machine learning. All libraries, including pandas, Matplotlib, and sci-kit-learn, are developed using Numpy.

The pandas library, which is widely used for data processing and analysis, was developed using Python, a versatile, open-source programming language. The Python programming language supports the machine learning library scikit-learn. It largely relies on NumPy for the calculations using linear algebra. It supports both supervised and unsupervised learning algorithms.

Matplotlib: Python's Matplotlib library, which is quite large, is used for visualization. It's open sourced as well. I have to import the required libraries using an import line in the script.

3.3 IMAGE PRE PROCESSING AND AUGMENTATION

Before training, pre-processing and photo augmentation are essential steps in customizing the visuals to the model's requirements. The Keras library provides the ImageDataGenerator class. This class can be instantiated to produce an object, which is particularly useful for image pre-processing. I can perform image pre-processing by passing inputs to the object constructor.

I can improve photographs using the parameters shown below:

- Increasing the image's zoom by entering zoom range=0.2.
- Rotating the image by turning on the True value for the horizontal flip attribute.
- Setting rescale=1/255.0 to rescale the image so that all pixel values fall between 0 and 1.
  (data generator obj = ImageDataGenerator, zoom range = 0.2)
  shear range = 0.2, rescale = 1 /255, and horizontal flip = True.

The flow from directory method of the ImageDataGenerator will help us with

- Load the dataset in batches. I can pass a parameter to the function that specifies the batch size.
- By including a parameter to the that specifies the input size that the models require, I can additionally resize the image to 224 224.

3.4 EVALUATE THE MODEL OUTPUT THE RESULTS:

To create classifications and evaluate the model's performance after training, a test dataset can be used. This model is evaluated by applying the evaluate function to the model object. The evaluate function will produce a report with the evaluation's results. A model's output often includes a number of performance metrics, such as accuracy, which are crucial for understanding the model's effectiveness.

The aforementioned steps are used to run all of the different pre-trained models created for analysis. The study compares and contrasts the resulting models. The analysis' results are used to choose the optimal model.

- VGG16
- VGG19
- ResNet50V2
- RsNet152
- Xception
- No. 6 InceptionV3
- DenseNet169
- DenseNet201
- InceptionResNetV2
- NASNetMobile

4 RESULTS

RESULTS OF COMPARISION OF PRE TRAINED MODELS

A number of factors, including accuracy, which is significantly weighted in comparisons, were constructed and evaluated for the models. During training or testing, all of the models were put under the same experimental conditions. The hardware and software configurations were the same for each model..

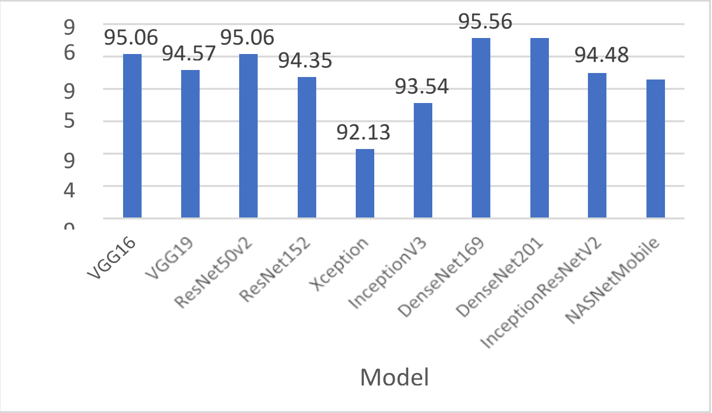


Figure 6.1

The results are depicted in figure 6.1 above. The graph up top displays the plot of the best validation accuracy each model was able to achieve throughout training. The findings show that the DenseNet Models DenseNet169 and DenseNet201 have the highest validation accuracy with a value of 95.56 percent when compared to other models.

The minimum amount of time, measured in seconds, required for each epoch, and the models were compared. Figure 6.2 shows a graph comparing the shortest time required for each epoch for different models.

