Importing libraries

In [2]:
```
import os                        # for working with files
import numpy as np               # for numerical computationss
import pandas as pd              # for working with dataframes
import seaborn as sns
import torch                     # Pytorch module
import matplotlib.pyplot as plt # for plotting informations on graph and images using t
import torch.nn as nn            # for creating  neural networks
from torch.utils.data import DataLoader # for dataloaders
from PIL import Image            # for checking images
import torch.nn.functional as F # for functions for calculating loss
import torchvision.transforms as transforms   # for transforming images into tensors
from torchvision.utils import make_grid       # for data checking
from torchvision.datasets import ImageFolder  # for working with classes and images
#from torchsummary import summary              # for getting the summary of our model
import tensorflow as tf
from  tensorflow import keras
import itertools
from sklearn.metrics import precision_score, accuracy_score, recall_score, confusion_ma

%matplotlib inline

import cv2
from tensorflow.keras.preprocessing import image

from glob import glob
import shutil
```

Data loading and exploring

In [117…
```
# # Remove comment and run only to remove following directories if they exist previousl
# shutil.rmtree("/kaggle/working/lung_aca")
# shutil.rmtree("/kaggle/working/lung_scc")
# shutil.rmtree("/kaggle/working/lung_n")
```

In [118…
```
os.makedirs('/kaggle/working/lung_aca')
os.makedirs('/kaggle/working/lung_scc')
os.makedirs('/kaggle/working/lung_n')
```

In [119…
```
folders = glob('/kaggle/input/lung-and-colon-cancer-histopathological-images/lung_colon
print('New Paths: ', folders)
```

```
New Paths:  ['/kaggle/input/lung-and-colon-cancer-histopathological-images/lung_colon_im
age_set/lung_image_sets/lung_aca', '/kaggle/input/lung-and-colon-cancer-histopathologica
l-images/lung_colon_image_set/lung_image_sets/lung_scc', '/kaggle/input/lung-and-colon-c
ancer-histopathological-images/lung_colon_image_set/lung_image_sets/lung_n']
```

In [120…
```
clahe = cv2.createCLAHE(clipLimit=2.0, tileGridSize=(16, 16))
for i in folders:
    IMAGE_FILES = glob(i + '/*.jpeg')
```

```
    train_imgs = IMAGE_FILES
    num_show = len(IMAGE_FILES)
    columns = 5

    plt.figure(figsize=(25,12))
    for idx, train_img in enumerate(train_imgs):
        if idx >= num_show:
            break

        t = train_img.split('/')
        temp_img = cv2.imread(train_img, cv2.IMREAD_COLOR)
        img_lab = cv2.cvtColor(temp_img, cv2.COLOR_BGR2Lab)

        l, a, b = cv2.split(img_lab)
        img_l = clahe.apply(l)
        img_clahe = cv2.merge((img_l, a, b))
        img_clahe = cv2.cvtColor(img_clahe, cv2.COLOR_Lab2BGR)

        cv2.imwrite('/kaggle/working/' + t[6] + '/' + t[7], img_clahe)
```

```
<Figure size 1800x864 with 0 Axes>
<Figure size 1800x864 with 0 Axes>
<Figure size 1800x864 with 0 Axes>
```

Show some example for lung cancer

In [121…

```
lung_dir = "/kaggle/working/"
lungs = os.listdir(lung_dir)
lungs
```

Out[121…

```
['lung_n', 'lung_aca', 'lung_scc']
```

In [122…

```
# Number of images for each disease
nums_train = {}
nums_val = {}
for lung in lungs:
    nums_train[lung] = len(os.listdir(lung_dir + '/' + lung))
img_per_class_train = pd.DataFrame(nums_train.values(), index=nums_train.keys(), column
print('Train data distribution :')
img_per_class_train
```

```
Train data distribution :
```

Out[122…

	no. of images
lung_n	5000
lung_aca	5000
lung_scc	5000

In [123…

```
# Function to show image
train = ImageFolder(lung_dir, transform=transforms.ToTensor())
def show_image(image, label):
    print("Label :" + train.classes[label] + "(" + str(label) + ")")
    return image.permute(1, 2, 0)
```

