TUBERCULOSIS DETECTION IN CHEST RADIOGRAPHY

MINI PROJECT REPORT

Submitted by

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MUTHAYAMMAL ENGINEERING COLLEGE(AUTONOMOUS)

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CHAPTER 6

PROJECT DESCRIPTION

6.1 System Implementation

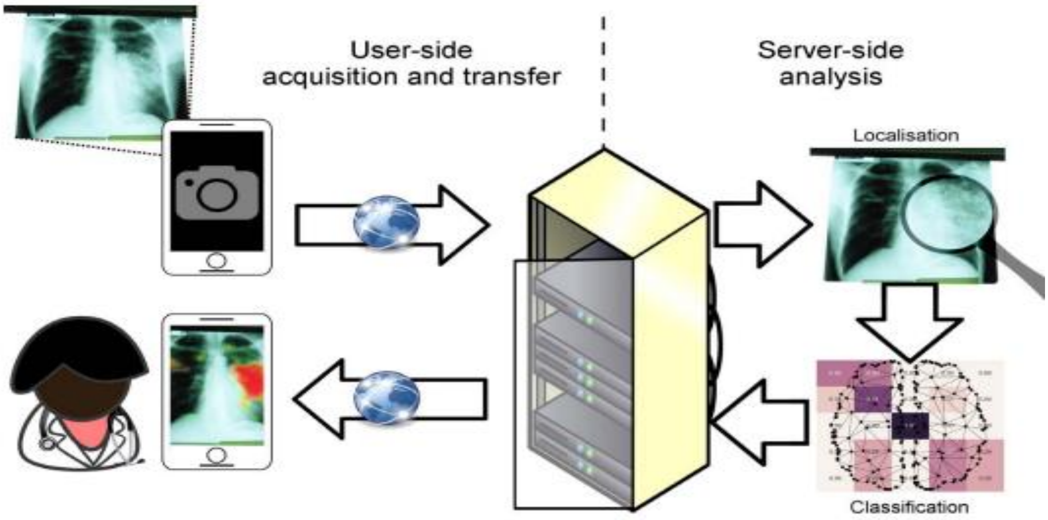


Fig no: 6.1 Proposed image processing pipeline.

Possible workflow for a teleradiological TB detection service for health care providers working remotely (schematic). After taking a photograph of the original chest X-ray with a smartphone application, the image is transferred wirelessly to a remote server, where image analysis is carried out in two steps: anomaly detection and classification. The server then sends the image with an overlaid heatmap and a structured report back to the user (health care provider), who may use it to augment his/her clinical judgement for optimal management of the patient.

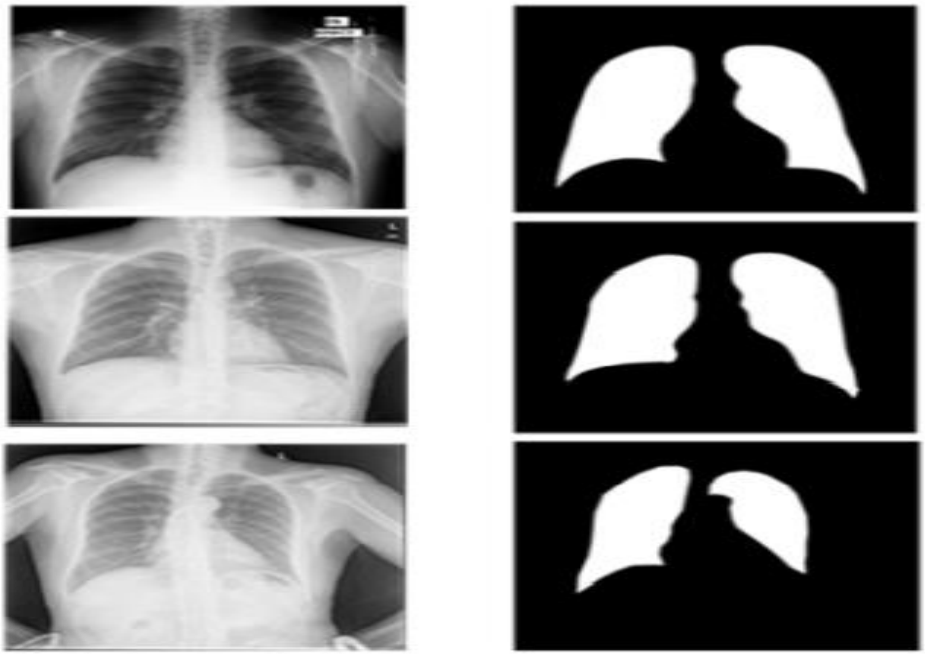


Fig .no:6.2.1 Example of X-ray images and corresponding ground truth lung masks from Kaggle dataset

During the phase of collecting the photographs for the dataset, images with smaller resolution and dimension but 500 pixels weren't considered as valid imagesfor the dataset. additionally, only the pictures where the region of interest was in higher resolution were marked as eligible candidates for the dataset. in this way, it had been ensured that images contain all the needed information for feature learning.Many resources may be found by searching across the net, but their relevance is usually unreliable. within the interest of confirming the accuracy of classes within the dataset, initially grouped by a keywords search, medical experts examined chest x-ray images and labeled all the photographs with appropriate disease acronym.

Because it is thought, it's important to use accurately classified images for thetraining and validation dataset. Only in this way may an appropriate and reliable detecting model be developed. during this stage, duplicated images that were left after the initial iteration of gathering and grouping images into

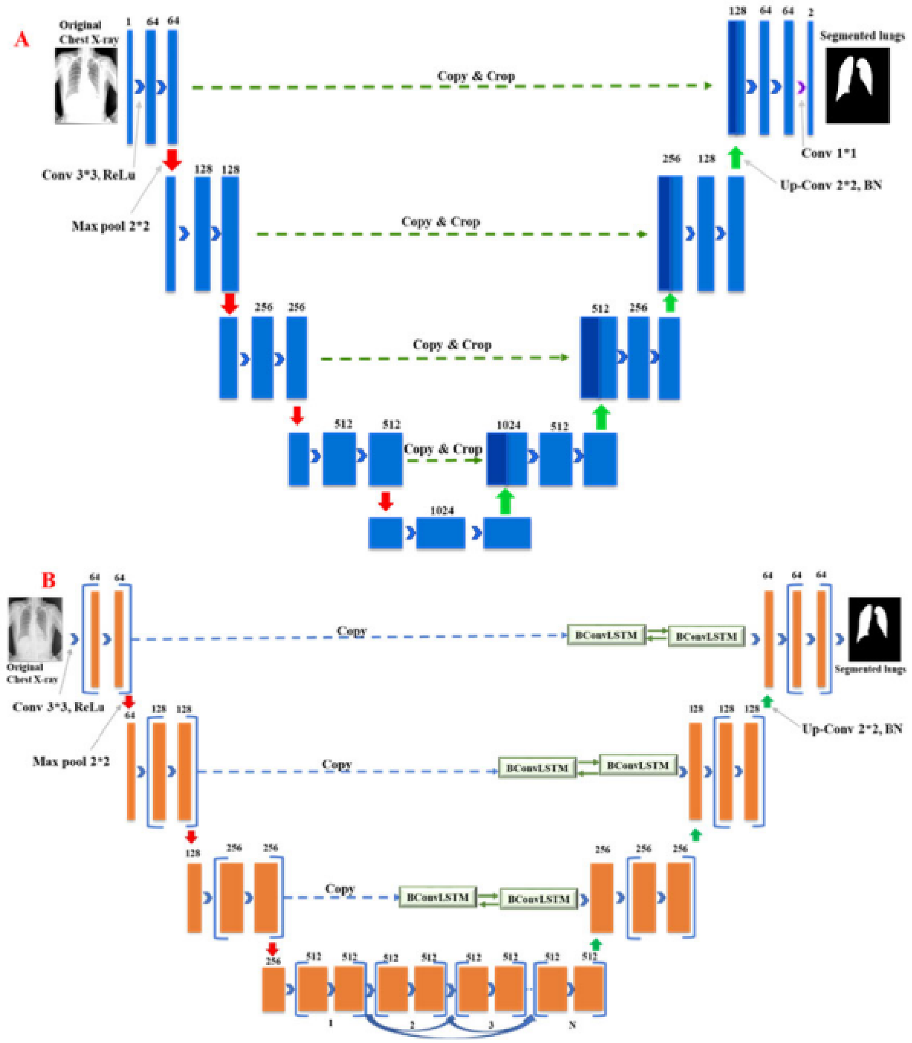


Fig no 7.1: Architecture of A) original U-Net and B) modified U-Net.

