Perform standard imports

In [ ]:
```
! pip install split-folders
```

```
Requirement already satisfied: split-folders in /usr/local/lib/python3.10/dist-packages (0.5.1)
```

In [2]:
```
import tensorflow as tf
from keras.models import Sequential
from keras.layers import Activation, Dropout, Flatten, Dense, Conv2D, MaxPooling2D, BatchNormalization, GlobalAveragePooling2D
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import splitfolders
import numpy as np
import copy
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import style
style.use('dark_background')
```

In [3]:
```
print('GPU name: ', tf.config.experimental.list_physical_devices('GPU'))
```

```
GPU name:  []
```

In [5]:
```
gpus = tf.config.experimental.list_physical_devices('GPU')
if gpus:
    try:
        for gpu in gpus:
            tf.config.experimental.set_memory_growth(gpu, True)
            logical_gpus = tf.config.experimental.list_logical_devices('GPU')
            print(len(gpus), "Physical GPUs,", len(logical_gpus), "Logical GPUs")
    except RuntimeError as e:
        print(e)
```

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

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=Tru
e).
```

In [ ]:
```
%cd/content/drive/MyDrive/Course Material/Supervised Machine Learning/CNN_TF
```

```
/content/drive/MyDrive/CNN_TF
```

Prepare train and test sets, loaders

In [6]:
```
splitfolders.ratio("dataset", output="circle_square",
    seed=1337, ratio=(.8, .2), group_prefix=None, move=False) # default values
```

```
Copying files: 200 files [00:00, 539.09 files/s]
```

In [7]:
```
train_datagen = ImageDataGenerator(rotation_range=90,
                                   brightness_range=[0.1, 0.7],
                                   horizontal_flip=True,
                                   vertical_flip=True,
                                   validation_split=0.2,
                                   rescale = 1./255)


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

In [8]:
```
batch_size = 32

training_set = train_datagen.flow_from_directory('circle_square/train/',
                                                 target_size = (200,200),
                                                 class_mode='binary',
                                                 shuffle = True,
                                                 batch_size = batch_size)
test_set = train_datagen.flow_from_directory('circle_square/val/',
                                                 target_size = (200,200),
                                                 class_mode='binary',
                                                 shuffle = False,
                                                 batch_size = 1)
```

```
Found 160 images belonging to 2 classes.
Found 40 images belonging to 2 classes.
```

Import ResNet-50

In [9]:
```
base_model = tf.keras.applications.resnet50.ResNet50(weights='imagenet', include_top = False)
# setting include_top to False means the classification layers are not added and it is only a feature extracter and we will ad
# the clasification layers by ourself.
output = base_model.output
```

```
Downloading data from https://storage.googleapis.com/tensorflow/keras-applications/resnet/resnet50_weights_tf_dim_ordering_tf_k
ernels_notop.h5
94765736/94765736 ━━━━━━━━━━━━━━━━━━━━ 6s 0us/step
```

In [10]:
```
base_model.summary()
```

```
Model: "resnet50"
```

Layer (type)	Output Shape	Param #	Connected to
input_layer (InputLayer)	(None, None, None, 3)	0	-
conv1_pad (ZeroPadding2D)	(None, None, None, 3)	0	input_layer[0][0]
conv1_conv (Conv2D)	(None, None, None, 64)	9,472	conv1_pad[0][0]
conv1_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv1_conv[0][0]
conv1_relu (Activation)	(None, None, None, 64)	0	conv1_bn[0][0]
pool1_pad (ZeroPadding2D)	(None, None, None, 64)	0	conv1_relu[0][0]
pool1_pool (MaxPooling2D)	(None, None, None, 64)	0	pool1_pad[0][0]
conv2_block1_1_conv (Conv2D)	(None, None, None, 64)	4,160	pool1_pool[0][0]
conv2_block1_1_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv2_block1_1_c…
conv2_block1_1_relu (Activation)	(None, None, None, 64)	0	conv2_block1_1_b…
conv2_block1_2_conv (Conv2D)	(None, None, None, 64)	36,928	conv2_block1_1_r…
conv2_block1_2_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv2_block1_2_c…
conv2_block1_2_relu (Activation)	(None, None, None, 64)	0	conv2_block1_2_b…

conv2_block1_0_conv (Conv2D)	(None, None, None, 256)	16,640	pool1_pool[0][0]
conv2_block1_3_conv (Conv2D)	(None, None, None, 256)	16,640	conv2_block1_2_r…
conv2_block1_0_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv2_block1_0_c…
conv2_block1_3_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv2_block1_3_c…
conv2_block1_add (Add)	(None, None, None, 256)	0	conv2_block1_0_b… conv2_block1_3_b…
conv2_block1_out (Activation)	(None, None, None, 256)	0	conv2_block1_add…
conv2_block2_1_conv (Conv2D)	(None, None, None, 64)	16,448	conv2_block1_out…
conv2_block2_1_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv2_block2_1_c…
conv2_block2_1_relu (Activation)	(None, None, None, 64)	0	conv2_block2_1_b…
conv2_block2_2_conv (Conv2D)	(None, None, None, 64)	36,928	conv2_block2_1_r…
conv2_block2_2_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv2_block2_2_c…
conv2_block2_2_relu (Activation)	(None, None, None, 64)	0	conv2_block2_2_b…
conv2_block2_3_conv (Conv2D)	(None, None, None, 256)	16,640	conv2_block2_2_r…
conv2_block2_3_bn	(None, None,	1,024	conv2_block2_3_c…

