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Deep Learning Techniques for Discerning Various Phases in Lung Cancer Disease using Chest X-Ray Images

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Abstract: - Deep neural network models are boon to the society especially for medical field in diagnosing deadly diseases before any symptom could occur like cancerous cells. Usually predicting the cancer existence requires abundant time with skilled technicians to confirm whether cancer has invaded the human body. But the development of deep learning methods along with image processing relieved the entire process of detecting the infection earlier than other expertise. Cancer can affect any part in the body and lung cancer is predominant among other types around the world. So additional precaution is essential in diagnosing lung cancer in the premature stage. This paper focuses on the identification of lung cancer and various stages to determine the patient health condition using chest x-ray images. The images are acquired from diverse sources and preprocessed for further investigation. The images are then segmented using K means mask with bitwise AND operator and classified by deep learning methods to find the stages of cancer. The classification methods are Dense Net 121, Xception and Inception V3 model where best accuracy is produced by both models Dense net and Xception around 80% in classification.

Keywords: Deep neural network, image processing, lung cancer, x-ray images, K means mask, AND operator, Dense net 121, Xception, Inception V3.

I. INTRODUCTION

Almost in western and Asian countries there is sudden shift of lung cancer number for both women and non-smokers affected by the ailment along with heavy smoker. The Council of Medical research (ICMR) has the shocking report that in India lung cancer cases may have seven pleat increase by the year 2025 [1] intimating the lack of best screening methods to identify the cancer prevalence. Nearly 80 percent of the lung cancer patients are addict to smoking which causes 8.1 percent of death allied to cancer. Though cancer rates increase in India still there is lack of proper screening methods and many problems like charge, logistic limitations, least awareness are faced which in turn raises the mortality rate. Moreover, consumption of tobacco in the form of cigars or other usage leads to fatal where India is one of the leading countries in the manufacture and use of tobacco. Other reasons like air pollution or exposure to smoke and asbestos may be the reason for the infection. Passive smokers are also more in number affected by this disease. For better understanding of lung cancer first the anatomy of lung is described and given as Fig.1.

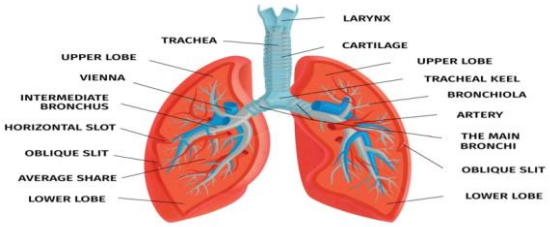

Fig.1. Anatomy of Lungs

Lungs are the cone shaped part of the human body which is in pair nearby heart and sub divided into bronchus, blood vessels, lymphatic vessels and nerves. Lungs have upper and lower lobes supplied by lobar bronchus. Trachea through which air passes is divided into bronchus connected by both left and right lungs. Blood vessels and nerves also connected forming the root of the lungs. These are the vital parts used in gas exchange for the survival of human and infection occurs as lung nodules which may be benign or malignant.

For medical diagnosis image processing methods are used for better accuracy and deep learning techniques work faster and provide precise results. Deep learning proves to be best method in feature extraction and classification approaches [2]. Physicians first choice for detection of cancer is the x-ray images which are 2Dimensional images portraying inner organs and tissues that absorb the radiation. The abnormalities appear in solid area of grey shade identified by the radiologist and usually cancer infects the outer edges of the lungs along with space near large airway. Deep learning is implemented in the images for earlier diagnosis of this disease using advanced algorithms and methodology. DL is the extended version of machine learning and artificial knowledge used as

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crucial tool for study of oncology [3]. Deep learning models include Convolution Neural Network and Artificial network models that diagnose the disease using patterns and huge data set for timely results. For this purpose, multi layered neural network algorithms are utilized for classification, projection and exactness of the disease.