7.2 TB CLASSIFICATION

As mentioned earlier, there are two different experiments (using non-segmented and segmented lungs X-ray images) were conducted for the classification of TB and normal (non-TB) cases. The comparative performance for different CNNs for the binary classification is shown in Table 5. It is apparent from Table 5 that all the evaluated pre-trained models perform very well in classifying TB and normal images in this two-class problem. Among the networks trained with X-ray images without segmentation, CheXNet is performing better for classifying the X-ray images. Even though CheXNet is shallower than DenseNet201, it was originally trained on X-ray

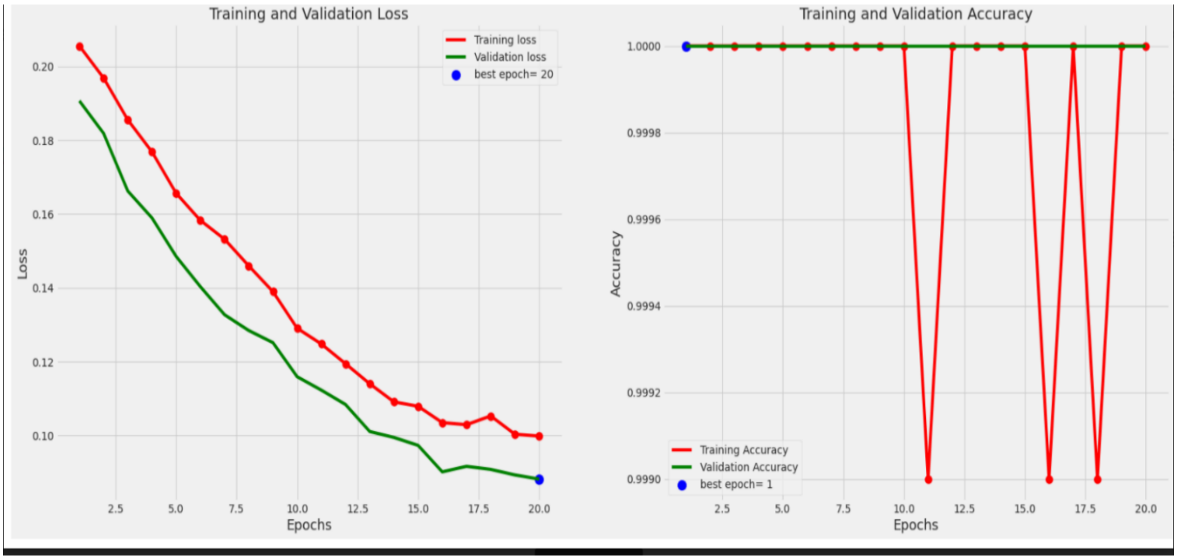
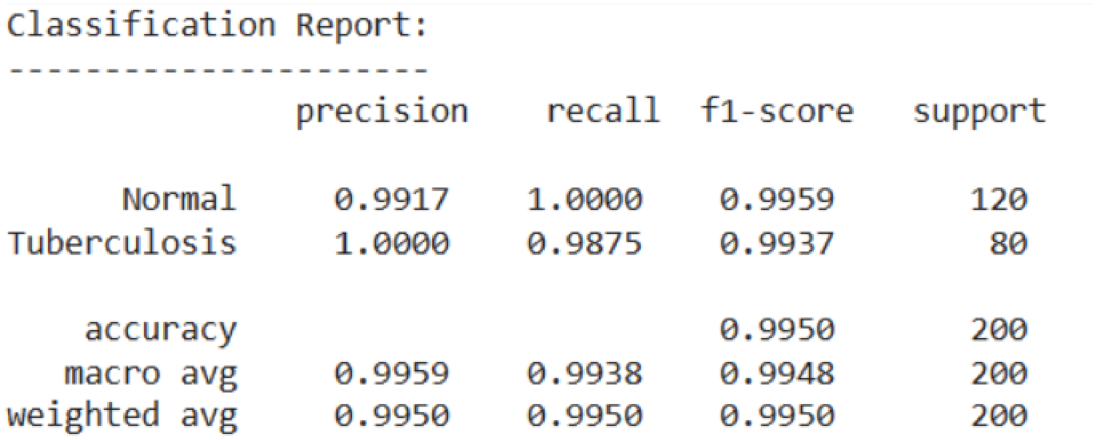


Fig no .7.2.1:Comparison of the ROC curves for Normal, and Tuberculosis classification using CNN based models for non-segmented (A) and segmented(B) CXR images.



```
Classification Report:
----------------------
              precision    recall  f1-score   support

      Normal     0.9917    1.0000    0.9959       120
Tuberculosis     1.0000    0.9875    0.9937        80

    accuracy                         0.9950       200
   macro avg     0.9959    0.9938    0.9948       200
weighted avg     0.9950    0.9950    0.9950       200
```

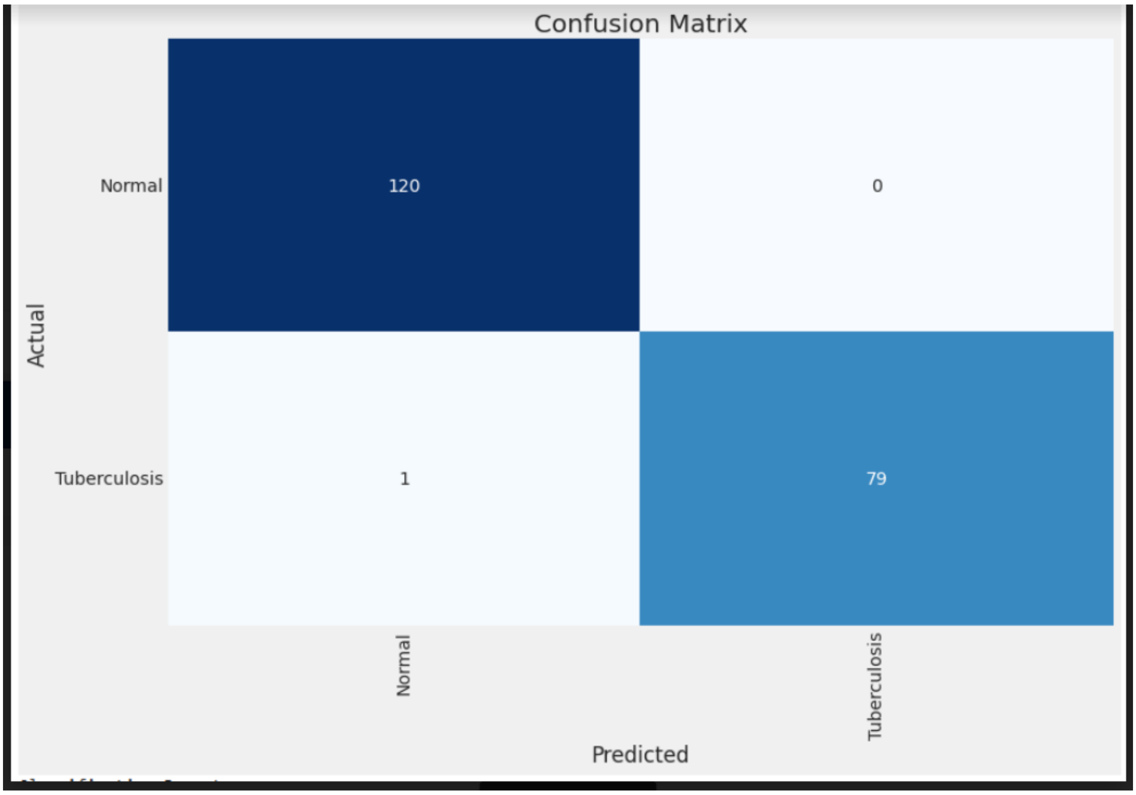


Fig no: 7.2.2 Confusion matrix for Normal and Tuberculosis (TB) classification for ChexNet model without segmented X-ray (A), and DenseNet201 model with segmented X-ray (B).