(BatchNormalizatio…	None, 256)		
conv2_block2_add (Add)	(None, None, None, 256)	0	conv2_block1_out… conv2_block2_3_b…
conv2_block2_out (Activation)	(None, None, None, 256)	0	conv2_block2_add…
conv2_block3_1_conv (Conv2D)	(None, None, None, 64)	16,448	conv2_block2_out…
conv2_block3_1_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv2_block3_1_c…
conv2_block3_1_relu (Activation)	(None, None, None, 64)	0	conv2_block3_1_b…
conv2_block3_2_conv (Conv2D)	(None, None, None, 64)	36,928	conv2_block3_1_r…
conv2_block3_2_bn (BatchNormalizatio…	(None, None, None, 64)	256	conv2_block3_2_c…
conv2_block3_2_relu (Activation)	(None, None, None, 64)	0	conv2_block3_2_b…
conv2_block3_3_conv (Conv2D)	(None, None, None, 256)	16,640	conv2_block3_2_r…
conv2_block3_3_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv2_block3_3_c…
conv2_block3_add (Add)	(None, None, None, 256)	0	conv2_block2_out… conv2_block3_3_b…
conv2_block3_out (Activation)	(None, None, None, 256)	0	conv2_block3_add…
conv3_block1_1_conv (Conv2D)	(None, None, None, 128)	32,896	conv2_block3_out…

conv3_block1_1_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block1_1_c…
conv3_block1_1_relu (Activation)	(None, None, None, 128)	0	conv3_block1_1_b…
conv3_block1_2_conv (Conv2D)	(None, None, None, 128)	147,584	conv3_block1_1_r…
conv3_block1_2_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block1_2_c…
conv3_block1_2_relu (Activation)	(None, None, None, 128)	0	conv3_block1_2_b…
conv3_block1_0_conv (Conv2D)	(None, None, None, 512)	131,584	conv2_block3_out…
conv3_block1_3_conv (Conv2D)	(None, None, None, 512)	66,048	conv3_block1_2_r…
conv3_block1_0_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv3_block1_0_c…
conv3_block1_3_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv3_block1_3_c…
conv3_block1_add (Add)	(None, None, None, 512)	0	conv3_block1_0_b… conv3_block1_3_b…
conv3_block1_out (Activation)	(None, None, None, 512)	0	conv3_block1_add…
conv3_block2_1_conv (Conv2D)	(None, None, None, 128)	65,664	conv3_block1_out…
conv3_block2_1_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block2_1_c…
conv3_block2_1_relu (Activation)	(None, None, None, 128)	0	conv3_block2_1_b…

conv3_block2_2_conv (Conv2D)	(None, None, None, 128)	147,584	conv3_block2_1_r…
conv3_block2_2_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block2_2_c…
conv3_block2_2_relu (Activation)	(None, None, None, 128)	0	conv3_block2_2_b…
conv3_block2_3_conv (Conv2D)	(None, None, None, 512)	66,048	conv3_block2_2_r…
conv3_block2_3_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv3_block2_3_c…
conv3_block2_add (Add)	(None, None, None, 512)	0	conv3_block1_out… conv3_block2_3_b…
conv3_block2_out (Activation)	(None, None, None, 512)	0	conv3_block2_add…
conv3_block3_1_conv (Conv2D)	(None, None, None, 128)	65,664	conv3_block2_out…
conv3_block3_1_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block3_1_c…
conv3_block3_1_relu (Activation)	(None, None, None, 128)	0	conv3_block3_1_b…
conv3_block3_2_conv (Conv2D)	(None, None, None, 128)	147,584	conv3_block3_1_r…
conv3_block3_2_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block3_2_c…
conv3_block3_2_relu (Activation)	(None, None, None, 128)	0	conv3_block3_2_b…
conv3_block3_3_conv	(None, None,	66,048	conv3_block3_2_r…

(Conv2D)	None, 512)		
conv3_block3_3_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv3_block3_3_c…
conv3_block3_add (Add)	(None, None, None, 512)	0	conv3_block2_out… conv3_block3_3_b…
conv3_block3_out (Activation)	(None, None, None, 512)	0	conv3_block3_add…
conv3_block4_1_conv (Conv2D)	(None, None, None, 128)	65,664	conv3_block3_out…
conv3_block4_1_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block4_1_c…
conv3_block4_1_relu (Activation)	(None, None, None, 128)	0	conv3_block4_1_b…
conv3_block4_2_conv (Conv2D)	(None, None, None, 128)	147,584	conv3_block4_1_r…
conv3_block4_2_bn (BatchNormalizatio…	(None, None, None, 128)	512	conv3_block4_2_c…
conv3_block4_2_relu (Activation)	(None, None, None, 128)	0	conv3_block4_2_b…
conv3_block4_3_conv (Conv2D)	(None, None, None, 512)	66,048	conv3_block4_2_r…
conv3_block4_3_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv3_block4_3_c…
conv3_block4_add (Add)	(None, None, None, 512)	0	conv3_block3_out… conv3_block4_3_b…
conv3_block4_out (Activation)	(None, None, None, 512)	0	conv3_block4_add…

conv4_block1_1_conv (Conv2D)	(None, None, None, 256)	131,328	conv3_block4_out…
conv4_block1_1_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block1_1_c…
conv4_block1_1_relu (Activation)	(None, None, None, 256)	0	conv4_block1_1_b…
conv4_block1_2_conv (Conv2D)	(None, None, None, 256)	590,080	conv4_block1_1_r…
conv4_block1_2_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block1_2_c…
conv4_block1_2_relu (Activation)	(None, None, None, 256)	0	conv4_block1_2_b…
conv4_block1_0_conv (Conv2D)	(None, None, None, 1024)	525,312	conv3_block4_out…
conv4_block1_3_conv (Conv2D)	(None, None, None, 1024)	263,168	conv4_block1_2_r…
conv4_block1_0_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block1_0_c…
conv4_block1_3_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block1_3_c…
conv4_block1_add (Add)	(None, None, None, 1024)	0	conv4_block1_0_b… conv4_block1_3_b…
conv4_block1_out (Activation)	(None, None, None, 1024)	0	conv4_block1_add…
conv4_block2_1_conv (Conv2D)	(None, None, None, 256)	262,400	conv4_block1_out…
conv4_block2_1_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block2_1_c…

