

# Pneumonia Diagnosis Using Deep Learning: A CNN and Transfer Learning Approach

## Models Used:

- CNN
- EfficientNetB0
- EfficientNetB3

## Importing Necessary Libraries

```
In [1]: import numpy as np #numerical operations
import pandas as pd #data manipulation and analysis
import matplotlib
import matplotlib.pyplot as plt #reating static, animated, and interactive
import cv2, os, random #image processing tasks, interaction with the oper
import plotly
import plotly.graph_objs as go
import plotly.express as px
from plotly.offline import init_notebook_mode, plot, iplot

import glob # Used for finding file paths based on patterns, e.g., *.jpg
import tensorflow
from tensorflow.keras.preprocessing.image import array_to_img, img_to_arr
from tensorflow.keras.layers import Conv2D, Flatten, MaxPooling2D, Dense,
from tensorflow.keras.models import Sequential
from mlxtend.plotting import plot_confusion_matrix
from tensorflow.keras.preprocessing import image
from tensorflow.keras.preprocessing.image import ImageDataGenerator # Au
from sklearn.metrics import classification_report, confusion_matrix, accu
from tensorflow.keras.callbacks import ReduceLROnPlateau #reduce the lear
from tensorflow.keras.applications.vgg16 import VGG16
from sklearn.model_selection import train_test_split
```

## Load the datasets

**Note:** If you use Google Colab, First Mount the Drive then Load from the Drive file Given

```
In [2]: train_df = glob.glob("chest_xray/train/**/*.*.jpeg")
test_df = glob.glob("chest_xray/test/**/*.*.jpeg")
validation_df = glob.glob("chest_xray/val/**/*.*.jpeg")
```

## Look at train and test sets

```
In [3]: train_df[:5], test_df[:5]
```

```
Out[3]: ([ '../input/chest-xray-pneumonia/chest_xray/train/PNEUMONIA/person1180_virus_2010.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/train/PNEUMONIA/person1230_virus_2081.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/train/PNEUMONIA/person1513_virus_2632.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/train/PNEUMONIA/person124_virus_238.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/train/PNEUMONIA/person746_virus_1369.jpeg'],  
         [ '../input/chest-xray-pneumonia/chest_xray/test/PNEUMONIA/person1676_virus_2892.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/test/PNEUMONIA/person1650_virus_2852.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/test/PNEUMONIA/person22_virus_55.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/test/PNEUMONIA/person122_bacteria_582.jpeg',  
          '../input/chest-xray-pneumonia/chest_xray/test/PNEUMONIA/person85_bacteria_417.jpeg'])
```

## Data Exploration

*How many images are in each dataset?*

```
In [4]: print("There is {} images in the training dataset".format(len(train_df)))  
        print("There is {} images in the test dataset".format(len(test_df)))  
        print("There is {} images in the validation dataset".format(len(validation_df)))
```

There is 5216 images in the training dataset

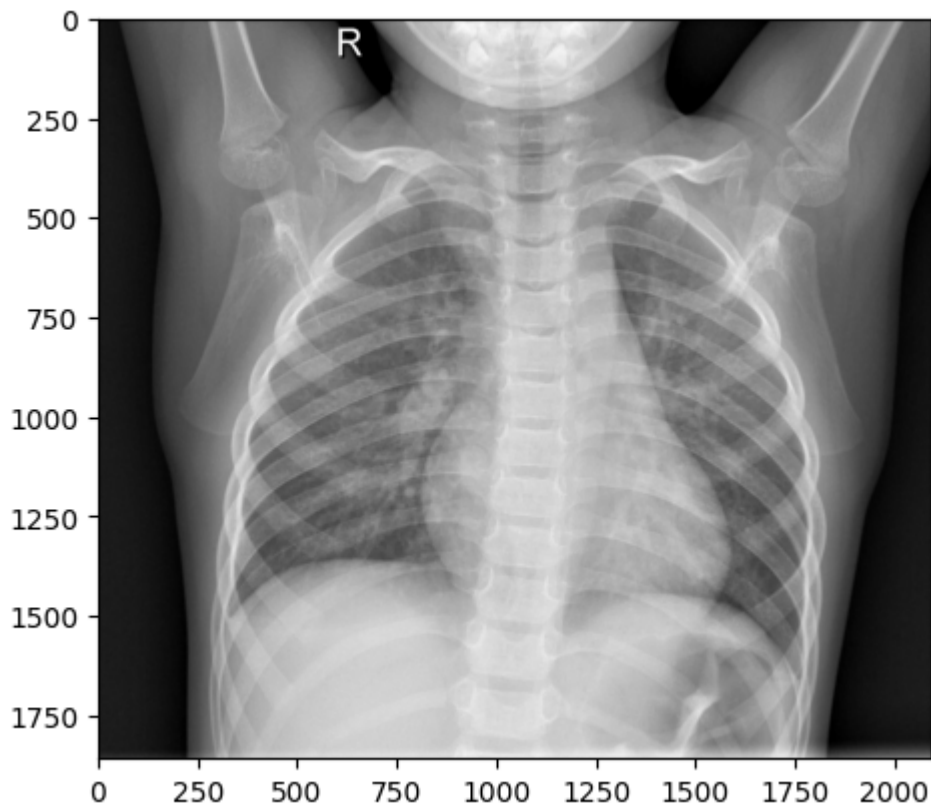
There is 624 images in the test dataset

There is 16 images in the validation dataset

*View the images in X-ray format*

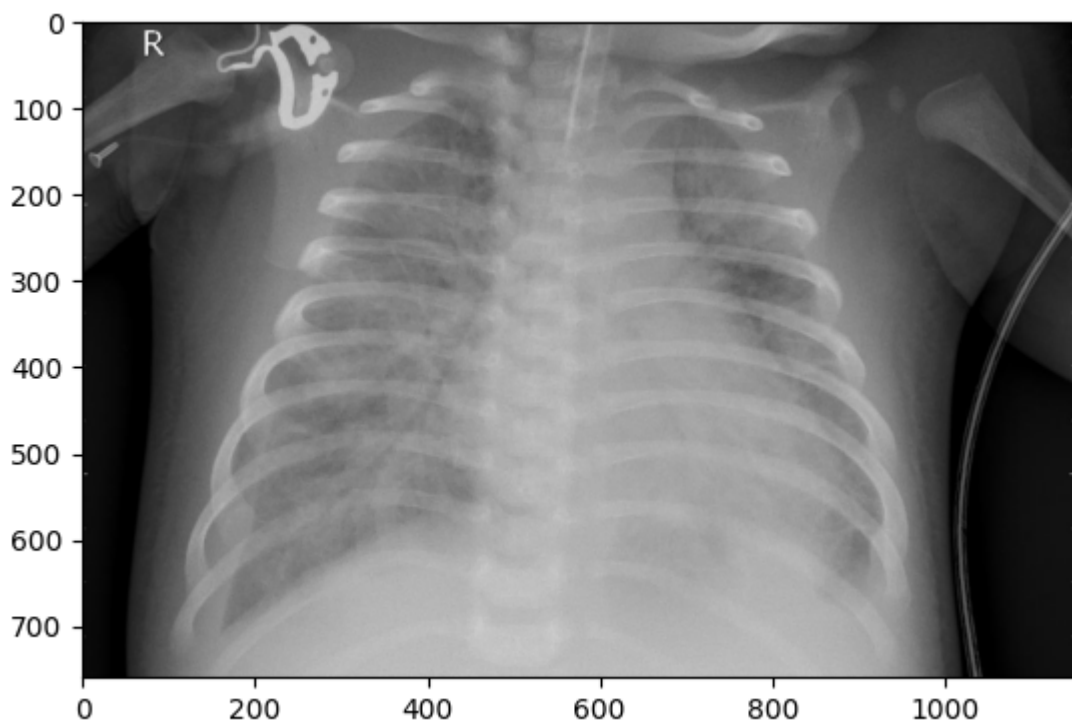
```
In [5]: normal_lung_image = load_img("chest_xray/train/NORMAL/IM-0115-0001.jpeg")  
        print("NORMAL")  
        plt.imshow(normal_lung_image)  
        plt.show()
```

NORMAL



```
In [6]: normal_lung_image = load_img("chest_xray/train/PNEUMONIA/person1000_bacte  
print("PNEUMONIA")  
plt.imshow(normal_lung_image)  
plt.show()
```

PNEUMONIA



## Building Deep Learning Models

```
In [7]: train_dir = "chest_xray/train"
test_dir = "chest_xray/test"
validation_dir = "chest_xray/val"
```

```
In [8]: train_datagen = ImageDataGenerator(
    rescale=1./255., # Normalize pixel values
    horizontal_flip=True, # Randomly flip images horizontally
    vertical_flip=True, # Randomly flip images vertically
    rotation_range=30, # Rotate images by up to 30 degrees
    width_shift_range=0.2, # Randomly shift images horizontally
    height_shift_range=0.2, # Randomly shift images vertically
    shear_range=0.3, # Shear transformation
    zoom_range=0.3, # Zoom in/out
    channel_shift_range=20.0, # Randomly shift the color channels
    fill_mode='nearest', # Fill any newly created pixels after transform
    brightness_range=[0.5, 1.5] # Adjust brightness
)
```

```
val_test_datagen = ImageDataGenerator(rescale = 1./255)
```

```
train_set = train_datagen.flow_from_directory(train_dir, class_mode = "binary_crossentropy")
validation_set = val_test_datagen.flow_from_directory(validation_dir, class_mode = "binary_crossentropy")
test_set = val_test_datagen.flow_from_directory(test_dir, class_mode = "binary_crossentropy")
```

Found 5216 images belonging to 2 classes.

Found 16 images belonging to 2 classes.

Found 624 images belonging to 2 classes.

## Building CNN model

```
In [9]: from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Conv2D, MaxPooling2D, Dropout, Flatten

# Create the Sequential model
model1 = Sequential()

# Convolutional Neural Networks (CNNs)
model1.add(Conv2D(64, (3, 3), strides=(1, 1), activation="relu", padding="same"))
model1.add(MaxPooling2D(pool_size=(2, 2)))
model1.add(Conv2D(128, (3, 3), strides=(1, 1), padding="same", activation="relu"))
model1.add(MaxPooling2D(pool_size=(2, 2)))
model1.add(Dropout(0.3)) # Increased dropout to prevent overfitting
model1.add(Conv2D(256, (3, 3), strides=(1, 1), padding="same", activation="relu"))
model1.add(MaxPooling2D(pool_size=(2, 2)))
model1.add(Conv2D(512, (3, 3), strides=(1, 1), padding="same", activation="relu"))
model1.add(MaxPooling2D(pool_size=(2, 2)))
model1.add(Dropout(0.3)) # Increased dropout

# Flatten the output of the convolutional layers
model1.add(Flatten())

# Fully connected layers
model1.add(Dense(256, activation="relu")) # Increased neurons
model1.add(Dropout(0.4)) # Increased dropout
model1.add(Dense(128, activation="relu")) # Increased neurons
model1.add(Dense(64, activation="relu")) # Increased neurons
```

```
# Output layer (binary classification)
model1.add(Dense(1, activation="sigmoid"))

# Summary of the model architecture
model1.summary()
```

/opt/conda/lib/python3.10/site-packages/keras/src/layers/convolutional/base\_conv.py:107: UserWarning:

Do not pass an `input\_shape`/`input\_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object as the first layer in the model instead.