II. PROBLEM DEFINITION AND RELATED WORK

In medical field nowadays various screening methods are used for identifying deadly diseases like cancer mass and lesions. Techniques like Computed Tomography (CT), PET, MRI and x-ray images along with digital equipment are accurate in detecting lung nodules, masses and lesions. According to the recent investigation [4] using chest x-ray images cancer can be identified with 121- layer convolutional neural network called Dense Net 121 with transfer learning for classification purpose. Small data set problem is removed in this method using lung nodule data to spot the presence of nodules in the images. The accuracy provided by this method was 74.43% with specificity and sensitivity. Another survey demonstrates [5] the analysis of chest x-ray images to identify mass or tumor in lung cancer persons. Four types of data sets are used for this examination with JSRT data set, BSE-JSRT before and after segmentation. The pre- processing methods used in this paper even simplified the configuration for better result. G.M.M. Alshmrani et al. in their work [6] proposed DL architecture for classification of various lung diseases using chest x-ray images like Pneumonia, Tuberculosis, cancer and Corona. For classification pre-trained model like VGG19 embedded with convolutional model of three blocks for feature extraction and classification. The proposed model proved accuracy up to 96% with good recall, precision, F1 score and AUC.

The recent survey [7] analysis supports CT scan images more efficient than chest x-ray images for classification of lung images as normal or abnormal using some deep learning techniques. The deep convolution neural network used for this study is Dense net model and adaptive boosting algorithm for accurate classification. More than 200 images are used for this purpose and best accuracy is derived from this model. Another innovative approach is the hybrid framework model [8] that uses the combination of VGG model with data augmentation and spatial transformer network (STN) is used for the classification of x-ray images into benign and malignant. For execution Jupyter Notebook is employed with NIH images for categorization. Akitoshi Shimazaki et.al [9] developed deep learning model with hybrid segmentation method and evaluated lung cancer using chest radiographs. Data sets were collected for both training and testing process to produce sensitivity of 0.73 with 0.13 mFPI for the test data set.

III. MATERIALS AND METHODS

This section discusses about the sources of data sets retrieved for chest x-ray images from online and other methods. Next the processes used for handling the images are deliberated in the forth coming topics. The methods include data preparation, segmenting the images to get the region of interest and finally classification with automatic feature extraction for categorizing the images of lung cancer into three stages namely advance, middle and starting stages.

A. Data set acquisition

Data sets of images predicting lung cancer and normal can be retrieved from many online sources available. In the dataset [10] NCI, National Cancer Institute contains cancer data access system with nearly two lakh images of both raw and processed for lung cancer. The images are in TIF format with low contrast. The NIH chest x-ray dataset contains more than 1, 00, 000 images in PNG format and the images are extracted from clinical centres and the link is available online also. Another large data base for cancer images means the Lung Image Database Consortium (LIDC) providing images for nodule detection and annotation to increase the CAD methods development with spatial, temporal and pathological ground truth. The major data source is the Kaggle data set providing images with masks from Shenzhen Hospital data set and Montgomery from China for the prediction of lung cancer.

IV. PROPOSED METHODOLOGY

The methods used for processing of x-ray images to identify the cancerous persons from normal ones are described in this segment. The images mined from different data sources are first cleaned and prepared for further handling. Standard methods for pre -processing like Resizing and Normalization are used to organize the images. Next the images are segmented to remove the cancer region from the affected images using Mask segmentation method. After segmenting the images the region of interest is discovered and with the segmented images taken as input classification is done. Deep learning models based on transfer learning like Dense net121, Xception and Inception V3 methods are used for grouping the images into three stages to identify the phase the patient belongs to enable further treatment. The entire architecture is given as block diagram in Fig.2.