conv4_block2_1_relu (Activation)	(None, None, None, 256)	0	conv4_block2_1_b…
conv4_block2_2_conv (Conv2D)	(None, None, None, 256)	590,080	conv4_block2_1_r…
conv4_block2_2_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block2_2_c…
conv4_block2_2_relu (Activation)	(None, None, None, 256)	0	conv4_block2_2_b…
conv4_block2_3_conv (Conv2D)	(None, None, None, 1024)	263,168	conv4_block2_2_r…
conv4_block2_3_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block2_3_c…
conv4_block2_add (Add)	(None, None, None, 1024)	0	conv4_block1_out… conv4_block2_3_b…
conv4_block2_out (Activation)	(None, None, None, 1024)	0	conv4_block2_add…
conv4_block3_1_conv (Conv2D)	(None, None, None, 256)	262,400	conv4_block2_out…
conv4_block3_1_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block3_1_c…
conv4_block3_1_relu (Activation)	(None, None, None, 256)	0	conv4_block3_1_b…
conv4_block3_2_conv (Conv2D)	(None, None, None, 256)	590,080	conv4_block3_1_r…
conv4_block3_2_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block3_2_c…
conv4_block3_2_relu	(None, None,	0	conv4_block3_2_b…

(Activation)	None, 256)		
conv4_block3_3_conv (Conv2D)	(None, None, None, 1024)	263,168	conv4_block3_2_r…
conv4_block3_3_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block3_3_c…
conv4_block3_add (Add)	(None, None, None, 1024)	0	conv4_block2_out… conv4_block3_3_b…
conv4_block3_out (Activation)	(None, None, None, 1024)	0	conv4_block3_add…
conv4_block4_1_conv (Conv2D)	(None, None, None, 256)	262,400	conv4_block3_out…
conv4_block4_1_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block4_1_c…
conv4_block4_1_relu (Activation)	(None, None, None, 256)	0	conv4_block4_1_b…
conv4_block4_2_conv (Conv2D)	(None, None, None, 256)	590,080	conv4_block4_1_r…
conv4_block4_2_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block4_2_c…
conv4_block4_2_relu (Activation)	(None, None, None, 256)	0	conv4_block4_2_b…
conv4_block4_3_conv (Conv2D)	(None, None, None, 1024)	263,168	conv4_block4_2_r…
conv4_block4_3_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block4_3_c…
conv4_block4_add (Add)	(None, None, None, 1024)	0	conv4_block3_out… conv4_block4_3_b…

conv4_block4_out (Activation)	(None, None, None, 1024)	0	conv4_block4_add…
conv4_block5_1_conv (Conv2D)	(None, None, None, 256)	262,400	conv4_block4_out…
conv4_block5_1_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block5_1_c…
conv4_block5_1_relu (Activation)	(None, None, None, 256)	0	conv4_block5_1_b…
conv4_block5_2_conv (Conv2D)	(None, None, None, 256)	590,080	conv4_block5_1_r…
conv4_block5_2_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block5_2_c…
conv4_block5_2_relu (Activation)	(None, None, None, 256)	0	conv4_block5_2_b…
conv4_block5_3_conv (Conv2D)	(None, None, None, 1024)	263,168	conv4_block5_2_r…
conv4_block5_3_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block5_3_c…
conv4_block5_add (Add)	(None, None, None, 1024)	0	conv4_block4_out… conv4_block5_3_b…
conv4_block5_out (Activation)	(None, None, None, 1024)	0	conv4_block5_add…
conv4_block6_1_conv (Conv2D)	(None, None, None, 256)	262,400	conv4_block5_out…
conv4_block6_1_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block6_1_c…
conv4_block6_1_relu (Activation)	(None, None, None, 256)	0	conv4_block6_1_b…

conv4_block6_2_conv (Conv2D)	(None, None, None, 256)	590,080	conv4_block6_1_r…
conv4_block6_2_bn (BatchNormalizatio…	(None, None, None, 256)	1,024	conv4_block6_2_c…
conv4_block6_2_relu (Activation)	(None, None, None, 256)	0	conv4_block6_2_b…
conv4_block6_3_conv (Conv2D)	(None, None, None, 1024)	263,168	conv4_block6_2_r…
conv4_block6_3_bn (BatchNormalizatio…	(None, None, None, 1024)	4,096	conv4_block6_3_c…
conv4_block6_add (Add)	(None, None, None, 1024)	0	conv4_block5_out… conv4_block6_3_b…
conv4_block6_out (Activation)	(None, None, None, 1024)	0	conv4_block6_add…
conv5_block1_1_conv (Conv2D)	(None, None, None, 512)	524,800	conv4_block6_out…
conv5_block1_1_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv5_block1_1_c…
conv5_block1_1_relu (Activation)	(None, None, None, 512)	0	conv5_block1_1_b…
conv5_block1_2_conv (Conv2D)	(None, None, None, 512)	2,359,808	conv5_block1_1_r…
conv5_block1_2_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv5_block1_2_c…
conv5_block1_2_relu (Activation)	(None, None, None, 512)	0	conv5_block1_2_b…
conv5_block1_0_conv	(None, None,	2,099,200	conv4_block6_out…