SUPPLEMENTARY MATERIALS

A chest X-ray database of 796 Tuberculosis patients' image and 1200 normal images were released. This database was created from the 4 publicly available databases, which are referenced in the database. https://www.kaggle.com/ tawsifurrahman/tuberculosis-tb-chest-x ray-dataset

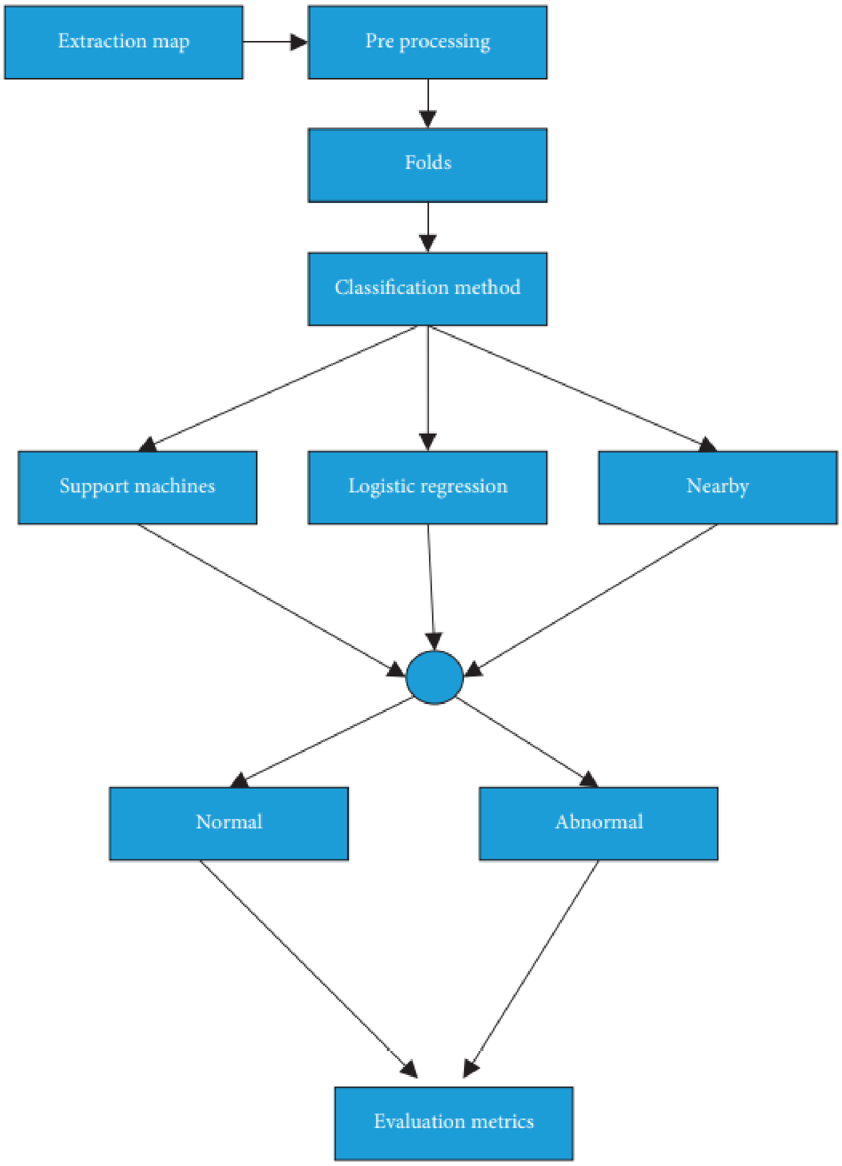


Fig no.8: Overview of the complete system using methodology in tuberculosis detection system

APPENDIX A
SOURCE CODE

```
import pandas as pd
import numpy as np
import os
os.environ['TF_CPP_MIN_LOG_LEVEL'] = '2'
import time
import matplotlib.pyplot as plt
import cv2
import seaborn as sns
sns.set_style('darkgrid')
import shutil
from sklearn.metrics import confusion_matrix, classification_report
from sklearn.model_selection import train_test_split
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras.preprocessing.image import ImageDataGenerator
from tensorflow.keras.layers import Dense, Activation,Dropout,Conv2D
, MaxPooling2D,BatchNormalization
from tensorflow.keras.optimizers import Adam, Adamax
from tensorflow.keras.metrics import categorical_crossentropy
from tensorflow.keras import regularizers
from tensorflow.keras.models import Model
from tensorflow.keras import backend as K
import time
from tqdm import tqdm
from sklearn.metrics import f1_score
from IPython.display import YouTubeVideo
import sys
if not sys.warnoptions:
    import warnings
    warnings.simplefilter("ignore")
pd.set_option('display.max_columns', None)  # or 1000
pd.set_option('display.max_rows', None)  # or 1000
pd.set_option('display.max_colwidth', None)  # or 199
print ('Modules loaded')
def print_in_color(txt_msg,fore_tupple=(0,255,255),back_tupple=(100,
100,100)):
    #prints the text_msg in the foreground color specified by fore_t
upple with the background specified by back_tupple
    #text_msg is the text, fore_tupple is foregroud color tupple (r,
g,b), back_tupple is background tupple (r,g,b)
    # default parameter print in cyan foreground and gray background
    rf,gf,bf=fore_tupple
    rb,gb,bb=back_tupple
    msg='{0}' + txt_msg
    mat='\33[38;2;' + str(rf) +';' + str(gf) + ';' + str(bf) + ';48;
2;' + str(rb) + ';' +str(gb) + ';' + str(bb) +'m'
```

