# COVID-19
# X-RAY DETECTION

Vijay Saddi
August 2020

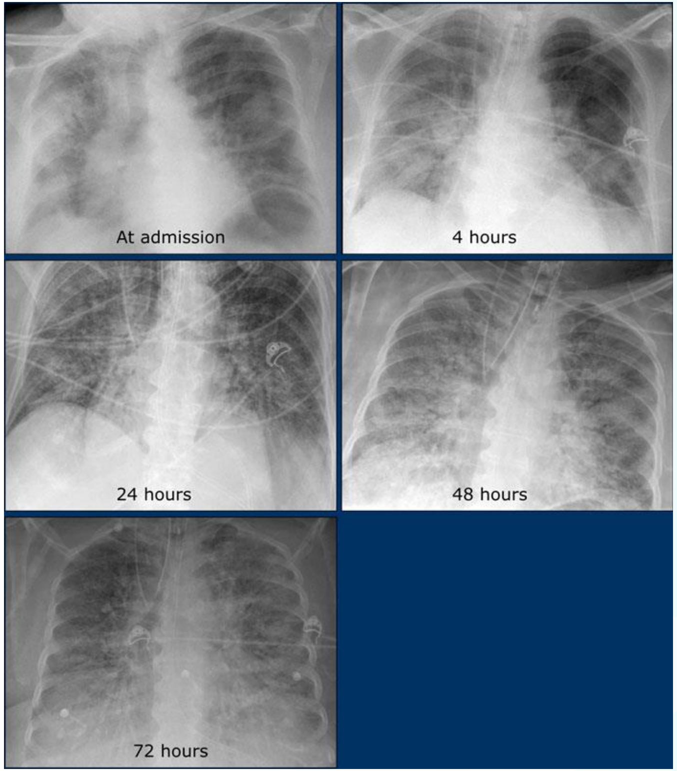
# AGENDA

USE CASE › DATA SET › DATA PREP › MODEL BUILDING › EVALUATION

# COVID-19 BACKGROUND

- The 2019 outbreak of Covid-19 has kept the world on lockdown with the effort to stop the spread
- It is a highly contagious illness which affects the lungs of the respiratory system
- Transmitted via close proximity via small droplets produced by coughing , sneezing & talking
- X-rays and CT scans of Covid-19 victims can depict the damage inflicted on the lungs

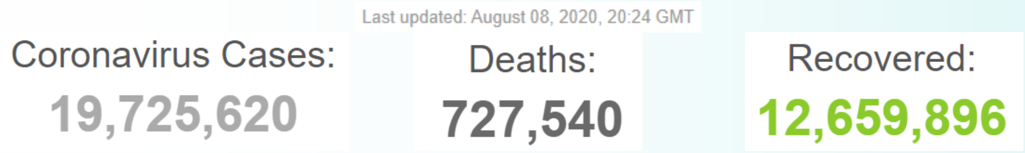
# RADIOLOGY



- Chest x-rays are useful in the follow-up of the disease (it is insensitive early on)
- The image on the left is an 83-year old male with Covid-19
- Image findings:
  - Admission: Ill defined bilateral alveolar consolidation
  - 4-hrs: Radiology worsening, affected lower lobes
  - 24-hrs: Bilateral alveolar consolidation[1]
  - 48-hrs: Further radiology worsening
  - 72-hrs: Panlobar affectation[2], with typical radiology findings of ARDS[3]; 24 hrs later patient passed away

1. Infers an alveolar spread of disease, commonly due to pneumonia
2. Alveolar destruction within the lobule
3. Acute Respiratory Distress Syndrome: fluid buildup in the alveoli