Lung_aca

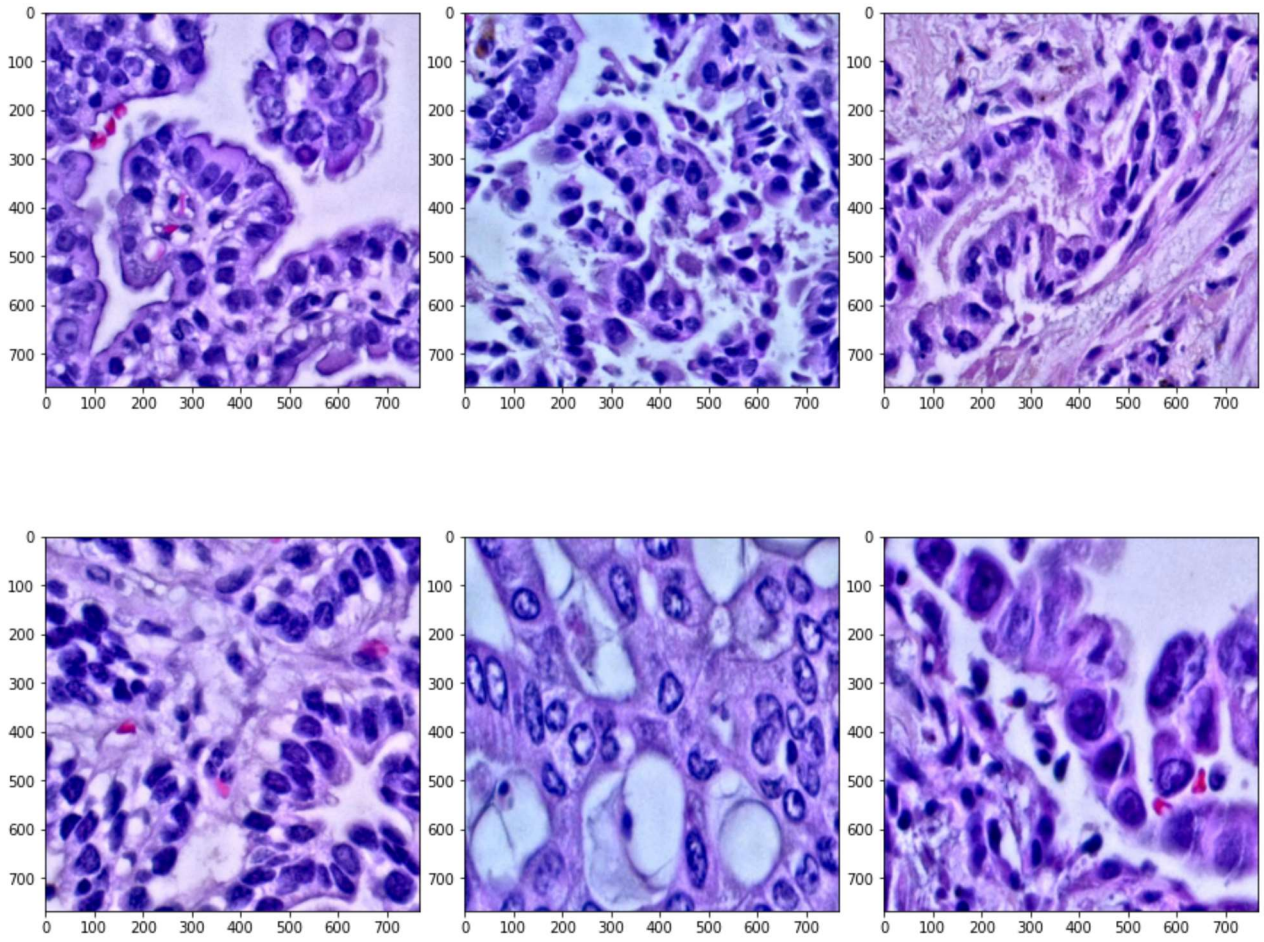
In [124…

```
fig, axs = plt.subplots(2, 3,figsize=(12,10))
fig.tight_layout(pad=0)
axs[0,0].imshow(show_image(*train[1]))
axs[0,1].imshow(show_image(*train[1100]))
axs[1, 0].imshow(show_image(*train[2010]))
axs[1,1].imshow(show_image(*train[3500]))
axs[0,2].imshow(show_image(*train[4120]))
axs[1,2].imshow(show_image(*train[4860]))
```

```
Label :lung_aca(0)
Label :lung_aca(0)
Label :lung_aca(0)
Label :lung_aca(0)
Label :lung_aca(0)
Label :lung_aca(0)
```