(Conv2D)	None, 2048)		
conv5_block1_3_conv (Conv2D)	(None, None, None, 2048)	1,050,624	conv5_block1_2_r…
conv5_block1_0_bn (BatchNormalizatio…	(None, None, None, 2048)	8,192	conv5_block1_0_c…
conv5_block1_3_bn (BatchNormalizatio…	(None, None, None, 2048)	8,192	conv5_block1_3_c…
conv5_block1_add (Add)	(None, None, None, 2048)	0	conv5_block1_0_b… conv5_block1_3_b…
conv5_block1_out (Activation)	(None, None, None, 2048)	0	conv5_block1_add…
conv5_block2_1_conv (Conv2D)	(None, None, None, 512)	1,049,088	conv5_block1_out…
conv5_block2_1_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv5_block2_1_c…
conv5_block2_1_relu (Activation)	(None, None, None, 512)	0	conv5_block2_1_b…
conv5_block2_2_conv (Conv2D)	(None, None, None, 512)	2,359,808	conv5_block2_1_r…
conv5_block2_2_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv5_block2_2_c…
conv5_block2_2_relu (Activation)	(None, None, None, 512)	0	conv5_block2_2_b…
conv5_block2_3_conv (Conv2D)	(None, None, None, 2048)	1,050,624	conv5_block2_2_r…
conv5_block2_3_bn (BatchNormalizatio…	(None, None, None, 2048)	8,192	conv5_block2_3_c…

conv5_block2_add (Add)	(None, None, None, 2048)	0	conv5_block1_out… conv5_block2_3_b…
conv5_block2_out (Activation)	(None, None, None, 2048)	0	conv5_block2_add…
conv5_block3_1_conv (Conv2D)	(None, None, None, 512)	1,049,088	conv5_block2_out…
conv5_block3_1_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv5_block3_1_c…
conv5_block3_1_relu (Activation)	(None, None, None, 512)	0	conv5_block3_1_b…
conv5_block3_2_conv (Conv2D)	(None, None, None, 512)	2,359,808	conv5_block3_1_r…
conv5_block3_2_bn (BatchNormalizatio…	(None, None, None, 512)	2,048	conv5_block3_2_c…
conv5_block3_2_relu (Activation)	(None, None, None, 512)	0	conv5_block3_2_b…
conv5_block3_3_conv (Conv2D)	(None, None, None, 2048)	1,050,624	conv5_block3_2_r…
conv5_block3_3_bn (BatchNormalizatio…	(None, None, None, 2048)	8,192	conv5_block3_3_c…
conv5_block3_add (Add)	(None, None, None, 2048)	0	conv5_block2_out… conv5_block3_3_b…
conv5_block3_out (Activation)	(None, None, None, 2048)	0	conv5_block3_add…

Total params: 23,587,712 (89.98 MB)

Trainable params: 23,534,592 (89.78 MB)

Non-trainable params: 53,120 (207.50 KB)