# CURRENT STATISTICS ON COVID-19

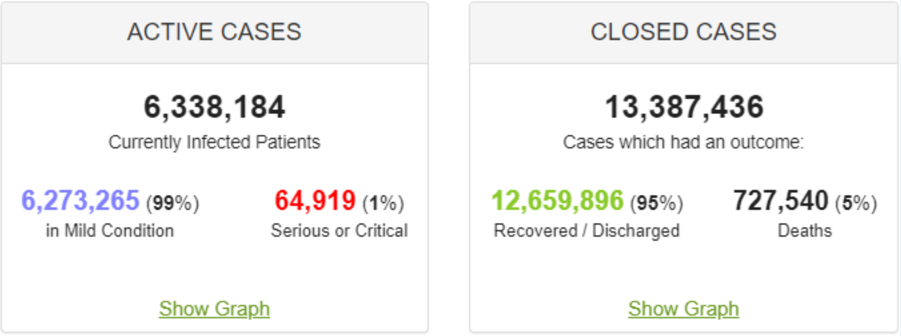


Last updated: August 08, 2020, 20:24 GMT

Coronavirus Cases:
19,725,620

Deaths:
727,540

Recovered:
12,659,896



ACTIVE CASES

6,338,184
Currently Infected Patients

6,273,265 (99%)
in Mild Condition

64,919 (1%)
Serious or Critical

Show Graph

CLOSED CASES

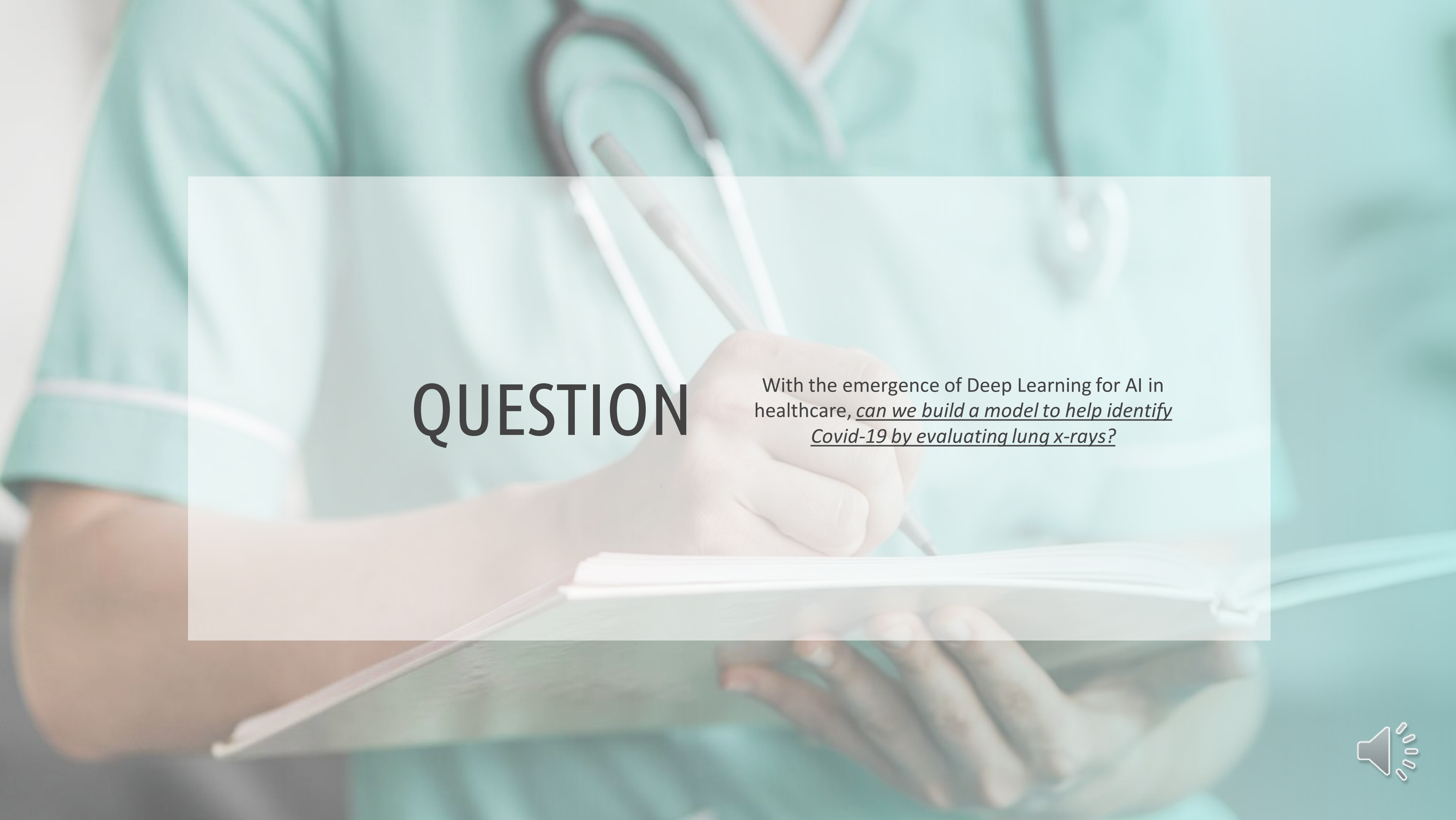
13,387,436
Cases which had an outcome:

12,659,896 (95%)
Recovered / Discharged

727,540 (5%)
Deaths

Show Graph

- High rate of infection
- High rate of recovery (95%)
- 5% death rate (August 2020)



# QUESTION

With the emergence of Deep Learning for AI in healthcare, *can we build a model to help identify Covid-19 by evaluating lung x-rays?*

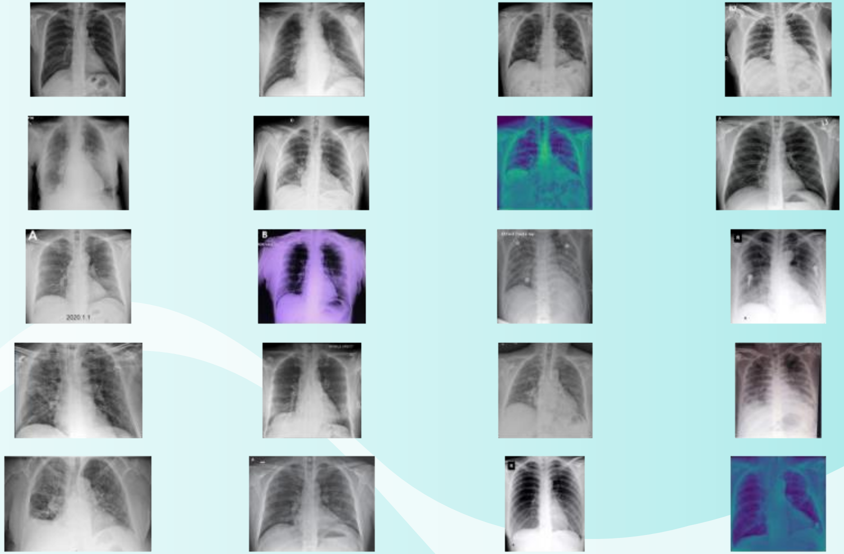
# DATA SET

- 2 main data sources for Covid-19 and Normal x-ray images

- Covid-19 x-rays were taken from Github: https://github.com/ieee8023/covid-chestxray-dataset

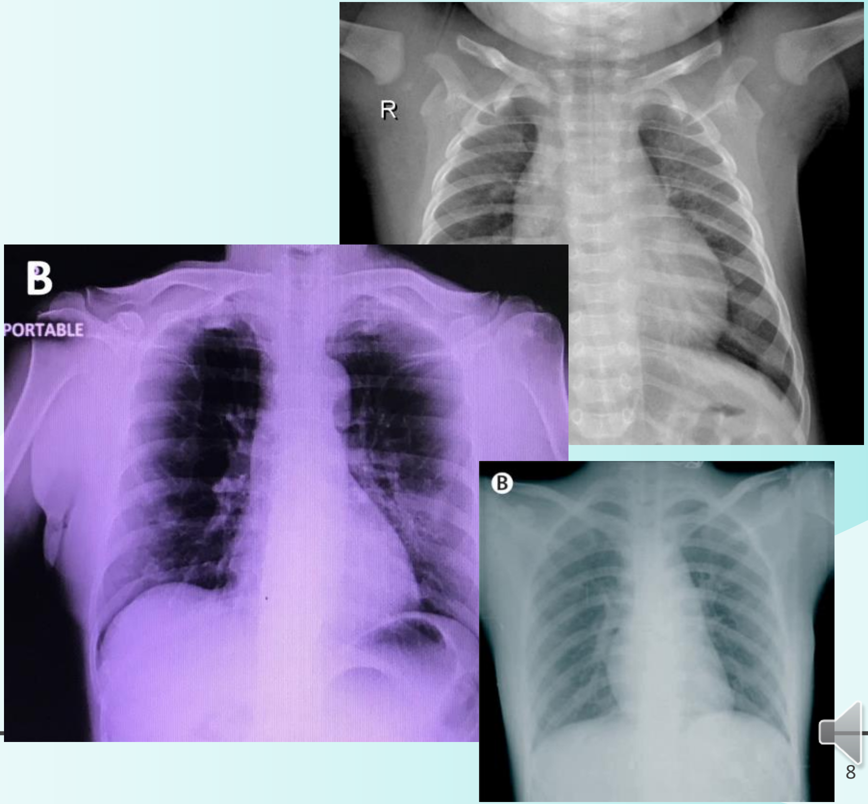
- Normal x-ray images were taken from Kaggle: https://www.kaggle.com/paultimothymooney/chest-xray-pneumonia