Out[124…

```
<matplotlib.image.AxesImage at 0x7f53bfc13450>
```



Lung_n

In [125…

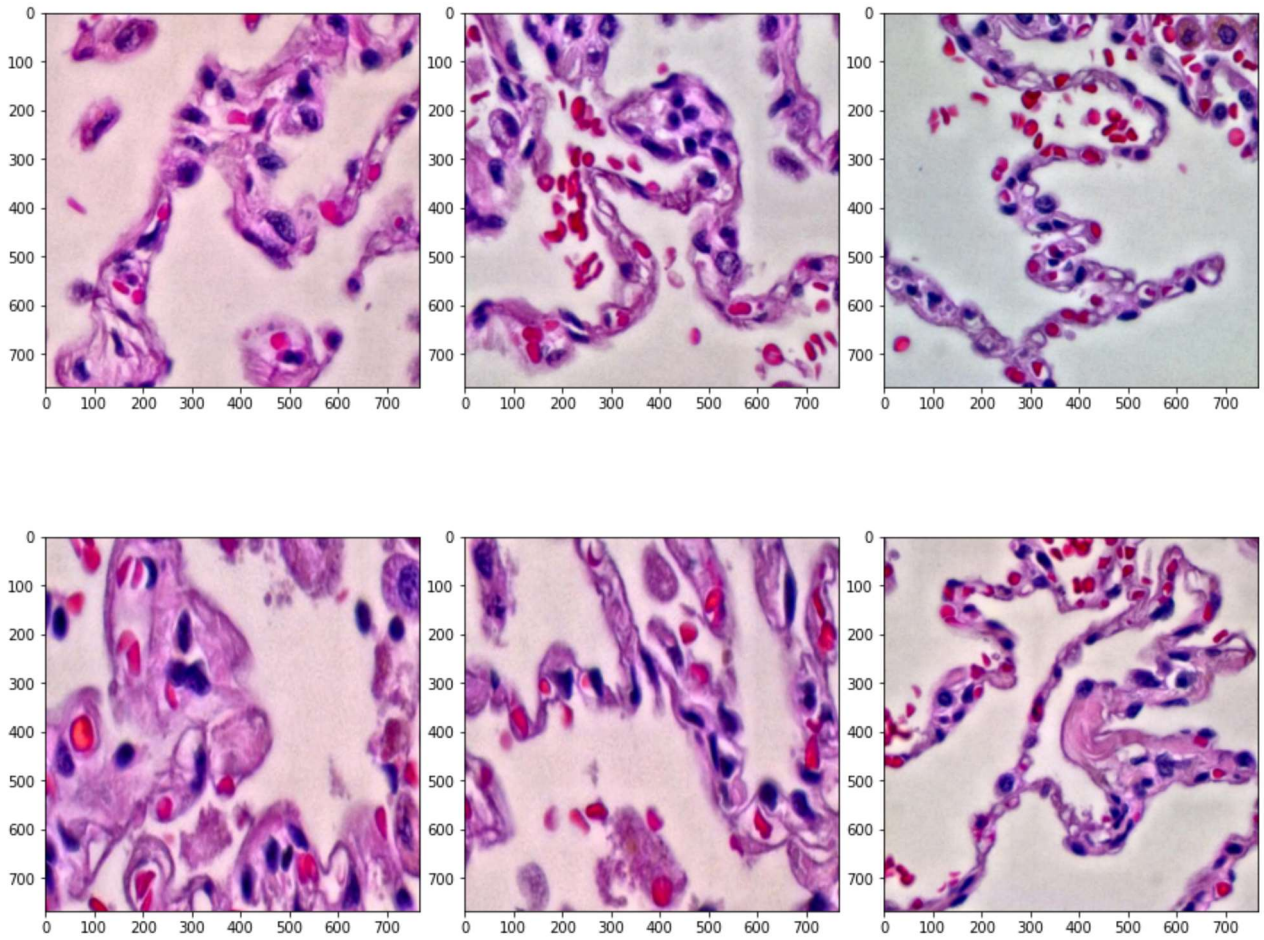
```
fig, axs = plt.subplots(2, 3,figsize=(12,10))
fig.tight_layout(pad=0)
axs[0,0].imshow(show_image(*train[5010]))
axs[0,1].imshow(show_image(*train[6050]))
```

```
axs[1, 0].imshow(show_image(*train[7000]))
axs[1,1].imshow(show_image(*train[7500]))
axs[0,2].imshow(show_image(*train[8000]))
axs[1,2].imshow(show_image(*train[8620]))
```

```
Label :lung_n(1)
Label :lung_n(1)
Label :lung_n(1)
Label :lung_n(1)
Label :lung_n(1)
Label :lung_n(1)
```