**Model: "sequential"**

Layer (type)	Output Shape	
conv2d (Conv2D)	(None, 224, 224, 64)	
max_pooling2d (MaxPooling2D)	(None, 112, 112, 64)	
conv2d_1 (Conv2D)	(None, 112, 112, 128)	
max_pooling2d_1 (MaxPooling2D)	(None, 56, 56, 128)	
dropout (Dropout)	(None, 56, 56, 128)	
conv2d_2 (Conv2D)	(None, 56, 56, 256)	
max_pooling2d_2 (MaxPooling2D)	(None, 28, 28, 256)	
conv2d_3 (Conv2D)	(None, 28, 28, 512)	
max_pooling2d_3 (MaxPooling2D)	(None, 14, 14, 512)	
dropout_1 (Dropout)	(None, 14, 14, 512)	
flatten (Flatten)	(None, 100352)	
dense (Dense)	(None, 256)	
dropout_2 (Dropout)	(None, 256)	
dense_1 (Dense)	(None, 128)	
dense_2 (Dense)	(None, 64)	
dense_3 (Dense)	(None, 1)	

**Total params:** 27,282,561 (104.07 MB)

**Trainable params:** 27,282,561 (104.07 MB)

**Non-trainable params:** 0 (0.00 B)

## Compiling the model

```
In [10]: model.compile(optimizer = "rmsprop", loss = "binary_crossentropy", metrics=[#Root Mean Square Propagation])
```

## Training the model

```
In [11]: early_stopping_callbacks = tensorflow.keras.callbacks.EarlyStopping(patience=10, restore_best_weights=True)
```

```
In [12]: history = model.fit(train_set, epochs=20,
                             validation_data=validation_set,
                             steps_per_epoch=100,
                             callbacks=[early_stopping_callbacks])
```

Epoch 1/20


/opt/conda/lib/python3.10/site-packages/keras/src/trainers/data\_adapters/python\_dataset\_adapter.py:121: UserWarning:

Your `PyDataset` class should call `super().\_\_init\_\_(\*\*kwargs)` in its constructor. `\*\*kwargs` can include `workers`, `use\_multiprocessing`, `max\_queue\_size`. Do not pass these arguments to `fit()`, as they will be ignored.


WARNING: All log messages before absl::InitializeLog() is called are written to STDERR

I0000 00:00:1733391503.770061 88 service.cc:145] XLA service 0x7ac20400f250 initialized for platform CUDA (this does not guarantee that XLA will be used). Devices:


I0000 00:00:1733391503.770121 88 service.cc:153] StreamExecutor device (0): Tesla P100-PCIE-16GB, Compute Capability 6.0

**1/100**  **21:46** 13s/step - accuracy: 0.6250 - loss: 0.6893


I0000 00:00:1733391512.210558 88 device\_compiler.h:188] Compiled cluster using XLA! This line is logged at most once for the lifetime of the process.

**100/100**  **53s** 400ms/step - accuracy: 0.6933 - loss: 0.7470 - val\_accuracy: 0.5000 - val\_loss: 0.7840


Epoch 2/20

**100/100**  **36s** 368ms/step - accuracy: 0.7248 - loss: 0.5097 - val\_accuracy: 0.5000 - val\_loss: 2.6668

Epoch 3/20

**100/100**  **35s** 349ms/step - accuracy: 0.7308 - loss: 0.5203 - val\_accuracy: 0.5000 - val\_loss: 1.5146

Epoch 4/20

**25/100**  **19s** 264ms/step - accuracy: 0.7764 - loss: 0.4070

/opt/conda/lib/python3.10/contextlib.py:153: UserWarning:

Your input ran out of data; interrupting training. Make sure that your dataset or generator can generate at least `steps\_per\_epoch \* epochs` batches. You may need to use the `.repeat()` function when building your dataset.

**100/100** ————— **7s** 68ms/step - accuracy: 0.7854 - loss: 0.429  
 5 - val\_accuracy: 0.6250 - val\_loss: 0.7435  
 Epoch 5/20  
**100/100** ————— **36s** 330ms/step - accuracy: 0.7985 - loss: 0.4  
 496 - val\_accuracy: 0.5625 - val\_loss: 0.9289  
 Epoch 6/20  
**100/100** ————— **32s** 326ms/step - accuracy: 0.8612 - loss: 0.3  
 266 - val\_accuracy: 0.6250 - val\_loss: 0.7143  
 Epoch 7/20  
**100/100** ————— **32s** 318ms/step - accuracy: 0.8536 - loss: 0.3  
 332 - val\_accuracy: 0.6250 - val\_loss: 0.7480  
 Epoch 8/20  
**100/100** ————— **6s** 63ms/step - accuracy: 0.8651 - loss: 0.303  
 4 - val\_accuracy: 0.6250 - val\_loss: 0.6332  
 Epoch 9/20  
**100/100** ————— **34s** 319ms/step - accuracy: 0.8401 - loss: 0.3  
 447 - val\_accuracy: 0.6250 - val\_loss: 1.0844  
 Epoch 10/20  
**100/100** ————— **31s** 316ms/step - accuracy: 0.8247 - loss: 0.3  
 778 - val\_accuracy: 0.7500 - val\_loss: 0.5157  
 Epoch 11/20  
**100/100** ————— **31s** 311ms/step - accuracy: 0.8296 - loss: 0.3  
 618 - val\_accuracy: 0.6250 - val\_loss: 2.2816  
 Epoch 12/20  
**100/100** ————— **6s** 60ms/step - accuracy: 0.8560 - loss: 0.358  
 0 - val\_accuracy: 0.6875 - val\_loss: 0.5704  
 Epoch 13/20  
**100/100** ————— **34s** 313ms/step - accuracy: 0.8432 - loss: 0.3  
 252 - val\_accuracy: 0.8125 - val\_loss: 0.4858  
 Epoch 14/20  
**100/100** ————— **31s** 310ms/step - accuracy: 0.8516 - loss: 0.3  
 668 - val\_accuracy: 0.5000 - val\_loss: 1.9260  
 Epoch 15/20  
**100/100** ————— **31s** 310ms/step - accuracy: 0.8227 - loss: 0.3  
 685 - val\_accuracy: 0.6875 - val\_loss: 0.5426  
 Epoch 16/20  
**100/100** ————— **6s** 60ms/step - accuracy: 0.8128 - loss: 0.354  
 7 - val\_accuracy: 0.5625 - val\_loss: 1.3290  
 Epoch 17/20  
**100/100** ————— **33s** 312ms/step - accuracy: 0.8569 - loss: 0.3  
 408 - val\_accuracy: 0.6250 - val\_loss: 0.9780  
 Epoch 18/20  
**100/100** ————— **31s** 310ms/step - accuracy: 0.8640 - loss: 0.3  
 071 - val\_accuracy: 0.6875 - val\_loss: 0.5771  
 Epoch 19/20  
**100/100** ————— **30s** 305ms/step - accuracy: 0.8531 - loss: 0.2  
 990 - val\_accuracy: 0.6250 - val\_loss: 1.0886  
 Epoch 20/20  
**100/100** ————— **6s** 59ms/step - accuracy: 0.8593 - loss: 0.393  
 0 - val\_accuracy: 0.5625 - val\_loss: 1.1142

```

In [13]: #scores = model1.evaluate_generator(test_set)
          #print("\n%s: %.3f%%" % (model1.metrics_names[0], scores[0]*100))
          #print("\n%s: %.3f%%" % (model1.metrics_names[1], scores[1]*100))

          test_loss, test_accuracy = model1.evaluate(test_set, steps = 50)
          print("The testing accuracy is: ", test_accuracy * 100, "%")
  
```

**50/50** ————— **8s** 153ms/step - accuracy: 0.7337 - loss: 0.5069  
 The testing accuracy is: 74.03846383094788 %

# TRANSFER LEARNING MODELS

## 1. EfficientNetB0

```
In [14]: from tensorflow.keras.applications import EfficientNetB0

base_model1 = EfficientNetB0(include_top=False, weights="imagenet", input_shape=(224, 224, 3))

# EfficientNetB0 already has pre-trained weights on ImageNet, so there's no need to train from scratch

base_model1.summary()
```

Downloading data from [https://storage.googleapis.com/keras-applications/efficientnetb0\\_notop.h5](https://storage.googleapis.com/keras-applications/efficientnetb0_notop.h5)

16705208/16705208 ————— 0s 0us/step

Model: "efficientnetb0"



Layer (type)	Output Shape	Param #	Connected to
input_layer_1 (InputLayer)	(None, 224, 224, 3)	0	-
rescaling (Rescaling)	(None, 224, 224, 3)	0	input_layer_1
normalization (Normalization)	(None, 224, 224, 3)	7	rescaling[0]
rescaling_1 (Rescaling)	(None, 224, 224, 3)	0	normalization
stem_conv_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	rescaling_1
stem_conv (Conv2D)	(None, 112, 112, 32)	864	stem_conv_pad
stem_bn (BatchNormalization)	(None, 112, 112, 32)	128	stem_conv[0]
stem_activation (Activation)	(None, 112, 112, 32)	0	stem_bn[0]
block1a_dwconv (DepthwiseConv2D)	(None, 112, 112, 32)	288	stem_activation
block1a_bn (BatchNormalization)	(None, 112, 112, 32)	128	block1a_dwconv
block1a_activation (Activation)	(None, 112, 112, 32)	0	block1a_bn[0]
block1a_se_squeeze (GlobalAveragePooling2D)	(None, 32)	0	block1a_activation
block1a_se_reshape (Reshape)	(None, 1, 1, 32)	0	block1a_se_squeeze
block1a_se_reduce (Conv2D)	(None, 1, 1, 8)	264	block1a_se_reshape
block1a_se_expand (Conv2D)	(None, 1, 1, 32)	288	block1a_se_reduce
block1a_se_excite (Multiply)	(None, 112, 112, 32)	0	block1a_activation block1a_se_expand
block1a_project_conv (Conv2D)	(None, 112, 112, 16)	512	block1a_se_excite
block1a_project_bn (BatchNormalization)	(None, 112, 112, 16)	64	block1a_project_conv
block2a_expand_conv (Conv2D)	(None, 112, 112, 96)	1,536	block1a_project_bn
block2a_expand_bn (BatchNormalization)	(None, 112, 112, 96)	384	block2a_expand_conv
block2a_expand_act...	(None, 112, 112, 96)	0	block2a_expand_bn