- There were 180 images per group, with a total of **360**



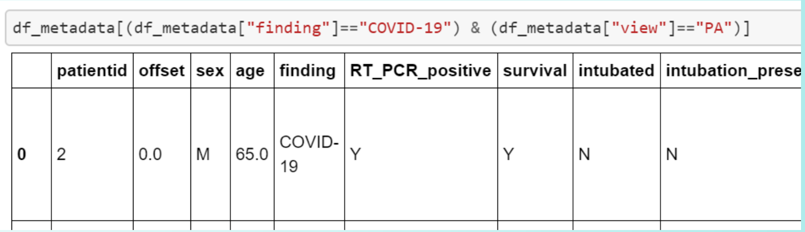
# EXPLORATION & QUALITY ASSESSMENT

- Image file sizes range from 400-600kb each
- Images are of high quality (720p-1080p resolution)
- Each image has different dimensions (width vs height)
- RGB & greyscale formats



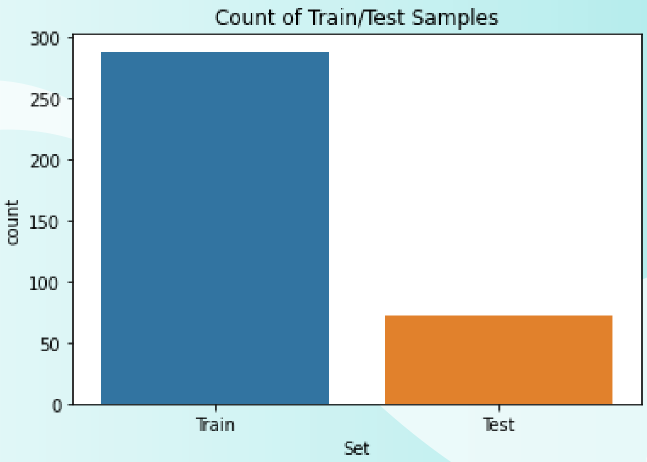
# DATA PRE-PROCESSING

- Github images were filtered to select only Covid-19 diagnosed, and Posteroanterior view
- From the entire pool of images, the *80/20 split* was implemented to divide the training/test data
- **Training**: 144 images per category (Covid & Normal)
- **Testing**: 36 images per category (Covid & Normal)



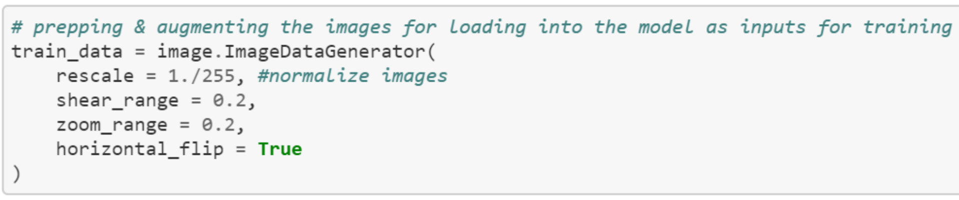
```
df_metadata[(df_metadata["finding"]=="COVID-19") & (df_metadata["view"]=="PA")]
```

| | patientid | offset | sex | age | finding | RT_PCR_positive | survival | intubated | intubation_prese |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 2 | 0.0 | M | 65.0 | COVID-19 | Y | Y | N | N |