Freeze upto 143 layers

In [11]:
```
for layer in base_model.layers[:143]: layer.trainable = False
```

In [12]:
```
for i, layer in enumerate(base_model.layers):
  print(i, layer.name,"-", layer.trainable)
```

```
0 input_layer - False
1 conv1_pad - False
2 conv1_conv - False
3 conv1_bn - False
4 conv1_relu - False
5 pool1_pad - False
6 pool1_pool - False
7 conv2_block1_1_conv - False
8 conv2_block1_1_bn - False
9 conv2_block1_1_relu - False
10 conv2_block1_2_conv - False
11 conv2_block1_2_bn - False
12 conv2_block1_2_relu - False
13 conv2_block1_0_conv - False
14 conv2_block1_3_conv - False
15 conv2_block1_0_bn - False
16 conv2_block1_3_bn - False
17 conv2_block1_add - False
18 conv2_block1_out - False
19 conv2_block2_1_conv - False
20 conv2_block2_1_bn - False
21 conv2_block2_1_relu - False
22 conv2_block2_2_conv - False
23 conv2_block2_2_bn - False
24 conv2_block2_2_relu - False
25 conv2_block2_3_conv - False
26 conv2_block2_3_bn - False
27 conv2_block2_add - False
28 conv2_block2_out - False
29 conv2_block3_1_conv - False
30 conv2_block3_1_bn - False
31 conv2_block3_1_relu - False
32 conv2_block3_2_conv - False
33 conv2_block3_2_bn - False
34 conv2_block3_2_relu - False
35 conv2_block3_3_conv - False
36 conv2_block3_3_bn - False
37 conv2_block3_add - False
38 conv2_block3_out - False
39 conv3_block1_1_conv - False
40 conv3_block1_1_bn - False
```

```
41 conv3_block1_1_relu - False
42 conv3_block1_2_conv - False
43 conv3_block1_2_bn - False
44 conv3_block1_2_relu - False
45 conv3_block1_0_conv - False
46 conv3_block1_3_conv - False
47 conv3_block1_0_bn - False
48 conv3_block1_3_bn - False
49 conv3_block1_add - False
50 conv3_block1_out - False
51 conv3_block2_1_conv - False
52 conv3_block2_1_bn - False
53 conv3_block2_1_relu - False
54 conv3_block2_2_conv - False
55 conv3_block2_2_bn - False
56 conv3_block2_2_relu - False
57 conv3_block2_3_conv - False
58 conv3_block2_3_bn - False
59 conv3_block2_add - False
60 conv3_block2_out - False
61 conv3_block3_1_conv - False
62 conv3_block3_1_bn - False
63 conv3_block3_1_relu - False
64 conv3_block3_2_conv - False
65 conv3_block3_2_bn - False
66 conv3_block3_2_relu - False
67 conv3_block3_3_conv - False
68 conv3_block3_3_bn - False
69 conv3_block3_add - False
70 conv3_block3_out - False
71 conv3_block4_1_conv - False
72 conv3_block4_1_bn - False
73 conv3_block4_1_relu - False
74 conv3_block4_2_conv - False
75 conv3_block4_2_bn - False
76 conv3_block4_2_relu - False
77 conv3_block4_3_conv - False
78 conv3_block4_3_bn - False
79 conv3_block4_add - False
80 conv3_block4_out - False
81 conv4_block1_1_conv - False
```

```
82 conv4_block1_1_bn - False
83 conv4_block1_1_relu - False
84 conv4_block1_2_conv - False
85 conv4_block1_2_bn - False
86 conv4_block1_2_relu - False
87 conv4_block1_0_conv - False
88 conv4_block1_3_conv - False
89 conv4_block1_0_bn - False
90 conv4_block1_3_bn - False
91 conv4_block1_add - False
92 conv4_block1_out - False
93 conv4_block2_1_conv - False
94 conv4_block2_1_bn - False
95 conv4_block2_1_relu - False
96 conv4_block2_2_conv - False
97 conv4_block2_2_bn - False
98 conv4_block2_2_relu - False
99 conv4_block2_3_conv - False
100 conv4_block2_3_bn - False
101 conv4_block2_add - False
102 conv4_block2_out - False
103 conv4_block3_1_conv - False
104 conv4_block3_1_bn - False
105 conv4_block3_1_relu - False
106 conv4_block3_2_conv - False
107 conv4_block3_2_bn - False
108 conv4_block3_2_relu - False
109 conv4_block3_3_conv - False
110 conv4_block3_3_bn - False
111 conv4_block3_add - False
112 conv4_block3_out - False
113 conv4_block4_1_conv - False
114 conv4_block4_1_bn - False
115 conv4_block4_1_relu - False
116 conv4_block4_2_conv - False
117 conv4_block4_2_bn - False
118 conv4_block4_2_relu - False
119 conv4_block4_3_conv - False
120 conv4_block4_3_bn - False
121 conv4_block4_add - False
122 conv4_block4_out - False
```

```
123 conv4_block5_1_conv - False
124 conv4_block5_1_bn - False
125 conv4_block5_1_relu - False
126 conv4_block5_2_conv - False
127 conv4_block5_2_bn - False
128 conv4_block5_2_relu - False
129 conv4_block5_3_conv - False
130 conv4_block5_3_bn - False
131 conv4_block5_add - False
132 conv4_block5_out - False
133 conv4_block6_1_conv - False
134 conv4_block6_1_bn - False
135 conv4_block6_1_relu - False
136 conv4_block6_2_conv - False
137 conv4_block6_2_bn - False
138 conv4_block6_2_relu - False
139 conv4_block6_3_conv - False
140 conv4_block6_3_bn - False
141 conv4_block6_add - False
142 conv4_block6_out - False
143 conv5_block1_1_conv - True
144 conv5_block1_1_bn - True
145 conv5_block1_1_relu - True
146 conv5_block1_2_conv - True
147 conv5_block1_2_bn - True
148 conv5_block1_2_relu - True
149 conv5_block1_0_conv - True
150 conv5_block1_3_conv - True
151 conv5_block1_0_bn - True
152 conv5_block1_3_bn - True
153 conv5_block1_add - True
154 conv5_block1_out - True
155 conv5_block2_1_conv - True
156 conv5_block2_1_bn - True
157 conv5_block2_1_relu - True
158 conv5_block2_2_conv - True
159 conv5_block2_2_bn - True
160 conv5_block2_2_relu - True
161 conv5_block2_3_conv - True
162 conv5_block2_3_bn - True
163 conv5_block2_add - True
```

```
164 conv5_block2_out - True
165 conv5_block3_1_conv - True
166 conv5_block3_1_bn - True
167 conv5_block3_1_relu - True
168 conv5_block3_2_conv - True
169 conv5_block3_2_bn - True
170 conv5_block3_2_relu - True
171 conv5_block3_3_conv - True
172 conv5_block3_3_bn - True
173 conv5_block3_add - True
174 conv5_block3_out - True
```

Adding more layers to base model

In [13]:
```
model = Sequential()
model.add(base_model)
model.add(tf.keras.layers.GlobalAveragePooling2D()) # For Flattening
model.add(Dense(1024, activation='relu'))
model.add(BatchNormalization())
model.add(Dropout(0.5))
model.add(Dense(1, activation='sigmoid'))
```

Training and Testing the model

In [14]:
```
model.compile(optimizer = tf.keras.optimizers.SGD(learning_rate = 0.001, momentum = 0.9) ,
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

In [15]:
```
history = model.fit(training_set, epochs = 20,  validation_data = test_set)
```

```
C:\Users\siddh\AppData\Roaming\Python\Python39\site-packages\keras\src\trainers\data_adapters\py_dataset_adapter.py:121: UserWa
rning: Your `PyDataset` class should call `super().__init__(**kwargs)` in its constructor. `**kwargs` can include `workers`, `u
se_multiprocessing`, `max_queue_size`. Do not pass these arguments to `fit()`, as they will be ignored.
  self._warn_if_super_not_called()
```