(Activation)	96)		
block2a_dwconv_pad (ZeroPadding2D)	(None, 113, 113, 96)	0	block2a_exp
block2a_dwconv (DepthwiseConv2D)	(None, 56, 56, 96)	864	block2a_dw
block2a_bn (BatchNormalizatio...	(None, 56, 56, 96)	384	block2a_dw
block2a_activation (Activation)	(None, 56, 56, 96)	0	block2a_bn
block2a_se_squeeze (GlobalAveragePool...	(None, 96)	0	block2a_act
block2a_se_reshape (Reshape)	(None, 1, 1, 96)	0	block2a_se_
block2a_se_reduce (Conv2D)	(None, 1, 1, 4)	388	block2a_se_
block2a_se_expand (Conv2D)	(None, 1, 1, 96)	480	block2a_se_
block2a_se_excite (Multiply)	(None, 56, 56, 96)	0	block2a_act block2a_se_
block2a_project_co... (Conv2D)	(None, 56, 56, 24)	2,304	block2a_se_
block2a_project_bn (BatchNormalizatio...	(None, 56, 56, 24)	96	block2a_pro
block2b_expand_conv (Conv2D)	(None, 56, 56, 144)	3,456	block2a_pro
block2b_expand_bn (BatchNormalizatio...	(None, 56, 56, 144)	576	block2b_exp
block2b_expand_act... (Activation)	(None, 56, 56, 144)	0	block2b_exp
block2b_dwconv (DepthwiseConv2D)	(None, 56, 56, 144)	1,296	block2b_exp
block2b_bn (BatchNormalizatio...	(None, 56, 56, 144)	576	block2b_dw
block2b_activation (Activation)	(None, 56, 56, 144)	0	block2b_bn
block2b_se_squeeze (GlobalAveragePool...	(None, 144)	0	block2b_act
block2b_se_reshape (Reshape)	(None, 1, 1, 144)	0	block2b_se_
block2b_se_reduce (Conv2D)	(None, 1, 1, 6)	870	block2b_se_
block2b_se_expand (Conv2D)	(None, 1, 1, 144)	1,008	block2b_se_

block2b_se_excite (Multiply)	(None, 56, 56, 144)	0	block2b_act block2b_se
block2b_project_co... (Conv2D)	(None, 56, 56, 24)	3,456	block2b_se
block2b_project_bn (BatchNormalizatio...	(None, 56, 56, 24)	96	block2b_pro
block2b_drop (Dropout)	(None, 56, 56, 24)	0	block2b_pro
block2b_add (Add)	(None, 56, 56, 24)	0	block2b_dro block2a_pro
block3a_expand_conv (Conv2D)	(None, 56, 56, 144)	3,456	block2b_add
block3a_expand_bn (BatchNormalizatio...	(None, 56, 56, 144)	576	block3a_exp
block3a_expand_act... (Activation)	(None, 56, 56, 144)	0	block3a_exp
block3a_dwconv_pad (ZeroPadding2D)	(None, 59, 59, 144)	0	block3a_exp
block3a_dwconv (DepthwiseConv2D)	(None, 28, 28, 144)	3,600	block3a_dw
block3a_bn (BatchNormalizatio...	(None, 28, 28, 144)	576	block3a_dw
block3a_activation (Activation)	(None, 28, 28, 144)	0	block3a_bn
block3a_se_squeeze (GlobalAveragePool...	(None, 144)	0	block3a_act
block3a_se_reshape (Reshape)	(None, 1, 1, 144)	0	block3a_se
block3a_se_reduce (Conv2D)	(None, 1, 1, 6)	870	block3a_se
block3a_se_expand (Conv2D)	(None, 1, 1, 144)	1,008	block3a_se
block3a_se_excite (Multiply)	(None, 28, 28, 144)	0	block3a_act block3a_se
block3a_project_co... (Conv2D)	(None, 28, 28, 40)	5,760	block3a_se
block3a_project_bn (BatchNormalizatio...	(None, 28, 28, 40)	160	block3a_pro
block3b_expand_conv (Conv2D)	(None, 28, 28, 240)	9,600	block3a_pro
block3b_expand_bn (BatchNormalizatio...	(None, 28, 28, 240)	960	block3b_exp

block3b_expand_act... (Activation)	(None, 28, 28, 240)	0	block3b_exp
block3b_dwconv (DepthwiseConv2D)	(None, 28, 28, 240)	6,000	block3b_exp
block3b_bn (BatchNormalizatio...	(None, 28, 28, 240)	960	block3b_dwconv
block3b_activation (Activation)	(None, 28, 28, 240)	0	block3b_bn
block3b_se_squeeze (GlobalAveragePool...	(None, 240)	0	block3b_act
block3b_se_reshape (Reshape)	(None, 1, 1, 240)	0	block3b_se_
block3b_se_reduce (Conv2D)	(None, 1, 1, 10)	2,410	block3b_se_
block3b_se_expand (Conv2D)	(None, 1, 1, 240)	2,640	block3b_se_
block3b_se_excite (Multiply)	(None, 28, 28, 240)	0	block3b_act block3b_se_
block3b_project_co... (Conv2D)	(None, 28, 28, 40)	9,600	block3b_se_
block3b_project_bn (BatchNormalizatio...	(None, 28, 28, 40)	160	block3b_pro
block3b_drop (Dropout)	(None, 28, 28, 40)	0	block3b_pro
block3b_add (Add)	(None, 28, 28, 40)	0	block3b_dro block3a_pro
block4a_expand_conv (Conv2D)	(None, 28, 28, 240)	9,600	block3b_ad
block4a_expand_bn (BatchNormalizatio...	(None, 28, 28, 240)	960	block4a_exp
block4a_expand_act... (Activation)	(None, 28, 28, 240)	0	block4a_exp
block4a_dwconv_pad (ZeroPadding2D)	(None, 29, 29, 240)	0	block4a_exp
block4a_dwconv (DepthwiseConv2D)	(None, 14, 14, 240)	2,160	block4a_dwconv
block4a_bn (BatchNormalizatio...	(None, 14, 14, 240)	960	block4a_dwconv
block4a_activation (Activation)	(None, 14, 14, 240)	0	block4a_bn
block4a_se_squeeze (GlobalAveragePool...	(None, 240)	0	block4a_act
block4a_se_reshape	(None, 1, 1, 240)	0	block4a_se_

(Reshape)			
block4a_se_reduce (Conv2D)	(None, 1, 1, 10)	2,410	block4a_se
block4a_se_expand (Conv2D)	(None, 1, 1, 240)	2,640	block4a_se
block4a_se_excite (Multiply)	(None, 14, 14, 240)	0	block4a_act block4a_se
block4a_project_conv (Conv2D)	(None, 14, 14, 80)	19,200	block4a_se
block4a_project_bn (BatchNormalizatio...	(None, 14, 14, 80)	320	block4a_pro
block4b_expand_conv (Conv2D)	(None, 14, 14, 480)	38,400	block4a_pro
block4b_expand_bn (BatchNormalizatio...	(None, 14, 14, 480)	1,920	block4b_exp
block4b_expand_act... (Activation)	(None, 14, 14, 480)	0	block4b_exp
block4b_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	4,320	block4b_exp
block4b_bn (BatchNormalizatio...	(None, 14, 14, 480)	1,920	block4b_dw
block4b_activation (Activation)	(None, 14, 14, 480)	0	block4b_bn
block4b_se_squeeze (GlobalAveragePool...	(None, 480)	0	block4b_act
block4b_se_reshape (Reshape)	(None, 1, 1, 480)	0	block4b_se
block4b_se_reduce (Conv2D)	(None, 1, 1, 20)	9,620	block4b_se
block4b_se_expand (Conv2D)	(None, 1, 1, 480)	10,080	block4b_se
block4b_se_excite (Multiply)	(None, 14, 14, 480)	0	block4b_act block4b_se
block4b_project_conv (Conv2D)	(None, 14, 14, 80)	38,400	block4b_se
block4b_project_bn (BatchNormalizatio...	(None, 14, 14, 80)	320	block4b_pro
block4b_drop (Dropout)	(None, 14, 14, 80)	0	block4b_pro
block4b_add (Add)	(None, 14, 14, 80)	0	block4b_dro block4a_pro
block4c_expand_conv (Conv2D)	(None, 14, 14, 480)	38,400	block4b_ad

block4c_expand_bn (BatchNormalizatio...	(None, 14, 14, 480)	1,920	block4c_exp
block4c_expand_act...	(None, 14, 14, 480)	0	block4c_exp
block4c_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	4,320	block4c_exp
block4c_bn (BatchNormalizatio...	(None, 14, 14, 480)	1,920	block4c_dw
block4c_activation (Activation)	(None, 14, 14, 480)	0	block4c_bn
block4c_se_squeeze (GlobalAveragePool...	(None, 480)	0	block4c_act
block4c_se_reshape (Reshape)	(None, 1, 1, 480)	0	block4c_se_
block4c_se_reduce (Conv2D)	(None, 1, 1, 20)	9,620	block4c_se_
block4c_se_expand (Conv2D)	(None, 1, 1, 480)	10,080	block4c_se_
block4c_se_excite (Multiply)	(None, 14, 14, 480)	0	block4c_act block4c_se_
block4c_project_co...	(None, 14, 14, 80)	38,400	block4c_se_
block4c_project_bn (BatchNormalizatio...	(None, 14, 14, 80)	320	block4c_pro
block4c_drop (Dropout)	(None, 14, 14, 80)	0	block4c_pro
block4c_add (Add)	(None, 14, 14, 80)	0	block4c_dro block4b_ad
block5a_expand_conv (Conv2D)	(None, 14, 14, 480)	38,400	block4c_ad
block5a_expand_bn (BatchNormalizatio...	(None, 14, 14, 480)	1,920	block5a_exp
block5a_expand_act...	(None, 14, 14, 480)	0	block5a_exp
block5a_dwconv (DepthwiseConv2D)	(None, 14, 14, 480)	12,000	block5a_exp
block5a_bn (BatchNormalizatio...	(None, 14, 14, 480)	1,920	block5a_dw
block5a_activation (Activation)	(None, 14, 14, 480)	0	block5a_bn
block5a_se_squeeze (GlobalAveragePool...	(None, 480)	0	block5a_act

block5a_se_reshape (Reshape)	(None, 1, 1, 480)	0	block5a_se
block5a_se_reduce (Conv2D)	(None, 1, 1, 20)	9,620	block5a_se
block5a_se_expand (Conv2D)	(None, 1, 1, 480)	10,080	block5a_se
block5a_se_excite (Multiply)	(None, 14, 14, 480)	0	block5a_act block5a_se
block5a_project_co... (Conv2D)	(None, 14, 14, 112)	53,760	block5a_se
block5a_project_bn (BatchNormalizatio...	(None, 14, 14, 112)	448	block5a_pro
block5b_expand_conv (Conv2D)	(None, 14, 14, 672)	75,264	block5a_pro
block5b_expand_bn (BatchNormalizatio...	(None, 14, 14, 672)	2,688	block5b_exp
block5b_expand_act... (Activation)	(None, 14, 14, 672)	0	block5b_exp
block5b_dwconv (DepthwiseConv2D)	(None, 14, 14, 672)	16,800	block5b_exp
block5b_bn (BatchNormalizatio...	(None, 14, 14, 672)	2,688	block5b_dw
block5b_activation (Activation)	(None, 14, 14, 672)	0	block5b_bn
block5b_se_squeeze (GlobalAveragePool...	(None, 672)	0	block5b_act
block5b_se_reshape (Reshape)	(None, 1, 1, 672)	0	block5b_se
block5b_se_reduce (Conv2D)	(None, 1, 1, 28)	18,844	block5b_se
block5b_se_expand (Conv2D)	(None, 1, 1, 672)	19,488	block5b_se
block5b_se_excite (Multiply)	(None, 14, 14, 672)	0	block5b_act block5b_se
block5b_project_co... (Conv2D)	(None, 14, 14, 112)	75,264	block5b_se
block5b_project_bn (BatchNormalizatio...	(None, 14, 14, 112)	448	block5b_pro
block5b_drop (Dropout)	(None, 14, 14, 112)	0	block5b_pro
block5b_add (Add)	(None, 14, 14, 112)	0	block5b_dro block5a_pro
block5c_expand_conv	(None, 14, 14,	75,264	block5b_ad

