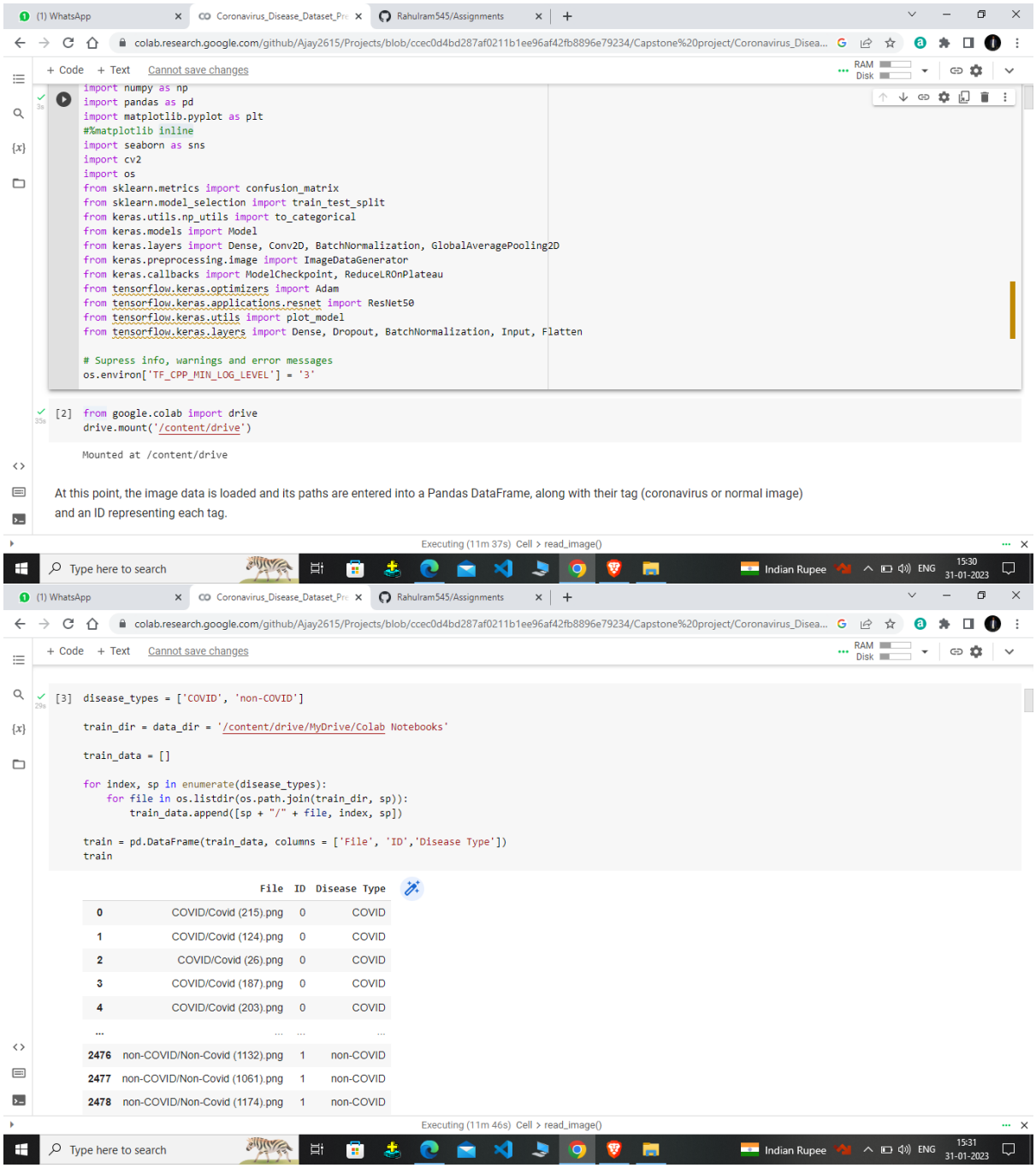


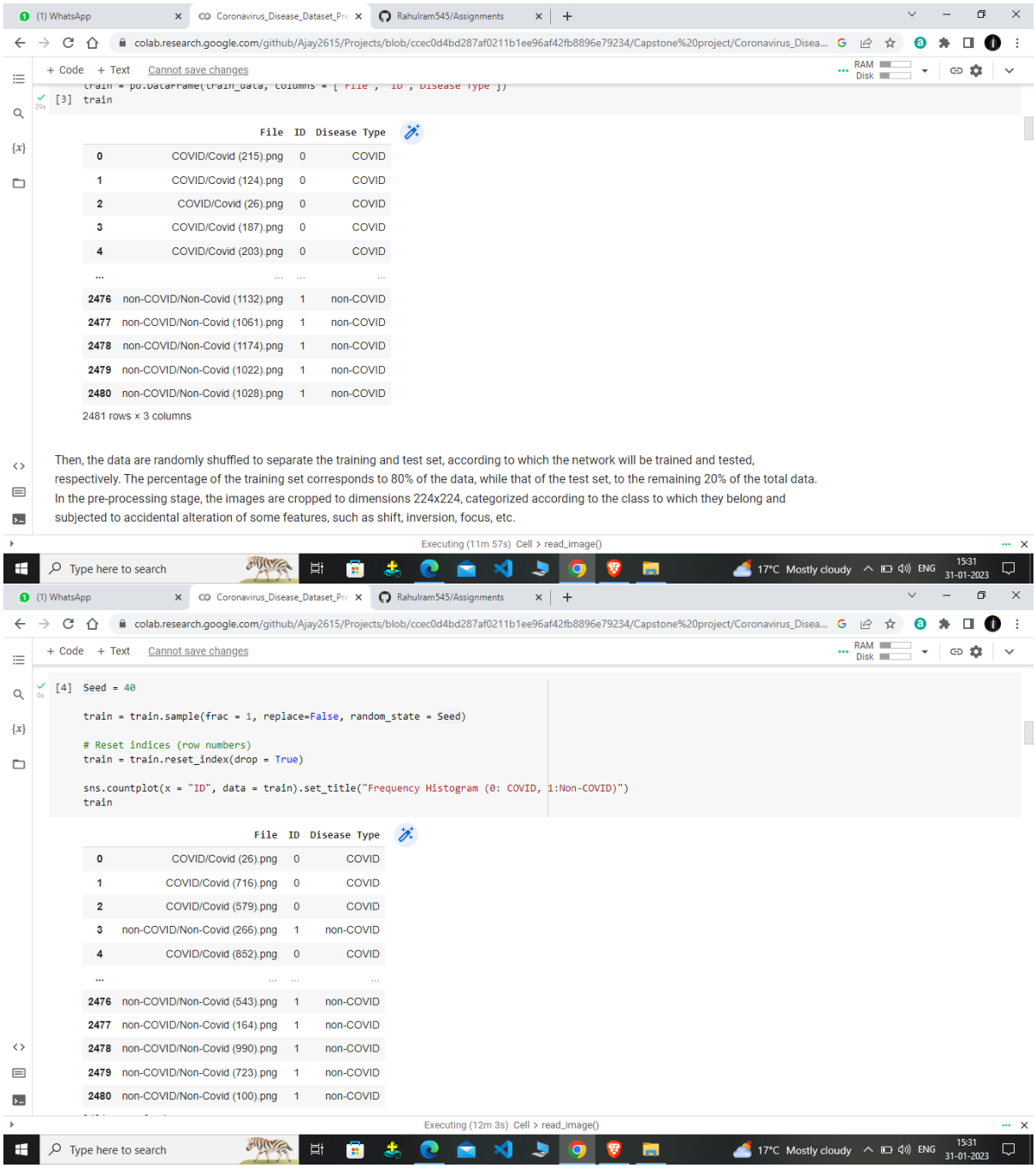
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
#%matplotlib inline
import seaborn as sns
import cv2
import os
from sklearn.metrics import confusion_matrix
from sklearn.model_selection import train_test_split
from keras.utils.np_utils import to_categorical
from keras.models import Model
from keras.layers import Dense, Conv2D, BatchNormalization, GlobalAveragePooling2D
from keras.preprocessing.image import ImageDataGenerator
from keras.callbacks import ModelCheckpoint, ReduceLROnPlateau
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.applications.resnet import ResNet50
from tensorflow.keras.utils import plot_model
from tensorflow.keras.layers import Dense, Dropout, BatchNormalization, Input, Flatten

# Supress info, warnings and error messages
os.environ['TF_CPP_MIN_LOG_LEVEL'] = '3'
```

```
[2] from google.colab import drive
    drive.mount('/content/drive')

    Mounted at /content/drive
```

At this point, the image data is loaded and its paths are entered into a Pandas DataFrame, along with their tag (coronavirus or normal image) and an ID representing each tag.