Out[125…

```
<matplotlib.image.AxesImage at 0x7f53bf97b110>
```



Lung_scc

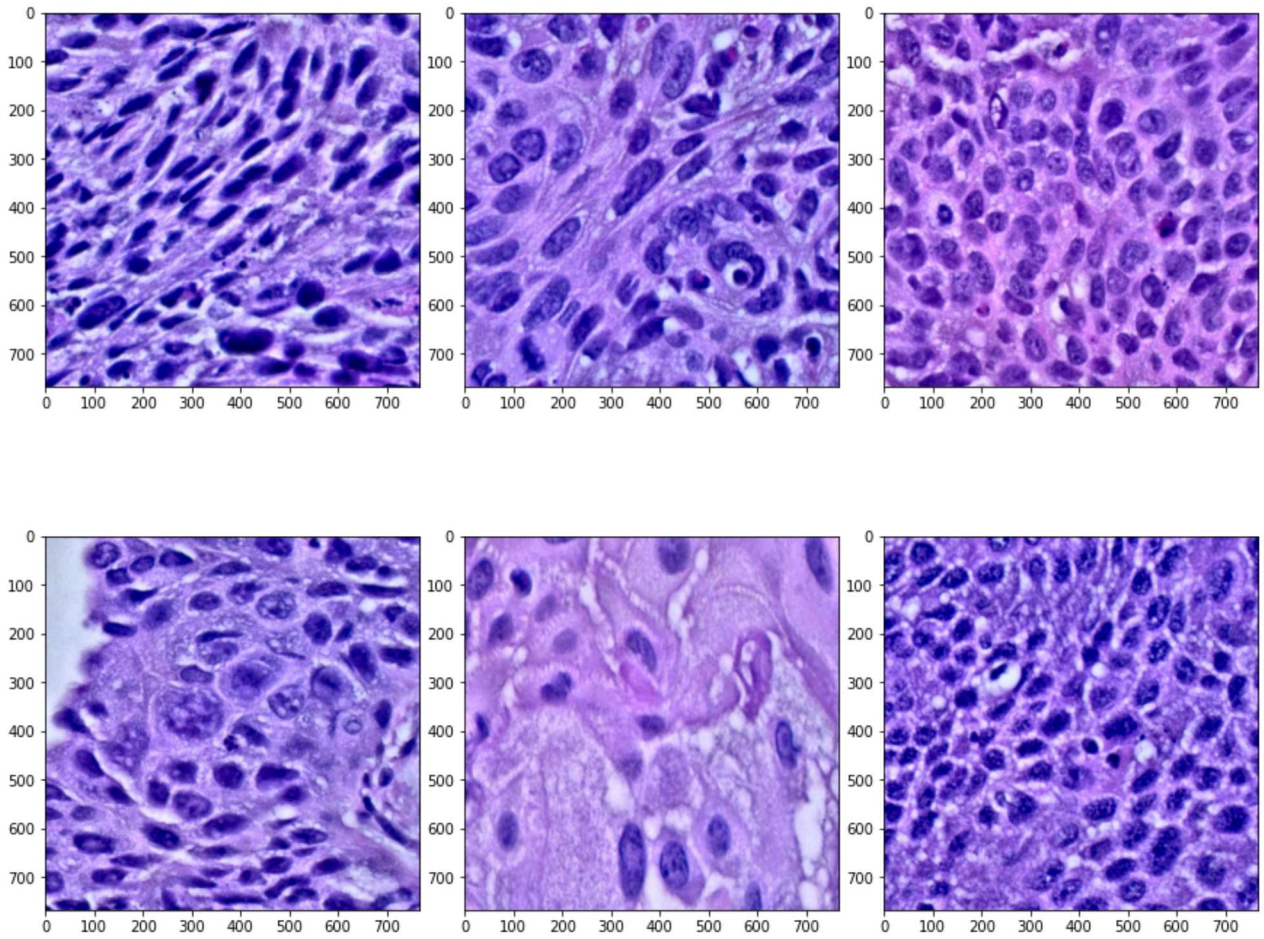
In [126…

```
fig, axs = plt.subplots(2, 3,figsize=(12,10))
fig.tight_layout(pad=0)
axs[0,0].imshow(show_image(*train[11001]))
axs[0,1].imshow(show_image(*train[12000]))
axs[1, 0].imshow(show_image(*train[13050]))
axs[1,1].imshow(show_image(*train[14000]))
axs[0,2].imshow(show_image(*train[14200]))
axs[1,2].imshow(show_image(*train[14800]))
```

```
Label :lung_scc(2)
Label :lung_scc(2)
Label :lung_scc(2)
Label :lung_scc(2)
```

```
Label :lung_scc(2)
Label :lung_scc(2)
```