(Conv2D)	(672)		
block5c_expand_bn (BatchNormalizatio...	(None, 14, 14, 672)	2,688	block5c_exp
block5c_expand_act... (Activation)	(None, 14, 14, 672)	0	block5c_exp
block5c_dwconv (DepthwiseConv2D)	(None, 14, 14, 672)	16,800	block5c_exp
block5c_bn (BatchNormalizatio...	(None, 14, 14, 672)	2,688	block5c_dw
block5c_activation (Activation)	(None, 14, 14, 672)	0	block5c_bn
block5c_se_squeeze (GlobalAveragePool...	(None, 672)	0	block5c_act
block5c_se_reshape (Reshape)	(None, 1, 1, 672)	0	block5c_se_
block5c_se_reduce (Conv2D)	(None, 1, 1, 28)	18,844	block5c_se_
block5c_se_expand (Conv2D)	(None, 1, 1, 672)	19,488	block5c_se_
block5c_se_excite (Multiply)	(None, 14, 14, 672)	0	block5c_act block5c_se_
block5c_project_co... (Conv2D)	(None, 14, 14, 112)	75,264	block5c_se_
block5c_project_bn (BatchNormalizatio...	(None, 14, 14, 112)	448	block5c_pro
block5c_drop (Dropout)	(None, 14, 14, 112)	0	block5c_pro
block5c_add (Add)	(None, 14, 14, 112)	0	block5c_dro block5b_ad
block6a_expand_conv (Conv2D)	(None, 14, 14, 672)	75,264	block5c_ad
block6a_expand_bn (BatchNormalizatio...	(None, 14, 14, 672)	2,688	block6a_exp
block6a_expand_act... (Activation)	(None, 14, 14, 672)	0	block6a_exp
block6a_dwconv_pad (ZeroPadding2D)	(None, 17, 17, 672)	0	block6a_exp
block6a_dwconv (DepthwiseConv2D)	(None, 7, 7, 672)	16,800	block6a_dw
block6a_bn (BatchNormalizatio...	(None, 7, 7, 672)	2,688	block6a_dw
block6a_activation (Activation)	(None, 7, 7, 672)	0	block6a_bn



block6a_se_squeeze (GlobalAveragePool...)	(None, 672)	0	block6a_act
block6a_se_reshape (Reshape)	(None, 1, 1, 672)	0	block6a_se
block6a_se_reduce (Conv2D)	(None, 1, 1, 28)	18,844	block6a_se
block6a_se_expand (Conv2D)	(None, 1, 1, 672)	19,488	block6a_se
block6a_se_excite (Multiply)	(None, 7, 7, 672)	0	block6a_act block6a_se
block6a_project_co... (Conv2D)	(None, 7, 7, 192)	129,024	block6a_se
block6a_project_bn (BatchNormalizatio...)	(None, 7, 7, 192)	768	block6a_pro
block6b_expand_conv (Conv2D)	(None, 7, 7, 1152)	221,184	block6a_pro
block6b_expand_bn (BatchNormalizatio...)	(None, 7, 7, 1152)	4,608	block6b_exp
block6b_expand_act... (Activation)	(None, 7, 7, 1152)	0	block6b_exp
block6b_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28,800	block6b_exp
block6b_bn (BatchNormalizatio...)	(None, 7, 7, 1152)	4,608	block6b_dw
block6b_activation (Activation)	(None, 7, 7, 1152)	0	block6b_bn
block6b_se_squeeze (GlobalAveragePool...)	(None, 1152)	0	block6b_act
block6b_se_reshape (Reshape)	(None, 1, 1, 1152)	0	block6b_se
block6b_se_reduce (Conv2D)	(None, 1, 1, 48)	55,344	block6b_se
block6b_se_expand (Conv2D)	(None, 1, 1, 1152)	56,448	block6b_se
block6b_se_excite (Multiply)	(None, 7, 7, 1152)	0	block6b_act block6b_se
block6b_project_co... (Conv2D)	(None, 7, 7, 192)	221,184	block6b_se
block6b_project_bn (BatchNormalizatio...)	(None, 7, 7, 192)	768	block6b_pro
block6b_drop (Dropout)	(None, 7, 7, 192)	0	block6b_pro

block6b_add (Add)	(None, 7, 7, 192)	0	block6b_drop block6a_project
block6c_expand_conv (Conv2D)	(None, 7, 7, 1152)	221,184	block6b_add
block6c_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4,608	block6c_expand_conv
block6c_expand_act... (Activation)	(None, 7, 7, 1152)	0	block6c_expand_bn
block6c_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28,800	block6c_expand_act...
block6c_bn (BatchNormalization)	(None, 7, 7, 1152)	4,608	block6c_dwconv
block6c_activation (Activation)	(None, 7, 7, 1152)	0	block6c_bn
block6c_se_squeeze (GlobalAveragePool2D)	(None, 1152)	0	block6c_activation
block6c_se_reshape (Reshape)	(None, 1, 1, 1152)	0	block6c_se_squeeze
block6c_se_reduce (Conv2D)	(None, 1, 1, 48)	55,344	block6c_se_reshape
block6c_se_expand (Conv2D)	(None, 1, 1, 1152)	56,448	block6c_se_reduce
block6c_se_excite (Multiply)	(None, 7, 7, 1152)	0	block6c_se_expand
block6c_project_co... (Conv2D)	(None, 7, 7, 192)	221,184	block6c_se_excite
block6c_project_bn (BatchNormalization)	(None, 7, 7, 192)	768	block6c_project_conv
block6c_drop (Dropout)	(None, 7, 7, 192)	0	block6c_project_bn
block6c_add (Add)	(None, 7, 7, 192)	0	block6c_drop
block6d_expand_conv (Conv2D)	(None, 7, 7, 1152)	221,184	block6c_add
block6d_expand_bn (BatchNormalization)	(None, 7, 7, 1152)	4,608	block6d_expand_conv
block6d_expand_act... (Activation)	(None, 7, 7, 1152)	0	block6d_expand_bn
block6d_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	28,800	block6d_expand_act...
block6d_bn (BatchNormalization)	(None, 7, 7, 1152)	4,608	block6d_dwconv
block6d_activation	(None, 7, 7, 1152)	0	block6d_bn

(Activation)	1152)		
block6d_se_squeeze (GlobalAveragePool...	(None, 1152)	0	block6d_act
block6d_se_reshape (Reshape)	(None, 1, 1, 1152)	0	block6d_se
block6d_se_reduce (Conv2D)	(None, 1, 1, 48)	55,344	block6d_se
block6d_se_expand (Conv2D)	(None, 1, 1, 1152)	56,448	block6d_se
block6d_se_excite (Multiply)	(None, 7, 7, 1152)	0	block6d_act block6d_se
block6d_project_co... (Conv2D)	(None, 7, 7, 192)	221,184	block6d_se
block6d_project_bn (BatchNormalizatio...	(None, 7, 7, 192)	768	block6d_pro
block6d_drop (Dropout)	(None, 7, 7, 192)	0	block6d_pro
block6d_add (Add)	(None, 7, 7, 192)	0	block6d_dro block6c_add
block7a_expand_conv (Conv2D)	(None, 7, 7, 1152)	221,184	block6d_add
block7a_expand_bn (BatchNormalizatio...	(None, 7, 7, 1152)	4,608	block7a_exp
block7a_expand_act... (Activation)	(None, 7, 7, 1152)	0	block7a_exp
block7a_dwconv (DepthwiseConv2D)	(None, 7, 7, 1152)	10,368	block7a_exp
block7a_bn (BatchNormalizatio...	(None, 7, 7, 1152)	4,608	block7a_dw
block7a_activation (Activation)	(None, 7, 7, 1152)	0	block7a_bn
block7a_se_squeeze (GlobalAveragePool...	(None, 1152)	0	block7a_act
block7a_se_reshape (Reshape)	(None, 1, 1, 1152)	0	block7a_se
block7a_se_reduce (Conv2D)	(None, 1, 1, 48)	55,344	block7a_se
block7a_se_expand (Conv2D)	(None, 1, 1, 1152)	56,448	block7a_se
block7a_se_excite (Multiply)	(None, 7, 7, 1152)	0	block7a_act block7a_se
block7a_project_co... (Conv2D)	(None, 7, 7, 320)	368,640	block7a_se



Epoch 1/20  
**100/100** ————— **65s** 361ms/step - accuracy: 0.6768 - loss: 0.7759 - val\_accuracy: 0.5000 - val\_loss: 1.3164  
Epoch 2/20  
**100/100** ————— **31s** 309ms/step - accuracy: 0.6986 - loss: 0.468 - val\_accuracy: 0.5000 - val\_loss: 0.7504  
Epoch 3/20  
**100/100** ————— **31s** 307ms/step - accuracy: 0.7506 - loss: 0.5837 - val\_accuracy: 0.5000 - val\_loss: 0.8354  
Epoch 4/20  
**100/100** ————— **6s** 59ms/step - accuracy: 0.7304 - loss: 0.5988 - val\_accuracy: 0.5000 - val\_loss: 0.7876  
Epoch 5/20  
**100/100** ————— **33s** 307ms/step - accuracy: 0.7391 - loss: 0.5822 - val\_accuracy: 0.5000 - val\_loss: 0.7869  
Epoch 6/20  
**100/100** ————— **31s** 310ms/step - accuracy: 0.7521 - loss: 0.5818 - val\_accuracy: 0.5000 - val\_loss: 0.7688  
Epoch 7/20  
**100/100** ————— **31s** 308ms/step - accuracy: 0.7478 - loss: 0.5804 - val\_accuracy: 0.5000 - val\_loss: 0.8760  
Epoch 8/20  
**100/100** ————— **6s** 60ms/step - accuracy: 0.7036 - loss: 0.6329 - val\_accuracy: 0.5000 - val\_loss: 0.8167  
Epoch 9/20  
**100/100** ————— **33s** 306ms/step - accuracy: 0.7288 - loss: 0.5870 - val\_accuracy: 0.5000 - val\_loss: 0.8307  
Epoch 10/20  
**100/100** ————— **31s** 310ms/step - accuracy: 0.7345 - loss: 0.5836 - val\_accuracy: 0.5000 - val\_loss: 0.8359  
Epoch 11/20  
**100/100** ————— **31s** 307ms/step - accuracy: 0.7407 - loss: 0.5761 - val\_accuracy: 0.5000 - val\_loss: 0.8055  
Epoch 12/20  
**100/100** ————— **6s** 59ms/step - accuracy: 0.7240 - loss: 0.5960 - val\_accuracy: 0.5000 - val\_loss: 0.8638  
Epoch 13/20  
**100/100** ————— **33s** 311ms/step - accuracy: 0.7399 - loss: 0.5793 - val\_accuracy: 0.5000 - val\_loss: 0.7501  
Epoch 14/20  
**100/100** ————— **31s** 311ms/step - accuracy: 0.7323 - loss: 0.5870 - val\_accuracy: 0.5000 - val\_loss: 0.9482  
Epoch 15/20  
**100/100** ————— **31s** 315ms/step - accuracy: 0.7605 - loss: 0.5573 - val\_accuracy: 0.5000 - val\_loss: 0.8250

## Evaluating EfficientNetB0 Model on the test set

```
In [17]: #scores = model1.evaluate_generator(test_set)
# print("\n%s: %.3f%%" % (model1.metrics_names[0], scores[0]*100))
# print("\n%s: %.3f%%" % (model1.metrics_names[1], scores[1]*100))

test_loss, test_accuracy = model2.evaluate(test_set, steps = 50)
print("The testing accuracy is: ", test_accuracy * 100, "%")
```

**50/50** ————— **5s** 100ms/step - accuracy: 0.6417 - loss: 0.9667  
The testing accuracy is: 62.5 %

## 2. EfficientNetB3

```
In [18]: from tensorflow.keras.applications import EfficientNetB3

base_model2 = EfficientNetB3(weights="imagenet", # Use pre-trained weights
                             input_shape=(224, 224, 3),
                             pooling="max", # Global average pooling
                             include_top=False) # Exclude the fully connected layer

# Freeze the layers of EfficientNetB3 for transfer learning
for layer in base_model2.layers:
    layer.trainable = False

base_model2.summary()
```

Downloading data from [https://storage.googleapis.com/keras-applications/efficientnetb3\\_notop.h5](https://storage.googleapis.com/keras-applications/efficientnetb3_notop.h5)

43941136/43941136 ————— 0s 0us/step

Model: "efficientnetb3"

Layer (type)	Output Shape	Param #	Connected to
input_layer_3 (InputLayer)	(None, 224, 224, 3)	0	-
rescaling_2 (Rescaling)	(None, 224, 224, 3)	0	input_layer_3
normalization_1 (Normalization)	(None, 224, 224, 3)	7	rescaling_2
rescaling_3 (Rescaling)	(None, 224, 224, 3)	0	normalization_1
stem_conv_pad (ZeroPadding2D)	(None, 225, 225, 3)	0	rescaling_3
stem_conv (Conv2D)	(None, 112, 112, 40)	1,080	stem_conv_pad
stem_bn (BatchNormalization)	(None, 112, 112, 40)	160	stem_conv[0]
stem_activation (Activation)	(None, 112, 112, 40)	0	stem_bn[0]
block1a_dwconv (DepthwiseConv2D)	(None, 112, 112, 40)	360	stem_activation
block1a_bn (BatchNormalization)	(None, 112, 112, 40)	160	block1a_dwconv
block1a_activation (Activation)	(None, 112, 112, 40)	0	block1a_bn[0]
block1a_se_squeeze (GlobalAveragePooling2D)	(None, 40)	0	block1a_activation
block1a_se_reshape (Reshape)	(None, 1, 1, 40)	0	block1a_se_squeeze
block1a_se_reduce (Conv2D)	(None, 1, 1, 10)	410	block1a_se_reshape
block1a_se_expand (Conv2D)	(None, 1, 1, 40)	440	block1a_se_reduce
block1a_se_excite (Multiply)	(None, 112, 112, 40)	0	block1a_activation block1a_se_expand
block1a_project_conv (Conv2D)	(None, 112, 112, 24)	960	block1a_se_excite
block1a_project_bn (BatchNormalization)	(None, 112, 112, 24)	96	block1a_project_conv
block1b_dwconv (DepthwiseConv2D)	(None, 112, 112, 24)	216	block1a_project_bn
block1b_bn (BatchNormalization)	(None, 112, 112, 24)	96	block1b_dwconv
block1b_activation	(None, 112, 112, 24)	0	block1b_bn[0]

(Activation)	24)		
block1b_se_squeeze (GlobalAveragePool...	(None, 24)	0	block1b_act
block1b_se_reshape (Reshape)	(None, 1, 1, 24)	0	block1b_se
block1b_se_reduce (Conv2D)	(None, 1, 1, 6)	150	block1b_se
block1b_se_expand (Conv2D)	(None, 1, 1, 24)	168	block1b_se
block1b_se_excite (Multiply)	(None, 112, 112, 24)	0	block1b_act block1b_se
block1b_project_co... (Conv2D)	(None, 112, 112, 24)	576	block1b_se
block1b_project_bn (BatchNormalizatio...	(None, 112, 112, 24)	96	block1b_pro
block1b_drop (Dropout)	(None, 112, 112, 24)	0	block1b_pro
block1b_add (Add)	(None, 112, 112, 24)	0	block1b_dro block1a_pro
block2a_expand_conv (Conv2D)	(None, 112, 112, 144)	3,456	block1b_ad
block2a_expand_bn (BatchNormalizatio...	(None, 112, 112, 144)	576	block2a_exp
block2a_expand_act... (Activation)	(None, 112, 112, 144)	0	block2a_exp
block2a_dwconv_pad (ZeroPadding2D)	(None, 113, 113, 144)	0	block2a_exp
block2a_dwconv (DepthwiseConv2D)	(None, 56, 56, 144)	1,296	block2a_dw
block2a_bn (BatchNormalizatio...	(None, 56, 56, 144)	576	block2a_dw
block2a_activation (Activation)	(None, 56, 56, 144)	0	block2a_bn
block2a_se_squeeze (GlobalAveragePool...	(None, 144)	0	block2a_act
block2a_se_reshape (Reshape)	(None, 1, 1, 144)	0	block2a_se
block2a_se_reduce (Conv2D)	(None, 1, 1, 6)	870	block2a_se
block2a_se_expand (Conv2D)	(None, 1, 1, 144)	1,008	block2a_se
block2a_se_excite (Multiply)	(None, 56, 56, 144)	0	block2a_act block2a_se



block2a_project_conv (Conv2D)	(None, 56, 56, 32)	4,608	block2a_se
block2a_project_bn (BatchNormalizatio...	(None, 56, 56, 32)	128	block2a_pro
block2b_expand_conv (Conv2D)	(None, 56, 56, 192)	6,144	block2a_pro
block2b_expand_bn (BatchNormalizatio...	(None, 56, 56, 192)	768	block2b_exp
block2b_expand_act... (Activation)	(None, 56, 56, 192)	0	block2b_exp
block2b_dwconv (DepthwiseConv2D)	(None, 56, 56, 192)	1,728	block2b_exp
block2b_bn (BatchNormalizatio...	(None, 56, 56, 192)	768	block2b_dw
block2b_activation (Activation)	(None, 56, 56, 192)	0	block2b_bn
block2b_se_squeeze (GlobalAveragePool...	(None, 192)	0	block2b_act
block2b_se_reshape (Reshape)	(None, 1, 1, 192)	0	block2b_se
block2b_se_reduce (Conv2D)	(None, 1, 1, 8)	1,544	block2b_se
block2b_se_expand (Conv2D)	(None, 1, 1, 192)	1,728	block2b_se
block2b_se_excite (Multiply)	(None, 56, 56, 192)	0	block2b_act block2b_se
block2b_project_conv (Conv2D)	(None, 56, 56, 32)	6,144	block2b_se
block2b_project_bn (BatchNormalizatio...	(None, 56, 56, 32)	128	block2b_pro
block2b_drop (Dropout)	(None, 56, 56, 32)	0	block2b_pro
block2b_add (Add)	(None, 56, 56, 32)	0	block2b_dro block2a_pro
block2c_expand_conv (Conv2D)	(None, 56, 56, 192)	6,144	block2b_add
block2c_expand_bn (BatchNormalizatio...	(None, 56, 56, 192)	768	block2c_exp
block2c_expand_act... (Activation)	(None, 56, 56, 192)	0	block2c_exp
block2c_dwconv (DepthwiseConv2D)	(None, 56, 56, 192)	1,728	block2c_exp

block2c_bn (BatchNormalizatio...	(None, 56, 56, 192)	768	block2c_dw
block2c_activation (Activation)	(None, 56, 56, 192)	0	block2c_bn
block2c_se_squeeze (GlobalAveragePool...	(None, 192)	0	block2c_act
block2c_se_reshape (Reshape)	(None, 1, 1, 192)	0	block2c_se_
block2c_se_reduce (Conv2D)	(None, 1, 1, 8)	1,544	block2c_se_
block2c_se_expand (Conv2D)	(None, 1, 1, 192)	1,728	block2c_se_
block2c_se_excite (Multiply)	(None, 56, 56, 192)	0	block2c_act block2c_se_
block2c_project_co... (Conv2D)	(None, 56, 56, 32)	6,144	block2c_se_
block2c_project_bn (BatchNormalizatio...	(None, 56, 56, 32)	128	block2c_pro
block2c_drop (Dropout)	(None, 56, 56, 32)	0	block2c_pro
block2c_add (Add)	(None, 56, 56, 32)	0	block2c_dro block2b_ad
block3a_expand_conv (Conv2D)	(None, 56, 56, 192)	6,144	block2c_ad
block3a_expand_bn (BatchNormalizatio...	(None, 56, 56, 192)	768	block3a_exp
block3a_expand_act... (Activation)	(None, 56, 56, 192)	0	block3a_exp
block3a_dwconv_pad (ZeroPadding2D)	(None, 59, 59, 192)	0	block3a_exp
block3a_dwconv (DepthwiseConv2D)	(None, 28, 28, 192)	4,800	block3a_dw
block3a_bn (BatchNormalizatio...	(None, 28, 28, 192)	768	block3a_dw
block3a_activation (Activation)	(None, 28, 28, 192)	0	block3a_bn
block3a_se_squeeze (GlobalAveragePool...	(None, 192)	0	block3a_act
block3a_se_reshape (Reshape)	(None, 1, 1, 192)	0	block3a_se_
block3a_se_reduce (Conv2D)	(None, 1, 1, 8)	1,544	block3a_se_
block3a_se_expand	(None, 1, 1, 192)	1,728	block3a_se_

(Conv2D)			
block3a_se_excite (Multiply)	(None, 28, 28, 192)	0	block3a_act block3a_se
block3a_project_conv (Conv2D)	(None, 28, 28, 48)	9,216	block3a_se
block3a_project_bn (BatchNormalizatio...	(None, 28, 28, 48)	192	block3a_pro
block3b_expand_conv (Conv2D)	(None, 28, 28, 288)	13,824	block3a_pro
block3b_expand_bn (BatchNormalizatio...	(None, 28, 28, 288)	1,152	block3b_exp
block3b_expand_act... (Activation)	(None, 28, 28, 288)	0	block3b_exp
block3b_dwconv (DepthwiseConv2D)	(None, 28, 28, 288)	7,200	block3b_exp
block3b_bn (BatchNormalizatio...	(None, 28, 28, 288)	1,152	block3b_dw
block3b_activation (Activation)	(None, 28, 28, 288)	0	block3b_bn
block3b_se_squeeze (GlobalAveragePool...	(None, 288)	0	block3b_act
block3b_se_reshape (Reshape)	(None, 1, 1, 288)	0	block3b_se
block3b_se_reduce (Conv2D)	(None, 1, 1, 12)	3,468	block3b_se
block3b_se_expand (Conv2D)	(None, 1, 1, 288)	3,744	block3b_se
block3b_se_excite (Multiply)	(None, 28, 28, 288)	0	block3b_act block3b_se
block3b_project_conv (Conv2D)	(None, 28, 28, 48)	13,824	block3b_se
block3b_project_bn (BatchNormalizatio...	(None, 28, 28, 48)	192	block3b_pro
block3b_drop (Dropout)	(None, 28, 28, 48)	0	block3b_pro
block3b_add (Add)	(None, 28, 28, 48)	0	block3b_dro block3a_pro
block3c_expand_conv (Conv2D)	(None, 28, 28, 288)	13,824	block3b_ad
block3c_expand_bn (BatchNormalizatio...	(None, 28, 28, 288)	1,152	block3c_exp
block3c_expand_act... (Activation)	(None, 28, 28, 288)	0	block3c_exp

block3c_dwconv (DepthwiseConv2D)	(None, 28, 28, 288)	7,200	block3c_exp
block3c_bn (BatchNormalizatio...	(None, 28, 28, 288)	1,152	block3c_dw
block3c_activation (Activation)	(None, 28, 28, 288)	0	block3c_bn
block3c_se_squeeze (GlobalAveragePool...	(None, 288)	0	block3c_act
block3c_se_reshape (Reshape)	(None, 1, 1, 288)	0	block3c_se_
block3c_se_reduce (Conv2D)	(None, 1, 1, 12)	3,468	block3c_se_
block3c_se_expand (Conv2D)	(None, 1, 1, 288)	3,744	block3c_se_
block3c_se_excite (Multiply)	(None, 28, 28, 288)	0	block3c_act block3c_se_
block3c_project_co... (Conv2D)	(None, 28, 28, 48)	13,824	block3c_se_
block3c_project_bn (BatchNormalizatio...	(None, 28, 28, 48)	192	block3c_pro
block3c_drop (Dropout)	(None, 28, 28, 48)	0	block3c_pro
block3c_add (Add)	(None, 28, 28, 48)	0	block3c_dro block3b_ad
block4a_expand_conv (Conv2D)	(None, 28, 28, 288)	13,824	block3c_ad
block4a_expand_bn (BatchNormalizatio...	(None, 28, 28, 288)	1,152	block4a_exp
block4a_expand_act... (Activation)	(None, 28, 28, 288)	0	block4a_exp
block4a_dwconv_pad (ZeroPadding2D)	(None, 29, 29, 288)	0	block4a_exp
block4a_dwconv (DepthwiseConv2D)	(None, 14, 14, 288)	2,592	block4a_dw
block4a_bn (BatchNormalizatio...	(None, 14, 14, 288)	1,152	block4a_dw
block4a_activation (Activation)	(None, 14, 14, 288)	0	block4a_bn
block4a_se_squeeze (GlobalAveragePool...	(None, 288)	0	block4a_act
block4a_se_reshape (Reshape)	(None, 1, 1, 288)	0	block4a_se_

block4a_se_reduce (Conv2D)	(None, 1, 1, 12)	3,468	block4a_se
block4a_se_expand (Conv2D)	(None, 1, 1, 288)	3,744	block4a_se
block4a_se_excite (Multiply)	(None, 14, 14, 288)	0	block4a_act block4a_se
block4a_project_co... (Conv2D)	(None, 14, 14, 96)	27,648	block4a_se
block4a_project_bn (BatchNormalizatio...	(None, 14, 14, 96)	384	block4a_pro
block4b_expand_conv (Conv2D)	(None, 14, 14, 576)	55,296	block4a_pro
block4b_expand_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4b_exp
block4b_expand_act... (Activation)	(None, 14, 14, 576)	0	block4b_exp
block4b_dwconv (DepthwiseConv2D)	(None, 14, 14, 576)	5,184	block4b_exp
block4b_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4b_dw
block4b_activation (Activation)	(None, 14, 14, 576)	0	block4b_bn
block4b_se_squeeze (GlobalAveragePool...	(None, 576)	0	block4b_act
block4b_se_reshape (Reshape)	(None, 1, 1, 576)	0	block4b_se
block4b_se_reduce (Conv2D)	(None, 1, 1, 24)	13,848	block4b_se
block4b_se_expand (Conv2D)	(None, 1, 1, 576)	14,400	block4b_se
block4b_se_excite (Multiply)	(None, 14, 14, 576)	0	block4b_act block4b_se
block4b_project_co... (Conv2D)	(None, 14, 14, 96)	55,296	block4b_se
block4b_project_bn (BatchNormalizatio...	(None, 14, 14, 96)	384	block4b_pro
block4b_drop (Dropout)	(None, 14, 14, 96)	0	block4b_pro
block4b_add (Add)	(None, 14, 14, 96)	0	block4b_dro block4a_pro
block4c_expand_conv (Conv2D)	(None, 14, 14, 576)	55,296	block4b_ad
block4c_expand_bn	(None, 14, 14,	2,304	block4c_exp

(BatchNormalizatio...	576)		
block4c_expand_act... (Activation)	(None, 14, 14, 576)	0	block4c_exp
block4c_dwconv (DepthwiseConv2D)	(None, 14, 14, 576)	5,184	block4c_exp
block4c_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4c_dw
block4c_activation (Activation)	(None, 14, 14, 576)	0	block4c_bn
block4c_se_squeeze (GlobalAveragePool...	(None, 576)	0	block4c_act
block4c_se_reshape (Reshape)	(None, 1, 1, 576)	0	block4c_se_
block4c_se_reduce (Conv2D)	(None, 1, 1, 24)	13,848	block4c_se_
block4c_se_expand (Conv2D)	(None, 1, 1, 576)	14,400	block4c_se_
block4c_se_excite (Multiply)	(None, 14, 14, 576)	0	block4c_act block4c_se_
block4c_project_co... (Conv2D)	(None, 14, 14, 96)	55,296	block4c_se_
block4c_project_bn (BatchNormalizatio...	(None, 14, 14, 96)	384	block4c_pro
block4c_drop (Dropout)	(None, 14, 14, 96)	0	block4c_pro
block4c_add (Add)	(None, 14, 14, 96)	0	block4c_dro block4b_add
block4d_expand_conv (Conv2D)	(None, 14, 14, 576)	55,296	block4c_ad
block4d_expand_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4d_exp
block4d_expand_act... (Activation)	(None, 14, 14, 576)	0	block4d_exp
block4d_dwconv (DepthwiseConv2D)	(None, 14, 14, 576)	5,184	block4d_exp
block4d_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4d_dw
block4d_activation (Activation)	(None, 14, 14, 576)	0	block4d_bn
block4d_se_squeeze (GlobalAveragePool...	(None, 576)	0	block4d_act
block4d_se_reshape (Reshape)	(None, 1, 1, 576)	0	block4d_se_

block4d_se_reduce (Conv2D)	(None, 1, 1, 24)	13,848	block4d_se
block4d_se_expand (Conv2D)	(None, 1, 1, 576)	14,400	block4d_se
block4d_se_excite (Multiply)	(None, 14, 14, 576)	0	block4d_act block4d_se
block4d_project_co... (Conv2D)	(None, 14, 14, 96)	55,296	block4d_se
block4d_project_bn (BatchNormalizatio...	(None, 14, 14, 96)	384	block4d_pro
block4d_drop (Dropout)	(None, 14, 14, 96)	0	block4d_pro
block4d_add (Add)	(None, 14, 14, 96)	0	block4d_dro block4c_add
block4e_expand_conv (Conv2D)	(None, 14, 14, 576)	55,296	block4d_add
block4e_expand_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4e_exp
block4e_expand_act... (Activation)	(None, 14, 14, 576)	0	block4e_exp
block4e_dwconv (DepthwiseConv2D)	(None, 14, 14, 576)	5,184	block4e_exp
block4e_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block4e_dw
block4e_activation (Activation)	(None, 14, 14, 576)	0	block4e_bn
block4e_se_squeeze (GlobalAveragePool...	(None, 576)	0	block4e_act
block4e_se_reshape (Reshape)	(None, 1, 1, 576)	0	block4e_se
block4e_se_reduce (Conv2D)	(None, 1, 1, 24)	13,848	block4e_se
block4e_se_expand (Conv2D)	(None, 1, 1, 576)	14,400	block4e_se
block4e_se_excite (Multiply)	(None, 14, 14, 576)	0	block4e_act block4e_se
block4e_project_co... (Conv2D)	(None, 14, 14, 96)	55,296	block4e_se
block4e_project_bn (BatchNormalizatio...	(None, 14, 14, 96)	384	block4e_pro
block4e_drop (Dropout)	(None, 14, 14, 96)	0	block4e_pro

block4e_add (Add)	(None, 14, 14, 96)	0	block4e_drc block4d_adc
block5a_expand_conv (Conv2D)	(None, 14, 14, 576)	55,296	block4e_adc
block5a_expand_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block5a_exp
block5a_expand_act... (Activation)	(None, 14, 14, 576)	0	block5a_exp
block5a_dwconv (DepthwiseConv2D)	(None, 14, 14, 576)	14,400	block5a_exp
block5a_bn (BatchNormalizatio...	(None, 14, 14, 576)	2,304	block5a_dwconv
block5a_activation (Activation)	(None, 14, 14, 576)	0	block5a_bn
block5a_se_squeeze (GlobalAveragePool...	(None, 576)	0	block5a_act
block5a_se_reshape (Reshape)	(None, 1, 1, 576)	0	block5a_se_
block5a_se_reduce (Conv2D)	(None, 1, 1, 24)	13,848	block5a_se_
block5a_se_expand (Conv2D)	(None, 1, 1, 576)	14,400	block5a_se_
block5a_se_excite (Multiply)	(None, 14, 14, 576)	0	block5a_act block5a_se_
block5a_project_co... (Conv2D)	(None, 14, 14, 136)	78,336	block5a_se_
block5a_project_bn (BatchNormalizatio...	(None, 14, 14, 136)	544	block5a_pro
block5b_expand_conv (Conv2D)	(None, 14, 14, 816)	110,976	block5a_pro
block5b_expand_bn (BatchNormalizatio...	(None, 14, 14, 816)	3,264	block5b_exp
block5b_expand_act... (Activation)	(None, 14, 14, 816)	0	block5b_exp
block5b_dwconv (DepthwiseConv2D)	(None, 14, 14, 816)	20,400	block5b_exp
block5b_bn (BatchNormalizatio...	(None, 14, 14, 816)	3,264	block5b_dwconv
block5b_activation (Activation)	(None, 14, 14, 816)	0	block5b_bn
block5b_se_squeeze (GlobalAveragePool...	(None, 816)	0	block5b_act
block5b_se_reshape	(None, 1, 1, 816)	0	block5b_se_



(Reshape)			
block5b_se_reduce (Conv2D)	(None, 1, 1, 34)	27,778	block5b_se
block5b_se_expand (Conv2D)	(None, 1, 1, 816)	28,560	block5b_se
block5b_se_excite (Multiply)	(None, 14, 14, 816)	0	block5b_act block5b_se
block5b_project_co... (Conv2D)	(None, 14, 14, 136)	110,976	block5b_se
block5b_project_bn (BatchNormalizatio...	(None, 14, 14, 136)	544	block5b_pro
block5b_drop (Dropout)	(None, 14, 14, 136)	0	block5b_pro
block5b_add (Add)	(None, 14, 14, 136)	0	block5b_dro block5a_pro
block5c_expand_conv (Conv2D)	(None, 14, 14, 816)	110,976	block5b_add
block5c_expand_bn (BatchNormalizatio...	(None, 14, 14, 816)	3,264	block5c_exp
block5c_expand_act... (Activation)	(None, 14, 14, 816)	0	block5c_exp
block5c_dwconv (DepthwiseConv2D)	(None, 14, 14, 816)	20,400	block5c_exp
block5c_bn (BatchNormalizatio...	(None, 14, 14, 816)	3,264	block5c_dw
block5c_activation (Activation)	(None, 14, 14, 816)	0	block5c_bn
block5c_se_squeeze (GlobalAveragePool...	(None, 816)	0	block5c_act
block5c_se_reshape (Reshape)	(None, 1, 1, 816)	0	block5c_se
block5c_se_reduce (Conv2D)	(None, 1, 1, 34)	27,778	block5c_se
block5c_se_expand (Conv2D)	(None, 1, 1, 816)	28,560	block5c_se
block5c_se_excite (Multiply)	(None, 14, 14, 816)	0	block5c_act block5c_se
block5c_project_co... (Conv2D)	(None, 14, 14, 136)	110,976	block5c_se
block5c_project_bn (BatchNormalizatio...	(None, 14, 14, 136)	544	block5c_pro
block5c_drop (Dropout)	(None, 14, 14, 136)	0	block5c_pro