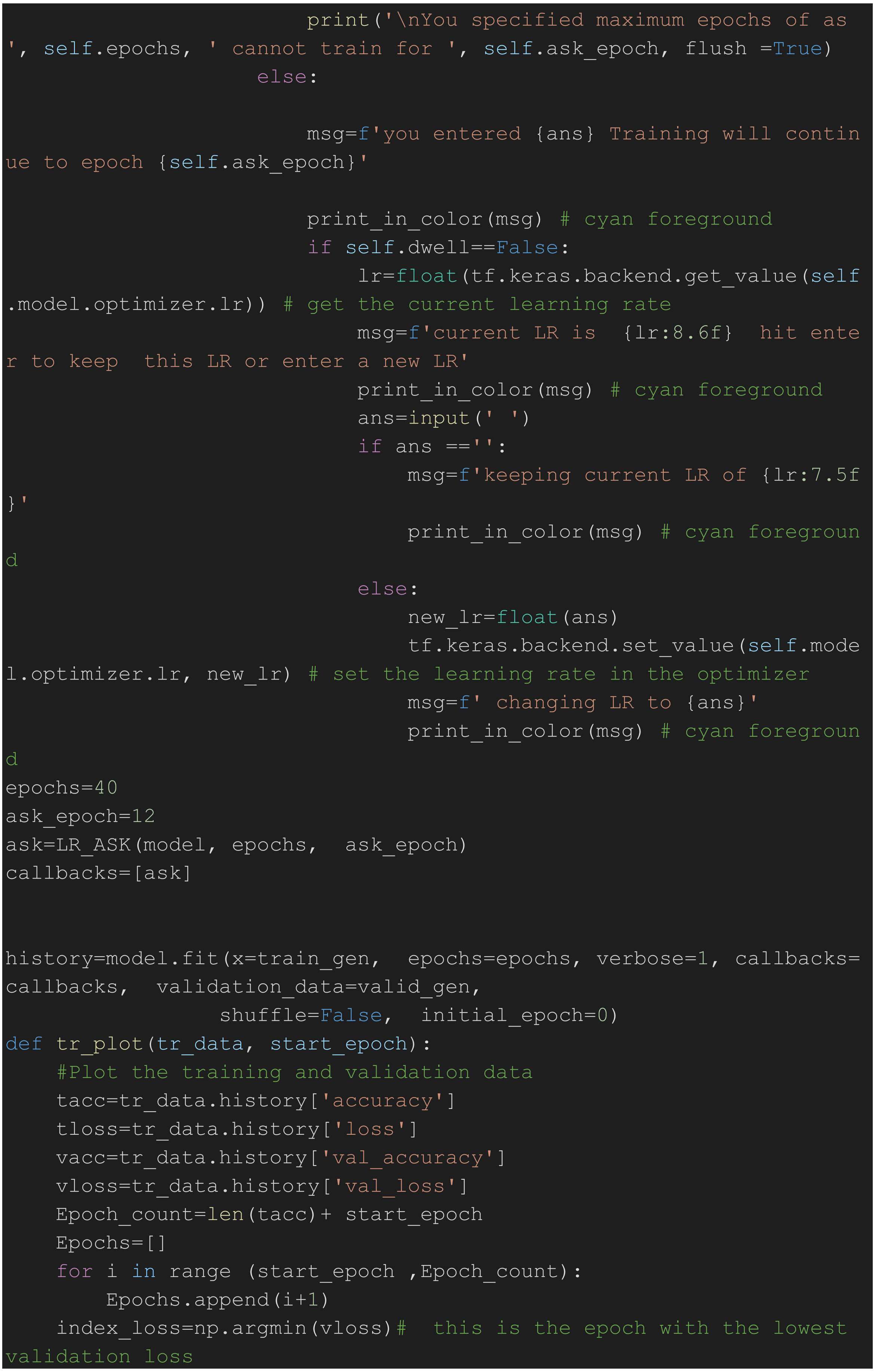
```
    print(msg .format(mat), flush=True)
    print('\33[0m', flush=True) # returns default print color to back to black
    return

# example default print
msg='test of default colors'
print_in_color(msg)
def make_dataframes(sdir):
    filepaths=[]
    labels=[]
    classlist=sorted(os.listdir(sdir) )
    for klass in classlist:
        classpath=os.path.join(sdir, klass)
        if os.path.isdir(classpath):
            flist=sorted(os.listdir(classpath))
            desc=f'{klass:25s}'
            for f in tqdm(flist, ncols=130,desc=desc, unit='files', colour='blue'):
                fpath=os.path.join(classpath,f)
                filepaths.append(fpath)
                labels.append(klass)
    Fseries=pd.Series(filepaths, name='filepaths')
    Lseries=pd.Series(labels, name='labels')
    df=pd.concat([Fseries, Lseries], axis=1)
    train_df, dummy_df=train_test_split(df, train_size=.8, shuffle=True, random_state=123, stratify=df['labels'])
    valid_df, test_df=train_test_split(dummy_df, train_size=.5, shuffle=True, random_state=123, stratify=dummy_df['labels'])
    classes=sorted(train_df['labels'].unique())
    class_count=len(classes)
    sample_df=train_df.sample(n=50, replace=False)
    # calculate the average image height and with
    ht=0
    wt=0
    count=0
    for i in range(len(sample_df)):
        fpath=sample_df['filepaths'].iloc[i]
        try:
            img=cv2.imread(fpath)
            h=img.shape[0]
            w=img.shape[1]
            wt +=w
            ht +=h
            count +=1
        except:
            pass
    have=int(ht/count)
```

```python
    wave=int(wt/count)
    aspect_ratio=have/wave
    print('number of classes in processed dataset= ', class_count)

    counts=list(train_df['labels'].value_counts())
    print(counts[0], type(counts[0]))
    print('the maximum files in any class in train_df is ', max(counts), '  the minimum files in any class in train_df is ', min(counts))
    print('train_df length: ', len(train_df), '  test_df length: ', len(test_df), '  valid_df length: ', len(valid_df))
    print('average image height= ', have, '  average image width= ', wave, ' aspect ratio h/w= ', aspect_ratio)
    return train_df, test_df, valid_df, classes, class_count

sdir=r'../content/drive/MyDrive/TB_Chest_Radiography_Database'
train_df, test_df, valid_df, classes, class_count=make_dataframes(sdir)
def trim(df, max_samples, min_samples, column):
    df=df.copy()
    classes=df[column].unique()
    class_count=len(classes)
    length=len(df)
    print ('dataframe initially is of length ',length, ' with ', class_count, ' classes')
    groups=df.groupby(column)
    trimmed_df = pd.DataFrame(columns = df.columns)
    groups=df.groupby(column)
    for label in df[column].unique():
        group=groups.get_group(label)
        count=len(group)
        if count > max_samples:
            sampled_group=group.sample(n=max_samples, random_state=123,axis=0)
            trimmed_df=pd.concat([trimmed_df, sampled_group], axis=0)
        else:
            if count>=min_samples:
                sampled_group=group
                trimmed_df=pd.concat([trimmed_df, sampled_group], axis=0)
    print('after trimming, the maximum samples in any class is now ',max_samples, ' and the minimum samples in any class is ', min_samples)
    classes=trimmed_df[column].unique()# return this in case some classes have less than min_samples
    class_count=len(classes) # return this in case some classes have less than min_samples
    length=len(trimmed_df)
    print ('the trimmed dataframe now is of length ',length, ' with ', class_count, ' classes')
    return trimmed_df, classes, class_count

max_samples=500
min_samples=500
column='labels'
train_df, classes, class_count=trim(train_df, max_samples, min_samples, column)
def balance(df, n, working_dir, img_size):
    df=df.copy()
    print('Initial length of dataframe is ', len(df))
    aug_dir=os.path.join(working_dir, 'aug')# directory to store augmented images
    if os.path.isdir(aug_dir):# start with an empty directory
        shutil.rmtree(aug_dir)
    os.mkdir(aug_dir)
    for label in df['labels'].unique():
        dir_path=os.path.join(aug_dir,label)
        os.mkdir(dir_path) # make class directories within aug directory
    # create and store the augmented images
    total=0
    gen=ImageDataGenerator(horizontal_flip=True,  rotation_range=20, width_shift_range=.2,
                                  height_shift_range=.2, zoom_range=.2)
    groups=df.groupby('labels') # group by class
    for label in df['labels'].unique():  # for every class

        group=groups.get_group(label)  # a dataframe holding only rows with the specified label
        sample_count=len(group)   # determine how many samples there are in this class
        if sample_count< n: # if the class has less than target number of images
            aug_img_count=0
            delta=n - sample_count  # number of augmented images to create
            target_dir=os.path.join(aug_dir, label)  # define where to write the images
            msg='{0:40s} for class {1:^30s} creating {2:^5s} augmented images'.format(' ', label, str(delta))
            print(msg, '\r', end='') # prints over on the same line
            aug_gen=gen.flow_from_dataframe( group,  x_col='filepaths', y_col=None, target_size=img_size,
                                            class_mode=None, batch_s
ize=1, shuffle=False,
                                            save_to_dir=target_dir,
save_prefix='aug-', color_mode='rgb',
                                            save_format='jpg')
            while aug_img_count<delta:
                images=next(aug_gen)
                aug_img_count += len(images)
            total +=aug_img_count
    print('Total Augmented images created= ', total)
    # create aug_df and merge with train_df to create composite trai
ning set ndf
    aug_fpaths=[]
    aug_labels=[]
    classlist=os.listdir(aug_dir)
    for klass in classlist:
        classpath=os.path.join(aug_dir, klass)
        flist=os.listdir(classpath)
        for f in flist:
            fpath=os.path.join(classpath,f)
            aug_fpaths.append(fpath)
            aug_labels.append(klass)
    Fseries=pd.Series(aug_fpaths, name='filepaths')
    Lseries=pd.Series(aug_labels, name='labels')
    aug_df=pd.concat([Fseries, Lseries], axis=1)
    df=pd.concat([df,aug_df], axis=0).reset_index(drop=True)
    print('Length of augmented dataframe is now ', len(df))
    return df

def make_gens(batch_size, train_df, test_df, valid_df, img_size):
    trgen=ImageDataGenerator()
    t_and_v_gen=ImageDataGenerator()
    msg='{0:70s} for train generator'.format(' ')
    print(msg, '\r', end='') # prints over on the same line
    train_gen=trgen.flow_from_dataframe(train_df, x_col='filepaths',
 y_col='labels', target_size=img_size,
                                        class_mode='categorical', co
lor_mode='rgb', shuffle=True,batch_size=batch_size)
    msg='{0:70s} for valid generator'.format(' ')
    print(msg, '\r', end='') # prints over on the same line
    valid_gen=t_and_v_gen.flow_from_dataframe(valid_df, x_col='filep
aths', y_col='labels', target_size=img_size,
                                       class_mode='categorical', col
or_mode='rgb', shuffle=False, batch_size=batch_size)
    # for the test_gen we want to calculate the batch size and test
steps such that batch_size X test_steps= number of samples in test s
et
```

```
    # this insures that we go through all the sample in the test set exactly once.
    length=len(test_df)
    test_batch_size=sorted([int(length/n) for n in range(1,length+1) if length % n ==0 and length/n<=80],reverse=True)[0]
    test_steps=int(length/test_batch_size)
    msg='{0:70s} for test generator'.format(' ')
    print(msg, '\r', end='') # prints over on the same line
    test_gen=t_and_v_gen.flow_from_dataframe(test_df, x_col='filepaths', y_col='labels', target_size=img_size,
                                       class_mode='categorical', color_mode='rgb', shuffle=False, batch_size=test_batch_size)
    # from the generator we can get information we will need later
    classes=list(train_gen.class_indices.keys())
    class_indices=list(train_gen.class_indices.values())
    class_count=len(classes)
    labels=test_gen.labels