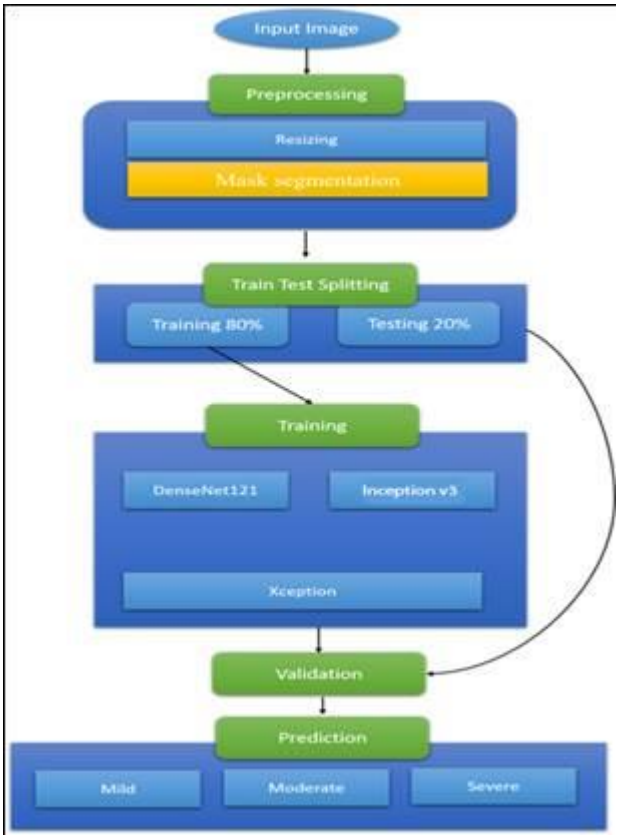

Figure 2: Architecture for Lung Cancer Classification

A. Pre-processing of Images

As the images are acquired from various sources in variety of forms, they need to be prepared for further usage. Since segmentation and classification needs same dimension of images, they are altered to standard size. To attain maximum resolution of the images they are normalized to regular scale. The two basic pre-processing steps used in this model are Resizing and Normalization of images.

B. *Resizing of Images*

There are two approaches for converting the images into required size. One is enlarging the given image into larger standard size by zooming the image and other method is reducing the outsized image into smaller one to satisfy the required scale by shrinking the image. These two techniques are implemented using the pixel relation method with Interpolation scheme studying the adjacent pixels intensity value. By maintaining the aspect ratio without losing any vital information of the image they are either increased or reduced to the regular shape. Inter area method is used for decreasing the size of the image while Linear interpolation method is used for increasing the magnitude of the image. The original image resized using the given technique is given as Fig.3.

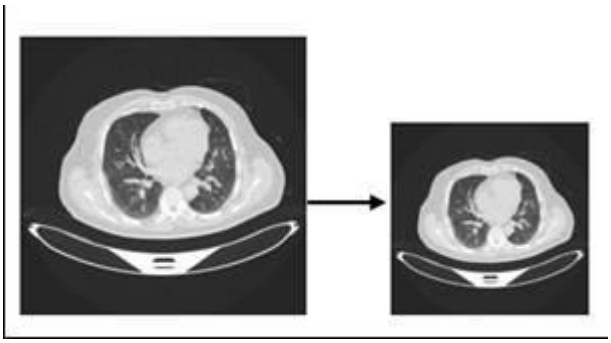

Figure 3: Resizing of images

C. *Normalization of Images:* To maintain resolution value and high contrast of x-ray images, normalization is done in the next step. In this step the pixel values are regularised to some standard values by deviating the pixels with the maximum value of the respective pixels. To evade poor contrast of the images and diverged angle, normalization is done.

D. Segmentation of Images

In image processing method segmentation plays a vital role by separating significant that is only required portion from the image. Segmentation produces collection of sections consisting of similar values of pixels that form the diseased portion in the image which vary from remaining regions. [11]. The similar qualities may be shape, colour, pixel intensity or texture. By segmenting the lung images only region of interest is retrieved and processed instead of the whole image thereby reducing time and complexity. So both the background and centre images are deviated based on similar attributes. Segmentation reduces the problems in further processing by cropping the diseased portion affected by cancer from the entire x-ray images. The output of segmentation is the cancer affected areas projected which is taken as input for classification. Classification determines the stage of cancer whether it is advance, middle or starting stage.