Out[126…
```
<matplotlib.image.AxesImage at 0x7f53bf60c050>
```



Modeling

In [129…
```
train_gen = keras.preprocessing.image.ImageDataGenerator(rescale=1./255,
                                                         rotation_range = 20 ,
                                                         horizontal_flip = True ,
                                                         validation_split = 0.2
                                                         )
valid_gen =  keras.preprocessing.image.ImageDataGenerator(rescale=1./255,validation_spl
train_data = train_gen.flow_from_directory(lung_dir, subset='training', target_size=(22
                                           class_mode='categorical', shuffle=True)

val_data = valid_gen.flow_from_directory(lung_dir, subset='validation', target_size=(22
                                           class_mode='categorical', shuffle=False)
```

```
Found 12000 images belonging to 3 classes.
Found 3000 images belonging to 3 classes.
```

In [130…
```
unique, counts = np.unique(val_data.classes, return_counts=True)
dict(zip(unique, counts))
```

Out[130…
```
{0: 1000, 1: 1000, 2: 1000}
```

model_1

In [131…

```
model_1 = keras.models.Sequential()
model_1.add(keras.layers.Conv2D(8, 3, activation='relu', input_shape=(224, 224, 3)))

model_1.add(keras.layers.Dropout(0.05))
model_1.add(keras.layers.MaxPooling2D())

model_1.add(keras.layers.Conv2D(16, 3, activation='relu', input_shape=(224, 224, 3)))

model_1.add(keras.layers.Dropout(0.1))
model_1.add(keras.layers.MaxPooling2D())

model_1.add(keras.layers.Conv2D(32, 3, activation='relu', input_shape=(224, 224, 3)))

model_1.add(keras.layers.Dropout(0.1))
model_1.add(keras.layers.MaxPooling2D())

model_1.add(keras.layers.Conv2D(64, 3, activation='relu'))
model_1.add(keras.layers.Dropout(0.15))
model_1.add(keras.layers.MaxPooling2D())

model_1.add(keras.layers.Conv2D(128, 3, activation='relu'))
model_1.add(keras.layers.Dropout(0.2))
model_1.add(keras.layers.MaxPooling2D())

model_1.add(keras.layers.Flatten())
model_1.add(keras.layers.Dense(256, activation='relu'))
model_1.add(keras.layers.Dense(3, activation='softmax'))

model_1.compile(optimizer='adam',loss='categorical_crossentropy', metrics=['accuracy'])
model_1.summary()
```

```
2023-02-03 13:24:11.132242: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.133203: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.134232: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.135005: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.135795: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.136503: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from S
Model: "sequential"
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
conv2d (Conv2D)              (None, 222, 222, 8)       224
_________________________________________________________________
dropout (Dropout)            (None, 222, 222, 8)       0
_________________________________________________________________
```

```
max_pooling2d (MaxPooling2D) (None, 111, 111, 8)       0
_________________________________________________________________
conv2d_1 (Conv2D)            (None, 109, 109, 16)      1168
_________________________________________________________________
dropout_1 (Dropout)          (None, 109, 109, 16)      0
_________________________________________________________________
max_pooling2d_1 (MaxPooling2 (None, 54, 54, 16)        0
_________________________________________________________________
conv2d_2 (Conv2D)            (None, 52, 52, 32)        4640