```
[3] disease_types = ['COVID', 'non-COVID']

    train_dir = data_dir = '/content/drive/MyDrive/Colab Notebooks'

    train_data = []

    for index, sp in enumerate(disease_types):
        for file in os.listdir(os.path.join(train_dir, sp)):
            train_data.append([sp + "/" + file, index, sp])

    train = pd.DataFrame(train_data, columns = ['File', 'ID','Disease Type'])
    train
```

	File	ID	Disease Type
0	COVID/Covid (215).png	0	COVID
1	COVID/Covid (124).png	0	COVID
2	COVID/Covid (26).png	0	COVID
3	COVID/Covid (187).png	0	COVID
4	COVID/Covid (203).png	0	COVID
...	...	...	...
2476	non-COVID/Non-Covid (1132).png	1	non-COVID
2477	non-COVID/Non-Covid (1061).png	1	non-COVID
2478	non-COVID/Non-Covid (1174).png	1	non-COVID



```
train = pd.DataFrame(train_data, columns = [ 'File' , 'ID' , 'Disease Type' ])
[3] train
```

	File	ID	Disease Type
0	COVID/Covid (215).png	0	COVID
1	COVID/Covid (124).png	0	COVID
2	COVID/Covid (26).png	0	COVID
3	COVID/Covid (187).png	0	COVID
4	COVID/Covid (203).png	0	COVID
...	...	...	...
2476	non-COVID/Non-Covid (1132).png	1	non-COVID
2477	non-COVID/Non-Covid (1061).png	1	non-COVID
2478	non-COVID/Non-Covid (1174).png	1	non-COVID
2479	non-COVID/Non-Covid (1022).png	1	non-COVID
2480	non-COVID/Non-Covid (1028).png	1	non-COVID

2481 rows × 3 columns

Then, the data are randomly shuffled to separate the training and test set, according to which the network will be trained and tested, respectively. The percentage of the training set corresponds to 80% of the data, while that of the test set, to the remaining 20% of the total data. In the pre-processing stage, the images are cropped to dimensions 224x224, categorized according to the class to which they belong and subjected to accidental alteration of some features, such as shift, inversion, focus, etc.


```
[4] Seed = 40

    train = train.sample(frac = 1, replace=False, random_state = Seed)

    # Reset indices (row numbers)
    train = train.reset_index(drop = True)

    sns.countplot(x = "ID", data = train).set_title("Frequency Histogram (0: COVID, 1:Non-COVID)")
    train
```

	File	ID	Disease Type
0	COVID/Covid (26).png	0	COVID
1	COVID/Covid (716).png	0	COVID
2	COVID/Covid (579).png	0	COVID
3	non-COVID/Non-Covid (266).png	1	non-COVID
4	COVID/Covid (852).png	0	COVID
...	...	...	...
2476	non-COVID/Non-Covid (543).png	1	non-COVID
2477	non-COVID/Non-Covid (164).png	1	non-COVID
2478	non-COVID/Non-Covid (990).png	1	non-COVID
2479	non-COVID/Non-Covid (723).png	1	non-COVID
2480	non-COVID/Non-Covid (100).png	1	non-COVID

```
[4] Seed = 40

    train = train.sample(frac = 1, replace=False, random_state = Seed)

    # Reset indices (row numbers)
    train = train.reset_index(drop = True)

    sns.countplot(x = "ID", data = train).set_title("Frequency Histogram (0: COVID, 1:Non-COVID)")
    train
```

	File	ID	Disease Type
0	COVID/Covid (26).png	0	COVID
1	COVID/Covid (716).png	0	COVID
2	COVID/Covid (579).png	0	COVID
3	non-COVID/Non-Covid (266).png	1	non-COVID
4	COVID/Covid (852).png	0	COVID
...	...	...	...
2476	non-COVID/Non-Covid (543).png	1	non-COVID
2477	non-COVID/Non-Covid (164).png	1	non-COVID
2478	non-COVID/Non-Covid (990).png	1	non-COVID
2479	non-COVID/Non-Covid (723).png	1	non-COVID
2480	non-COVID/Non-Covid (100).png	1	non-COVID

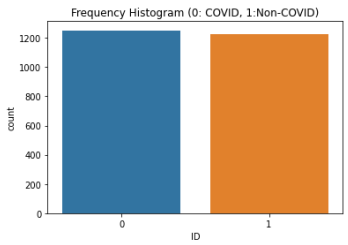
2481 rows × 3 columns

Executing (12m 17s) Cell > read_image()

[4]

2	COVID/Covid (579).png	0	COVID
3	non-COVID/Non-Covid (266).png	1	non-COVID
4	COVID/Covid (852).png	0	COVID
...	...	...	...
2476	non-COVID/Non-Covid (543).png	1	non-COVID
2477	non-COVID/Non-Covid (164).png	1	non-COVID
2478	non-COVID/Non-Covid (990).png	1	non-COVID
2479	non-COVID/Non-Covid (723).png	1	non-COVID
2480	non-COVID/Non-Covid (100).png	1	non-COVID

2481 rows × 3 columns



Executing (12m 23s) Cell > read_image()

(1) WhatsApp | Coronavirus_Disease_Dataset_Pre | Rahulram545/Assignments

colab.research.google.com/github/Ajay2615/Projects/blob/ccec0d4bd287af0211b1ee96af42fb8896e79234/Capstone%20project/Coronavirus_Disea...

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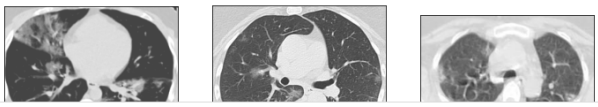
```
[5]  def plot_defects(defect_types, rows, cols):
         fig, ax = plt.subplots(rows, cols, figsize=(12, 12))
         defect_files = train['File'][train['Disease Type'] == defect_types].values

         n = 0
         fig.suptitle(defect_types, fontsize = 22, color = "white")
         for i in range(rows):
             for j in range(cols):
                 image_path = os.path.join(data_dir, defect_files[n])
                 ax[i, j].set_xticks([])
                 ax[i, j].set_yticks([])
                 ax[i, j].imshow(cv2.imread(image_path))
                 n += 1


     plot_defects('COVID', 3, 3)
     plot_defects('non-COVID', 3, 3)
```



Executing (12m 28s) Cell > read_image()

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(1) WhatsApp | Coronavirus_Disease_Dataset_Pre | Rahulram545/Assignments

colab.research.google.com/github/Ajay2615/Projects/blob/ccec0d4bd287af0211b1ee96af42fb8896e79234/Capstone%20project/Coronavirus_Disea...

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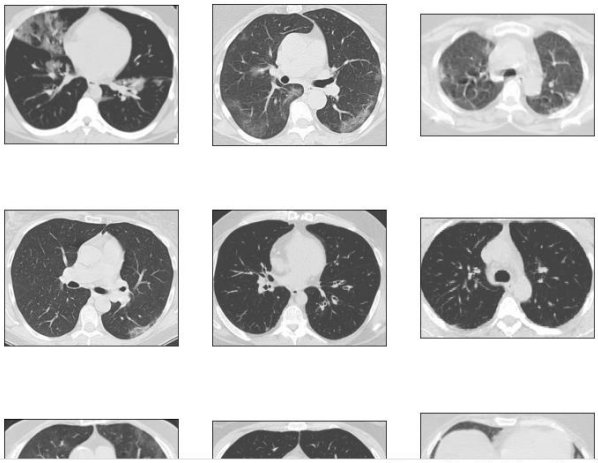
```
[5]
```



Executing (12m 36s) Cell > read_image()

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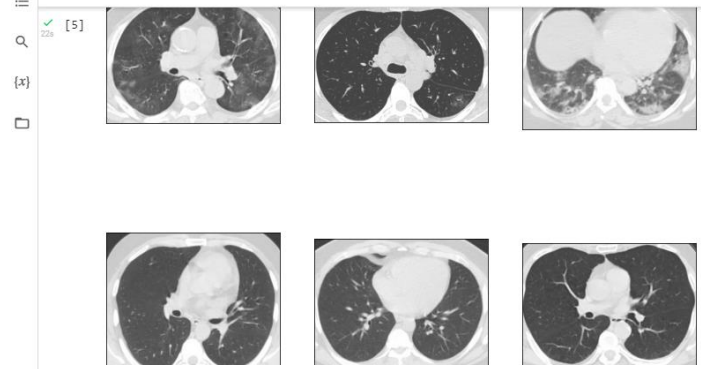


```
[6]  IMAGE_SIZE = 224

     # OpenCV Function to load colored image
     def read_image(filepath):
         return cv2.imread(os.path.join(data_dir, filepath))

     # OpenCV Function to resize an image
     def resize_image(image, image_size):
         return cv2.resize(image.copy(), image_size, interpolation = cv2.INTER_AREA)
```

Executing (12m 46s) Cell > read_image()

```
X_train = np.zeros((train.shape[0], IMAGE_SIZE, IMAGE_SIZE, 3))

for i, file in enumerate(train['File'].values):
    image = read_image(file)
    if image is not None:
        X_train[i] = resize_image(image, (IMAGE_SIZE, IMAGE_SIZE))

X_Train = X_train / 255.0   # Pixel normalization
print('Train Shape:', X_Train.shape)

Y_train = to_categorical(train['ID'].values, num_classes = 2)

print(Y_train)
```

```
Train Shape: (2481, 224, 224, 3)
[[1. 0.]
 [1. 0.]
 [1. 0.]
 ...
 [0. 1.]
 [0. 1.]
 [0. 1.]]
```