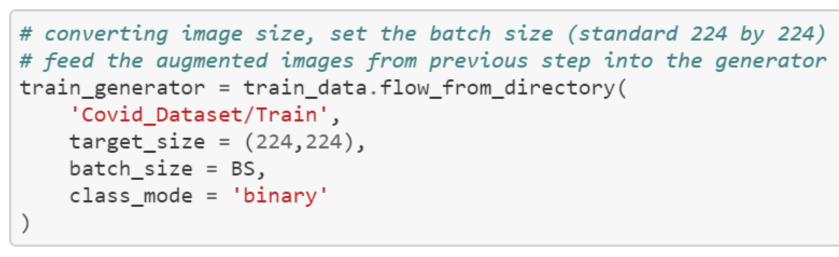


# FEATURE ENGINEERING

- Prior to model training, augmentation methods were required to account for variations in the image makeup:
    - **Normalization**: images rescaled by 1/255 to ensure pixel values range between 0 and 1
    - **Shear range**: shear angle for variations in image rotation
    - **Zoom range**: account for variations in zoom between images
    - **Horizontal flip**: reverses the rows/columns of pixels in random images – as lung images show symmetry in nature
    - **Target size**: resize all images to standard 224x224



```
# prepping & augmenting the images for loading into the model as inputs for training
train_data = image.ImageDataGenerator(
    rescale = 1./255, #normalize images
    shear_range = 0.2,
    zoom_range = 0.2,
    horizontal_flip = True
)
```



```
# converting image size, set the batch size (standard 224 by 224)
# feed the augmented images from previous step into the generator
train_generator = train_data.flow_from_directory(
    'Covid_Dataset/Train',
    target_size = (224,224),
    batch_size = BS,
    class_mode = 'binary'
)
```

# DEEP LEARNING MODEL

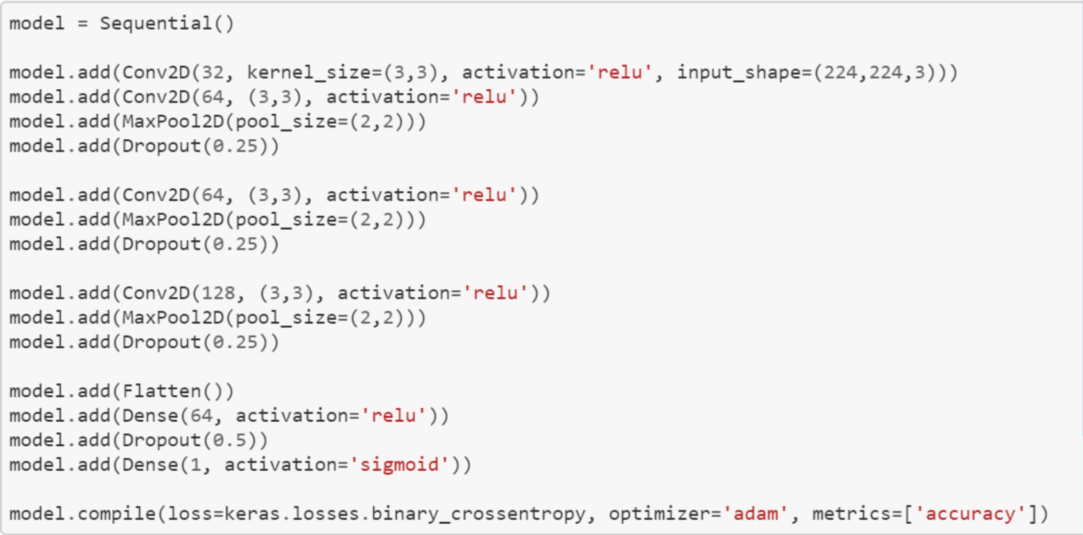
- A Convolutional Neural Network (CNN) is best suited for image processing

- Summary:
  - 4 convolutional layers
  - 3 pooling layers (2,2)
  - 4 dropout layers

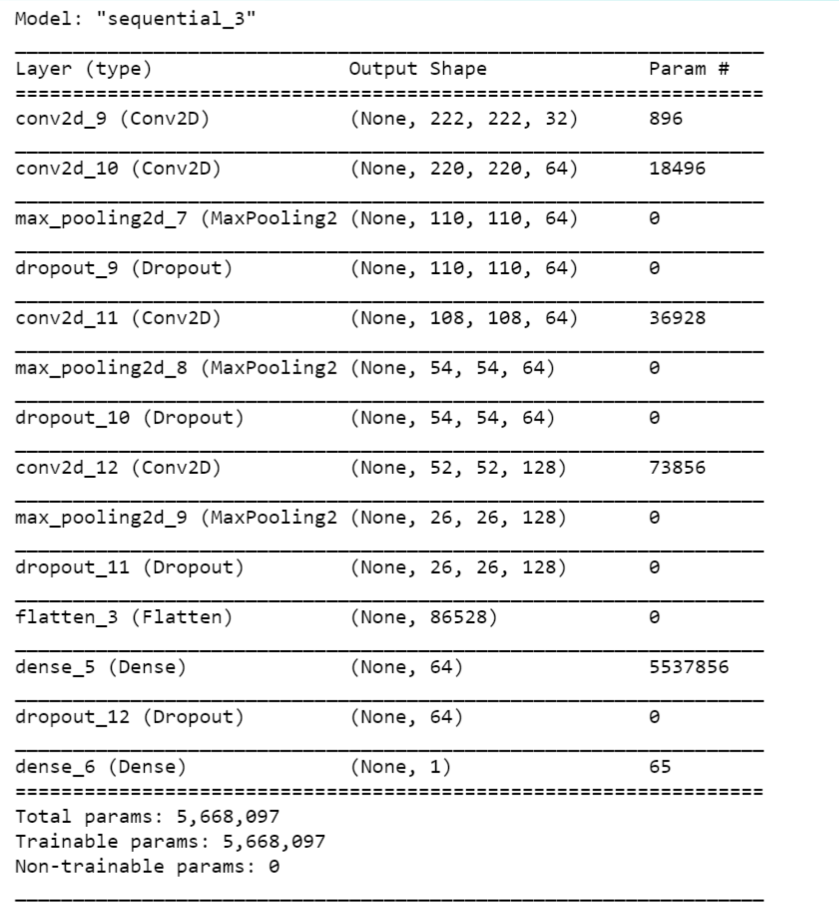
- Dropout Layer: reduction by 25% to prevent overfitting in first 3 layers

- Loss function: binary cross-entropy to classify between 2 classes

- Optimizer: Adam shows better performance on deep learning models



```
model = Sequential()

model.add(Conv2D(32, kernel_size=(3,3), activation='relu', input_shape=(224,224,3)))
model.add(Conv2D(64, (3,3), activation='relu'))
model.add(MaxPool2D(pool_size=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(64, (3,3), activation='relu'))
model.add(MaxPool2D(pool_size=(2,2)))
model.add(Dropout(0.25))

model.add(Conv2D(128, (3,3), activation='relu'))
model.add(MaxPool2D(pool_size=(2,2)))
model.add(Dropout(0.25))

model.add(Flatten())
model.add(Dense(64, activation='relu'))
model.add(Dropout(0.5))
model.add(Dense(1, activation='sigmoid'))

model.compile(loss=keras.losses.binary_crossentropy, optimizer='adam', metrics=['accuracy'])
```