_________________________________________________________________
dropout_2 (Dropout)          (None, 52, 52, 32)        0
_________________________________________________________________
max_pooling2d_2 (MaxPooling2 (None, 26, 26, 32)        0
_________________________________________________________________
conv2d_3 (Conv2D)            (None, 24, 24, 64)        18496
_________________________________________________________________
dropout_3 (Dropout)          (None, 24, 24, 64)        0
_________________________________________________________________
max_pooling2d_3 (MaxPooling2 (None, 12, 12, 64)        0
_________________________________________________________________
conv2d_4 (Conv2D)            (None, 10, 10, 128)       73856
_________________________________________________________________
dropout_4 (Dropout)          (None, 10, 10, 128)       0
_________________________________________________________________
max_pooling2d_4 (MaxPooling2 (None, 5, 5, 128)         0
_________________________________________________________________
flatten (Flatten)            (None, 3200)              0
_________________________________________________________________
dense (Dense)                (None, 256)               819456
_________________________________________________________________
dense_1 (Dense)              (None, 3)                 771
=================================================================
Total params: 918,611
Trainable params: 918,611
Non-trainable params: 0
_________________________________________________________________
ysFS had negative value (-1), but there must be at least one NUMA node, so returning NUM
A node zero
2023-02-03 13:24:11.138017: I tensorflow/core/platform/cpu_feature_guard.cc:142] This Te
nsorFlow binary is optimized with oneAPI Deep Neural Network Library (oneDNN) to use the
following CPU instructions in performance-critical operations:  AVX2 AVX512F FMA
To enable them in other operations, rebuild TensorFlow with the appropriate compiler fla
gs.
2023-02-03 13:24:11.379724: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.381001: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.382171: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.383263: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.384295: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:11.385409: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
```

```
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.060194: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.061561: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.062710: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.063785: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.064990: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.067482: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1510] Cre
ated device /job:localhost/replica:0/task:0/device:GPU:0 with 13349 MB memory:  -> devic
e: 0, name: Tesla T4, pci bus id: 0000:00:04.0, compute capability: 7.5
2023-02-03 13:24:19.072535: I tensorflow/stream_executor/cuda/cuda_gpu_executor.cc:937]
successful NUMA node read from SysFS had negative value (-1), but there must be at least
one NUMA node, so returning NUMA node zero
2023-02-03 13:24:19.073241: I tensorflow/core/common_runtime/gpu/gpu_device.cc:1510] Cre
ated device /job:localhost/replica:0/task:0/device:GPU:1 with 13349 MB memory:  -> devic
e: 1, name: Tesla T4, pci bus id: 0000:00:05.0, compute capability: 7.5
```

In [132…

```
history = model_1.fit(train_data,
          validation_data=val_data,
          epochs = 5)
```