```
[9]  # Dataframe split to train and validation set (80% train and 20% validation)
     X_train, X_val, Y_train, Y_val = train_test_split(X_Train,
                                                       Y_train,
                                                       test_size = 0.2, # Percent 20% of the data is using as test set
                                                       random_state = Seed)

     print(f'X_train:', X_train.shape)
     print(f'X_val:', X_val.shape)
```

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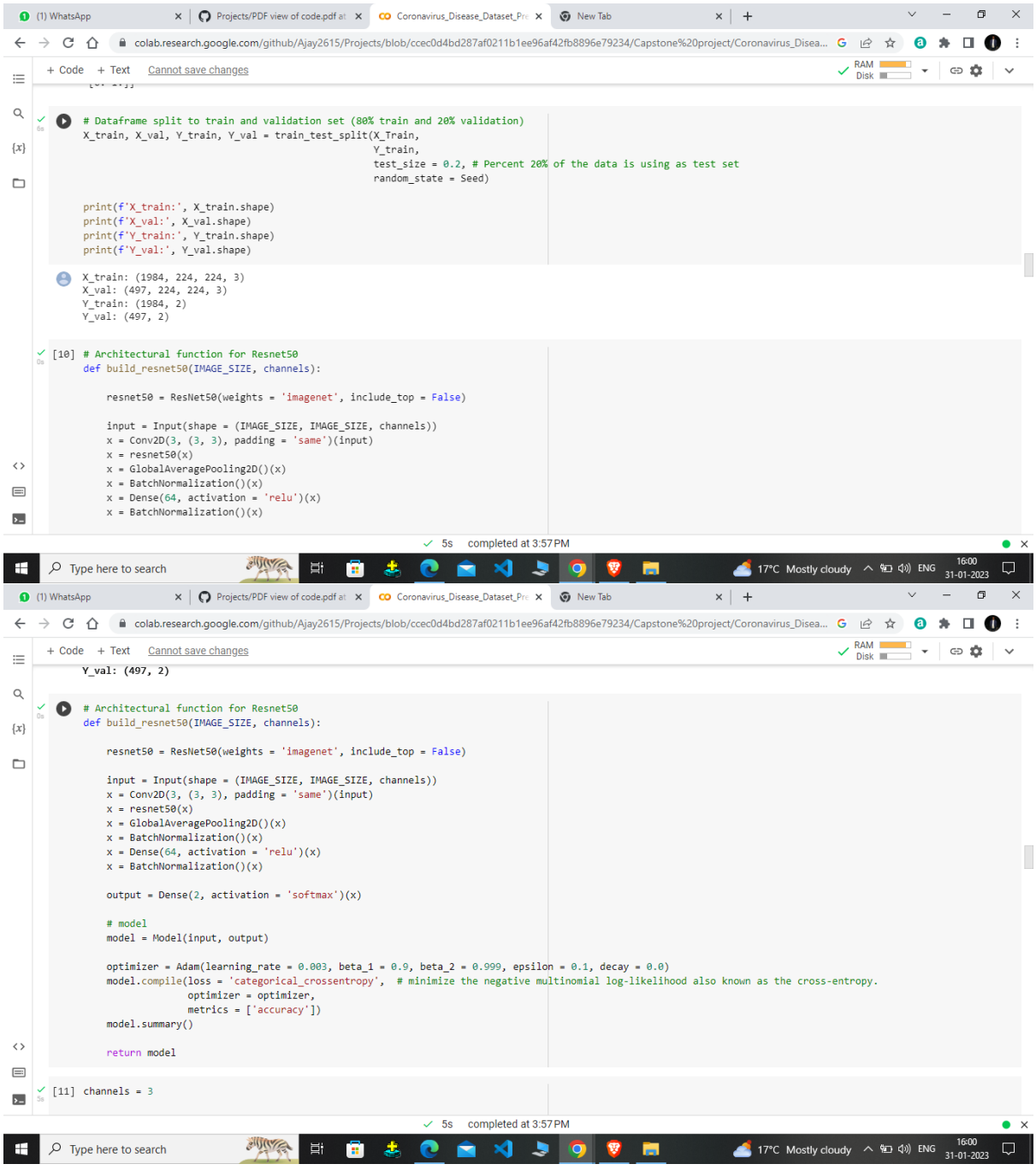


```
# Dataframe split to train and validation set (80% train and 20% validation)
X_train, X_val, Y_train, Y_val = train_test_split(X_Train,
                                                  Y_train,
                                                  test_size = 0.2, # Percent 20% of the data is using as test set
                                                  random_state = Seed)

print(f'X_train:', X_train.shape)
print(f'X_val:', X_val.shape)
print(f'Y_train:', Y_train.shape)
print(f'Y_val:', Y_val.shape)
```

```
X_train: (1984, 224, 224, 3)
X_val: (497, 224, 224, 3)
Y_train: (1984, 2)
Y_val: (497, 2)
```

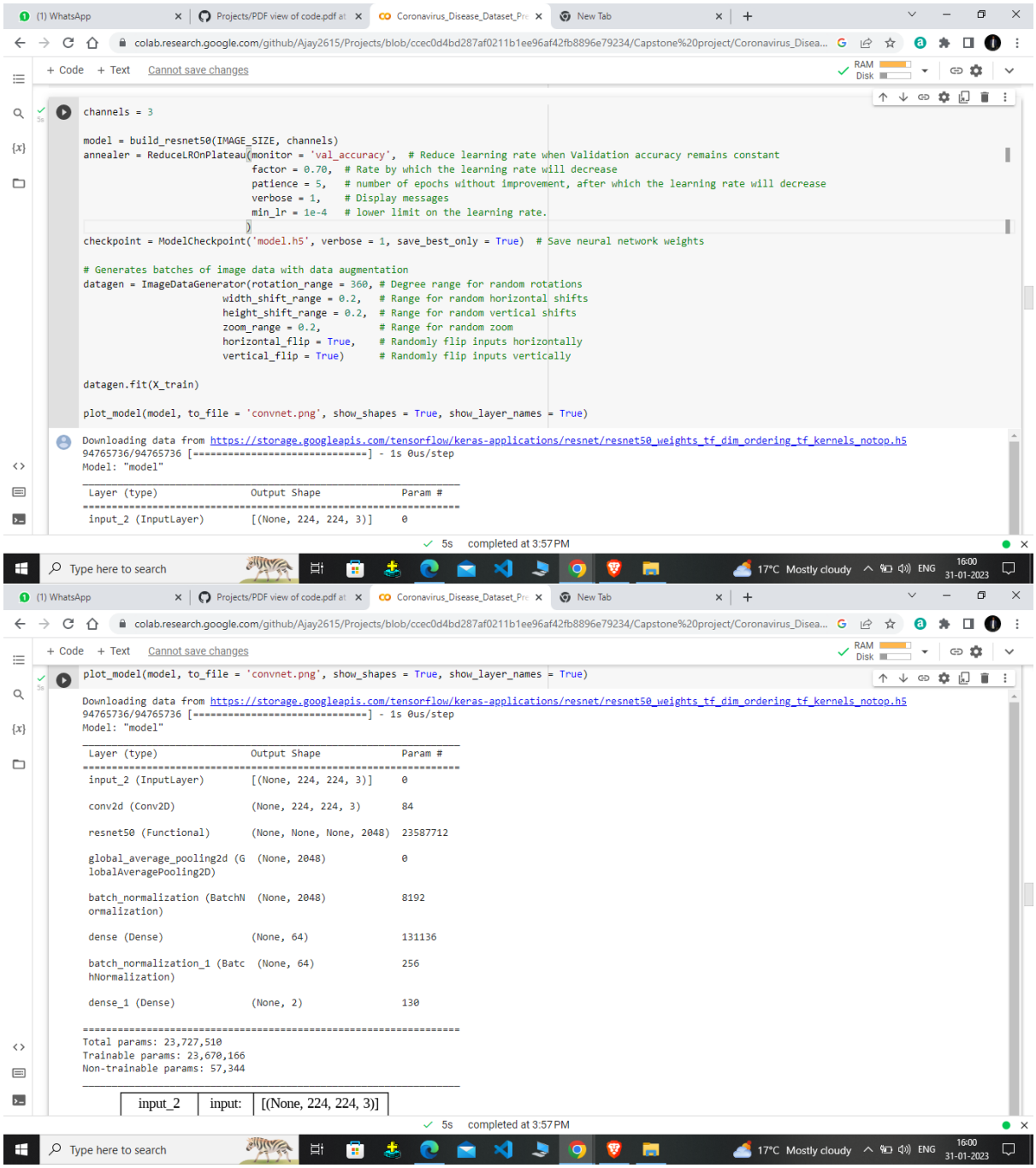
```
[10] # Architectural function for Resnet50
def build_resnet50(IMAGE_SIZE, channels):

    resnet50 = ResNet50(weights = 'imagenet', include_top = False)

    input = Input(shape = (IMAGE_SIZE, IMAGE_SIZE, channels))
    x = Conv2D(3, (3, 3), padding = 'same')(input)
    x = resnet50(x)
    x = GlobalAveragePooling2D()(x)
    x = BatchNormalization()(x)
    x = Dense(64, activation = 'relu')(x)
    x = BatchNormalization()(x)
```



```
Y_val: (497, 2)
```

```
# Architectural function for Resnet50
def build_resnet50(IMAGE_SIZE, channels):

    resnet50 = ResNet50(weights = 'imagenet', include_top = False)

    input = Input(shape = (IMAGE_SIZE, IMAGE_SIZE, channels))
    x = Conv2D(3, (3, 3), padding = 'same')(input)
    x = resnet50(x)
    x = GlobalAveragePooling2D()(x)
    x = BatchNormalization()(x)
    x = Dense(64, activation = 'relu')(x)
    x = BatchNormalization()(x)

    output = Dense(2, activation = 'softmax')(x)