block5c_add (Add)	(None, 14, 14, 136)	0	block5c_dropout block5b_add
block5d_expand_conv (Conv2D)	(None, 14, 14, 816)	110,976	block5c_add
block5d_expand_bn (BatchNormalization)	(None, 14, 14, 816)	3,264	block5d_expand_conv
block5d_expand_activation (Activation)	(None, 14, 14, 816)	0	block5d_expand_bn
block5d_dwconv (DepthwiseConv2D)	(None, 14, 14, 816)	20,400	block5d_expand_activation
block5d_bn (BatchNormalization)	(None, 14, 14, 816)	3,264	block5d_dwconv
block5d_activation (Activation)	(None, 14, 14, 816)	0	block5d_bn
block5d_se_squeeze (GlobalAveragePooling2D)	(None, 816)	0	block5d_activation
block5d_se_reshape (Reshape)	(None, 1, 1, 816)	0	block5d_se_squeeze
block5d_se_reduce (Conv2D)	(None, 1, 1, 34)	27,778	block5d_se_reshape
block5d_se_expand (Conv2D)	(None, 1, 1, 816)	28,560	block5d_se_reduce
block5d_se_excite (Multiply)	(None, 14, 14, 816)	0	block5d_se_expand
block5d_project_conv (Conv2D)	(None, 14, 14, 136)	110,976	block5d_se_excite
block5d_project_bn (BatchNormalization)	(None, 14, 14, 136)	544	block5d_project_conv
block5d_drop (Dropout)	(None, 14, 14, 136)	0	block5d_project_bn
block5d_add (Add)	(None, 14, 14, 136)	0	block5d_drop
block5e_expand_conv (Conv2D)	(None, 14, 14, 816)	110,976	block5d_add
block5e_expand_bn (BatchNormalization)	(None, 14, 14, 816)	3,264	block5e_expand_conv
block5e_expand_activation (Activation)	(None, 14, 14, 816)	0	block5e_expand_bn
block5e_dwconv (DepthwiseConv2D)	(None, 14, 14, 816)	20,400	block5e_expand_activation
block5e_bn (BatchNormalization)	(None, 14, 14, 816)	3,264	block5e_dwconv

block5e_activation (Activation)	(None, 14, 14, 816)	0	block5e_bn
block5e_se_squeeze (GlobalAveragePool...	(None, 816)	0	block5e_act
block5e_se_reshape (Reshape)	(None, 1, 1, 816)	0	block5e_se_
block5e_se_reduce (Conv2D)	(None, 1, 1, 34)	27,778	block5e_se_
block5e_se_expand (Conv2D)	(None, 1, 1, 816)	28,560	block5e_se_
block5e_se_excite (Multiply)	(None, 14, 14, 816)	0	block5e_act block5e_se_
block5e_project_co... (Conv2D)	(None, 14, 14, 136)	110,976	block5e_se_
block5e_project_bn (BatchNormalizatio...	(None, 14, 14, 136)	544	block5e_pro
block5e_drop (Dropout)	(None, 14, 14, 136)	0	block5e_pro
block5e_add (Add)	(None, 14, 14, 136)	0	block5e_dro block5d_add
block6a_expand_conv (Conv2D)	(None, 14, 14, 816)	110,976	block5e_ad
block6a_expand_bn (BatchNormalizatio...	(None, 14, 14, 816)	3,264	block6a_exp
block6a_expand_act... (Activation)	(None, 14, 14, 816)	0	block6a_exp
block6a_dwconv_pad (ZeroPadding2D)	(None, 17, 17, 816)	0	block6a_exp
block6a_dwconv (DepthwiseConv2D)	(None, 7, 7, 816)	20,400	block6a_dw
block6a_bn (BatchNormalizatio...	(None, 7, 7, 816)	3,264	block6a_dw
block6a_activation (Activation)	(None, 7, 7, 816)	0	block6a_bn
block6a_se_squeeze (GlobalAveragePool...	(None, 816)	0	block6a_act
block6a_se_reshape (Reshape)	(None, 1, 1, 816)	0	block6a_se_
block6a_se_reduce (Conv2D)	(None, 1, 1, 34)	27,778	block6a_se_
block6a_se_expand (Conv2D)	(None, 1, 1, 816)	28,560	block6a_se_
block6a_se_excite	(None, 7, 7, 816)	0	block6a_act

(Multiply)			block6a_se
block6a_project_co... (Conv2D)	(None, 7, 7, 232)	189,312	block6a_se
block6a_project_bn (BatchNormalizatio...	(None, 7, 7, 232)	928	block6a_pro
block6b_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6a_pro
block6b_expand_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6b_exp
block6b_expand_act... (Activation)	(None, 7, 7, 1392)	0	block6b_exp
block6b_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	34,800	block6b_exp
block6b_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6b_dw
block6b_activation (Activation)	(None, 7, 7, 1392)	0	block6b_bn
block6b_se_squeeze (GlobalAveragePool...	(None, 1392)	0	block6b_act
block6b_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block6b_se
block6b_se_reduce (Conv2D)	(None, 1, 1, 58)	80,794	block6b_se
block6b_se_expand (Conv2D)	(None, 1, 1, 1392)	82,128	block6b_se
block6b_se_excite (Multiply)	(None, 7, 7, 1392)	0	block6b_act block6b_se
block6b_project_co... (Conv2D)	(None, 7, 7, 232)	322,944	block6b_se
block6b_project_bn (BatchNormalizatio...	(None, 7, 7, 232)	928	block6b_pro
block6b_drop (Dropout)	(None, 7, 7, 232)	0	block6b_pro
block6b_add (Add)	(None, 7, 7, 232)	0	block6b_dro block6a_pro
block6c_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6b_ad
block6c_expand_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6c_exp
block6c_expand_act... (Activation)	(None, 7, 7, 1392)	0	block6c_exp
block6c_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	34,800	block6c_exp

block6c_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6c_dwconv
block6c_activation (Activation)	(None, 7, 7, 1392)	0	block6c_bn
block6c_se_squeeze (GlobalAveragePool...	(None, 1392)	0	block6c_act
block6c_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block6c_se_
block6c_se_reduce (Conv2D)	(None, 1, 1, 58)	80,794	block6c_se_
block6c_se_expand (Conv2D)	(None, 1, 1, 1392)	82,128	block6c_se_
block6c_se_excite (Multiply)	(None, 7, 7, 1392)	0	block6c_act block6c_se_
block6c_project_co... (Conv2D)	(None, 7, 7, 232)	322,944	block6c_se_
block6c_project_bn (BatchNormalizatio...	(None, 7, 7, 232)	928	block6c_pro
block6c_drop (Dropout)	(None, 7, 7, 232)	0	block6c_pro
block6c_add (Add)	(None, 7, 7, 232)	0	block6c_dro block6b_adc
block6d_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6c_adc
block6d_expand_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6d_exp
block6d_expand_act... (Activation)	(None, 7, 7, 1392)	0	block6d_exp
block6d_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	34,800	block6d_exp
block6d_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6d_dwconv
block6d_activation (Activation)	(None, 7, 7, 1392)	0	block6d_bn
block6d_se_squeeze (GlobalAveragePool...	(None, 1392)	0	block6d_act
block6d_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block6d_se_
block6d_se_reduce (Conv2D)	(None, 1, 1, 58)	80,794	block6d_se_
block6d_se_expand (Conv2D)	(None, 1, 1, 1392)	82,128	block6d_se_

block6d_se_excite (Multiply)	(None, 7, 7, 1392)	0	block6d_act block6d_se
block6d_project_co... (Conv2D)	(None, 7, 7, 232)	322,944	block6d_se
block6d_project_bn (BatchNormalizatio...	(None, 7, 7, 232)	928	block6d_pro
block6d_drop (Dropout)	(None, 7, 7, 232)	0	block6d_pro
block6d_add (Add)	(None, 7, 7, 232)	0	block6d_dro block6c_ad
block6e_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6d_ad
block6e_expand_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6e_exp
block6e_expand_act... (Activation)	(None, 7, 7, 1392)	0	block6e_exp
block6e_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	34,800	block6e_exp
block6e_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6e_dw
block6e_activation (Activation)	(None, 7, 7, 1392)	0	block6e_bn
block6e_se_squeeze (GlobalAveragePool...	(None, 1392)	0	block6e_act
block6e_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block6e_se
block6e_se_reduce (Conv2D)	(None, 1, 1, 58)	80,794	block6e_se
block6e_se_expand (Conv2D)	(None, 1, 1, 1392)	82,128	block6e_se
block6e_se_excite (Multiply)	(None, 7, 7, 1392)	0	block6e_act block6e_se
block6e_project_co... (Conv2D)	(None, 7, 7, 232)	322,944	block6e_se
block6e_project_bn (BatchNormalizatio...	(None, 7, 7, 232)	928	block6e_pro
block6e_drop (Dropout)	(None, 7, 7, 232)	0	block6e_pro
block6e_add (Add)	(None, 7, 7, 232)	0	block6e_dro block6d_ad
block6f_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6e_ad
block6f_expand_bn	(None, 7, 7,	5,568	block6f_exp

(BatchNormalizatio...	1392)		
block6f_expand_act... (Activation)	(None, 7, 7, 1392)	0	block6f_exp
block6f_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	34,800	block6f_exp
block6f_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block6f_dw
block6f_activation (Activation)	(None, 7, 7, 1392)	0	block6f_bn
block6f_se_squeeze (GlobalAveragePool...	(None, 1392)	0	block6f_act
block6f_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block6f_se_
block6f_se_reduce (Conv2D)	(None, 1, 1, 58)	80,794	block6f_se_
block6f_se_expand (Conv2D)	(None, 1, 1, 1392)	82,128	block6f_se_
block6f_se_excite (Multiply)	(None, 7, 7, 1392)	0	block6f_act block6f_se_
block6f_project_co... (Conv2D)	(None, 7, 7, 232)	322,944	block6f_se_
block6f_project_bn (BatchNormalizatio...	(None, 7, 7, 232)	928	block6f_pro
block6f_drop (Dropout)	(None, 7, 7, 232)	0	block6f_pro
block6f_add (Add)	(None, 7, 7, 232)	0	block6f_dro block6e_ad
block7a_expand_conv (Conv2D)	(None, 7, 7, 1392)	322,944	block6f_ad
block7a_expand_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block7a_exp
block7a_expand_act... (Activation)	(None, 7, 7, 1392)	0	block7a_exp
block7a_dwconv (DepthwiseConv2D)	(None, 7, 7, 1392)	12,528	block7a_exp
block7a_bn (BatchNormalizatio...	(None, 7, 7, 1392)	5,568	block7a_dw
block7a_activation (Activation)	(None, 7, 7, 1392)	0	block7a_bn
block7a_se_squeeze (GlobalAveragePool...	(None, 1392)	0	block7a_act
block7a_se_reshape (Reshape)	(None, 1, 1, 1392)	0	block7a_se_

block7a_se_reduce (Conv2D)	(None, 1, 1, 58)	80,794	block7a_se
block7a_se_expand (Conv2D)	(None, 1, 1, 1392)	82,128	block7a_se
block7a_se_excite (Multiply)	(None, 7, 7, 1392)	0	block7a_act block7a_se
block7a_project_co... (Conv2D)	(None, 7, 7, 384)	534,528	block7a_se
block7a_project_bn (BatchNormalizatio...	(None, 7, 7, 384)	1,536	block7a_pro
block7b_expand_conv (Conv2D)	(None, 7, 7, 2304)	884,736	block7a_pro
block7b_expand_bn (BatchNormalizatio...	(None, 7, 7, 2304)	9,216	block7b_exp
block7b_expand_act... (Activation)	(None, 7, 7, 2304)	0	block7b_exp
block7b_dwconv (DepthwiseConv2D)	(None, 7, 7, 2304)	20,736	block7b_exp
block7b_bn (BatchNormalizatio...	(None, 7, 7, 2304)	9,216	block7b_dw
block7b_activation (Activation)	(None, 7, 7, 2304)	0	block7b_bn
block7b_se_squeeze (GlobalAveragePool...	(None, 2304)	0	block7b_act
block7b_se_reshape (Reshape)	(None, 1, 1, 2304)	0	block7b_se
block7b_se_reduce (Conv2D)	(None, 1, 1, 96)	221,280	block7b_se
block7b_se_expand (Conv2D)	(None, 1, 1, 2304)	223,488	block7b_se
block7b_se_excite (Multiply)	(None, 7, 7, 2304)	0	block7b_act block7b_se
block7b_project_co... (Conv2D)	(None, 7, 7, 384)	884,736	block7b_se
block7b_project_bn (BatchNormalizatio...	(None, 7, 7, 384)	1,536	block7b_pro
block7b_drop (Dropout)	(None, 7, 7, 384)	0	block7b_pro
block7b_add (Add)	(None, 7, 7, 384)	0	block7b_dro block7a_pro
top_conv (Conv2D)	(None, 7, 7, 1536)	589,824	block7b_ad



top_bn (BatchNormalizatio...	(None, 7, 7, 1536)	6,144	top_conv[0]
top_activation (Activation)	(None, 7, 7, 1536)	0	top_bn[0][0]
max_pool (GlobalMaxPooling2...	(None, 1536)	0	top_activa