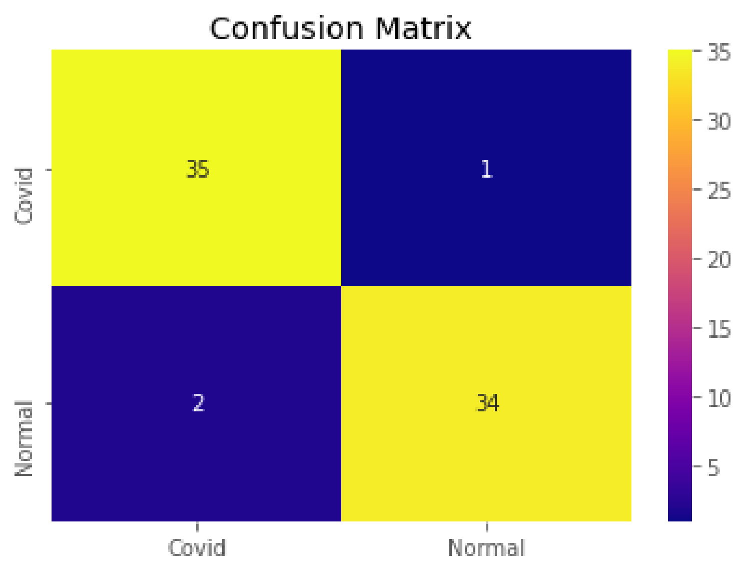


```
Model: "sequential_3"
_________________________________________________________________
Layer (type)                 Output Shape              Param #   
=================================================================
conv2d_9 (Conv2D)            (None, 222, 222, 32)      896       
_________________________________________________________________
conv2d_10 (Conv2D)           (None, 220, 220, 64)      18496     
_________________________________________________________________
max_pooling2d_7 (MaxPooling2 (None, 110, 110, 64)      0         
_________________________________________________________________
dropout_9 (Dropout)          (None, 110, 110, 64)      0         
_________________________________________________________________
conv2d_11 (Conv2D)           (None, 108, 108, 64)      36928     
_________________________________________________________________
max_pooling2d_8 (MaxPooling2 (None, 54, 54, 64)        0         
_________________________________________________________________
dropout_10 (Dropout)         (None, 54, 54, 64)        0         
_________________________________________________________________
conv2d_12 (Conv2D)           (None, 52, 52, 128)       73856     
_________________________________________________________________
max_pooling2d_9 (MaxPooling2 (None, 26, 26, 128)       0         
_________________________________________________________________
dropout_11 (Dropout)         (None, 26, 26, 128)       0         
_________________________________________________________________
flatten_3 (Flatten)          (None, 86528)             0         
_________________________________________________________________
dense_5 (Dense)              (None, 64)                5537856   
_________________________________________________________________
dropout_12 (Dropout)         (None, 64)                0         
_________________________________________________________________
dense_6 (Dense)              (None, 1)                 65        
=================================================================
Total params: 5,668,097
Trainable params: 5,668,097
Non-trainable params: 0
_________________________________________________________________
```

# MODEL PERFORMANCE

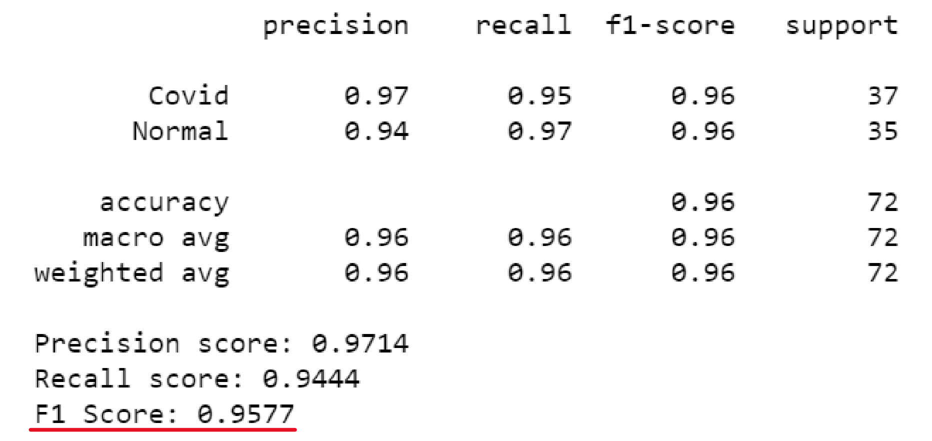
- Based on the confusion matrix, the model has a high accuracy when predicting Covid-19 and Normal x-rays

- **97%** accuracy when predicting Covid-19 x-rays
- **94%** accuracy when predicting normal x-rays



# PERFORMANCE INDICATORS

- **F1-Score** is used as the best performance indicator for binary classification problems
- **Precision** – correctly identified 97% of positive cases from all the predicted positive cases
- **Recall** – correctly identified 94% of positive cases from all the actual positive cases