    # model
    model = Model(input, output)

    optimizer = Adam(learning_rate = 0.003, beta_1 = 0.9, beta_2 = 0.999, epsilon = 0.1, decay = 0.0)
    model.compile(loss = 'categorical_crossentropy',  # minimize the negative multinomial log-likelihood also known as the cross-entropy.
                  optimizer = optimizer,
                  metrics = ['accuracy'])
    model.summary()

    return model
```

```
[11] channels = 3
```



```
channels = 3

model = build_resnet50(IMAGE_SIZE, channels)
annealer = ReduceLROnPlateau(monitor = 'val_accuracy',  # Reduce learning rate when Validation accuracy remains constant
                             factor = 0.70,  # Rate by which the learning rate will decrease
                             patience = 5,   # number of epochs without improvement, after which the learning rate will decrease
                             verbose = 1,    # Display messages
                             min_lr = 1e-4   # lower limit on the learning rate.
                            )
checkpoint = ModelCheckpoint('model.h5', verbose = 1, save_best_only = True)  # Save neural network weights

# Generates batches of image data with data augmentation
datagen = ImageDataGenerator(rotation_range = 360, # Degree range for random rotations
                         width_shift_range = 0.2,   # Range for random horizontal shifts
                         height_shift_range = 0.2,  # Range for random vertical shifts
                         zoom_range = 0.2,          # Range for random zoom
                         horizontal_flip = True,    # Randomly flip inputs horizontally
                         vertical_flip = True)      # Randomly flip inputs vertically

datagen.fit(X_train)

plot_model(model, to_file = 'convnet.png', show_shapes = True, show_layer_names = True)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94765736/94765736 [==============================] - 1s 0us/step
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 224, 224, 3)]     0
```

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```
plot_model(model, to_file = 'convnet.png', show_shapes = True, show_layer_names = True)
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_kernels_notop.h5
94765736/94765736 [==============================] - 1s 0us/step
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_2 (InputLayer)        [(None, 224, 224, 3)]     0

 conv2d (Conv2D)             (None, 224, 224, 3)       84

 resnet50 (Functional)       (None, None, None, 2048)  23587712

 global_average_pooling2d (G  (None, 2048)             0
 lobalAveragePooling2D)

 batch_normalization (BatchN  (None, 2048)             8192
 ormalization)

 dense (Dense)               (None, 64)                131136

 batch_normalization_1 (Batc  (None, 64)               256
 hNormalization)

 dense_1 (Dense)             (None, 2)                 130

=================================================================
Total params: 23,727,510
Trainable params: 23,670,166
Non-trainable params: 57,344
_________________________________________________________________
```

input_2	input:	[(None, 224, 224, 3)]

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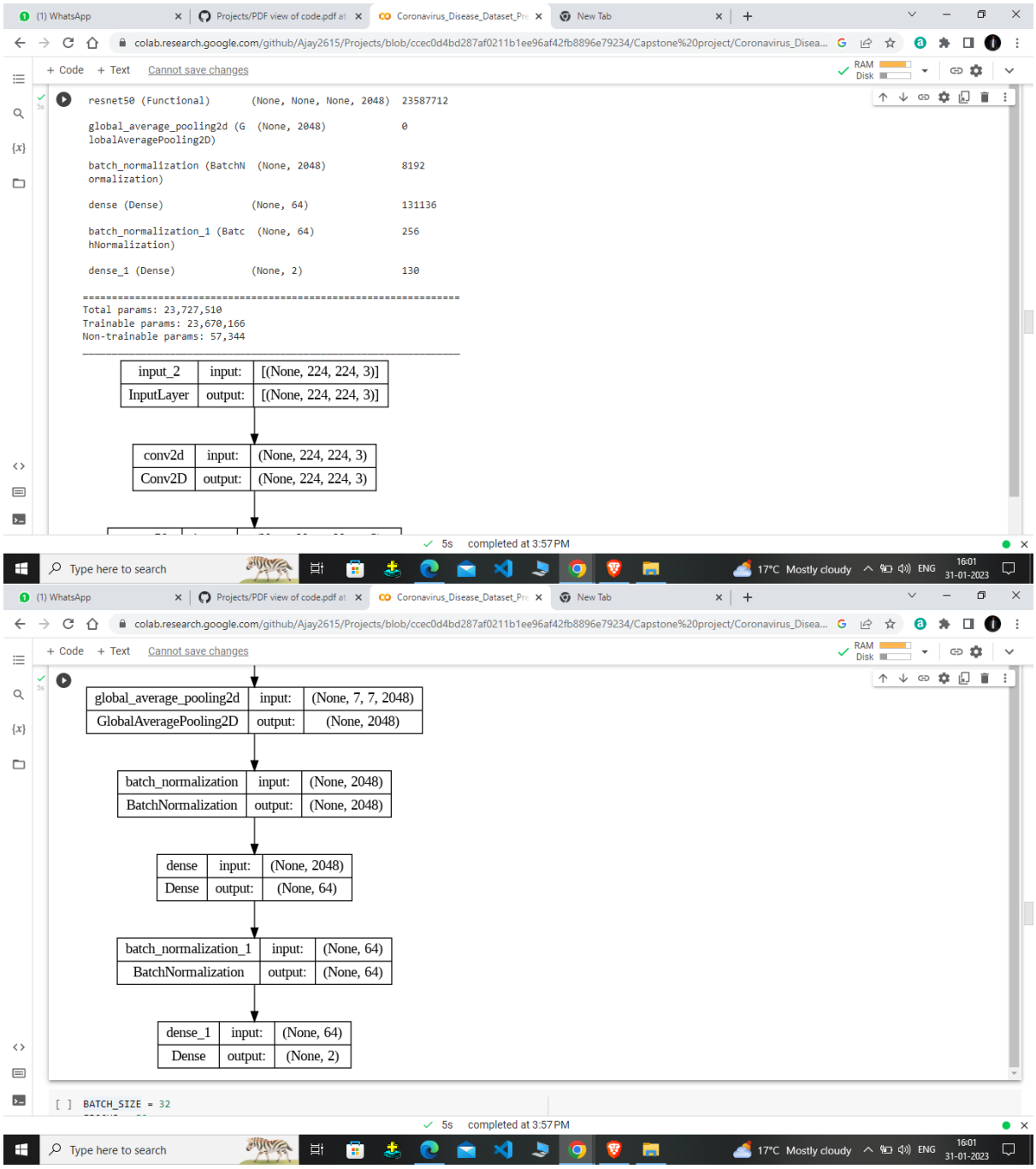
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resnet50 (Functional) (None, None, None, 2048) 23587712
global_average_pooling2d (GlobalAveragePooling2D) (None, 2048) 0
batch_normalization (BatchNormalization) (None, 2048) 8192
dense (Dense) (None, 64) 131136
batch_normalization_1 (BatchNormalization) (None, 64) 256
dense_1 (Dense) (None, 2) 130
Total params: 23,727,510
Trainable params: 23,670,166
Non-trainable params: 57,344
input_2 | input: | [(None, 224, 224, 3)]
InputLayer | output: | [(None, 224, 224, 3)]
conv2d | input: | (None, 224, 224, 3)
Conv2D | output: | (None, 224, 224, 3)
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global_average_pooling2d | input: | (None, 7, 7, 2048)
GlobalAveragePooling2D | output: | (None, 2048)
batch_normalization | input: | (None, 2048)
BatchNormalization | output: | (None, 2048)
dense | input: | (None, 2048)
Dense | output: | (None, 64)
batch_normalization_1 | input: | (None, 64)
BatchNormalization | output: | (None, 64)
dense_1 | input: | (None, 64)
Dense | output: | (None, 2)
[ ] BATCH_SIZE = 32
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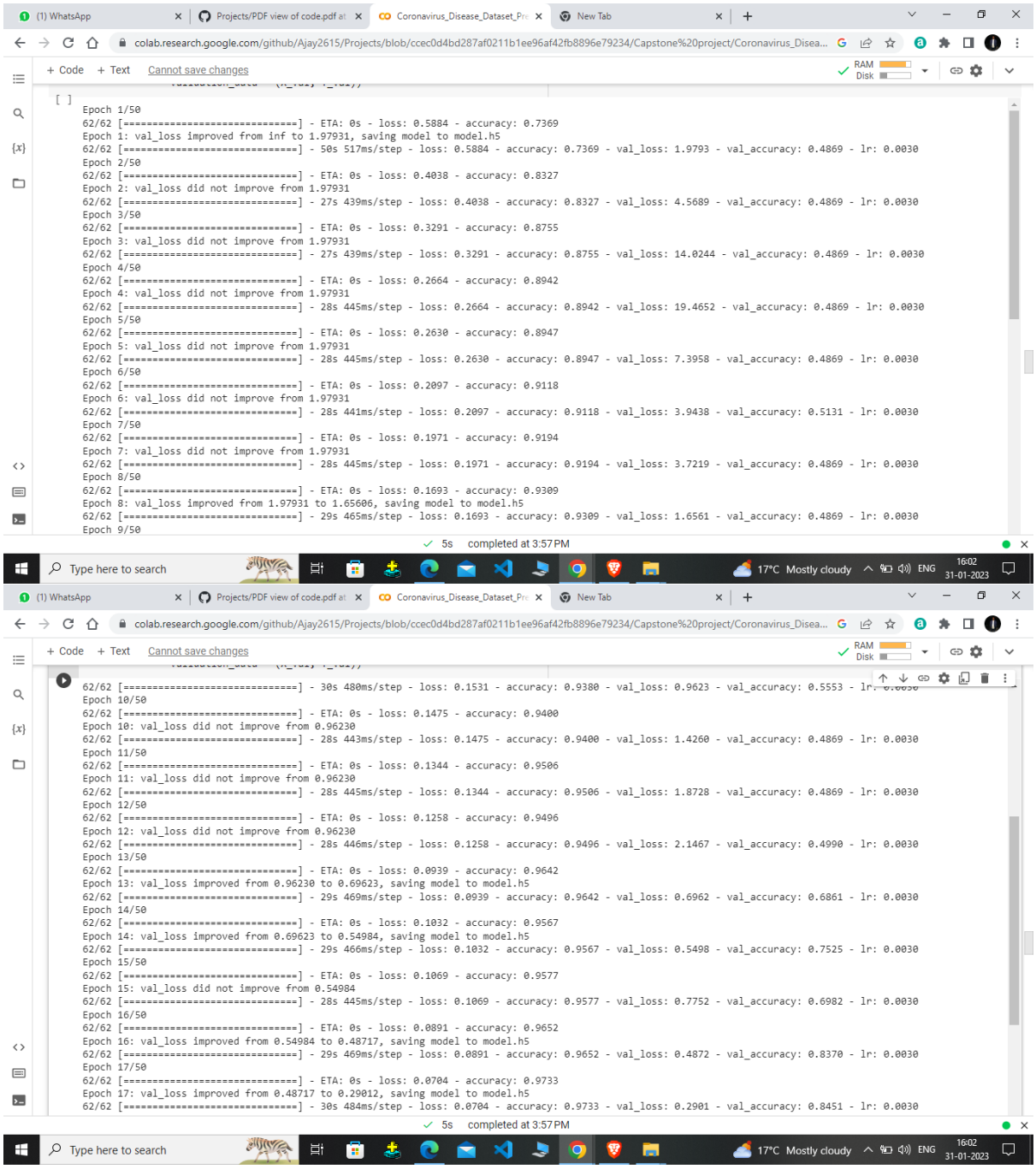
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[ ]
Epoch 1/50
62/62 [==============================] - ETA: 0s - loss: 0.5884 - accuracy: 0.7369
Epoch 1: val_loss improved from inf to 1.97931, saving model to model.h5
62/62 [==============================] - 50s 517ms/step - loss: 0.5884 - accuracy: 0.7369 - val_loss: 1.9793 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 2/50
62/62 [==============================] - ETA: 0s - loss: 0.4038 - accuracy: 0.8327
Epoch 2: val_loss did not improve from 1.97931
62/62 [==============================] - 27s 439ms/step - loss: 0.4038 - accuracy: 0.8327 - val_loss: 4.5689 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 3/50
62/62 [==============================] - ETA: 0s - loss: 0.3291 - accuracy: 0.8755
Epoch 3: val_loss did not improve from 1.97931
62/62 [==============================] - 27s 439ms/step - loss: 0.3291 - accuracy: 0.8755 - val_loss: 14.0244 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 4/50
62/62 [==============================] - ETA: 0s - loss: 0.2664 - accuracy: 0.8942
Epoch 4: val_loss did not improve from 1.97931
62/62 [==============================] - 28s 445ms/step - loss: 0.2664 - accuracy: 0.8942 - val_loss: 19.4652 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 5/50
62/62 [==============================] - ETA: 0s - loss: 0.2630 - accuracy: 0.8947
Epoch 5: val_loss did not improve from 1.97931
62/62 [==============================] - 28s 445ms/step - loss: 0.2630 - accuracy: 0.8947 - val_loss: 7.3958 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 6/50
62/62 [==============================] - ETA: 0s - loss: 0.2097 - accuracy: 0.9118
Epoch 6: val_loss did not improve from 1.97931
62/62 [==============================] - 28s 441ms/step - loss: 0.2097 - accuracy: 0.9118 - val_loss: 3.9438 - val_accuracy: 0.5131 - lr: 0.0030
Epoch 7/50
62/62 [==============================] - ETA: 0s - loss: 0.1971 - accuracy: 0.9194
Epoch 7: val_loss did not improve from 1.97931
62/62 [==============================] - 28s 445ms/step - loss: 0.1971 - accuracy: 0.9194 - val_loss: 3.7219 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 8/50
62/62 [==============================] - ETA: 0s - loss: 0.1693 - accuracy: 0.9309
Epoch 8: val_loss improved from 1.97931 to 1.65606, saving model to model.h5
62/62 [==============================] - 29s 465ms/step - loss: 0.1693 - accuracy: 0.9309 - val_loss: 1.6561 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 9/50
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62/62 [==============================] - 30s 480ms/step - loss: 0.1531 - accuracy: 0.9380 - val_loss: 0.9623 - val_accuracy: 0.5553 - lr: 0.0030
Epoch 10/50
62/62 [==============================] - ETA: 0s - loss: 0.1475 - accuracy: 0.9400
Epoch 10: val_loss did not improve from 0.96230
62/62 [==============================] - 28s 443ms/step - loss: 0.1475 - accuracy: 0.9400 - val_loss: 1.4260 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 11/50
62/62 [==============================] - ETA: 0s - loss: 0.1344 - accuracy: 0.9506
Epoch 11: val_loss did not improve from 0.96230
62/62 [==============================] - 28s 445ms/step - loss: 0.1344 - accuracy: 0.9506 - val_loss: 1.8728 - val_accuracy: 0.4869 - lr: 0.0030
Epoch 12/50
62/62 [==============================] - ETA: 0s - loss: 0.1258 - accuracy: 0.9496
Epoch 12: val_loss did not improve from 0.96230
62/62 [==============================] - 28s 446ms/step - loss: 0.1258 - accuracy: 0.9496 - val_loss: 2.1467 - val_accuracy: 0.4990 - lr: 0.0030
Epoch 13/50
62/62 [==============================] - ETA: 0s - loss: 0.0939 - accuracy: 0.9642
Epoch 13: val_loss improved from 0.96230 to 0.69623, saving model to model.h5
62/62 [==============================] - 29s 469ms/step - loss: 0.0939 - accuracy: 0.9642 - val_loss: 0.6962 - val_accuracy: 0.6861 - lr: 0.0030
Epoch 14/50
62/62 [==============================] - ETA: 0s - loss: 0.1032 - accuracy: 0.9567
Epoch 14: val_loss improved from 0.69623 to 0.54984, saving model to model.h5
62/62 [==============================] - 29s 466ms/step - loss: 0.1032 - accuracy: 0.9567 - val_loss: 0.5498 - val_accuracy: 0.7525 - lr: 0.0030
Epoch 15/50
62/62 [==============================] - ETA: 0s - loss: 0.1069 - accuracy: 0.9577
Epoch 15: val_loss did not improve from 0.54984
62/62 [==============================] - 28s 445ms/step - loss: 0.1069 - accuracy: 0.9577 - val_loss: 0.7752 - val_accuracy: 0.6982 - lr: 0.0030
Epoch 16/50
62/62 [==============================] - ETA: 0s - loss: 0.0891 - accuracy: 0.9652
Epoch 16: val_loss improved from 0.54984 to 0.48717, saving model to model.h5
62/62 [==============================] - 29s 469ms/step - loss: 0.0891 - accuracy: 0.9652 - val_loss: 0.4872 - val_accuracy: 0.8370 - lr: 0.0030
Epoch 17/50
62/62 [==============================] - ETA: 0s - loss: 0.0704 - accuracy: 0.9733
Epoch 17: val_loss improved from 0.48717 to 0.29012, saving model to model.h5
62/62 [==============================] - 30s 484ms/step - loss: 0.0704 - accuracy: 0.9733 - val_loss: 0.2901 - val_accuracy: 0.8451 - lr: 0.0030
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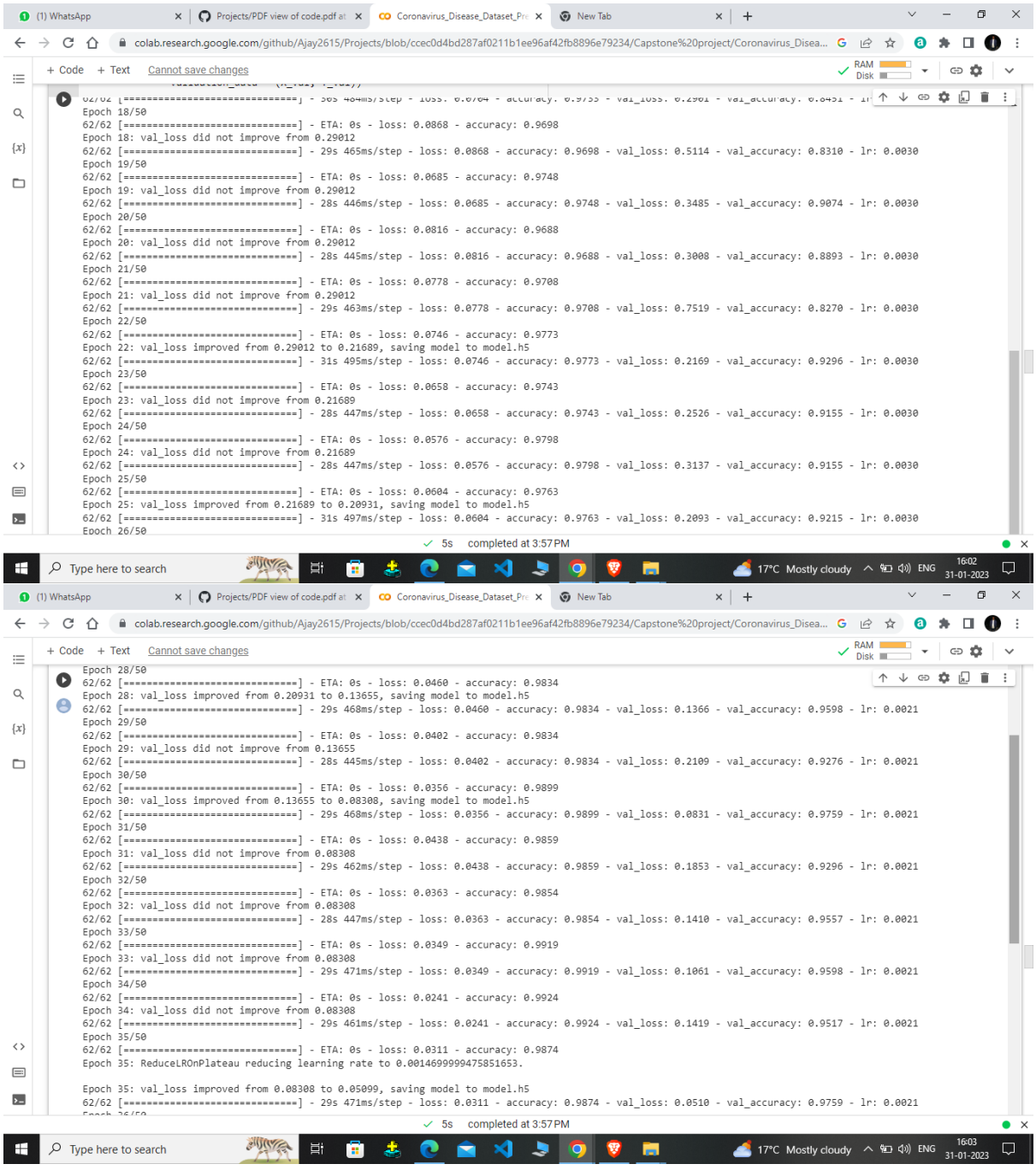
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Epoch 18/50
62/62 [==========] - ETA: 0s - loss: 0.0868 - accuracy: 0.9698
Epoch 18: val_loss did not improve from 0.29012
62/62 [==========] - 29s 465ms/step - loss: 0.0868 - accuracy: 0.9698 - val_loss: 0.5114 - val_accuracy: 0.8310 - lr: 0.0030
Epoch 19/50
62/62 [==========] - ETA: 0s - loss: 0.0685 - accuracy: 0.9748
Epoch 19: val_loss did not improve from 0.29012
62/62 [==========] - 28s 446ms/step - loss: 0.0685 - accuracy: 0.9748 - val_loss: 0.3485 - val_accuracy: 0.9074 - lr: 0.0030
Epoch 20/50
62/62 [==========] - ETA: 0s - loss: 0.0816 - accuracy: 0.9688
Epoch 20: val_loss did not improve from 0.29012
62/62 [==========] - 28s 445ms/step - loss: 0.0816 - accuracy: 0.9688 - val_loss: 0.3008 - val_accuracy: 0.8893 - lr: 0.0030
Epoch 21/50
62/62 [==========] - ETA: 0s - loss: 0.0778 - accuracy: 0.9708
Epoch 21: val_loss did not improve from 0.29012
62/62 [==========] - 29s 463ms/step - loss: 0.0778 - accuracy: 0.9708 - val_loss: 0.7519 - val_accuracy: 0.8270 - lr: 0.0030
Epoch 22/50
62/62 [==========] - ETA: 0s - loss: 0.0746 - accuracy: 0.9773
Epoch 22: val_loss improved from 0.29012 to 0.21689, saving model to model.h5
62/62 [==========] - 31s 495ms/step - loss: 0.0746 - accuracy: 0.9773 - val_loss: 0.2169 - val_accuracy: 0.9296 - lr: 0.0030
Epoch 23/50
62/62 [==========] - ETA: 0s - loss: 0.0658 - accuracy: 0.9743
Epoch 23: val_loss did not improve from 0.21689
62/62 [==========] - 28s 447ms/step - loss: 0.0658 - accuracy: 0.9743 - val_loss: 0.2526 - val_accuracy: 0.9155 - lr: 0.0030
Epoch 24/50
62/62 [==========] - ETA: 0s - loss: 0.0576 - accuracy: 0.9798
Epoch 24: val_loss did not improve from 0.21689
62/62 [==========] - 28s 447ms/step - loss: 0.0576 - accuracy: 0.9798 - val_loss: 0.3137 - val_accuracy: 0.9155 - lr: 0.0030
Epoch 25/50
62/62 [==========] - ETA: 0s - loss: 0.0604 - accuracy: 0.9763
Epoch 25: val_loss improved from 0.21689 to 0.20931, saving model to model.h5
62/62 [==========] - 31s 497ms/step - loss: 0.0604 - accuracy: 0.9763 - val_loss: 0.2093 - val_accuracy: 0.9215 - lr: 0.0030
Epoch 26/50
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Epoch 28/50
62/62 [==========] - ETA: 0s - loss: 0.0460 - accuracy: 0.9834
Epoch 28: val_loss improved from 0.20931 to 0.13655, saving model to model.h5
62/62 [==========] - 29s 468ms/step - loss: 0.0460 - accuracy: 0.9834 - val_loss: 0.1366 - val_accuracy: 0.9598 - lr: 0.0021
Epoch 29/50
62/62 [==========] - ETA: 0s - loss: 0.0402 - accuracy: 0.9834
Epoch 29: val_loss did not improve from 0.13655
62/62 [==========] - 28s 445ms/step - loss: 0.0402 - accuracy: 0.9834 - val_loss: 0.2109 - val_accuracy: 0.9276 - lr: 0.0021
Epoch 30/50
62/62 [==========] - ETA: 0s - loss: 0.0356 - accuracy: 0.9899
Epoch 30: val_loss improved from 0.13655 to 0.08308, saving model to model.h5
62/62 [==========] - 29s 468ms/step - loss: 0.0356 - accuracy: 0.9899 - val_loss: 0.0831 - val_accuracy: 0.9759 - lr: 0.0021
Epoch 31/50
62/62 [==========] - ETA: 0s - loss: 0.0438 - accuracy: 0.9859
Epoch 31: val_loss did not improve from 0.08308
62/62 [==========] - 29s 462ms/step - loss: 0.0438 - accuracy: 0.9859 - val_loss: 0.1853 - val_accuracy: 0.9296 - lr: 0.0021
Epoch 32/50
62/62 [==========] - ETA: 0s - loss: 0.0363 - accuracy: 0.9854
Epoch 32: val_loss did not improve from 0.08308
62/62 [==========] - 28s 447ms/step - loss: 0.0363 - accuracy: 0.9854 - val_loss: 0.1410 - val_accuracy: 0.9557 - lr: 0.0021
Epoch 33/50
62/62 [==========] - ETA: 0s - loss: 0.0349 - accuracy: 0.9919
Epoch 33: val_loss did not improve from 0.08308
62/62 [==========] - 29s 471ms/step - loss: 0.0349 - accuracy: 0.9919 - val_loss: 0.1061 - val_accuracy: 0.9598 - lr: 0.0021
Epoch 34/50
62/62 [==========] - ETA: 0s - loss: 0.0241 - accuracy: 0.9924
Epoch 34: val_loss did not improve from 0.08308
62/62 [==========] - 29s 461ms/step - loss: 0.0241 - accuracy: 0.9924 - val_loss: 0.1419 - val_accuracy: 0.9517 - lr: 0.0021
Epoch 35/50
62/62 [==========] - ETA: 0s - loss: 0.0311 - accuracy: 0.9874
Epoch 35: ReduceLROnPlateau reducing learning rate to 0.0014699999475851653.
Epoch 35: val_loss improved from 0.08308 to 0.05099, saving model to model.h5
62/62 [==========] - 29s 471ms/step - loss: 0.0311 - accuracy: 0.9874 - val_loss: 0.0510 - val_accuracy: 0.9759 - lr: 0.0021
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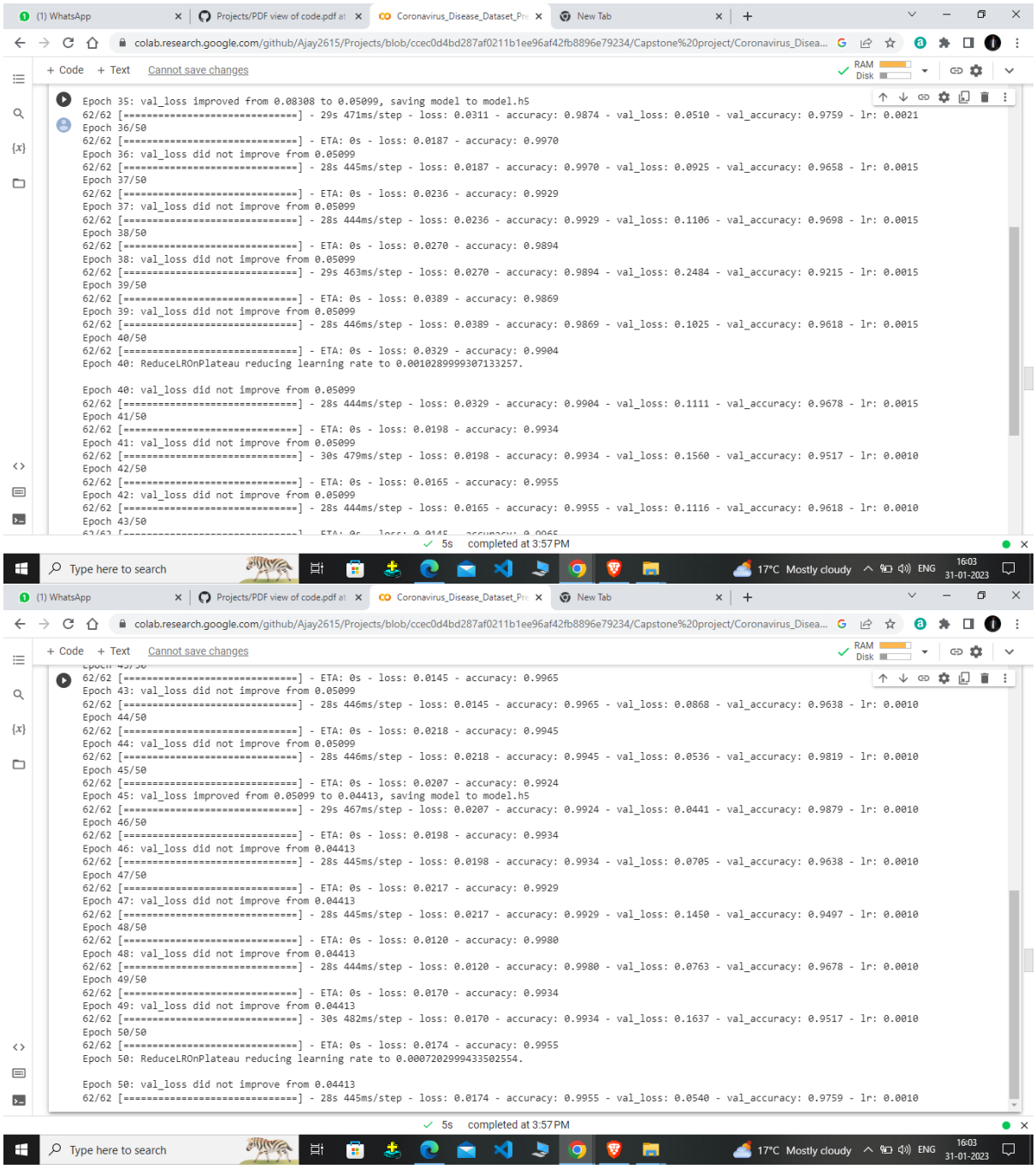
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Epoch 35: val_loss improved from 0.08308 to 0.05099, saving model to model.h5
62/62 [==============================] - 29s 471ms/step - loss: 0.0311 - accuracy: 0.9874 - val_loss: 0.0510 - val_accuracy: 0.9759 - lr: 0.0021
Epoch 36/50
62/62 [==============================] - ETA: 0s - loss: 0.0187 - accuracy: 0.9970
Epoch 36: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 445ms/step - loss: 0.0187 - accuracy: 0.9970 - val_loss: 0.0925 - val_accuracy: 0.9658 - lr: 0.0015
Epoch 37/50
62/62 [==============================] - ETA: 0s - loss: 0.0236 - accuracy: 0.9929
Epoch 37: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 444ms/step - loss: 0.0236 - accuracy: 0.9929 - val_loss: 0.1106 - val_accuracy: 0.9698 - lr: 0.0015
Epoch 38/50
62/62 [==============================] - ETA: 0s - loss: 0.0270 - accuracy: 0.9894
Epoch 38: val_loss did not improve from 0.05099
62/62 [==============================] - 29s 463ms/step - loss: 0.0270 - accuracy: 0.9894 - val_loss: 0.2484 - val_accuracy: 0.9215 - lr: 0.0015
Epoch 39/50
62/62 [==============================] - ETA: 0s - loss: 0.0389 - accuracy: 0.9869
Epoch 39: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 446ms/step - loss: 0.0389 - accuracy: 0.9869 - val_loss: 0.1025 - val_accuracy: 0.9618 - lr: 0.0015
Epoch 40/50
62/62 [==============================] - ETA: 0s - loss: 0.0329 - accuracy: 0.9904
Epoch 40: ReduceLROnPlateau reducing learning rate to 0.0010289999307133257.
Epoch 40: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 444ms/step - loss: 0.0329 - accuracy: 0.9904 - val_loss: 0.1111 - val_accuracy: 0.9678 - lr: 0.0015
Epoch 41/50
62/62 [==============================] - ETA: 0s - loss: 0.0198 - accuracy: 0.9934
Epoch 41: val_loss did not improve from 0.05099
62/62 [==============================] - 30s 479ms/step - loss: 0.0198 - accuracy: 0.9934 - val_loss: 0.1560 - val_accuracy: 0.9517 - lr: 0.0010
Epoch 42/50
62/62 [==============================] - ETA: 0s - loss: 0.0165 - accuracy: 0.9955
Epoch 42: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 444ms/step - loss: 0.0165 - accuracy: 0.9955 - val_loss: 0.1116 - val_accuracy: 0.9618 - lr: 0.0010
Epoch 43/50
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62/62 [==============================] - ETA: 0s - loss: 0.0145 - accuracy: 0.9965
Epoch 43: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 446ms/step - loss: 0.0145 - accuracy: 0.9965 - val_loss: 0.0868 - val_accuracy: 0.9638 - lr: 0.0010
Epoch 44/50
62/62 [==============================] - ETA: 0s - loss: 0.0218 - accuracy: 0.9945
Epoch 44: val_loss did not improve from 0.05099
62/62 [==============================] - 28s 446ms/step - loss: 0.0218 - accuracy: 0.9945 - val_loss: 0.0536 - val_accuracy: 0.9819 - lr: 0.0010
Epoch 45/50
62/62 [==============================] - ETA: 0s - loss: 0.0207 - accuracy: 0.9924
Epoch 45: val_loss improved from 0.05099 to 0.04413, saving model to model.h5
62/62 [==============================] - 29s 467ms/step - loss: 0.0207 - accuracy: 0.9924 - val_loss: 0.0441 - val_accuracy: 0.9879 - lr: 0.0010
Epoch 46/50
62/62 [==============================] - ETA: 0s - loss: 0.0198 - accuracy: 0.9934
Epoch 46: val_loss did not improve from 0.04413
62/62 [==============================] - 28s 445ms/step - loss: 0.0198 - accuracy: 0.9934 - val_loss: 0.0705 - val_accuracy: 0.9638 - lr: 0.0010
Epoch 47/50
62/62 [==============================] - ETA: 0s - loss: 0.0217 - accuracy: 0.9929
Epoch 47: val_loss did not improve from 0.04413
62/62 [==============================] - 28s 445ms/step - loss: 0.0217 - accuracy: 0.9929 - val_loss: 0.1450 - val_accuracy: 0.9497 - lr: 0.0010
Epoch 48/50
62/62 [==============================] - ETA: 0s - loss: 0.0120 - accuracy: 0.9980
Epoch 48: val_loss did not improve from 0.04413
62/62 [==============================] - 28s 444ms/step - loss: 0.0120 - accuracy: 0.9980 - val_loss: 0.0763 - val_accuracy: 0.9678 - lr: 0.0010
Epoch 49/50
62/62 [==============================] - ETA: 0s - loss: 0.0170 - accuracy: 0.9934
Epoch 49: val_loss did not improve from 0.04413
62/62 [==============================] - 30s 482ms/step - loss: 0.0170 - accuracy: 0.9934 - val_loss: 0.1637 - val_accuracy: 0.9517 - lr: 0.0010
Epoch 50/50
62/62 [==============================] - ETA: 0s - loss: 0.0174 - accuracy: 0.9955
Epoch 50: ReduceLROnPlateau reducing learning rate to 0.0007202999433502554.
Epoch 50: val_loss did not improve from 0.04413
62/62 [==============================] - 28s 445ms/step - loss: 0.0174 - accuracy: 0.9955 - val_loss: 0.0540 - val_accuracy: 0.9759 - lr: 0.0010
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```
Y_pred = model.predict(X_val)

Y_pred = np.argmax(Y_pred, axis = 1)
Y_true = np.argmax(Y_val, axis = 1)

cm = confusion_matrix(Y_true, Y_pred)
plt.figure(figsize = (12, 12))
ax = sns.heatmap(cm, cmap = plt.cm.Greens, annot = True, square = True, xticklabels = disease_types, yticklabels = disease_types)
ax.set_ylabel('Actual', fontsize = 40)
ax.set_xlabel('Predicted', fontsize = 40)


TP = cm[1][1]
print(f"True Positive: {TP}")


FN = cm[1][0]
print(f"False Negative: {FN}")

TN = cm[0][0]
print(f"True Negative: {TN}")

FP = cm[0][1]
print(f"False Positive: {FP}")

# Sensitivity, recall, or true positive rate
print(f"True Positive Rate: {TP / (TP + FN)}")

# Specificity or true negative rate
print(f"True Negative Rate: {TN / (TN + FP)}\n")
```

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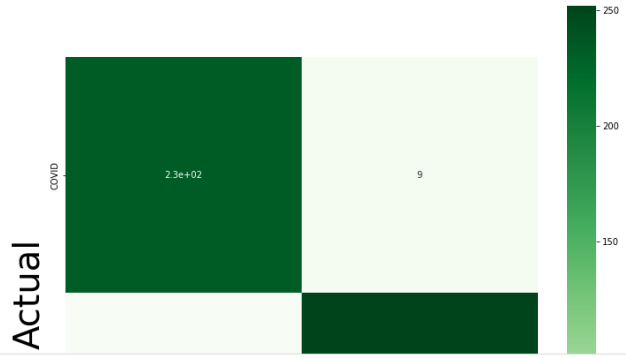
```
True Positive: 252
False Negative: 3
True Negative: 233
False Positive: 9
True Positive Rate: 0.9882352941176471
True Negative Rate: 0.9628099173553719

16/16 [==============================] - 2s 98ms/step - loss: 0.0540 - accuracy: 0.9759

Final Loss: 0.05403857305645943, Final Accuracy: 0.9758551120758057
```



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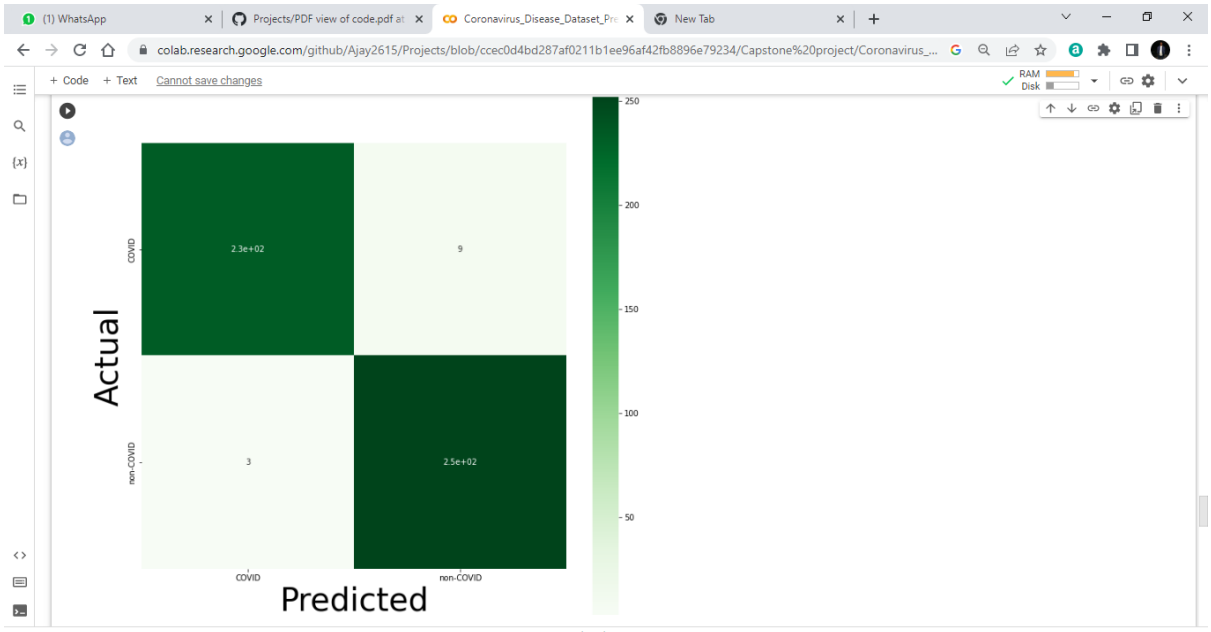
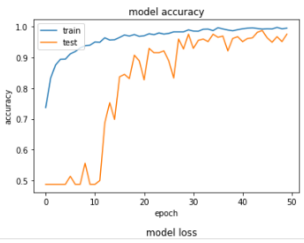
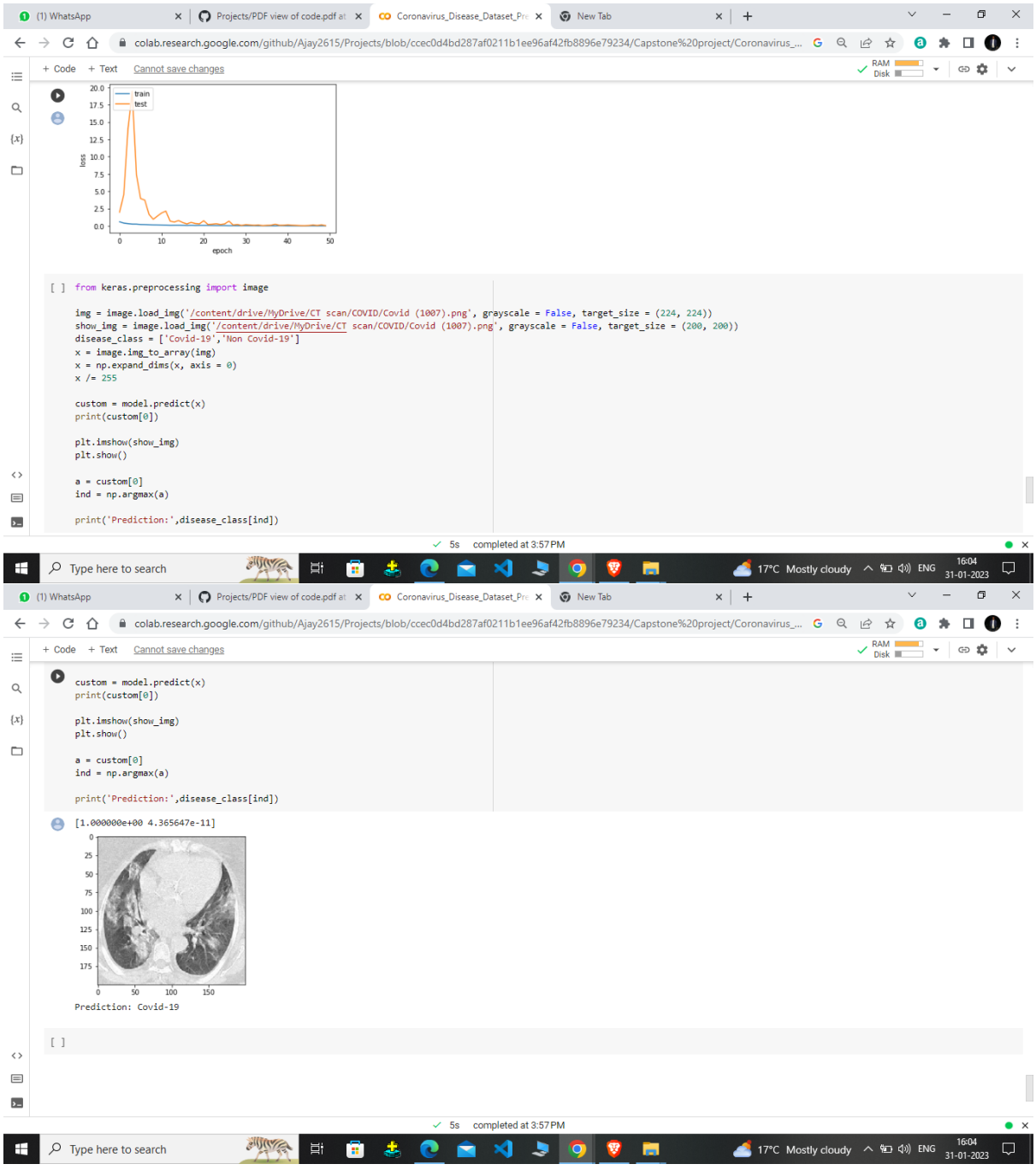



```
# Accuracy plot
plt.plot(hist.history['accuracy'])
plt.plot(hist.history['val_accuracy'])
plt.title('model accuracy')
plt.ylabel('accuracy')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc = 'upper left')
plt.show()

# Loss plot
plt.plot(hist.history['loss'])
plt.plot(hist.history['val_loss'])
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epoch')
plt.legend(['train', 'test'], loc = 'upper left')
plt.show()
```



model loss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train
test
loss
epoch
from keras.preprocessing import image
img = image.load_img('/content/drive/MyDrive/CT scan/COVID/Covid (1007).png', grayscale = False, target_size = (224, 224))
show_img = image.load_img('/content/drive/MyDrive/CT scan/COVID/Covid (1007).png', grayscale = False, target_size = (200, 200))
disease_class = ['Covid-19','Non Covid-19']
x = image.img_to_array(img)
x = np.expand_dims(x, axis = 0)
x /= 255
custom = model.predict(x)
print(custom[0])
plt.imshow(show_img)
plt.show()
a = custom[0]
ind = np.argmax(a)
print('Prediction:',disease_class[ind])
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custom = model.predict(x)
print(custom[0])
plt.imshow(show_img)
plt.show()
a = custom[0]
ind = np.argmax(a)
print('Prediction:',disease_class[ind])
[1.000000e+00 4.365647e-11]
Prediction: Covid-19
[ ]
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