**Total params:** 10,783,535 (41.14 MB)

**Trainable params:** 0 (0.00 B)

**Non-trainable params:** 10,783,535 (41.14 MB)

```
In [19]: model3 = Sequential()
model3.add(base_model2)
model3.add(Flatten())

model3.add(Dense(128, activation = "relu"))
model3.add(Dense(64, activation = "relu"))
model3.add(Dense(32, activation = "relu"))
model3.add(Dense(1, activation = "sigmoid"))

# freeze the layers
for layer in base_model2.layers:
    layer.trainable = False

model3.compile(optimizer = "adam", loss = "binary_crossentropy", metrics
```

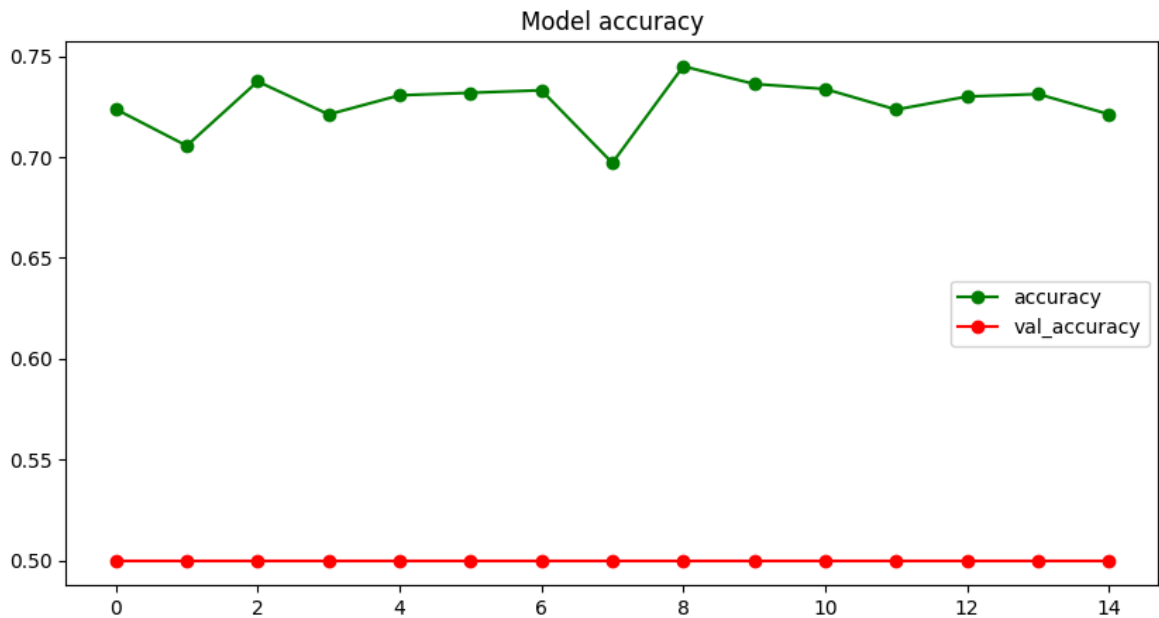
```
In [20]: %%time

history = model3.fit(train_set, epochs = 20, validation_data = validation
                    callbacks = [early_stopping_callbacks])
```

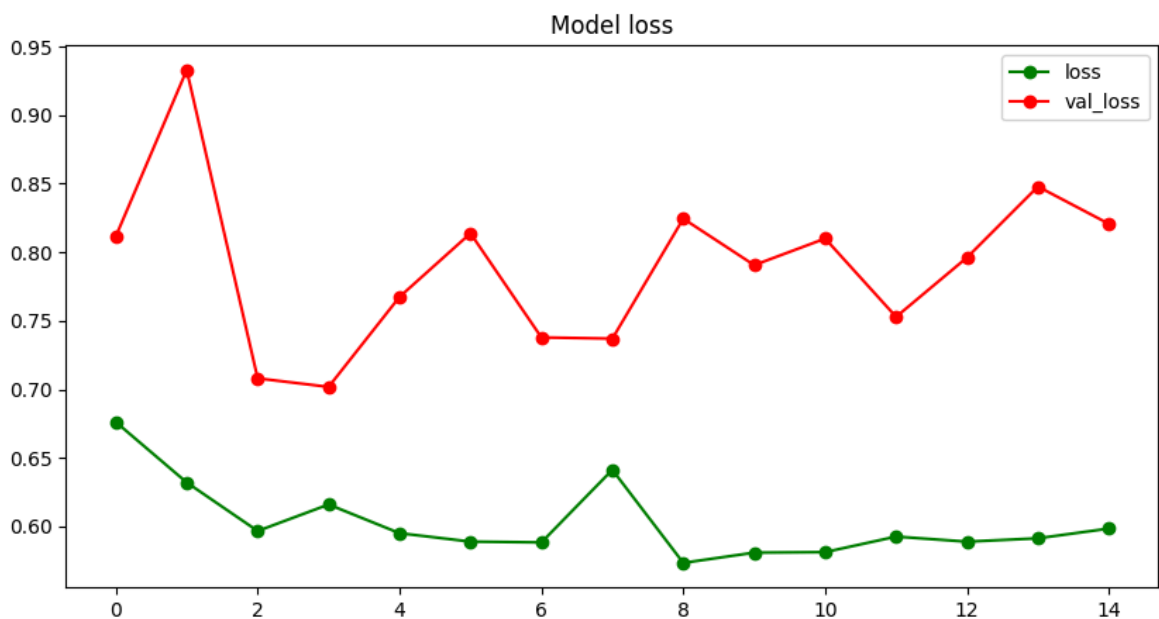
Epoch 1/20  
**100/100** ————— **92s** 381ms/step - accuracy: 0.6821 - loss: 0.8369 - val\_accuracy: 0.5000 - val\_loss: 0.8115  
Epoch 2/20  
**100/100** ————— **31s** 312ms/step - accuracy: 0.7054 - loss: 0.6309 - val\_accuracy: 0.5000 - val\_loss: 0.9328  
Epoch 3/20  
**100/100** ————— **31s** 314ms/step - accuracy: 0.7444 - loss: 0.5822 - val\_accuracy: 0.5000 - val\_loss: 0.7080  
Epoch 4/20  
**100/100** ————— **6s** 61ms/step - accuracy: 0.7268 - loss: 0.6128 - val\_accuracy: 0.5000 - val\_loss: 0.7018  
Epoch 5/20  
**100/100** ————— **34s** 315ms/step - accuracy: 0.7460 - loss: 0.5890 - val\_accuracy: 0.5000 - val\_loss: 0.7674  
Epoch 6/20  
**100/100** ————— **31s** 313ms/step - accuracy: 0.7034 - loss: 0.6114 - val\_accuracy: 0.5000 - val\_loss: 0.8138  
Epoch 7/20  
**100/100** ————— **31s** 310ms/step - accuracy: 0.7401 - loss: 0.5839 - val\_accuracy: 0.5000 - val\_loss: 0.7379  
Epoch 8/20  
**100/100** ————— **6s** 61ms/step - accuracy: 0.6957 - loss: 0.6416 - val\_accuracy: 0.5000 - val\_loss: 0.7370  
Epoch 9/20  
**100/100** ————— **34s** 315ms/step - accuracy: 0.7436 - loss: 0.5765 - val\_accuracy: 0.5000 - val\_loss: 0.8245  
Epoch 10/20  
**100/100** ————— **31s** 316ms/step - accuracy: 0.7386 - loss: 0.5782 - val\_accuracy: 0.5000 - val\_loss: 0.7906  
Epoch 11/20  
**100/100** ————— **31s** 315ms/step - accuracy: 0.7350 - loss: 0.5791 - val\_accuracy: 0.5000 - val\_loss: 0.8100  
Epoch 12/20  
**100/100** ————— **6s** 62ms/step - accuracy: 0.7211 - loss: 0.5953 - val\_accuracy: 0.5000 - val\_loss: 0.7529  
Epoch 13/20  
**100/100** ————— **33s** 311ms/step - accuracy: 0.7187 - loss: 0.5984 - val\_accuracy: 0.5000 - val\_loss: 0.7962  
Epoch 14/20  
**100/100** ————— **31s** 309ms/step - accuracy: 0.7335 - loss: 0.5878 - val\_accuracy: 0.5000 - val\_loss: 0.8479  
Epoch 15/20  
**100/100** ————— **31s** 313ms/step - accuracy: 0.7305 - loss: 0.5937 - val\_accuracy: 0.5000 - val\_loss: 0.8207  
CPU times: user 8min 8s, sys: 8.02 s, total: 8min 16s  
Wall time: 7min 41s

## Visualizing Performance of EfficientNetB3

```
In [21]: plt.figure(figsize = (10, 5))
plt.title("Model accuracy")
plt.plot(history.history["accuracy"], "go-")
plt.plot(history.history["val_accuracy"], "ro-")
plt.legend(["accuracy", "val_accuracy"])
plt.show()
```



```
In [22]: plt.figure(figsize = (10, 5))
plt.title("Model loss")
plt.plot(history.history["loss"], "go-")
plt.plot(history.history["val_loss"], "ro-")
plt.legend(["loss", "val_loss"])
plt.show()
```



## Evaluate the EfficientNetB3 Model on the Test Set

```
In [23]: #scores = model1.evaluate_generator(test_set)
#print("\n%s: %.3f%%" % (model1.metrics_names[0], scores[0]*100))
#print("\n%s: %.3f%%" % (model1.metrics_names[1], scores[1]*100))

test_loss, test_accuracy = model3.evaluate(test_set, steps = 50)
print("The testing accuracy is: ", test_accuracy * 100, "%")
print("The testing loss is: ", test_loss * 100, "%")
```

**50/50** ————— 5s 95ms/step - accuracy: 0.6084 - loss: 0.7038  
The testing accuracy is: 62.5 %  
The testing loss is: 68.71474981307983 %

***Thank you!***