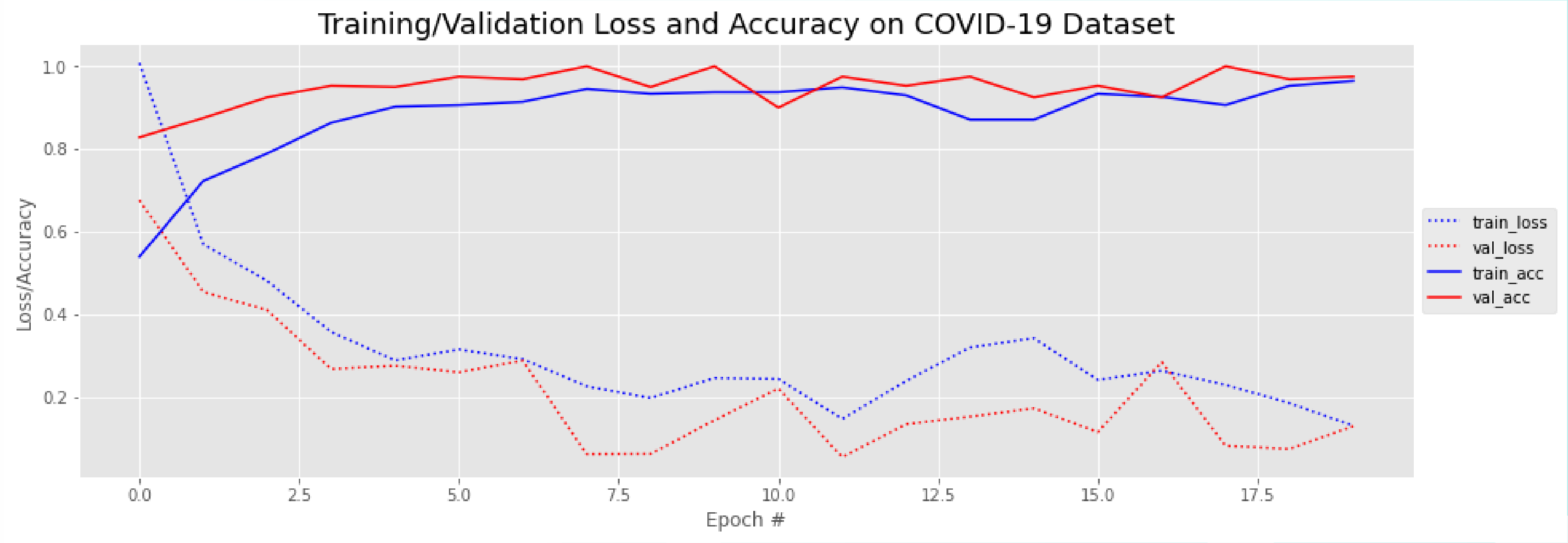


```
              precision    recall  f1-score   support

       Covid       0.97      0.95      0.96        37
      Normal       0.94      0.97      0.96        35

    accuracy                           0.96        72
   macro avg       0.96      0.96      0.96        72
weighted avg       0.96      0.96      0.96        72

Precision score: 0.9714
Recall score: 0.9444
F1 Score: 0.9577
```

# MODEL EVALUATION

The CNN model yields an F1-score of 96% on test data

# TRAINING HISTORY



- Does the model overfit to the training data?
- Based on the plot history, the accuracy and loss follows the same trend, although does not overfit!
- Throughout each Epoch, there are slight variations in loss and accuracy

# SUMMARY/NEXT STEPS

## CNN MODEL

- Successful working model
- 96% Accuracy
- Does not overfit

## LIMITATION

Data set is very small for large scale use; more data needed

## NEXT STEP

- Using ImageNet to import a larger data set for training
- Compare model with a transfer learning model results

# THANKS!

# CONTACT

Does anyone have any questions?

Email: vijay.saddi@outlook.com
LinkedIn: https://www.linkedin.com/in/vijay-ss/
Github: https://github.com/vijay-ss
Portfolio: https://vijay-ss.github.io/Vijay_Portfolio/