```
Epoch 1/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 39s 5s/step - accuracy: 0.5881 - loss: 0.6863 - val_accuracy: 0.5000 - val_loss: 0.6973
Epoch 2/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.7839 - loss: 0.3975 - val_accuracy: 0.5000 - val_loss: 0.6992
Epoch 3/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.8193 - loss: 0.3336 - val_accuracy: 0.5000 - val_loss: 0.7023
Epoch 4/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.8134 - loss: 0.3530 - val_accuracy: 0.5000 - val_loss: 0.6964
Epoch 5/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.7542 - loss: 0.3505 - val_accuracy: 0.5000 - val_loss: 0.6893
Epoch 6/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.8986 - loss: 0.2298 - val_accuracy: 0.5000 - val_loss: 0.6882
Epoch 7/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.7795 - loss: 0.4719 - val_accuracy: 0.5000 - val_loss: 0.6893
Epoch 8/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.7600 - loss: 0.4445 - val_accuracy: 0.5000 - val_loss: 0.6878
Epoch 9/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.8731 - loss: 0.2251 - val_accuracy: 0.5500 - val_loss: 0.6821
Epoch 10/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.9298 - loss: 0.1943 - val_accuracy: 0.6000 - val_loss: 0.6795
Epoch 11/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.9364 - loss: 0.1691 - val_accuracy: 0.7250 - val_loss: 0.6723
Epoch 12/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 22s 5s/step - accuracy: 0.9183 - loss: 0.1550 - val_accuracy: 0.7250 - val_loss: 0.6700
Epoch 13/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.8884 - loss: 0.2270 - val_accuracy: 0.7500 - val_loss: 0.6661
Epoch 14/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.9082 - loss: 0.1710 - val_accuracy: 0.6500 - val_loss: 0.6609
Epoch 15/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 25s 5s/step - accuracy: 0.8845 - loss: 0.1957 - val_accuracy: 0.7250 - val_loss: 0.6622
Epoch 16/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.9425 - loss: 0.1326 - val_accuracy: 0.8750 - val_loss: 0.6433
Epoch 17/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 23s 5s/step - accuracy: 0.8885 - loss: 0.2290 - val_accuracy: 0.6000 - val_loss: 0.6442
Epoch 18/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 22s 5s/step - accuracy: 0.9232 - loss: 0.2294 - val_accuracy: 0.6250 - val_loss: 0.6396
Epoch 19/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 24s 5s/step - accuracy: 0.9329 - loss: 0.1362 - val_accuracy: 0.6000 - val_loss: 0.6293
Epoch 20/20
5/5 ━━━━━━━━━━━━━━━━━━━━ 22s 5s/step - accuracy: 0.9027 - loss: 0.1810 - val_accuracy: 0.7250 - val_loss: 0.5989
```

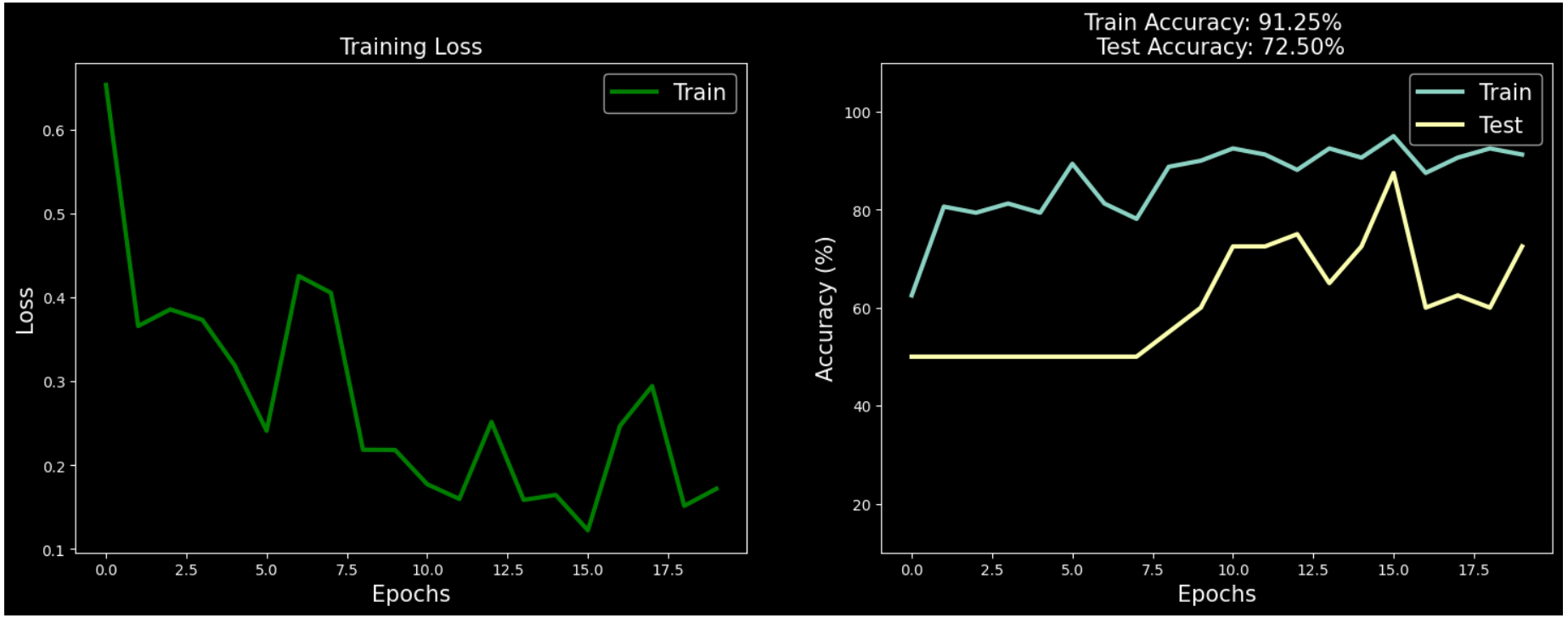
In [16]:
```
trainAcc = [100 * x for x in history.history['accuracy']]
testAcc = [100 * x for x in history.history['val_accuracy']]
```

In [17]:
```
fig,ax = plt.subplots(1,2,figsize=(18,6))