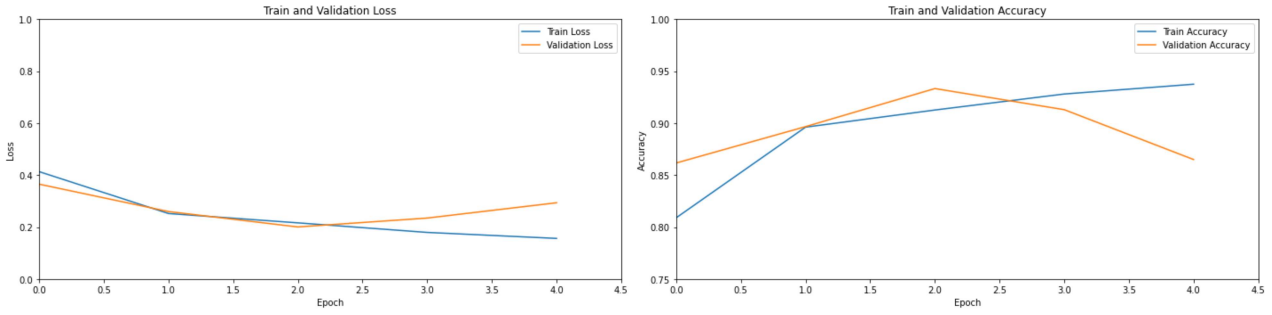
```
2023-02-03 13:24:31.898708: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Alloca
tion of 38535168 exceeds 10% of free system memory.
2023-02-03 13:24:32.050344: I tensorflow/compiler/mlir/mlir_graph_optimization_pass.cc:1
85] None of the MLIR Optimization Passes are enabled (registered 2)
Epoch 1/5
2023-02-03 13:24:34.234468: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Alloca
tion of 38535168 exceeds 10% of free system memory.
2023-02-03 13:24:35.831269: I tensorflow/stream_executor/cuda/cuda_dnn.cc:369] Loaded cu
DNN version 8005
2023-02-03 13:24:36.007555: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Alloca
tion of 38535168 exceeds 10% of free system memory.
  3/188 [..............................] - ETA: 2:34 - loss: 1.1132 - accuracy: 0.3281
2023-02-03 13:24:45.704425: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Alloca
tion of 38535168 exceeds 10% of free system memory.
  4/188 [..............................] - ETA: 3:07 - loss: 1.0958 - accuracy: 0.3398
2023-02-03 13:24:47.071782: W tensorflow/core/framework/cpu_allocator_impl.cc:80] Alloca
tion of 38535168 exceeds 10% of free system memory.
188/188 [==============================] - 307s 2s/step - loss: 0.4134 - accuracy: 0.808
9 - val_loss: 0.3652 - val_accuracy: 0.8617
Epoch 2/5
188/188 [==============================] - 285s 2s/step - loss: 0.2521 - accuracy: 0.896
2 - val_loss: 0.2597 - val_accuracy: 0.8967
Epoch 3/5
188/188 [==============================] - 276s 1s/step - loss: 0.2161 - accuracy: 0.912
7 - val_loss: 0.2003 - val_accuracy: 0.9333
Epoch 4/5
188/188 [==============================] - 276s 1s/step - loss: 0.1793 - accuracy: 0.928
1 - val_loss: 0.2345 - val_accuracy: 0.9130
```

```
Epoch 5/5
188/188 [==============================] - 278s 1s/step - loss: 0.1562 - accuracy: 0.937
5 - val_loss: 0.2934 - val_accuracy: 0.8650
```

In [133…

```
plt.figure(figsize = (20,5))
plt.subplot(1,2,1)
plt.title("Train and Validation Loss")
plt.xlabel("Epoch")
plt.ylabel("Loss")
plt.plot(history.history['loss'],label="Train Loss")
plt.plot(history.history['val_loss'], label="Validation Loss")
plt.xlim(0, 4.5)
plt.ylim(0.0,1.0)
plt.legend()

plt.subplot(1,2,2)
plt.title("Train and Validation Accuracy")
plt.xlabel("Epoch")
plt.ylabel("Accuracy")
plt.plot(history.history['accuracy'], label="Train Accuracy")
plt.plot(history.history['val_accuracy'], label="Validation Accuracy")
plt.xlim(0, 4.5)
plt.ylim(0.75,1.0)
plt.legend()
plt.tight_layout()
```



In [134…

```
Y_pred = model_1.predict(val_data)
y_pred = np.argmax(Y_pred, axis=1)

print(classification_report(val_data.classes, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.98      0.61      0.75      1000
           1       1.00      0.99      1.00      1000
           2       0.72      0.99      0.83      1000

    accuracy                           0.86      3000
   macro avg       0.90      0.86      0.86      3000
weighted avg       0.90      0.86      0.86      3000
```

In [135…

```
from mlxtend.plotting import plot_confusion_matrix
# calculating and plotting the confusion matrix
cm1 = confusion_matrix(val_data.classes, y_pred)
plot_confusion_matrix(conf_mat=cm1,show_absolute=True,
                                show_normed=True,
```

```
                                      colorbar=True)
plt.show()
```