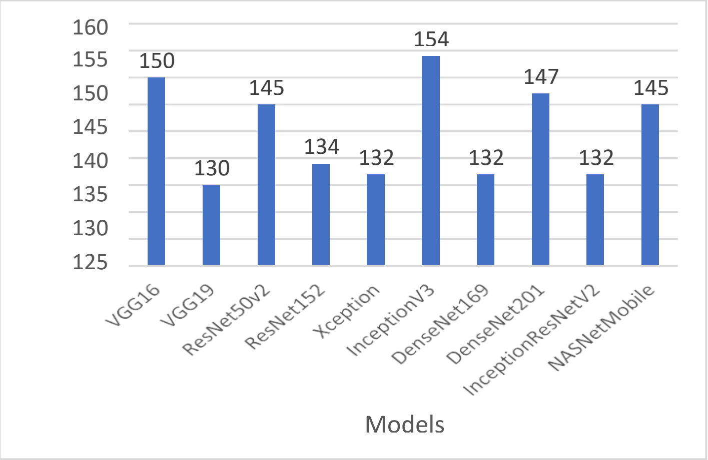
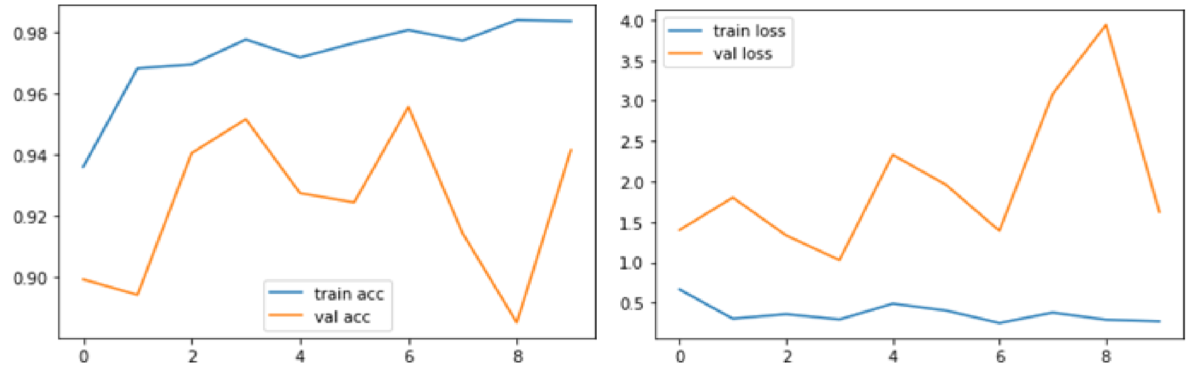


Figure 6.2

I was able to compare DenseNet169 and DenseNet201 once more in terms of the least amount of time per epoch required because both models had the same validation accuracy. I found that DenseNet169 requires 132 seconds, while DenseNet201 requires 147. In terms of both the best validation accuracy and the least amount of time required every epoch, I can state that the DenseNet169 model performs well.

The graphs below show the accuracy and loss for the DenseNet169 model during training and validation.



(a) Training accuracy and validation accuracy (b) train loss and validation loss

Figure 6.3 DenseNet169 model.

Figure 6.4 below displays the confusion matrix plotted for the DenseNet169..

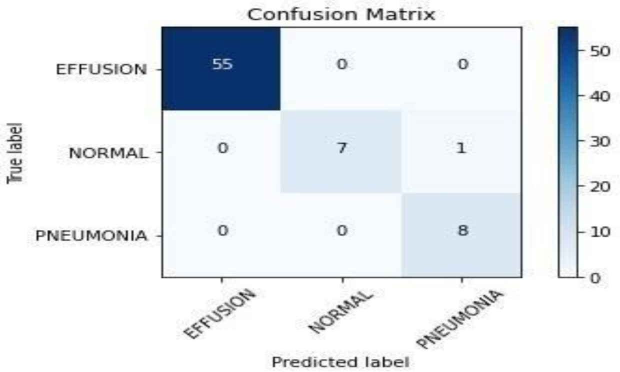


Figure 6.4 Confusion matrix

The classification report for the DenseNet169 model is shown in Table 6.5, along with the accuracy macro average, weighted average, and several metrics for the different classes, including precision, recall, and f1-score.

	Precision	Recall	f1-score	Support
EFFUSION	1.0	1.0	1.0	55
NORMAL	1.0	.88	.93	8
PNEUMONIA	.89	1.0	.94	8
accuracy			.99	71
Macro avg	.96	.96	.96	71
Weighted avg	.99	.99	.99	71

Table 6.5: Classification report

5 CONCLUSION AND FUTURE WORK

5.1 CONCLUSION

The project I worked on was aimed at solving problems in healthcare brought about by a lack of radiologists and accessibility to medical facilities, especially in rural areas of the nation. Experienced radiologists are crucial for the quick and accurate identification of the numerous thoracic illnesses that could save the lives of innocent people. The project uses a system with artificial intelligence at its core to provide a strong fix for the issues. I developed a web application that consumers may use with almost no effort after installing on web servers. After a thorough analysis of ten previously trained application models employing transfer learning, DenseNet169 was chosen as the top model. 95.56 percent is a very good validation accuracy for this model.

5.2 SCOPE FOR FUTURE WORK

The deep learning model I created for this project is used to classify the chest x-ray images into different groups. Only a tiny percentage of the dataset with images bearing a single target label was taken into account for the project because the dataset was unbalanced and there weren't many images with multiple label occurrences available for the training model. I can keep progressing toward multi-label classification by looking at targets with multiple labels for which I have a significant number of photographs in the dataset for the model to train. Using the project's findings as a springboard, the top three models with the best accuracy may be further enhanced. By using techniques like hyper parameter optimization to construct models that are optimized and deliver better results, I can improve our work.

6 REFERENCES

[1] D. Varshni, K. Thakral, L. Agarwal, R. Nijhawan and A. Mittal, "Pneumonia Detection Using CNN based Feature Extraction," 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT),2019, pp. 1-7, doi: 10.1109/ICECCT.2019.8869364

[2] Hongyu Wang and Yong Xia," ChestNet: A Deep Neural Network for Classification of Thoracic Diseases on Chest Radiography", arXiv,2018, 1807.03058

[3] Rahib H. Abiyev, Mohammad Khaleel Sallam Ma'aitah, "Deep Convolutional Neural Networks for Chest Diseases Detection", Journal of Healthcare Engineering,vol 2018, Article ID 4168538,11 pages,2018.https://doi.org/10.1155/2018/4168538

[4] Pranav Rajpurkar, Jeremy Irvin, Kaylie Zhu, Brandon Yang and Hershel Mehta, Tony Duan, Daisy Ding, Aarti Bagul, Curtis Langlotz, Katie Shpanskaya, Matthew P. Lungren and Andrew Y. Ng," CheXNet: Radiologist-Level Pneumonia Detectionon Chest X-Rays with Deep Learning", arXiv, 2017, 1711.05225

[5] T. Rahman, M. E. H. Chowdhury, A. Khandakar, K. R. Islam, K. F. Islam, Z. B. Mahbub, M. A. Kadir, and S. Kashem, "Transfer Learning with Deep Convolutional Neural Network (CNN) for Pneumonia Detection Using Chest X- ray," Applied Sciences, vol. 10, no. 9, p. 3233, May 2020

[6] Russakovsky, O., Deng, J., Su, H. et al. ImageNet Large Scale Visual Recognition Challenge. Int J Comput Vis 115, 211–252 (2015). https://doi.org/10.1007/s11263-015-0816-y
[7] Karen Simonyan and Andrew Zisserman," Very Deep Convolutional Networks forLarge-Scale Image Recognition", arXiv,2015, 1409.1556
[8] Kaiming He, Xiangyu Zhang, Shaoqing Ren and Jian Sun," Deep Residual Learningfor Image Recognition", arXiv,2015, 1512.03385
[9]Kaiming He, Xiangyu Zhang, Shaoqing Ren and Jian Sun," Identity Mappings in Deep Residual Networks", arXiv, 2016, 1603.05027
[10] Christian Szegedy, Vincent Vanhoucke, Sergey Ioffe, Jonathon Shlens and Zbigniew Wojna," Rethinking the Inception Architecture for Computer Vision", arXiv, 2015, 1512.00567
[11] Christian Szegedy, Sergey Ioffe, Vincent Vanhoucke and Alex Alemi," Inception- v4, Inception-ResNet and the Impact of Residual Connections on Learning", arXiv,2016, 1602.07261
[12] François Chollet, "Xception: Deep Learning with Depth wise Separable Convolutions", arXiv, 2017, 1610.02357
[13]Gao Huang, Zhuang Liu, Laurens van der Maaten and Kilian Q. Weinberger," Densely Connected Convolutional Networks", arXiv,2018, 1608.06993
[14] Barret Zoph, Vijay Vasudevan, Jonathon Shlens and Quoc V. Le," Learning Transferable Architectures for Scalable Image Recognition", arXiv, 2018, 1707.07012
[15] Xiaosong Wang, Yifan Peng, Le Lu, Zhiyong Lu, Mohammadhadi Bagheri, Ronald M. Summers.ChestX-ray8: Hospital-scale Chest X-ray Database and Benchmarks on Weakly-Supervised Classification and Localization of Common Thorax Diseases, IEEE CVPR, pp. 3462-