    print ( 'test batch size: ' ,test_batch_size, '  test steps: ', test_steps, ' number of classes : ', class_count)
    return train_gen, test_gen, valid_gen, test_steps

img_size=(224,224)
batch_size =30
train_gen, test_gen, valid_gen, test_steps =make_gens(batch_size, train_df, test_df, valid_df, img_size)
def show_image_samples(gen ):
    t_dict=gen.class_indices
    classes=list(t_dict.keys())
    images,labels=next(gen) # get a sample batch from the generator
    plt.figure(figsize=(25, 25))
    length=len(labels)
    if length<25:   #show maximum of 25 images
        r=length
    else:
        r=25
    for i in range(r):
        plt.subplot(5, 5, i + 1)
        image=images[i] /255
        plt.imshow(image)
        index=np.argmax(labels[i])
        class_name=classes[index]
        plt.title(class_name, color='blue', fontsize=18)
        plt.axis('off')
    plt.show()
```

```
show_image_samples(train_gen )
def make_model(img_size, lr, mod_num=3):
    img_shape=(img_size[0], img_size[1], 3)
    if mod_num == 0:
        base_model=tf.keras.applications.efficientnet.EfficientNetB0(include_top=False, weights="imagenet",input_shape=img_shape, pooling='max')
        msg='Created EfficientNet B0 model'
    elif mod_num == 3:
        base_model=tf.keras.applications.efficientnet.EfficientNetB3(include_top=False, weights="imagenet",input_shape=img_shape, pooling='max')
        msg='Created EfficientNet B3 model'
    elif mod_num == 5:
        base_model=tf.keras.applications.efficientnet.EfficientNetB5(include_top=False, weights="imagenet",input_shape=img_shape, pooling='max')
        msg='Created EfficientNet B5 model'

    else:
        base_model=tf.keras.applications.efficientnet.EfficientNetB7(include_top=False, weights="imagenet",input_shape=img_shape, pooling='max')
        msg='Created EfficientNet B7 model'

    base_model.trainable=True
    x=base_model.output
    x=BatchNormalization(axis=-1, momentum=0.99, epsilon=0.001 )(x)
    x = Dense(256, kernel_regularizer = regularizers.l2(l = 0.016),activity_regularizer=regularizers.l1(0.006),
                    bias_regularizer=regularizers.l1(0.006) ,activation='relu')(x)
    x=Dropout(rate=.4, seed=123)(x)
    output=Dense(class_count, activation='softmax')(x)
    model=Model(inputs=base_model.input, outputs=output)
    model.compile(Adamax(learning_rate=lr), loss='categorical_crossentropy', metrics=['accuracy'])
    msg=msg + f' with initial learning rate set to {lr}'
    print_in_color(msg)
    return model




lr=.001
model=make_model(img_size, lr) # using B3 model by default
lass LR_ASK(keras.callbacks.Callback):
    def __init__ (self, model, epochs,  ask_epoch, dwell=True, factor=.4): # initialization of the callback
```

```
        super(LR_ASK, self).__init__()
        self.model=model
        self.ask_epoch=ask_epoch
        self.epochs=epochs
        self.ask=True # if True query the user on a specified epoch
        self.lowest_vloss=np.inf
        self.lowest_aloss=np.inf
        self.best_weights=self.model.get_weights() # set best weights to model's initial weights
        self.best_epoch=1
        self.plist=[]
        self.alist=[]
        self.dwell= dwell
        self.factor=factor




    def get_list(self): # define a function to return the list of % validation change
        return self.plist, self.alist
    def on_train_begin(self, logs=None): # this runs on the beginning of training
        if self.ask_epoch == 0:
            print('you set ask_epoch = 0, ask_epoch will be set to 1', flush=True)
            self.ask_epoch=1
        if self.ask_epoch >= self.epochs: # you are running for epochs but ask_epoch>epochs
            print('ask_epoch >= epochs, will train for ', epochs, ' epochs', flush=True)
            self.ask=False # do not query the user
        if self.epochs == 1:
            self.ask=False # running only for 1 epoch so do not query user
        else:
            msg =f'Training will proceed until epoch {ask_epoch} then you will be asked to'
            print_in_color(msg )
            msg='enter H to halt training or enter an integer for how many more epochs to run then be asked again'
            print_in_color(msg)
            if self.dwell:
                msg='learning rate will be automatically adjusted during training'
                print_in_color(msg, (0,255,0))
        self.start_time= time.time() # set the time at which training started
    def on_train_end(self, logs=None):   # runs at the end of training
        msg=f'loading model with weights from epoch {self.best_epoch}'
        print_in_color(msg, (0,255,255))
        self.model.set_weights(self.best_weights) # set the weights of the model to the best weights
        tr_duration=time.time() - self.start_time   # determine how long the training cycle lasted
        hours = tr_duration // 3600
        minutes = (tr_duration - (hours * 3600)) // 60
        seconds = tr_duration - ((hours * 3600) + (minutes * 60))
        msg = f'training elapsed time was {str(hours)} hours, {minutes:4.1f} minutes, {seconds:4.2f} seconds)'
        print_in_color (msg) # print out training duration time



    def on_epoch_end(self, epoch, logs=None):  # method runs on the end of each epoch
        vloss=logs.get('val_loss')  # get the validation loss for this epoch
        aloss=logs.get('loss')
        if epoch >0:
            deltav = self.lowest_vloss- vloss
            pimprov=(deltav/self.lowest_vloss) * 100
            self.plist.append(pimprov)
            deltaa=self.lowest_aloss-aloss
            aimprov=(deltaa/self.lowest_aloss) * 100
            self.alist.append(aimprov)
        else:
            pimprov=0.0
            aimprov=0.0
        if vloss< self.lowest_vloss:
            self.lowest_vloss=vloss
            self.best_weights=self.model.get_weights() # set best weights to model's initial weights
            self.best_epoch=epoch + 1
            msg=f'\n validation loss of {vloss:7.4f} is {pimprov:7.4f} % below lowest loss, saving weights from epoch {str(epoch + 1):3s} as best weights'
            print_in_color(msg, (0,255,0)) # green foreground
        else: # validation loss increased
            pimprov=abs(pimprov)
            msg=f'\n validation loss of {vloss:7.4f} is {pimprov:7.4f} % above lowest loss of {self.lowest_vloss:7.4f} keeping weights from epoch {str(self.best_epoch)} as best weights'
            print_in_color(msg, (255,255,0)) # yellow foreground
            if self.dwell: # if dwell is True when the validation loss increases the learning rate is automatically reduced and model weights are set to best weights
                lr=float(tf.keras.backend.get_value(self.model.optimizer.lr)) # get the current learning rate
                new_lr=lr * self.factor
                msg=f'learning rate was automatically adjusted from {lr:8.6f} to {new_lr:8.6f}, model weights set to best weights'
                print_in_color(msg) # cyan foreground
                tf.keras.backend.set_value(self.model.optimizer.lr, new_lr) # set the learning rate in the optimizer
                self.model.set_weights(self.best_weights) # set the weights of the model to the best weights





        if aloss< self.lowest_aloss:
            self.lowest_aloss=aloss
        if self.ask: # are the conditions right to query the user?
            if epoch + 1 ==self.ask_epoch: # is this epoch the one for quering the user?
                msg='press enter to continue or enter a comment  below '
                print_in_color(msg)
                comment=input(' ')
                if comment !='':
                    print_in_color(comment, (155,245,66))
                msg='\n Enter H to end training or  an integer for the number of additional epochs to run then ask again'
                print_in_color(msg) # cyan foreground
                ans=input()

                if ans == 'H' or ans =='h' or ans == '0': # quit training for these conditions

                    msg=f'you entered {ans},  Training halted on epoch {epoch+1} due to user input\n'
                    print_in_color(msg)
                    self.model.stop_training = True # halt training
                else: # user wants to continue training
                    self.ask_epoch += int(ans)
                    if self.ask_epoch > self.epochs:
```