ax[0].plot(history.history['loss'], 'g', lw = 3, label = 'Train')
ax[0].set_xlabel('Epochs', fontsize = 15)
ax[0].set_ylabel('Loss', fontsize = 15)
ax[0].legend(fontsize = 15)
ax[0].set_title('Training Loss', fontsize = 15)


ax[1].plot(trainAcc, label ='Train', lw = 3)
ax[1].plot(testAcc, label ='Test', lw = 3)
ax[1].set_xlabel('Epochs', fontsize = 15)
ax[1].set_ylabel('Accuracy (%)', fontsize = 15)
ax[1].set_ylim([10,110])
ax[1].set_title(f'Train Accuracy: {trainAcc[-1]:.2f}% \n Test Accuracy: {testAcc[-1]:.2f}%', fontsize = 15)
ax[1].legend(fontsize = 15)

plt.show()
```



In [20]:
```
import tensorflow as tf
from keras.models import Sequential
from keras.layers import Activation, Dropout, Flatten, Dense, Conv2D, MaxPooling2D
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import splitfolders
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from matplotlib import style
style.use('dark_background')
```

Prepare train and test sets, loaders

In [21]:
```
splitfolders.ratio("dataset", output="Train_Test",
    seed=1337, ratio=(.8, .2), group_prefix=None, move=False) # default values
```

```
Copying files: 200 files [00:00, 533.33 files/s]
```

Creating train and test data generators

In [22]:
```
train_datagen = ImageDataGenerator(rescale = 1./255)

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

In [23]:
```
num_classes = 2
img_shape = (200,200,3)
batch_size = 32
```

Creating Training and Testing Datasets

In [24]:
```
training_set = train_datagen.flow_from_directory('Train_Test/train',
                                                 target_size = (200,200),
                                                 class_mode='binary',
                                                 shuffle = True,
                                                 batch_size = batch_size)
```

```
Found 160 images belonging to 2 classes.
```

In [25]:
```
test_set = train_datagen.flow_from_directory('Train_Test/val',
                                             target_size = (200,200),
                                             class_mode='binary',
                                             shuffle = False,
                                             batch_size = batch_size)
```

```
Found 40 images belonging to 2 classes.
```

Create CNN

In [26]:
```
model = Sequential()
model.add(Conv2D(10 ,kernel_size = (5, 5), padding = 'SAME', input_shape = img_shape))
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2),strides = 2))
```

```
model.add(Conv2D(20, (5, 5), padding='SAME')) # "SAME" tries to pad evenly left and right
model.add(Activation('relu'))
model.add(MaxPooling2D(pool_size=(2, 2),strides = 2))

model.add(Flatten())
model.add(Dense(64))
model.add(Activation('relu'))
model.add(Dense(1))
model.add(Activation('sigmoid'))
```

```
C:\Users\siddh\AppData\Roaming\Python\Python39\site-packages\keras\src\layers\convolutional\base_conv.py:107: UserWarning: Do n
ot pass an `input_shape`/`input_dim` argument to a layer. When using Sequential models, prefer using an `Input(shape)` object a
s the first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [27]:
```
model.summary()
```

Model: "sequential_1"

Layer (type)	Output Shape	Param #
conv2d (Conv2D)	(None, 200, 200, 10)	760
activation (Activation)	(None, 200, 200, 10)	0
max_pooling2d (MaxPooling2D)	(None, 100, 100, 10)	0
conv2d_1 (Conv2D)	(None, 100, 100, 20)	5,020
activation_1 (Activation)	(None, 100, 100, 20)	0
max_pooling2d_1 (MaxPooling2D)	(None, 50, 50, 20)	0
flatten (Flatten)	(None, 50000)	0
dense_2 (Dense)	(None, 64)	3,200,064
activation_2 (Activation)	(None, 64)	0
dense_3 (Dense)	(None, 1)	65
activation_3 (Activation)	(None, 1)	0

Total params: 3,205,909 (12.23 MB)

Trainable params: 3,205,909 (12.23 MB)

Non-trainable params: 0 (0.00 B)

Setting Early Stopping Criterion

In [28]:
```
from keras.callbacks import EarlyStopping
earlystop = EarlyStopping(monitor = 'val_loss',
                          min_delta = 0,
                          patience = 3,
                          verbose =1,
                          restore_best_weights = True)
```

Training and Testing the model

In [29]:
```
model.compile(optimizer = tf.keras.optimizers.SGD(learning_rate = 0.01, momentum = 0.9) ,
              loss='binary_crossentropy',
              metrics=['accuracy'])
```

In [30]:
```
hist = model.fit(training_set,
                 epochs = 500,
                 validation_data = test_set,
                 callbacks = earlystop)
```

```
Epoch 1/500
C:\Users\siddh\AppData\Roaming\Python\Python39\site-packages\keras\src\trainers\data_adapters\py_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.
  self._warn_if_super_not_called()
```