E. Segmentation using K means Automated Mask

Lung images are segmented and the affected portions are removed from the x-ray images but the regions are out of shape due to various range of the disease spread. So segmentation is carried out using K means mask where K value equal to 2 with bit-wise arithmetic operators. For the lung segmentation AND operator is used with automatic mask. Following are the steps used for segmenting lung cancer images. They are:

- The lung cancer images are acquired from variety of sources and prepared for segmentation using basic methods.
- For segmentation the images are selected with annotated k means mask for capturing the diseased portion. Each image is generated with separate mask.
- There are two input images, one is original and other is the mask with the region of interest. The output image is produced by matching both the input images and recovering only similar areas in both the images.
- Object Detection Method is used to produce similar regions from both the images that are required by comparing the intensity of pixel values.
- AND operation is performed for cropping necessary portion based on the pixels whose intensity values are same. For both the pixels greater than 0, Bitwise AND is true.
- Otherwise segmenting is not done leaving the remaining portion of the image. Thus diseased area alone is produced in the output image.
- The lung images are segmented using mask with proper bitwise operator AND producing the output used for classification.

F. Segmentation Result

After applying AND operator on the lung image output is produced which is the result of segmentation. The segmented image is given as Fig.4.

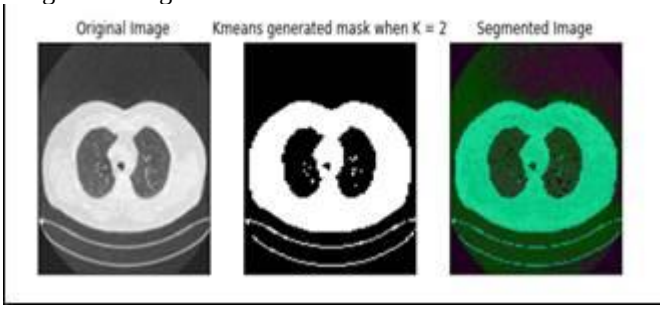

Figure 4: Segmented lung image with mask and input image

G. Classification Methods

Classification is the process of grouping the data elements as ordered set of similar categories to produce significant data. In image processing the acquired images are grouped into three sets that represent the stages the images belong by systematic sorting according to the criteria essential for grouping. For the proposed method,

three classification methods are used to classify the lung images into three stages. They are Dense net 121 model, Xception and Inception V3 Model used for classification purpose. They are explained in detail in forthcoming sections.

(i) Dense Net 121 Model

Dense Net model is the modified version of the basic CNN architecture to remove the barriers in deep learning by solving vanishing gradient problem. Feature transmission is encouraged with reusability to reduce the parameters. In this model every input layers are interconnected with each other and the inputs are the feature maps of the previous layers and current features are used as input for the next succeeding layer. All the feature maps are concatenated from the previous layers.

H. Architecture of the Model

The architecture of Dense Net 121 model contains two vital parts and three consecutive operations. The model contains first the Dense Blocks to maintain the count of feature maps as they increase for each layer. Next measure is the Transition Layer between each block to decrease the channels to partial of the existing ones. The three operations are Batch Normalization, Activation function and convolution.

Dense Block – Each block maintains constant number of feature maps for concatenation. Growth rate is monitored for each layer when new features are added after each pass. Growth rate is denoted as K, regulating the parameters in each layer and for Lth layer the feature maps are given as $KL = K0 + K * (L – 1)$ where K0 is the channel number.

Transition Layer – Between each block down sampling operation is performed where the size of the feature maps are reduced to half of the number by performing Convolution and Pooling operations.

Convolution operation – The original input image is convolved using filters of various sizes to produce feature maps. Batch normalization and Relu activation function is performed along with Conv2D function. The parameters used in this model are given as Table 1 below.

Table 1: List of Parameters

Parameter Name	Value
Batch Size	50
Optimizer	Adam
Loss	Binary cross Entropy
Epochs	10
Activation Function	Sigmoid

Block diagram for the proposed Dense Net121 model is given as Fig.5 with four Dense Blocks and three Transition layers. The description is given as overall architecture diagram for classification of lung cancer into three stages using the proposed model.

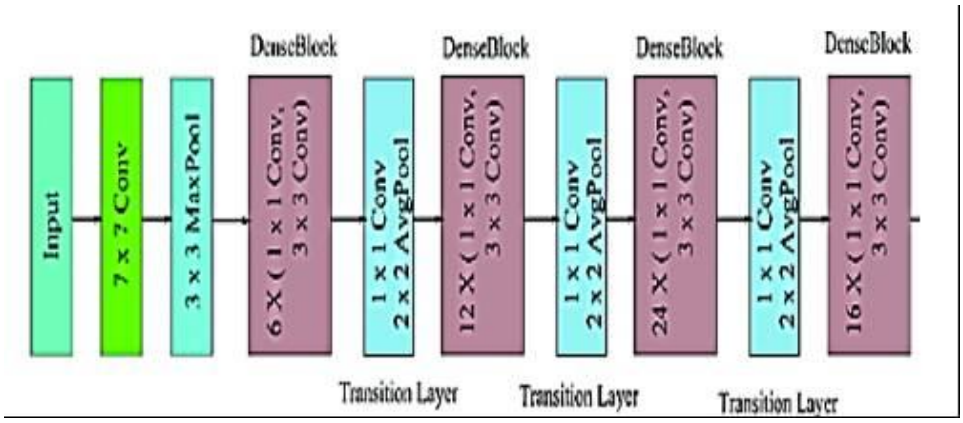

Figure 5: Proposed Dense Net 121 model for lung cancer classification

I. Xception Model

The next CNN model used for classification of lung cancer using transfer learning is the Xception model. Deep convolutional architecture based on depth-wise separable convolutions is the Xception model which is the extreme version of the Inception method with lot of towers used for classification. The inception modules namely Block A, B and C are replaced by depth-wise separable convolutions. The architecture contains 36 convolutional layers which forms the network base for mining of features. The basic three parts of the design are first the entry flow through which the data enters then middle flow reiterated for eight times

and finally the exit flow. Each operation is followed by batch normalization with a depth multiplier of 1. To create the model for classifying lung cancer disease into three stages the arguments required are:
Include-top means to decide whether top layer should comprise the fully connected layer.

- Weights means either initialization of weight is performed randomly or weight file path should be attached.
- Input shape means by default the input shape should be 299 x 299 x 3 where there are 3 input channels with width and height not more than 71.
- Pooling means the type of pooling operation needed for feature extraction like Global Max Pooling and Global Average Pooling.
- Classes representing the number of classes the image belongs like Severe, Moderate and Mild stages.
- Activation function which is used on the top layer and sigmoid is the classifier used for classification of lung images.

The basic architecture proposed for classification of lung images is given as block diagram in Fig.6.
The main components in the suggested model are

- Input image of size 299 x 299 is used as default for all images in this model. First three convolution operations namely A, B and C are performed.
- Convolution and max pooling operations are performed except B block in three stages multiple times.
- Finally Global max pooling operation is performed for necessary features required for classification.

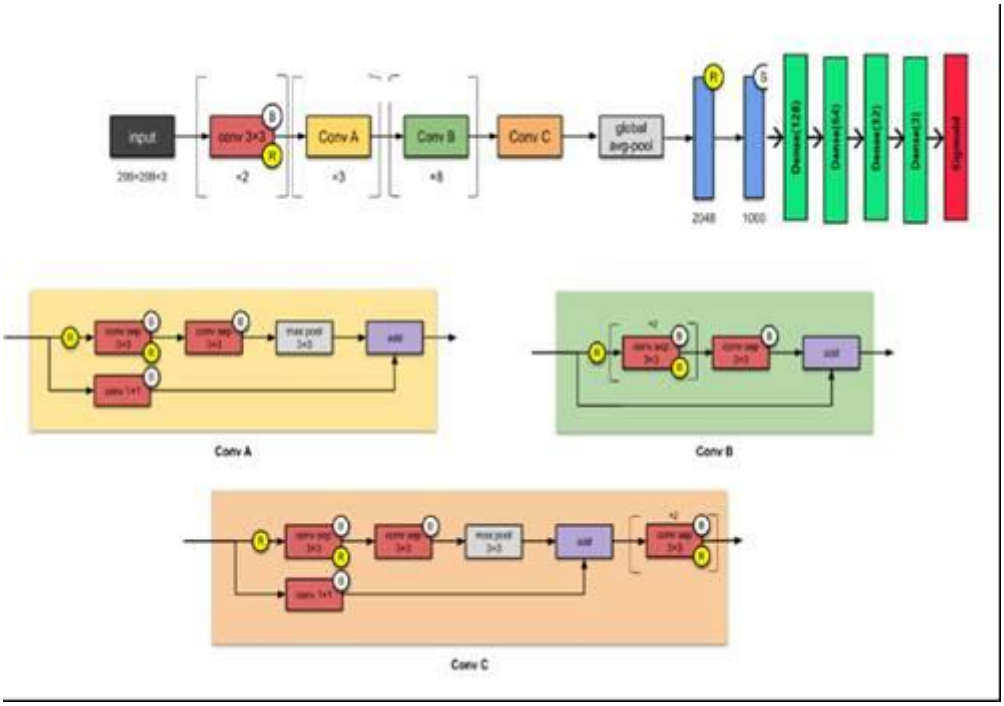

Figure 6: Proposed Xception model for lung cancer classification

J. Inception V3 Model

The variant model based on CNN architecture having different functionality compared with the previous ideal for classification of lung cancer is the Inception V3 method using the automatic extracted attributes. An extended version of V1 is the current model based on the fac0074 that wider networks perform better compared with deeper modules. The proposed architecture is constructed by preserving the top standard layers in the Image net model and adding the new required layers for cancer classification in the bottom of the model. There are
two basic segments in the architecture. They are
(1) Equivalent filters of various sizes like (5 x 5, 3 x 3, 1 x 1) are used in the same layer for preserving the pixel information in the image used for classification.
(2) Over fitting problem is avoided by dimension reduction process where the parameters are diminished in number dropping the time and complexity. The two segments are followed by 5 x 5 convolutions to facilitate the classification purpose.
The basic units of Inception V3 model are three blocks namely A, B and C used for classification of lung images into three required classes. They are

(i) Block A used for factorization of smaller convolutions. In this segment single 5 x 5 layer is converted into two 3 x 3 convolutions for parameter reduction.
(ii) Block B used for factorization of 7 x 7 convolutions. Single 7 x 7 convolutions are replaced by 1 x 7 and 7 x 1 convolutions. Next in asymmetric convolution 7 x 7 convolutions are improved into multiple 3 x 3 convolutions.
(iii) Block C is the middle segment where asymmetric convolutions occur with factorization. 3 x 3 convolutions are replaced by 1 x 3 and 3 x1 reducing the parameters.

V. ARCHITECTURE OF ANTICIPATED MODEL

The Inception V3 model is built for classification of lung images into three classes namely severe, moderate and mild. This model is known as 48 layer model primarily used for image recognition and classification determination. The proposed Inception V3 model for classification of lung cancer images into three stages is given as block diagram in Fig.7.

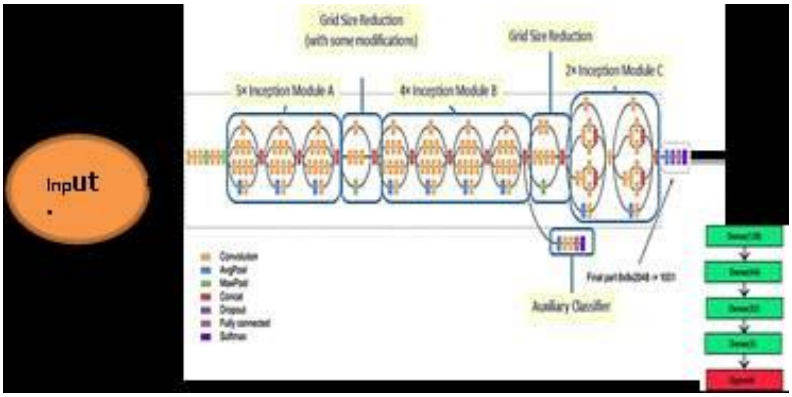

Figure 7: Architecture for Inception V3 model.

The proposed model contains basic constituents as follows. They are
- The input image of size 299 x 299 x 3 is taken for classification and transmitted to the convolutional layers of filter size 3x3 with 32 filters of stride 2 for I layer, 32 filters for II layer and 64 filters for III layer with stride 1.
- Three convolution layer functions are followed by one max pooling layer with size 3x3 and stride 2 tracked by 2 convolutions and 1 max pooling layer.
- The proposed design contains Inception Block A executed 5 times by altering 5x5 layers as two 3x3 layers. Next Inception Block B is performed 4 times and finally Inception Block C accomplished.
- To end with 2048 features are received as output of the model which is appended with the Global Max pooling layer.
- Four dense layers are added in the rear part of the model to reduce the number of features from 32 to 16 and finally to three representing the three classes namely severe, moderate and mild.
- Sigmoid is the classifier used for classification of lung images into three required classes.

Finally, three classification models are used for classification of lung images into three classes namely severe, moderate and mild. The results achieved from these methods are compared for accuracy. Both the models Dense Net and Xception produce an accuracy of 80% while Inception proves to have 60% of accuracy.

VI. EXPERIMENTAL ANALYSIS

The lung images are segmented and classified using deep learning techniques and finally best accuracy is provided by two models. The classified images output for three classes are shown in Fig.8.

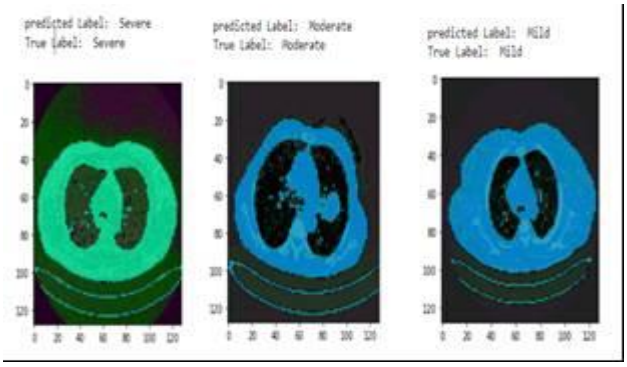

Figure 8: Classification result for three classes

The output for three classes namely severe, moderate and mild are shown in the above figure using two best models like Dense net and Xception model. All the three methods are evaluated and compared using the performance metrics to find the measures like accuracy, precision and F1 score. The calculated measures are presented in the form of tabular column Table 2 for comparison purpose. The classification methods for lung cancer images are calculated and associated for best accuracy.

Table 2: Performance comparison for classification methods

METHODS	STAGES	PRECISION (%)	F1 SCORE (%)	ACCURACY (%)
Dense net121	Severe	99.90	40.00	80
	Moderate	76.04	86.12	
	Mild	87.12	72.30	
Xception	Severe	28.12	43.03	80
	Moderate	96.01	97.32	
	Mild	99.99	70.31	
Inception V3	Severe	00.0	01.00	60
	Moderate	58.51	73.00	
	Mild	89.30	30.43	

VII. CONCLUSION AND FUTURE WORK

The last section is the conclusion part where the sample lung images are processed to check whether lung cancer is present. Further the stages of lung cancer are determined using deep learning models to find the accuracy. The lung images are retrieved from different online sources and real images from cancer centres. The images are pre-processed using standard techniques and segmented by K means method to produce mask and bitwise operators. Finally the segmented images are classified to find the stage the cancer present in the image. Out of three models trained, two methods like Dense Net and Xception proves to be the best with accuracy 80% while Inception model provides accuracy up to 60%. The proposed models can be extended to diagnose various lung diseases like pneumonia and corona. The deep learning models can be trained using other image modalities also.

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