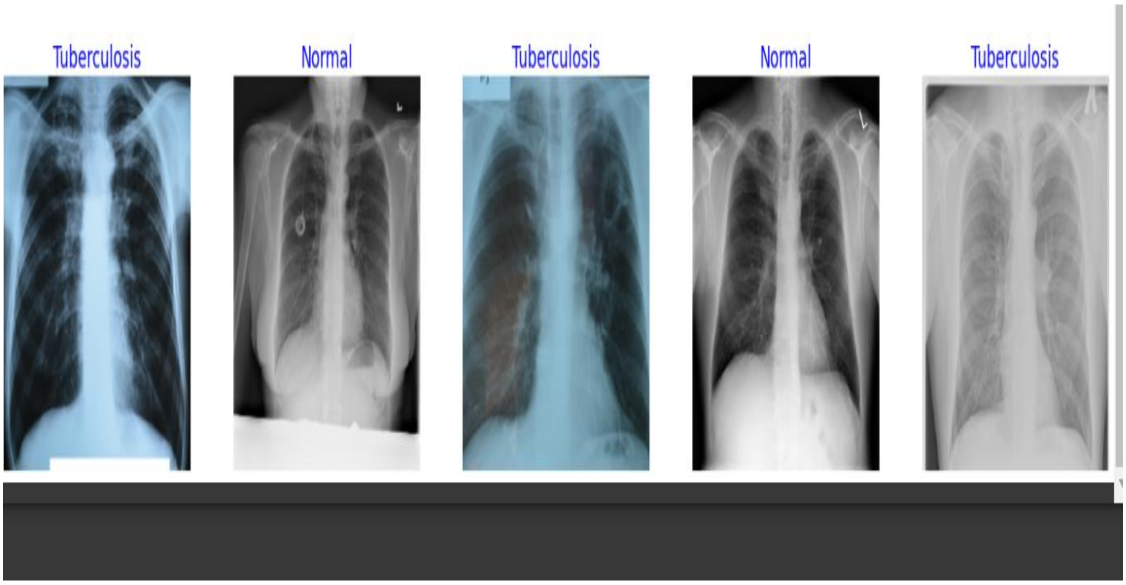
```
                        print('\nYou specified maximum epochs of as
', self.epochs, ' cannot train for ', self.ask_epoch, flush =True)
                    else:

                        msg=f'you entered {ans} Training will contin
ue to epoch {self.ask_epoch}'

                        print_in_color(msg) # cyan foreground
                        if self.dwell==False:
                            lr=float(tf.keras.backend.get_value(self
.model.optimizer.lr)) # get the current learning rate
                            msg=f'current LR is  {lr:8.6f}  hit ente
r to keep  this LR or enter a new LR'
                            print_in_color(msg) # cyan foreground
                            ans=input(' ')
                            if ans =='':
                                msg=f'keeping current LR of {lr:7.5f
}'

                                print_in_color(msg) # cyan foregroun
d

                            else:
                                new_lr=float(ans)
                                tf.keras.backend.set_value(self.mode
l.optimizer.lr, new_lr) # set the learning rate in the optimizer
                                msg=f' changing LR to {ans}'
                                print_in_color(msg) # cyan foregroun
d
epochs=40
ask_epoch=12
ask=LR_ASK(model, epochs,  ask_epoch)
callbacks=[ask]


history=model.fit(x=train_gen,  epochs=epochs, verbose=1, callbacks=
callbacks,  validation_data=valid_gen,
                 shuffle=False,  initial_epoch=0)
def tr_plot(tr_data, start_epoch):
    #Plot the training and validation data
    tacc=tr_data.history['accuracy']
    tloss=tr_data.history['loss']
    vacc=tr_data.history['val_accuracy']
    vloss=tr_data.history['val_loss']
    Epoch_count=len(tacc)+ start_epoch
    Epochs=[]
    for i in range (start_epoch ,Epoch_count):
        Epochs.append(i+1)
    index_loss=np.argmin(vloss)#  this is the epoch with the lowest
validation loss
```

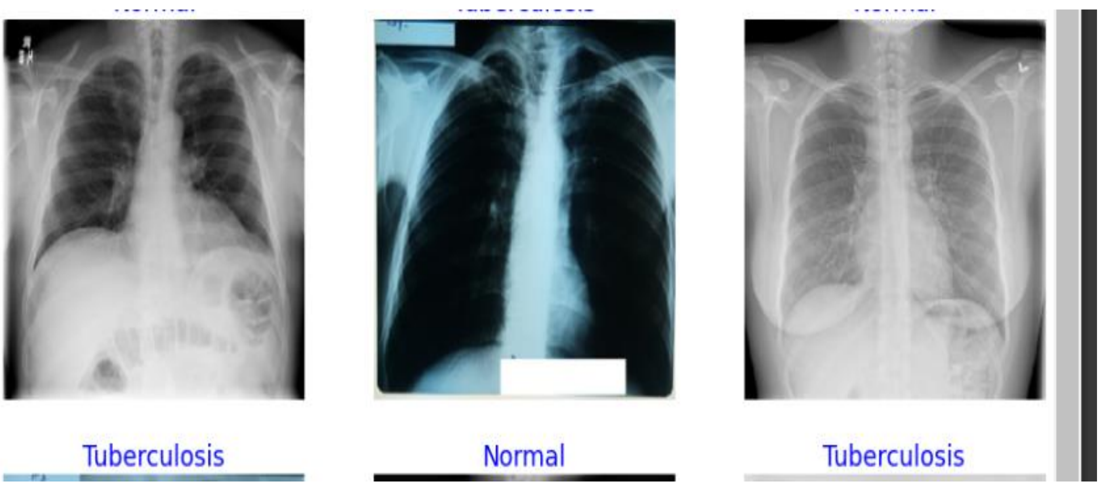
```
    val_lowest=vloss[index_loss]
    index_acc=np.argmax(vacc)
    acc_highest=vacc[index_acc]
    plt.style.use('fivethirtyeight')
    sc_label='best epoch= '+ str(index_loss+1 +start_epoch)
    vc_label='best epoch= '+ str(index_acc + 1+ start_epoch)
    fig,axes=plt.subplots(nrows=1, ncols=2, figsize=(25,10))
    axes[0].plot(Epochs,tloss, 'r', label='Training loss')
    axes[0].plot(Epochs,vloss,'g',label='Validation loss' )
    axes[0].scatter(index_loss+1 +start_epoch,val_lowest, s=150, c=
'blue', label=sc_label)
    axes[0].scatter(Epochs, tloss, s=100, c='red')
    axes[0].set_title('Training and Validation Loss')
    axes[0].set_xlabel('Epochs', fontsize=18)
    axes[0].set_ylabel('Loss', fontsize=18)
    axes[0].legend()
    axes[1].plot (Epochs,tacc,'r',label= 'Training Accuracy')
    axes[1].scatter(Epochs, tacc, s=100, c='red')
    axes[1].plot (Epochs,vacc,'g',label= 'Validation Accuracy')
    axes[1].scatter(index_acc+1 +start_epoch,acc_highest, s=150, c=
'blue', label=vc_label)
    axes[1].set_title('Training and Validation Accuracy')
    axes[1].set_xlabel('Epochs', fontsize=18)
    axes[1].set_ylabel('Accuracy', fontsize=18)
    axes[1].legend()
    plt.tight_layout
    plt.show()
    return index_loss
```

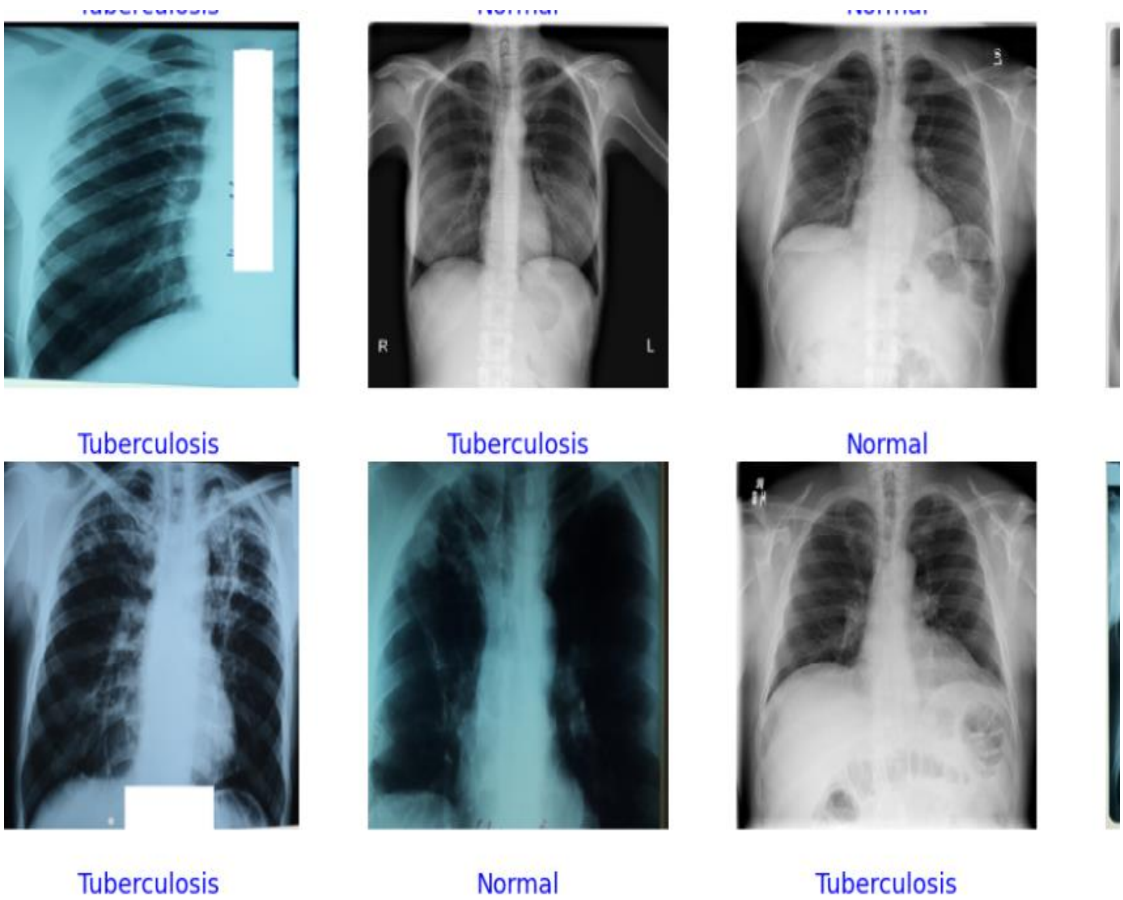
APPENDIX B

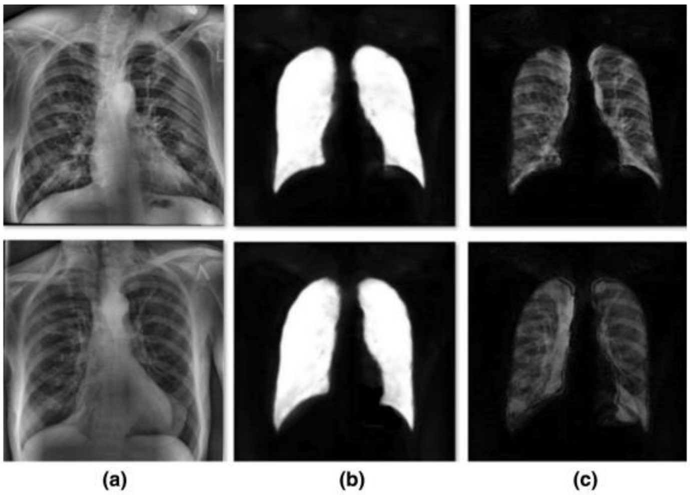
Screen Shots

Image table in server where the images are uploaded





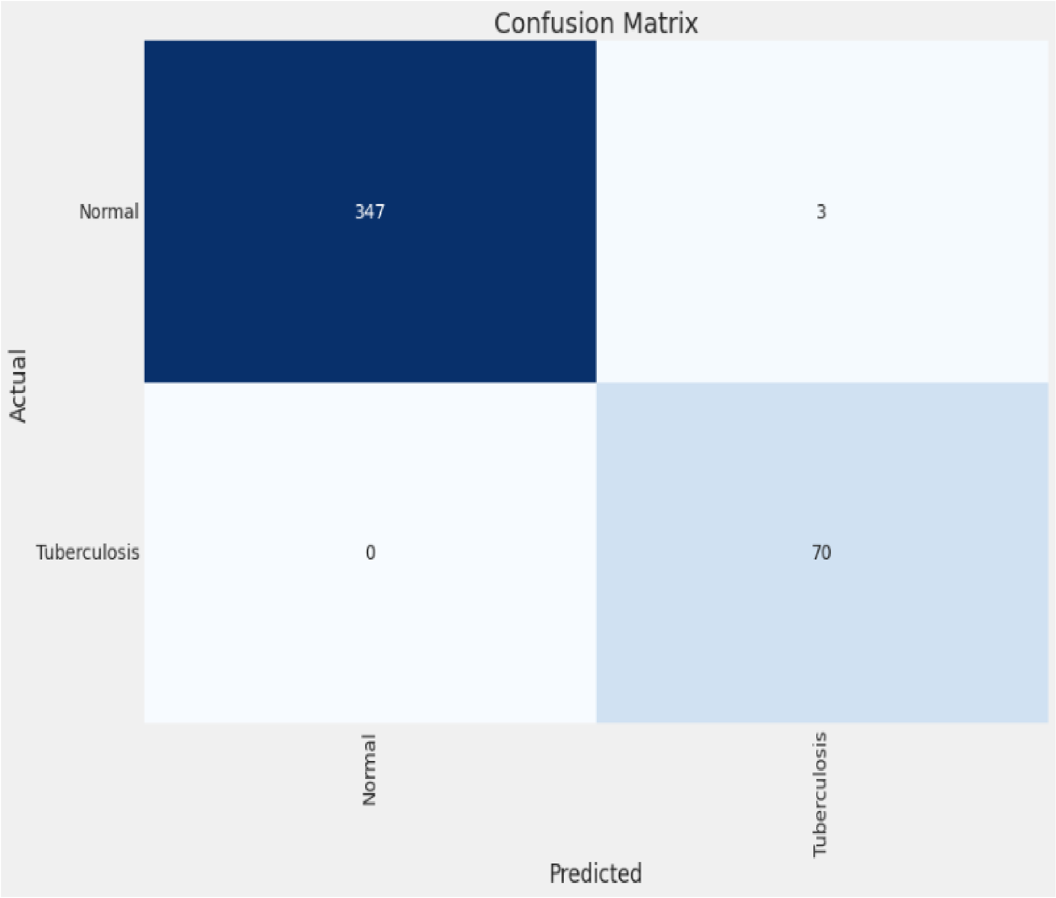


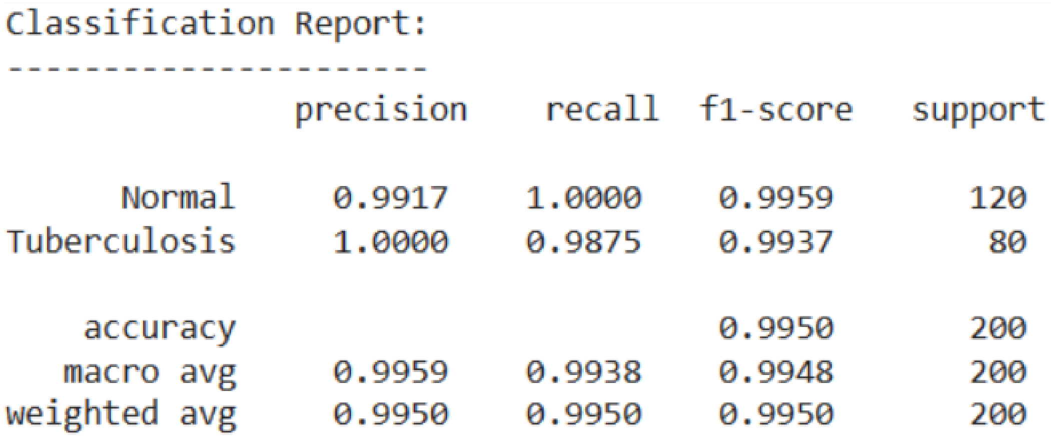


U-Net output segmentation results for two sample lung CXR images. a shows the original images. b shows the results of U-Net. c show the results after ROI extraction

Clustering Of The Input Image

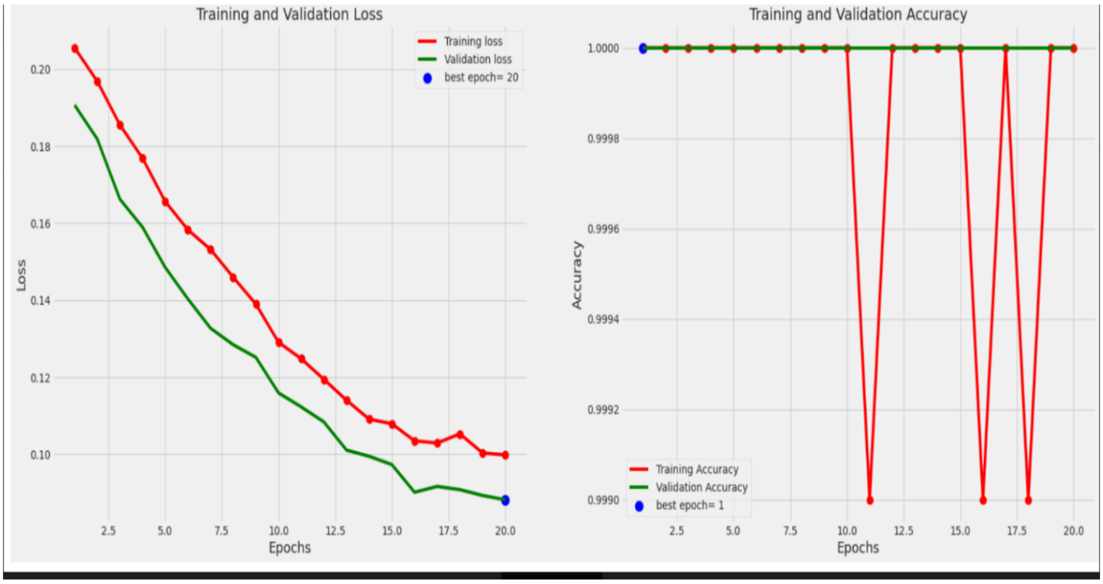
Matlab Command Prompt Where The Affected Area
Is Displayed





```
Classification Report:
----------------------
              precision    recall  f1-score   support

      Normal     0.9917    1.0000    0.9959       120
Tuberculosis     1.0000    0.9875    0.9937        80

    accuracy                         0.9950       200
   macro avg     0.9959    0.9938    0.9948       200
weighted avg     0.9950    0.9950    0.9950       200
```

Help Dialog Displaying the Tuberculosis disease name



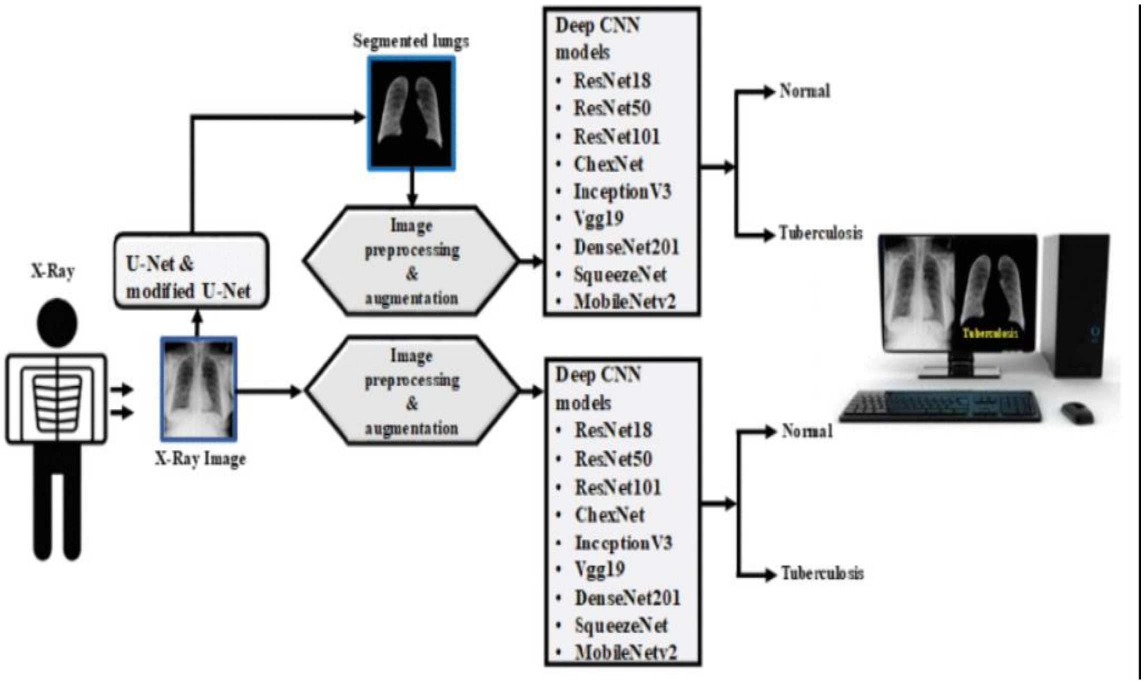


Fig no.9: Overview of the complete system in detection system