```
5/5 ━━━━━━━━━━━━━━━━━━━━ 3s 386ms/step - accuracy: 0.4552 - loss: 1.1016 - val_accuracy: 0.5000 - val_loss: 0.8297
Epoch 2/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 312ms/step - accuracy: 0.5218 - loss: 0.7595 - val_accuracy: 0.5000 - val_loss: 0.6904
Epoch 3/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 328ms/step - accuracy: 0.5923 - loss: 0.6895 - val_accuracy: 0.6750 - val_loss: 0.6838
Epoch 4/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 363ms/step - accuracy: 0.5990 - loss: 0.6841 - val_accuracy: 0.7000 - val_loss: 0.6772
Epoch 5/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 324ms/step - accuracy: 0.7078 - loss: 0.6723 - val_accuracy: 0.7000 - val_loss: 0.6627
Epoch 6/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 337ms/step - accuracy: 0.6490 - loss: 0.6654 - val_accuracy: 0.7000 - val_loss: 0.6494
Epoch 7/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 313ms/step - accuracy: 0.7002 - loss: 0.6468 - val_accuracy: 0.7000 - val_loss: 0.6528
Epoch 8/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 329ms/step - accuracy: 0.7217 - loss: 0.6289 - val_accuracy: 0.7250 - val_loss: 0.6107
Epoch 9/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 356ms/step - accuracy: 0.7745 - loss: 0.5584 - val_accuracy: 0.6750 - val_loss: 0.5411
Epoch 10/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 345ms/step - accuracy: 0.7902 - loss: 0.4827 - val_accuracy: 0.7000 - val_loss: 0.6525
Epoch 11/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 380ms/step - accuracy: 0.7530 - loss: 0.4981 - val_accuracy: 0.7000 - val_loss: 0.5611
Epoch 12/500
5/5 ━━━━━━━━━━━━━━━━━━━━ 2s 390ms/step - accuracy: 0.8387 - loss: 0.4459 - val_accuracy: 0.7250 - val_loss: 0.5804
Epoch 12: early stopping
Restoring model weights from the end of the best epoch: 9.
```

In [31]:
```
trainAcc = [100 * x for x in hist.history['accuracy']]
testAcc = [100 * x for x in hist.history['val_accuracy']]
```

Visualize the Model Performance

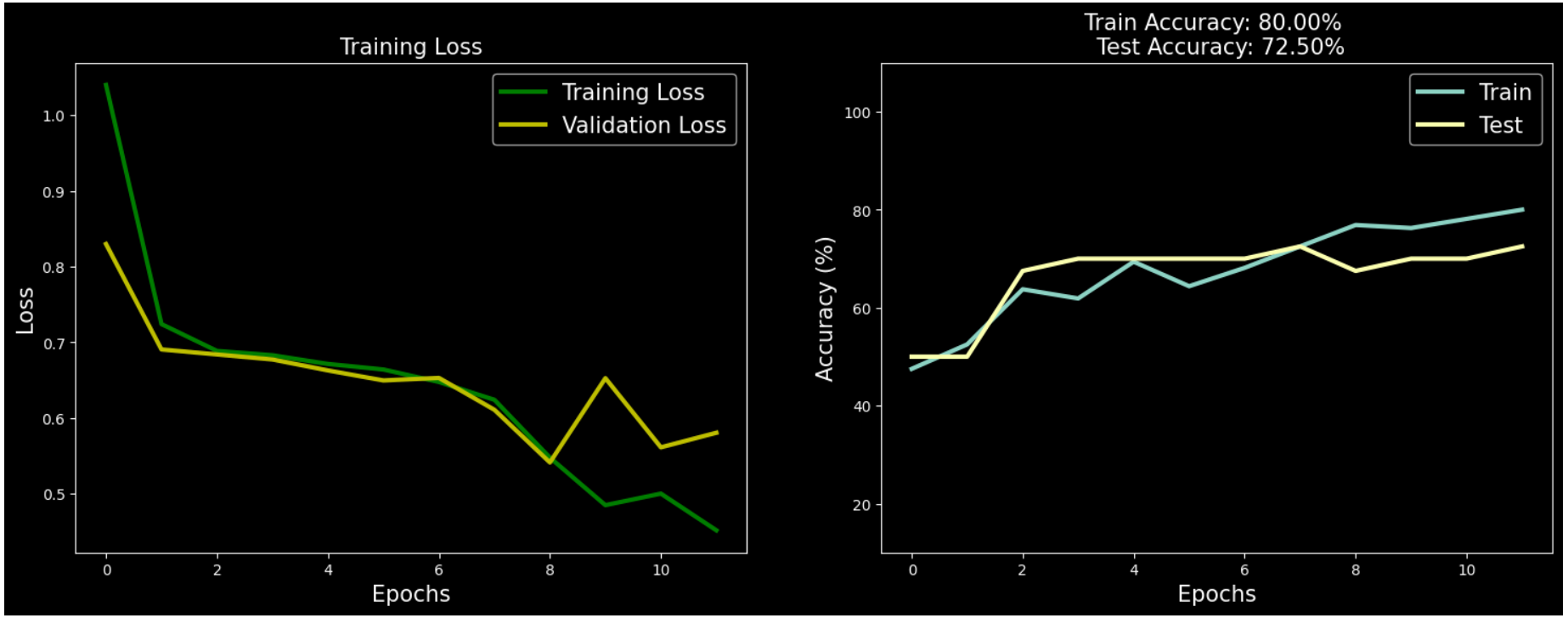
In [32]:
```
fig,ax = plt.subplots(1,2,figsize=(18,6))

ax[0].plot(hist.history['loss'], 'g', lw = 3, label = 'Training Loss')
ax[0].plot(hist.history['val_loss'], 'y', lw = 3, label = 'Validation Loss')
ax[0].set_xlabel('Epochs', fontsize = 15)
ax[0].set_ylabel('Loss', fontsize = 15)
ax[0].legend(fontsize = 15)
```

```
ax[0].set_title('Training Loss', fontsize = 15)


ax[1].plot(trainAcc, label ='Train', lw = 3)
ax[1].plot(testAcc, label ='Test', lw = 3)
ax[1].set_xlabel('Epochs', fontsize = 15)
ax[1].set_ylabel('Accuracy (%)', fontsize = 15)
ax[1].set_ylim([10,110])
ax[1].set_title(f'Train Accuracy: {trainAcc[-1]:.2f}% \n Test Accuracy: {testAcc[-1]:.2f}%', fontsize = 15)
ax[1].legend(fontsize = 15)

plt.show()
```



In [ ]: